Water governance in Brazil

The need to share water in the anthropocene

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6.

6. WATER GOVERNANCE IN THE SFRB

> **Legend of the tears of Iati:** *"It is believed that a long time ago, deep in the heart of the Canastra Mountains in Minas Gerais (state), Brazil, there was a beautiful young Indian girl named Iati. In her time, there was a great war and Iati's lover was called to defend their land and their people from the invaders. But the invaders were many, with great powers and ammunition, and the Indian warriors sank in the wrinkles of the deep forest. Iati, sad and alone, cried copiously until the last days of her life. Her desperate tears formed the waterfall whose waters follow the sunken footsteps of the Indian warriors, forming the great river-sea, known to the Indians then as Opara, and to us today as the São Francisco River" (Andrade, 2006:1). The river was known to the Indians as the 'Opara' until 500 years ago when the Portuguese arrived and renamed it 'São Francisco'.*

6.1. Introduction

The São Francisco River Basin (SFRB) provides nearly 70% of the surface water in Northeast Brazil (Torres et al., 2012). The river is considered a strategic connection between the well-developed Southeast and the economic poorer North-eastern regions of Brazil. Its economic and political importance is linked to the irrigation and hydropower industries. The SFRB mirrors the water sharing challenges of the country as a whole. Commercial irrigated agriculture is by far the main water user in the basin. This chapter discusses current drivers of water challenges in the SFRB and policy instruments, particularly addressing water-sharing challenges. The chapter answers the following questions: What are the current drivers of water challenges in the SFRB? Which policy instruments are addressing the water-sharing challenges in the SFRB?

First, the chapter provides the general historical context of the SFRB (see 6.2), and then presents the existing policy framework and sharing instruments (see 6.3). Section 6.4 further explores the water-sharing instruments, comparing their implications on paper versus in practice. The closing section (6.5) highlights which policy instruments have actually been addressing water-sharing problems in the basin.

6.2. The context of the São Francisco River Basin

6.2.1. The political context

Regional elites[17] have controlled the evolution of the political regime in the SFRB. Since the 1950s, the SFRB was chosen as part of the hydroelectricity strategy plan for national development (electricity production) and regional policies were implemented by the federal government to restructure the economic, social, and agrarian relationships (e.g., SUDENE; see Box 6.1) (Furtado, 1962; Chilcote, 1990). The evolution of political issues in the SFRB (from democratic to authoritarian to democratic; and increasingly becoming more neo-liberal) shows how inequality has increasingly widened between the few who have access to federal opportunities and the majority who are excluded from those opportunities (Sampaio, 2002; Andrade, 2006). Despite considerable improvements, including reducing inequalities and poverty during the early 2000s, issues regarding rural land rights remain the main driver of structural inequalities in the Basin (Scott, 2013; Empinotti, Gontijo &de Oliveira, 2018). Over time, this has contributed to land concentration, evidenced in the loss of land for traditional subsistence farming (e.g., maize, beans, and cassava) to commercial farming (Lindoso et al., 2018).

Table 6.1 presents the evolution of political issues in the SFRB, the characteristics of corresponding governance systems, and their objectives, analysing this from an inclusive development (ID) perspective. It shows how the development of large infrastructure (large hydroelectric plants and irrigation systems) re-shaped the landscape of the river basin. And the promotion of capital-intensive agriculture and drastically expansion of the agricultural frontier increased over time (Alcoforado de Moraes et al., 2018; Fernandes et al., 2021).

6.2.2. The physical context of water and related problems

The SFRB is Brazil's third-largest river, spanning 2,900 km in length, and it is one of the main rivers exclusively draining in Brazil (Mescolotti et

17 A privileged group called 'latifundiários', which had achieved larger concessions from the state in the economic and political arena (Chilcote, 1990). This group was able to control the election process through the relations between the state level and the local level. Specially, at local level, the 'coronéis' controlled the electors trough economic relations of dependency (Chilcote, 1990).

Table 6.1. The evolution of political issues in the SFRB (1950s – 2020s)

Nature of political regime	Characteristics of the development strategy	Objectives	Analysis from an ID perspective
Democratic (1950 - 1964) Populist State (restricted democracy)	The political regime controlled by regional elites; SFRB was chosen as part of the hydroelectricity strategy plan for national development (electricity production); Implementation of regional policies by the federal government to restructure the economic, social, and agrarian relationships (e.g., SUDENE)	Industrial promotion	Although GDP increased there was growing inequalities and poverty; ecological damage and social disruption due to relocation
Authoritarian (1964 - 1985) Military dictatorship	Development of large infrastructure (large hydroelectric plants and irrigation systems); promotion of capital-intensive agriculture and expansion of agricultural frontier; increased social movements	Energy development to support industrialization; agricultural development	Increased GDP; increased inequalities, poverty, rural-urban migration, unemployment and ecological damage
Democratic (1985 - 1990) Democratization	Expansion of agricultural frontiers and promotion of capital-intensive agriculture; social and environmental conflicts became more frequent; increased protests along the SFRB against large water projects; increased support by priests of the Catholic Church, NGOs, and civil society	Energy development; commercial agricultural development	Increased GDP; increased inequalities, ecological damage continued, poverty, rural-urban migration, and unemployment
Democratic (1990 - 2002) Liberalization	Received federal investment to expand agriculture development; agricultural frontier continued to expand (coexisted with higher productivity in settled areas); formation of the basin committee (CBHSF) and the Brazilian Semi-Arid Articulation (ASA)	Energy development; commercial agricultural development	Economic growth; high unemployment, ecological damage continued, inequalities, and poverty
Democratic (2003 - 2016) Developmental state	High investment in commercial agricultural development; implementation of the controversial Water Diversion Project (Inter-basin); received specific policy intervention to alleviate poverty and inequality (i.e., conditional cash transfers, school-feeding programmes)	Commercial agricultural development and poverty alleviation	Economic growth; reduction of inequalities and poverty; expansion of the middle class; ecological damage continued
Democratic (2016 -2020) Neo-liberal approach	Neoliberal economy; agricultural development continues to expand; suppression of opposition: environmental/social movements	Commercial agricultural development	Corruption scandals; economic recession; poverty; violence; ecological destruction

Source: Building further on Andrade(2006); Buckley (2006); Duque (2008); Empinotti, Gontijo & de Oliveira (2018) ; Empinotti, Gontijo & de Oliveira (2018);Alcoforado de Moraes et al., (2018); Fernandes et al. (2021)

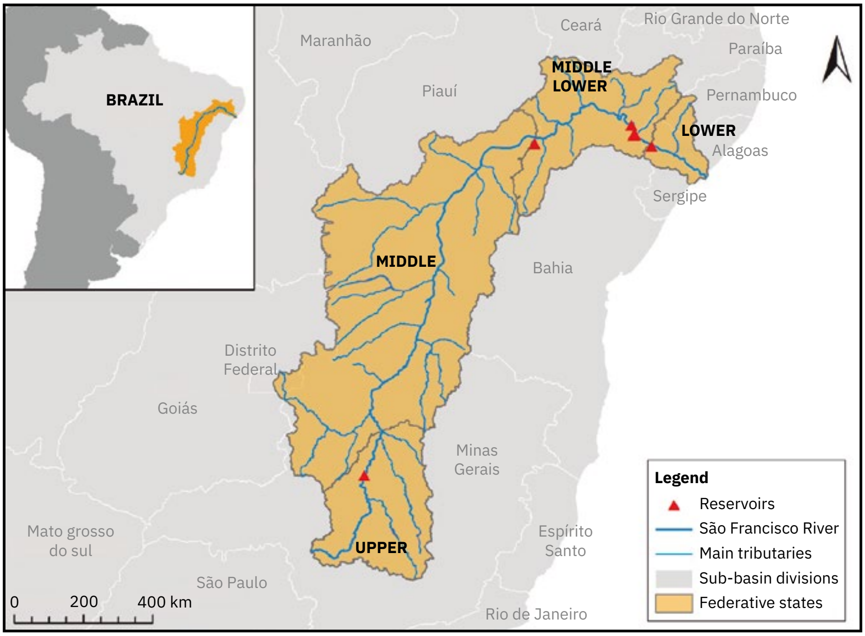
Box 6.1. The Northeast Development Superintendence (SUDENE)

> The Superintendence of the Development of the Northeast (SUDENE) was created in 1959 by the federal government as an immediate response to the recurring drought problem (Ortega & Sobel, 2011). With support from the Bank of Development of the Northeast (BNDE), SUDENE aimed to reorganize the economic, social, and agrarian relationships between rural elites and small farmers in the Northeast using land reform in areas susceptible to famine during the drought period (Furtado, 1989; Andrade, 2006). However, powerful local rural elites did not agree with the new land and agrarian reforms, and the financial resources for SUDENE and BNDE eventually decreased. Moreover, corrupt local governments (Andrade, 2006) ignored the needs of small farmers.

al., 2021). It is the 25th river in the world in terms of its length (Tan & Sheng, 2004; O'Hanley et al., 2020) and has also been labelled 'the river of national integration' because it links the wealthier Southeast with the poor Northeast of the country (Sun et al., 2016; Bouckaert et al., 2020); it crosses many different ecosystems and links different biomes, and it is generally classified into four sections based on size and other differences throughout the course of the river. The four sections are the Upper (48.8% of the basin area); the Middle (25.3% of the basin area); the Sub-Middle (15.2% of the basin area); and the Lower São Francisco (10.7% of the basin area) (MMA, 2006; Mescolotti et al., 2021) (see Map 6.1).

The SFRB covers an area of about 638,500 km², approximately 8% of the national territory, with 57% located in the semi-arid region (361.825km²) (MMA, 2006; Mescolotti et al., 2021). The SFRB supplies water for around 16 million people in 521 municipalities (CODEVASF, 2016; Lucas et al., 2020). It has 168 tributaries: 99 are perennial and 69 are intermittent (Figueiredo et al., 2011; Brazil, 2004). The river originates from a mountain range located in the South-Central region of the state of Minas Gerais. It crosses the Brazilian federal district and five states (Minas Gerais, Bahia, Alagoas, Sergipe, Pernambuco, and Goiás). It flows from south to north through the states of Bahia and Pernambuco, where it changes course to flow from south to east. It reaches the Atlantic Ocean at the border between the states of Alagoas and Sergipe. Currently, its waters are being artificially redirected to reach several other water-scarce states (Mescolotti et al., 2021).

Map 6.1. Regional classification of the São Francisco River Basin



Source: Author's elaboration based on raw data from the Sao Francisco River Basin Committee (2020)

NB. Note that the majority of dams are set in the middle-lower sector

The São Francisco Hydrographic Region comprises three major groundwater reserves: the Tucana, located at the border between the states of Bahia and Pernambuco; the Chapada do Araripe, located within the states of Ceará, Pernambuco, and Piauí; and the Urucuia Aquifer System, located in the states of Bahia and Minas Gerais (MMA, 2006). The Urucuia Aquifer System has the highest contribution to baseline flows into the São Francisco River. This is estimated at around 730 m³/s, an average of 30% of its streamflow (ANA, 2018, p. 37). During dry seasons, it can reach 80 to 90% (ANA, 2018, p. 37).

The climate ranges from humid in the headwaters in the south to semi-arid in the north (Siqueira Filho, 2012). In the semi-arid area, the "rainy season lasts three months on average and is concentrated in the summer months (December, January, and February)" (Lindoso et al., 2018,p.3). Annual and seasonal patterns of rainfall are irregular, impacting the natural conditions and biodiversity of the SFRB landscape. This is evident in the biomes of Caatinga Forest (see Box 5.4), Cerrado, and Atlantic Forest (Siqueira Filho, 2012; Fernandes et al., 2021).

Table 6.2. Water problems in the São Francisco River Basin

Issues	Water problems
Water quantity	Shortages; unequal spatial distribution (upstream is wet and the downstream is dry); unequal distribution between people; increasing water withdrawals for irrigation purposes
Water quality	Organic pollutants (pathogens and microbial contaminants); pollution (arsenic, fluoride, iron, and aluminium); silt suspended particles; groundwater pollution (nitrate); residues of chemical fertilizers and pesticides; seawater intrusion; deforestation (leading to erosion and increasing sedimentation in the basin which affects the transportation on the river)
Climate variability & change	Increasing the number of droughts; greater water evaporation

Source: Bettencourt et al. (2016); Paulo Peter (2016); CBHSF (2016b); Ferrarini et al., (2020); Lucas et al. (2020)

Many factors, directly and indirectly, shape water-related problems in the SFRB (namely water quality, quantity and climate variability and change) (see Table 6.2). The historical evolution of ever increasing water demand in SFRB is clearly linked to the intertwined processes of development of large infrastructure (large hydroelectric plants and irrigation systems) and promotion of capital-intensive agriculture (expansion of agricultural frontier). Unpacking this, the four main direct drivers of freshwater problems include: 1) natural changes in the quantity of available water (e.g., droughts) (de Andrade et al., 1986; Andrade, 2006; Roman, 2017); 2) demand for commercial agriculture (e.g. crop-based ethanol) and livestock (Maneta et al., 2009; Ferrarini et al., 2020); 3) demand for energy (e.g. hydropower) (de Jong et al., 2018; Lucas et al., 2020); and 4) demand for households (Lucas et al., 2020; Salim Dantas et al., 2020) (see Table 6.3). The indirect drivers are population dynamics (e.g., migration, increase in population density, and rapid and disorganized urbanization) (Livingstone & Assunção, 1989; Howe et al., 1992; Neumann et al., 2015), technology (e.g., agriculture intensification), and climate change and variability (Alcoforado de Moraes et al., 2018).

First, droughts in the SFRB have been recorded since the 16th century (Roman, 2017), making natural changes in the quantity of available water an important direct driver. One of the most severe droughts occurred from 1877 to 1880, killing all of the cattle and half of the human population (more than 500,000 people)[18] living in the semi-arid region of São Francisco (Andrade, 2006). However, with climate change, the severity, duration, and spatial extent of droughts are projected to increase in the SFRB region (Awange, Mpelasoka & Goncalves, 2016; Souza Filho et al., 2018; Paredes-Trejo et al., 2021).

Second, commercial agriculture and livestock is a key driver. Agricultural production patterns in the SFRB are closely related to Brazilian production, closely intertwined with international export markets (Alcoforado de Moraes et al., 2018) and implies long-distance transfers of water in virtual form (trade in virtual water) (see 5.2.2). For instance, Brazilian agriculture is strongly influenced by the global market (31% of the national fruit production is exported)[19] and the sugarcane produced[20] (Alcoforado de Moraes et al., 2018). The SFRB is one of the key Brazilian regions producing fruit and sugarcane using irrigation systems (Assad & Pinto, 2008; Alcoforado de Moraes et al., 2018). Agricultural production, which has contributed to food security and income, also has many negative impacts, including over-exploitation of the groundwater (Paredes-Trejo et al., 2021) and water pollution from intense use of pesticides, chemical fertilizers, and insecticides (Interview B-3) (CBHSF, 2016a). Besides, commercial agriculture and livestock industries have also grown through deforesting important Brazilian biomes like the Cerrado, Caatinga, and Atlantic forests (CBHSF, 2016)(Interview N-12/N-9). Commercial agriculture and livestock have also directly affected transportation activities on the river and led to erosion, desertification, and sedimentation (Interview N -14/B-2/B-4).

The third driver is the demand for energy. SFRB is strategically important due to its hydroelectric potential (Bezerra et al., 2019), with a potential installed capacity of 10,708 MW (de Carvalho Barreto et al., 2020). It contributes almost 11% of national hydropower generation (Geriberto Hidalgo et al., 2020). It has eighteen reservoirs with multiple uses but mostly for power generation and irrigation (Medeiros et al., 2013). The

18 The largest death in Latin American history (*Andrade, 2006*). The drought of 1877–1879 reflected this new land context, there was a large influx of refugees from poor rural areas to regional urban centers and the deaths of hundreds of thousands of people from hunger and diseases (*Campos & Studart, 2008, p. 436*).

19 *http://www.brazilianfruit.org.br/Pbr/Brasil/ Brasil.asp*

20 According to *Alcoforado de Moraes et al. (2008)* “half is used for producing sugar and another half ethanol—about three quarters of Brazilian sugar is exported while 15–20% of the ethanol” (*Alcoforado de Moraes et al., 2018, p. 1944*)

Três Marias and Sobradinho reservoirs have a fundamental role in regulating the flow of the São Francisco River (ANA, 2014).

Fourth, household demand is also an important driver. Domestic water consumption is mainly concentrated in the Belo Horizonte Metropolitan Region in Minas Gerais state located upstream of the SFRB (Teixeira et al., 2021). It is also important to mention that the water losses in distribution systems are also a water sharing problem related to this driver (SINIS, 2019). For instance, the Brazilian National Sanitation Information System reports that between 2008 and 2018, while the national average of water losses in distribution systems was around 35%, in the Northeast where the SFRB is located, this number was 46.5% (SINIS, 2019). At the same time, millions of people have no or precarious access to WASH services in the SFRB (Interview B-7). Poor service includes a lack of drainage system, lack of potable water, and insufficient quality to protect human health, and this situation creates dependence on water trucks and implementation of rudimentary or untreated sewage systems (Interview B-7/ AL-3). Since 2000, drinking water access has increased, but there are still cities such as Rodelas in Bahia, where the population (around 9,000 people) do not have access to treated water[21] or Paulo Afonso city, where half of the municipality's sewage is released straight into the Sao Francisco river without treatment (three million cubic meters annually)[22]. This, directly impacts on water quality and on the water shared with nature.

Population dynamics have also been changing over time. For instance, constant drought episodes have forced people to migrate from rural to urban areas within and outside the region, particularly due to lack of drinking water (Livingstone & Assunção, 1989; Howe et al., 1992; Neumann et al., 2015). Since the 1960s, more than 8 million Brazilians have migrated from the Northeast to other Brazilian states (Reuveny, 2007). The usual flow of migration occurs towards more wealthy regions like the South or land reclamation areas in the Amazon (Livingstone & Assunção, 1989; Goodman, 1992; Krol & Bronstert, 2007; Nelson & Finan, 2009).

As already noted, an important underlying driver of water issues in SFRB is climate variability and change. Moreover, being predominantly

21 *https://cbhsaofrancisco.org.br/noticias/novidades/mais-de-9-mil-pessoas-nao-tem-acesso-a-agua-tratada-em-rodelas-ba-aponta-diagnostico-do-pmsb/*

22 *https://g1.globo.com/ba/bahia/noticia/2019/04/12/moradores-de-cidade-do-norte-da-bahia-denunciam-esgoto-despejado-no-rio-sao-francisco-mau-cheiro.ghtml*

Table 6.3. Drivers of water problems in the São Francisco River Basin

Direct Drivers	Indirect Drivers
Natural changes in available water quantity (droughts) Demand for agriculture and livestock Demand for energy Demand for households	Population dynamics (i.e., migration, increase in population density, and rapid and disorganized urbanization) Technology (i.e., agriculture intensification) Climate change

Source: Bettencourt et al. (2016); CBHSF (2016b); SNIS(2019); Teixeira et al. (2021)

fed by groundwater, freshwater resources in the SFRB are also under severe threat from climate variability and change, as seen with droughts in the past years (Paredes-Trejo et al., 2021). Recent studies on climate change point out that higher temperatures and reduced rainfall are expected in the semi-arid region where half of the SFRB is located (Desertificação, 2016; de Jong et al., 2018).

6.2.3. Sharing challenges

The water consumption across sectors relying on the SFRB is similar to other basins worldwide. The direct and indirect drivers discussed above have significantly impacted water use in the SFRB. Irrigation, industries, livestock, and urban and rural supply make up the majority of consumptive uses of water (CBHSF, 2016b), for instance, Table 6.4 shows the consumption by sectoral use in the basin. During this period, SFRB water consumption rose from 165.8 m^3/s in 2000 to 309.4 m^3/s in 2010. Most of the increases in consumption occurred in irrigation (from 114 to 244.4 m^3). Table 6.4 clearly shows that irrigation uses not only the largest share of the available water in the SFRB but also accounts for the steepest growth in consumption. Water consumption in the SFRB is related to human activity (for example, irrigated area expansion), with variability in meteorological conditions playing a smaller role.

Table 6.5 summarises surface water and groundwater used by purpose in the SFRB in 2000. For each use, there is the total amount of water used. In 2010, irrigation consumption was mainly based on surface water (95.6%). While livestock use was more dependent on groundwater when compared with the other uses, for instance, ~ 89% of its water

Table 6.4. Consumption by sectoral user (m³/s) in the Sao Francisco River

Use	2000	2006	2010
Irrigation	114	123.3	244.4 (2013)
Urban supply	26	27.3	31.3
Industrial	15.3	17.4	19.8
Rural supply	3.8	3.7	3.7
Livestock	6.7	9.1	10.2
Total	**165.8**	**180.8**	**309.4**

Source: Building on data from CBHSF (2015)

consumption comes from groundwater. Table 6.5 clearly shows that irrigation use is the largest surface water consumer. This fact mirrors the federal government's strategy to support agriculture development using the potential of the São Francisco River (see 6.4.3).

The different water uses cause many different sharing challenges in the SFRB, such as water sharing between uses (e.g., food production vs. urban supply) (Lucas et al., 2020; Siqueira et al., 2021). The uneven geographical distribution results in some regions of the basin having more than enough water such as Minas Gerais state (located upstream of the basin), whereas other parts of the basin face serious water scarcity, such as Alagoas state (located downstream of the basin).

Moreover, there are also tensions in sharing responsibility between the centre and states as evidenced in the São Francisco River Water Diversion Project (Roman, 2017; Empinotti, Gontijo &de Oliveira, 2018). This project remains one of the most important water-sharing issues between national and sub-national levels in the SFRB since 2000. The inter-basin Diversion Project was proposed by the Ministry of National Integration in 2001 as an attempt to once more deal with the issues of drought, poverty, and lack of access to water in the semi-arid region (Empinotti et al., 2018). This inter-basin project entailed a 2% transfer of freshwater from the São Francisco River to four federal units in the states of Ceará, Paraíba, Pernambuco, and the Rio Grande do Norte through a

Table 6.5. Water use (demands) by purpose in the SFRB in 2010

Uses (m^3/s)	Total	Surface water	Groundwater
Irrigation	244.38	233.83	10.55
Urban Supply	31.31	27.18	4.12
Industry	19.81	15.59	4.22
Rural Supply	3.71	0	3.71
Livestock	10.10	1.86	9.02
Total	**309.44**	**277.80**	**31.64**

Source: Building on data from CBHSF (2015)

NB. The hydroelectric plants are the main plants responsible for producing electric energy in the SFRB. Water resources are not consumed, but they are utilized to move the turbines. As the water can be used for other purposes, Table 6.5. does not consider energy as one of the uses.

channel system, supplying water to 12 million people in 391 municipalities in mainly urban areas (Soares, 2013).

The São Francisco River Water Diversion Project was the largest diversion scheme proposed in Brazil (Roman, 2017). It was favoured by the federal government and governments of the beneficiary states of Ceará, Paraíba, Pernambuco, and Rio Grande do Norte. However, donors in the states of Alagoas, Bahia, Minas Gerais, and Sergipe, as well as many members of the CBHSF, were against it (Suassuna, 2010) (Interview B-4). This tension between the beneficiaries and potential donors hints at how complex the project was (Roman, 2017; Castro et al., 2015) (Interview PE-3).

In 2004, ANA prepared the first São Francisco River Basin Plan, which involved the São Francisco River Water Diversion project. However, the plan was not approved by the São Francisco River Basin Committee[23] and a new version was proposed instead (Abers & Keck, 2013). Then in 2007, the Water National Council approved the proposal and the federal government launched the Diversion Project. The CBHSF played a significant role in the negotiations of this process (Roman, 2017), facing intense confrontation from civil society because of the Project's lack of transparency and consideration of civil society's opinion (Interview N-9/B-4).

23 It was created in 2001 and it will be further discussed in section 6.3.

The construction of the São Francisco River Water Diversion was not yet completed in 2021[24]. It has been entirely financed by the Brazilian government and constructed by the Brazilian army (Roman, 2017). The Brazilian government had requested funding from the World Bank but this was refused, mainly on the grounds that the project would have little impact on poverty alleviation or relieving water scarcity in the semi-arid region (Roman, 2017, p. 406). Negative consequences reported on the Project include 430 hectares of deforestation, loss of biodiversity (Sousa, de Almeida & dos Santos, 2018), and increased desertification in some areas (e.g., Monteiro municipality in the state of Paraiba) (Costa & Araujo, 2016).

The inter-basin São Francisco River Water Diversion project reveals the asymmetrical relationship between the multiple levels of water management. Despite having decentralized, participatory water institutions in place, the federal government still centralized and controlled the process of the project's approval, implementation, and management (Empinotti et al., 2018). The large-scale infrastructure intervention shows how intergovernmental relations under the Brazilian federal system still overrule decentralized decision-making processes (Interview N -22). The São Francisco River Water Diversion intensifies all environmental and economic constraints, even for the poor. As poor farmers in the North-East still do not have the infrastructure, instruments, and know-how to use the water. It will probably go to the commercial farmers. Therefore, water in the downstream part of the SFRB will be scarcer, salt intrusion may increase, and groundwater levels may go down. Whether groundwater levels will go up in the North-East is not really investigated and will depend on many factors.

6.2.4. Evolution of the water governance regime in the context of environmental policy

During colonial and imperial periods, water governance in Brazil was centralized at the federal level (see 5.2.4). Therefore, the SFRB water governance development was based on federal interests. Historically, the semi-arid climatic conditions and constant drought episodes in the SFRB semi-arid region obliged the federal government to develop an agenda in response (Livingstone and Assunção, 1989; 1993). This led to the adoption

24 https://g1.globo.com/rn/rio-grande-do-norte/noticia/2022/02/08/entenda-como-as-aguas-da-transposicao-do-rio-sao-francisco-vao-chegar-ao-rn.ghtml

of hydraulic engineering solutions, including the construction of a set of dams called "Açudes" and different sizes of water storage infrastructures to cope with the lack of drinking water in the region (Molle, 1991; Assunção & Livingstone, 1993). From an ID perspective, these efforts were positive in that they aimed to address issues of water access but were problematic considering, for instance, that many of the dams were constructed on private property (e.g. limiting which user can access, increasing the political influence of the landowner) (Buckley, 2010).

By the 1950s, water governance in Brazil was still centralized at the federal level (Barros &Naves, 2022). The governance strategy was to explore energy development using the great hydroelectric potential of the São Francisco River (Filho-Zuza, 2008)(Interview N-2/3). Accordingly, in 1944, the Company of Hydroelectricity of the São Francisco River (later transformed to CHESF) was created to advance the river's energy development (Filho-Zuza, 2008). The Company of Development of the São Francisco Valley (later transformed into CODEVASF) was also created in 1944 to explore the river's agricultural potential (CODEVASF, 1999)(Interview N-2/3).

Under military dictatorship (1964-1985), water governance was also still centralized at the federal level. Most actions implemented were focused on specific sectors, namely energy and agriculture (Maneta et al., 2009). These actions resulted in high social displacement and ecological externalization (Rodrigues Lima, 2004; Estrela, 2010)(Interview N-2/3). Nearly 72,000 people were displaced during the construction of the Sobradinho Power Plant, many of whom were not adequately compensated (Rodrigues Lima, 2004; Estrela, 2010). Furthermore, four towns (Pilão Arcado, Sento Sé, Remanso, and Casa Nova) were submerged, and fish reproduction in the areas decreased (Godinho et al., 2007; Domingos et al., 2012). These effects show how preferential sectoral management of the basin can have significant negative impacts on excluded water users.

Since the 1990s, water governance in the SFRB has been decentralized, taking a more participatory approach (Interview N-22). Water use and management practices allow for ongoing processes of negotiation and bargaining between different uses and users. However, energy and agriculture remain dominant sectors, and commercial agriculture still receives disproportionally more water than subsistence agriculture (see Table 6.4 and Table 6.5). It is no wonder that civil society has joined efforts to network against the policies (see Box 6.2).

Box 6.2. Brazilian Semi-Arid Articulation (ASA)

The Brazilian Semi-Arid Articulation (ASA) is a network formed by more than three thousand civil society organizations (e.g., rural unions, farmers' associations, cooperatives, NGOs, etc.) (Interview N-24). The network advocates for the human rights of low-income people and marginalized communities living in the Brazilian semi-arid area. One of its most recognized actions is the 'One Million Cisterns Program (P1MC)'. The P1MC was created in 2003 with the primary goal to build one million rainwater harvesting cisterns for water consumption of families living in the semi-arid region who otherwise lack adequate access to clean water (De Moraes & Rocha 2013, Interview N- 20/24). The P1MC was supported by the federal government through the National Secretariat for Food and Nutrition Security (SESAN) and the Ministry of Social Development and Hunger Alleviation (MDS) (Gomes et al., 2015; Lindoso et al., 2018). Between 2003 and 2016, 1.2 million rainwater harvesting cisterns for human consumption[25] were implemented in the Brazilian semi-arid region (Lindoso et al., 2018). The P1MC created profound changes in people's lives. It increased water access, decreased water-related diseases, empowered women and children, and enabled diversification of water production (Gomes et al., 2015). It also broke political dependence on water trucks and other privately owned water sources (Interview N- 20/24).

In exploring how water governance regimes have contributed to the SFRB environmental policy over time, Table 6.6 illustrates how, from an ID perspective, water governance regimes have contributed to environmental policy in the SFRB over time showing in particular how the externalization of the environment was exacerbated during the damming process in the river and social inequity intensified. The concentration of control over natural resources has not necessarily taken social and ecological inclusiveness into account.[25]

25 The beneficiary family receives a water storage cistern for human water consumption (16,000 litres of capacity) and has to attend a two day course on water resources management. The size of the water storage is expected to meet the water consumption needs for a family of five members for drinking, cooking, and teeth brushing for over an eight-month drought period (Gomes, Heller and Pena, 2012).

6.3. Current policy framework and the sharing of water

The current framework of water governance in the SFRB was established by the National Water Law in 1997, which rescaled water governance to the basin level. In 2001, the São Francisco River Basin Committee (CBHSF), one of the first federal basin committees in Brazil (Machado, 2008), was created through a presidential decree, encouraging participation of the public sector at federal, state, and municipal levels. The CBHSF also encouraged the participation of a wide range of water users and civil society organizations (Braga & Lotufo, 2008). Its first task was to discuss and approve the basin plan, and it rejected the first original version of the basin plan proposed by ANA for its detailed inter-state water allocation because it was rigid (Kleemans, 2010). The second version of the basin plan, which the CBHSF approved, omitted the water allocation proposal (Kleemans, 2010).

The CBHSF is responsible for managing the basin. It has normative and advisory responsibilities, including implementing the SFRB plan and mediating conflicts related to water resources at the first administrative instance (CBHSF, 2016a). In terms of structure, the CBHSF is divided into four branches (upper, middle, middle-lower, and lower) considering the expansive size of the basin, which is challenging to handle as a monobloc (Interview BA-17). The CBHSF also has an agency specifically on water, the AGB Peixe Vivo. Created in 2006, the AGB Peixe Vivo serves as the executive secretariat of the CBHSF and provides technical support in the implementation of the 2016 - 2025 São Francisco River Basin Water Resource Plan (CBHSF, 2016a).

Another key actor is CODEVASF, which was created in 1974, as the successor of the Company of Development of the São Francisco Valley (CODEVASF, 1999, 2016). This state-run company is responsible for developing the physical irrigation structures in the Brazilian semi-arid region (Interview N-14). Other actors include the Brazilian Semi-Arid Articulation (ASA)(Box 6.2) and various civil society organizations.

The previous sections have discussed the development of a set of instruments relevant to water governance as laid down in Brazilian law. Based on the criteria as outlined in section 2.9, a number of instruments were selected to assess their functioning at multiple levels of governance. Instruments that address water-sharing challenges between levels, states, uses, users, humans and nature, and/or water-related risks are

Table 6.6. Evolution of political regimes & environmental policy in the SFRB (1950s – 2020s)

Political regime	Environmental policy	
Democratic (1950 – 1964) Populist State (restricted democracy)	The federal government implemented hydraulic engineering solutions to solve the constant drought problem (e.g., “açudes” – dams); ecological and social concerns were neglected	
Authoritarian (1964 – 1985) Military dictatorship	Ecological concerns are neglected; intensive extraction and use of natural resources	
Democratic (1985 – 1990) Democratization	Creation of environmental legislation and governmental organizations	
Democratic (1990 – 2002) Liberalization	Environmental issues were recognized; Xingó’s dam project had EIA and mitigation plan	
Democratic (2003 – 2016) Developmental state	Environmental issues were recognized; Xingó’s dam project had EIA and mitigation plan	
Democratic (2016 – ...) Neo-liberal approach	Environmental issues were recognized and considered in the decision-making process	

Source: This table builds on Andrade (2006); Filho-Zuza (2008); Barros & Naves (2021)

	Water governance regime	Analysis from an ID perspective
	Water governance controlled by the federal government focused on energy and agricultural development; creation of the Company of Hydroelectricity of the Sao Francisco River to explore SFRB hydroelectric potential; creation of the Company of Development of the São Francisco Valley to explore agriculture potential; construction of three large hydroelectric plants: Três Marias - 396MW; Paulo Afonso I -180MW; and Paulo Alfonso II - 445MW	Social and ecological displacements; unequal access to WSS; fish decline
	Water governance is controlled by the federal government based on energy and agriculture development; construction of four large hydroelectric plants (e.g., Paulo Alfonso III 864MW; Moxotó - 400MW, Paulo Alfonso IV - 2460MW; and Sobradinho - 1050 MW with the largest Brazilian reservoir); implementation of regional agriculture programmes linked to the green revolution; implementation of physical irrigation structures; creation of the Canastra National Park to protect SFRB headwaters	Social and ecological displacements (e.g., in upstream/ headwaters area 200 families removed from their lands; middle of the SFRB, 77,000 families removed from their lands due to the Sobradinho reservoir dam construction); unequal access to WSS
	Transition from centralized to decentralized water governance; construction of Luiz Gonzaga hydroelectric plant (1500MW); capital-intensive agriculture; increased private large-scale commercial irrigation	Social and ecological displacements; unequal access to WSS
	Water governance decentralized with stakeholder participation; construction of the hydroelectric plant Xingó (3000MW); creation of CBHSF and implementation of the first river plan of the São Francisco River Water Diversion	Unequal access to WSS; increasing deforestation; water pollution from urban areas
	Water governance decentralized with stakeholder participation; 'One Million Cisterns' rainwater harvesting programme in the Semi-Arid region; expansion of agricultural frontiers (agriculture kept growing); construction of the São Francisco River Water Diversion	Unequal access to WSS; increasing deforestation; water pollution from diffuse sources (mainly agriculture and urban areas); salinization
	Water governance decentralized with stakeholder participation	Unequal access to WSS; deforestation; salinization

Table 6.7. Sharing instruments in the São Francisco River Basin policy documents

Instruments	Water-sharing categories	Law/Policy
Water Pact	Sharing of water between states	São Francisco River Basin Water Resource Plan (2016 till 2025)
Priority of Use	Sharing of water between uses	São Francisco River Basin Water Resource Plan (2016 till 2025)
Irrigation systems	Sharing of water between users	Irrigation Policy in 2013 (Law No. 12787/2013)
Bulk water charge	Sharing of water between users	National Water Law in 1997
Crisis Chamber	Sharing of water-related risks	Federal Constitution in 1988 (Art 21, XVIII and XIX)
Minimum flow	Sharing of water between humans and nature	Decree 3692/2000 in 2000

Source: Author's elaboration

considered relevant for this study. The instrument also has to be related to water quantity. This led to the following selection of instruments in the SfRB (see Table 6.7).

6.4. Analyzing sharing in paper and practice

This section assesses the functioning of the selected water-sharing instruments in SFRB. It provides a qualitative assessment of the functioning of the instrument from design to goal achievement (see Table 2.5 for the assessment criteria) and analyses to what extent the instrument contributes to inclusive development (see 2.2 for the assessment criteria).

5.4.1. Agreement between states ('Water Pact Agreement')

The Water Pact Agreement is a pre-determined water allocation agreement between the states proposed by the CHBSF (Bouckaert et al., 2020). The agreement is necessary because 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 main uses of water resources are irrigation and energy (Interview N-21/B-7). Over time, water availability has decreased downstream and water allocation has become an issue since 2000 (Interview N-21/B-7) (Bouckaert et al., 2020): water is seen as insufficient due to higher demand and climate variability, and pre-determined water allocation could theoretically prevent conflicts between states and users.

The first attempt to establish an agreement, an allocation proposal, between the states located in the basin occurred in 2004 (Interview B-7/B-9) (Kleemans, 2010). In terms of the design, ANA introduced the 2004 SFRB river basin plan, which defined the volumes of water that would be allocated to each state (Kleemans, 2010). One of the main principles that underlie the Water Pact is equitable water-sharing. The Water Pact draws inspiration from Articles 5 and 6 of the UN Convention on Watercourses in ensuring more equitable and reasonable utilization principles for water-sharing between upper riparian states and those with lower access to water downstream (see section 1.6). The Convention offers explicitly significant insight into factors that should be considered in the decision-making processes of water-sharing between countries and this could also be applied in the context of a federal river.

However, the states did not reach any agreement, not even just to set up the proposed Water Act Agreement (Interview B-7/B-9) (Kleemans, 2010). Hence, this section about allocation was omitted from the 2004 SFRB river basin plan.

In terms of operationalization, the SFRB committee is the main actor trying to make an agreement between the states part of the SFRB (Interview B-7/B-9). In 2016, the 2016 – 2025 River Basin Plan was adopted, and it emphasizes that it is fundamental to have a specific agreement between the SFRB states. In 2020, under its authority to implement the Plan, the CBHSF hired a consulting firm to carry out a detailed study on the proposed Water Pact Agreement. Since then, a technical team has been working on a proposal to facilitate discussion and encourage governors from the SFRB states to adopt the Agreement (Interview B-7).

As of June 2022, the Water Pact is still not yet agreed upon by all SFRB states, despite the instrument's remarkable potential to improve water-sharing between the upstream and downstream states. Some states remain reluctant to be part of the discussion towards a formal agreement (Bouckaert et al., 2020). This is the case in Minas Gerais state and Bahia. In the case of Bahia, which is the largest consumer of SFRB water. Bahia's governors have been strongly pressured through interests in agribusiness exportation to not sign the Water Pact (Interview B-7). A key argument against the Water Pact is that its implementation could limit economic growth as it restricts the planning of new economic actions, especially related to agricultural expansion (Interview B-7). Upstream states, namely Minas Gerais and Bahia, also simply do not want to lose their autonomy in planning new economic activities. As an instrument, the Water Pact has thus far been unsuccessful in accommodating the different rationales of the states involved.

If considered from an ID lens, certain states do not favour the equity aspect of participation in the decision-making process regarding water allocation and re-allocation in the SFRB. The state of Bahia, for instance, does not want any interference at all. As a direct consequence, cities located downstream have experienced changes in water stress levels (see Figure 7.2) that are primarily due to the disproportionate allocation of water to Bahia. The Diversion Project also indirectly contributes to the water stress downstream.

6.4.2. Priority of use

In terms of design, the 2016 – 2025 São Francisco River Basin Water Resource Plan adopts the priority of use idea as a principle, as presented in section 5.4.2 (Art. 5, I, Federal Law No. 9433/1997). The Water Resources Plan, priority is given first to humans, then to animal consumption within the livestock industry, not in nature. In the Federal Law, the priority of use is coordinated with available water, considering other elements of the Water Resources Plan and legislations at the sub-national level. Therefore, the 2016 – 2025 São Francisco River Basin Water Resource Plan explicitly presents the sequence of priorities of use in periods of water scarcity and in "normal periods".

In terms of the operationalization, the SFRB Committee and Peixe Vivo Agency are responsible for executing the 2016 – 2025 Basin Water Resource Plan. In terms of budget, the implementation of the river basin plan is financed by the bulk water charge instrument, which also means implementing the priority of use. Therefore, the implementation of this instrument has achieved the main goal designed, which is to prioritize some uses.

The recognition of the priority of use principle in the Water Resources Plan shows considerable progress. However, in practice, the principle is unable to provide strategic guidance on how water should be allocated in some cases. For instance, the instrument does not specify which animals should have priority when allocating to livestock uses. It also lacks clarity and does not adequately address water use by nature. It does not identify hotspots for ecosystems nor assess water flows required to maintain their services (Interview B-2). In periods of water scarcity, the priority of water allocation was given to producing energy, irrigated agriculture and water supply. Once more, water was allocated, not taking into account reserving water for nature.

Moreover, there is no equity among groups of users in the sub-basins of the SFRB, and conflicts have been increasing (Interview N-9) (CPT, 2018). The Water Resource Plan is confronted with disputes in the sub-basins of the SFRB (Rio Verde Grande, Rio Pontal, Rio Curaça, Alto do Rio Ipanema, Baixo Ipanema, and Lower São) (CBHSF, 2016b, p.35). These disputes pertain to uses, particularly livestock and industry, and are solved on a case-by-case basis by the SFRB Committee, which references the Basin Water Resource Plan and other water regulations in its rulings (CBHSF, 2016b, p.35) (Interview B-8). Priority of use, therefore, remains a paper narrative, also at the state level.

If considered from an ID lense, the design of priority of use as adopted in the 2016 – 2025 Basin Water Resource Plan can be considered partially socially inclusive because it commits to meeting human needs. It is considered ecologically inclusive because it promotes integration with other instruments such as river basin plans and water permits. However, it does not reserve water for nature nor promote the preservation of ecosystems. In the first case, all river basin plans should consider the priority of use principle in the design of the river basin plans. However, indeed, the priority of use instrument does not provide an objective foundation for allocating a limited resource taking nature as one of the users. For instance, during the water shortage periods, water for the environment is not part of the sequence of priority of use (Interview N-25). Relational inclusiveness is not considered in the design of the priority of use principle as it does not explicitly promote participation. At the same time, I believe that in this specific dimension, it can be justifiable. One of the main reasons is that promoting participation is likely to enable more powerful actors to demand access and thus distort the way priorities are defined.

6.4.3. Irrigation system

Irrigation systems are considered a technological instrument and were last enforced in Brazil by law in 2013 (Irrigation Policy Law No. 12787/2013). As presented in 4.5.2.3, this enables the allocation of water to different users through distribution and division of the resource by small- and large-scale hard engineering systems (Allan, 2003). As mentioned earlier, water infrastructure has traditionally been part of water sector development in Brazil and is strongly embedded in the SFRB development (see 6.4.2). In terms of design, the aims of the Irrigation Law published in 2013 are to:

> "(i) encourage the expansion of the irrigated area and increase productivity on an environmentally sustainable basis; (ii) reduce the climatic risks inherent to agricultural activity, especially in regions subject to low or irregular rainfall distribution; (iii) promote local and regional development, prioritizing regions with low social and economic indicators; (iv) contribute to increasing the competitiveness of Brazilian agribusiness and generating employment and income; (v) contribute to the supply of food, fibre and renewable energy to the domestic market, as well as to the generation of agricultural surpluses for export; (vi) train human resources and foster the generation and transfer of irrigation-related technologies; and (vii) encourage private irrigation projects, as defined in regulation" (Art.4, Law No. 12787/2013).

The operationalization of this instrument occurred through the state-owned company CODEVASF (CODEVASF, 1999). Within the SFRB, CODEVASF has been responsible for the physical development of the irrigated areas in the Brazilian Northeast since the 1970s (Brazil, 2017). In terms of budget, CODEVASF had a specific budget for its activities. It has received internal investments from the federal government of Brazil and external investments from the Japanese Government, the International Bank for Reconstruction and Development (BIRD), the

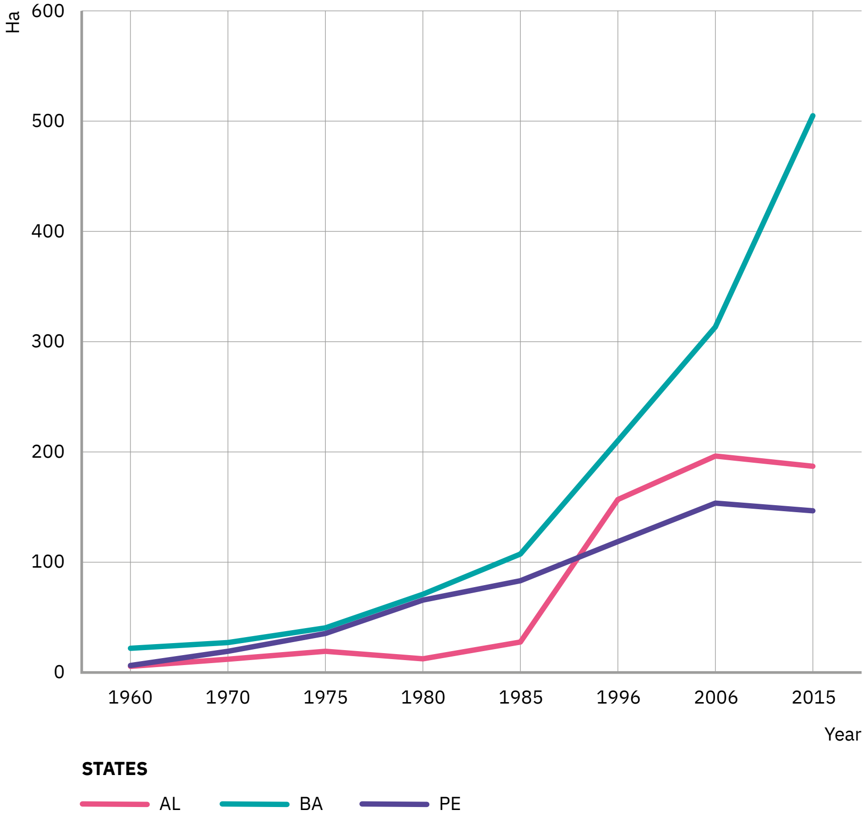
Inter-American Development Bank (IDB), Fundo Ultramarino de Cooperação Econômica (OECF), and Hungarian companies AGROBER and AGROINVEST (CODEVASF, 1999).

In terms of implementation, since the mid-1970s, a range of national and regional development programmes focusing on irrigation systems have been implemented in the semi-arid region of the SFRB (Brazil, 2017). This instrument has been enabling water-sharing between agricultural users. In specific, two programmes were implemented at the national level. The Provárzeas Programme, launched in 1981, focused on stimulating the rational use of irrigable land. The PROFIR Programme, launched in 1982, focused on financing new irrigation equipment for irrigators (Livingstone & Assunção, 1989; Brazil, 2017). At the regional level, three programmes were developed by the Ministry of the Interior: (1) the Polonordeste Programme, launched in 1974, focusing on interlinking different economic areas in the Brazilian Northeast; (2) the Sertanejo Programme, launched in 1976, focusing on increasing the capacity of small and medium farms to understand the effects of droughts; and (3) the Prohidro Programme, launched in 1979, focusing on maintaining water facilities for economic development during droughts (Brazil, 2017). These programmes led to significant economic and social advancements in the region (Maneta et al., 2009).

Figure 6.1 shows the progress of irrigation systems within different states in the SFRB over time. The irrigated area of the SFRB has steadily increased through the implementation of the aforementioned programmes. It illustrates the expansion of irrigated areas across the states of Bahia, Pernambuco, and Alagoas between 1960 and 2015. In 2009, the total irrigated area was estimated at 500,000 ha, with 360,000 ha belonging to the private sector and 140,000 ha to the public sector (Arrobas & Enei, 2009). Irrigated agriculture has enabled significant agribusinesses in the semi-arid region, where the irrigated area totals 626,000 ha (ANA, 2015).

Inspired by the green revolution technological packages, the Brazilian federal government envisioned applying direct modernization in agriculture in the semi-arid region through systems of credit, cooperatives, and rural extension (Bursztyn, 2008; Lindoso et al., 2018). However, the programmes and policies proposed were ill-adjusted to local dynamics (Bursztyn, 2008; Lindoso et al., 2018). First, the agricultural modernization process did not contribute to local knowledge of the design of the irrigation systems nor account for the lost areas of traditional subsistence

Figure 6.1. Total irrigated areas in Alagoas, Bahia, and Pernambuco states (1960 – 2015)



Source: Author's elaboration based on raw data from Atlas da irrigacao (2017)

**This analysis focused on the three states discussed in this thesis*

AL = Alagoas state, BA = Bahia state, and PE =Pernambuco state

farming (Lindoso et al., 2018). Second, the irrigation development policies did not enable small farmers to access water for food production and, in most cases, required them to first have the basic managerial, technological, and financial capacity (Bursztyn, 2008; Arrobas & Enei, 2009; Lindoso et al., 2018). An 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). Yet, the agricultural modernization process increased inequalities between the few who had access to federal opportunities and the majority who were excluded (Sampaio, 2002; Lindoso et al., 2018).

In terms of implementation, irrigation practices in the SFRB remain inefficient (Suassuna, 2000; Ferrarini et al., 2020) (Interview B-4). Most irrigators have yet to adopt more efficient practices, such as full soil and water profiling, drainage of irrigatable areas, and determining precise irrigation shifts, harvest schedules, the quality of water and soil, and tolerance of crops to salts in the soil (Suassuna, 2000) (Interview B-4). More than that, discussions are mostly focused on suggesting quick fixes linked to some specific contributing factors (e.g., food price speculation, increasing use of bio-energy). There is an urgent need to shift from conventional, monoculture-based and high external dependent approaches towards regenerative production systems that recognize the farmer as a producer of agricultural goods and maintain public goods and services such as water, soil, landscape, biodiversity, and others (Siqueira Filho, 2012). Therefore, some key elements and achievements are needed: increasing soil carbon content and better integration between crop and livestock production, increasing incorporation of three elements (agroforestry), optimization of organic and inorganic fertilizer use, reduction of water throughout the food chains; reduction of direct and indirect greenhouse-gas emissions of livestock production through the food chain (United Nations, 2013); and adopts "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" to reduce pollution (Jat et al., 2015; Siegmund-Schultze 2017, p.49).

Moreover, given trade liberalization and prioritization of the economy over the environment, the irrigation systems instrument has been unable to address the indirect drivers of water-sharing problems (e.g., migration and rapid and disorganized urbanization). Thus, it is crucial to invest in capacity building or strengthening programmes for small farmers includingnot only formal in-service education but also vocational and on-the-job training supported by combined irrigation and water supply projects.

If considered from an ID lense, the design of the instrument can be considered partially socially inclusive because it considers benefiting some uses of water, prioritizing regions with low social and economic indicators to promote local and regional development (Art. 4, III, Irrigation Policy Law No. 12787/2013). Besides, one of its goals indirectly considers the need to minimize the risk of water damage to humans when it states the importance of reducing the climatic risks inherent to agricultural activity, especially in regions subject to low or irregular rainfall distribution (Art. 4, II, Irrigation Policy Law No. 12787/2013). The design of the irrigation system instrument can also be considered partially ecologically inclusive because one of its goals recognizes the necessity of adopting sustainable practices (Art. 4, I, Irrigation Policy Law No. 12787/2013). The design of the irrigation system instrument can also be considered partially relationally inclusive because it considers positive discrimination toward the most marginalized regions (Art. 4, III, Irrigation Policy Law No. 12787/2013). For instance, one of its goals encourages to promote local and regional development, which prioritizes regions with low social and economic indicators.

6.4.4. Bulk water charges

In terms of design, the bulk charging of water use in Brazil was formally instituted in 1997 (Law No. 9433/1997). This aims to: (i) recognize water as an economic good and give the user an indication of its real value; (ii) encourage rational water use; and (iii) obtain financial resources to finance the programmes and interventions contemplated in the water resources plans (Art. 19).

Moreover, three activities require bulk water charges: water withdrawal, consumption, and effluent discharges. Water withdrawal charges are linked to the volume abstracted from a water body. Consumption charges are linked to abstracted water that does not return to the basin. Charges for effluent discharges are linked to the volume of wastewater released into the basin, with or without previous treatment to reduce pollutants. River basin committees define the values of the charges, which are based on unit prices and follow a set range of minimum and maximum limits (Interview B-8). The limits are determined by the National Council of Water Resources (CNRH) in the case of federal rivers, such as the SFRB, and by the State Water Resources Council (CERH) in the case of sub-national rivers (Interview B-8).

In terms of operationalization, ANA is responsible for collecting the charges since the SFRB is under the federal domain. This revenue is fully transferred to the Peixe Vivo Agency (Contract No. 14/10), which is responsible for implementing initiatives of the CBHSF. Bulk water charges, especially for large users (e.g., industries, agriculture, and sanitation companies), were implemented in the SFRB in 2010 (CBHSF, 2016, p.124). Hydropower, although considered a non-consumptive use, was also charged. The São Francisco River was the third federal river to implement bulk water charges (CBHSF, 2016, p.124).

The bulk water charge instrument was recognized in the 1997 National Water Law and operationalized in the SFRB. In terms of budget, revenue from the bulk water charges is shared between the Federation and sub-national units (Scatasta & Formiga-Johnsson, 2003). The revenue is handled in a participatory, decentralized, and integrated manner, as instructed in the SFRB Water Resources Plan. Between 2010 and 2016, the total amount collected was BRL 137 million, which is not significantly large but contributed to the implementation of initiatives proposed in the Basin Water Resources Plan (Interview B-7). It notably allowed the CBHSF to finance campaigns like Integrated Preventive Inspections and various hydro-environmental projects (Interview B-7/B-8). Furthermore, it allowed the CBHSF to be financially supportive of the Municipal Sanitation Plans in the SFRB. This is a significant step towards ensuring access to water and sanitation services (Interview B-7) and sharing the financial benefits with everyone.

In terms of implementation, bulk water charges in the SFRB were readjusted according to updated values of water resources in 2018. The new standard for calculating bulk water charges was analyzed by the Peixe Vivo Agency at the request of the CBHSF. The analysis revealed that the agricultural sector was due to be charged 40 times less than other sectors and, therefore, another standard was proposed (OECD, 2017). After extensive discussion at the National Council of Water Resources, a newer standard, which set higher charges for the agricultural sector, was approved. This standard intends to encourage irrigators to adopt more efficient irrigation techniques that contribute to better soil management practices (ANA, 2019b). In doing so, irrigators are eligible to receive several benefits, including discounts on their water charges[26] (Maceió - Participatory observation 2017).

The analysis by the Peixe Vivo Agency also revealed that several irrigators directly contacted ANA to discuss their water permits (ANA, 2019b). Because the bulk water charges were inexpensive, the irrigators requested permits with higher volumes than they needed in order to re-

26 The user which adopts the most efficient irrigation method and best practices was charged R$ 0.00188/m³ and the user with the least efficient irrigation method and best practices was charged R$ 0.00864/m³ (*ANA, 2019b*). These values are respectively 18 and 3 times lower than those charged for other users (*ANA, 2019b*).

serve 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)[27].

Moreover, there is increasing participation of agricultural users in the Committee since increasing of the value of bulk water charges (Interview B-7). Typically, there is usually less involvement of irrigators in participative decision-making processes (e.g., the CBHSF and the tributaries committees of the SFRB) once they have secured their water permits. However, since the decisions made by CBHSF have been directly impacting them, such as increased bulk water charges, the irrigators became more interested in being part of the discussions in the Committee. For instance, the National Confederation of Agriculture of Brazil contracted a professional to attend relevant meetings in place of irrigators (Interview N-15). The involvement of irrigators increased when water charges increased. This has since changed with the readjustment of standards for water charges.

If considered from an ID lens, the design of the bulk water charge instrument can be considered partially socially inclusive because one of the main goals of the bulk water charge instrument is to finance the programmes and interventions proposed by the water resources plans (Art. 19, III, Law No. 9433/1997). For instance, CBHSF has been financing monitoring campaigns, hydro-environmental projects, and Municipal Sanitation Plans in the SFRB. This is a significant step towards ensuring access to water and sanitation services as a human right, benefiting users of water (sharing the financial benefits with everyone), and supporting water permit systems. It is also essential that the division of the funds over the different purposes is decided upon in the committee after a participatory process (hence relationally inclusive). Some of the projects decided upon directly contributed to ecological goals (hydro-environmental projects).

6.4.5. Drought management – Crisis Chamber

In terms of *design*, the Crisis Chamber is a drought management policy instrument created in 2013 in response to the adverse effects of water shortages in the SFRB (Mendonça, 2019). It has two aims: to plan and promote permanent defence against public calamities, especially droughts

27 The users can use the Annual Declaration of Use of Water Resources (DAURH) to inform ANA.

and floods; and to institute a national water resources management system, defining criteria for granting rights for its use (Art. 21, XVIII, XIX).

In terms of *operationalization*, the Crisis Chamber was organized and coordinated by ANA. It has brought together relevant stakeholders to share information and ideas about alternative actions for improving water security in the affected areas of the basin (ANA, 2019e). In terms of *budget*, Brazil still does not have a specific budget for this instrument. In terms of *implementation*, it serves as a roundtable for decision-making processes regarding water-sharing between users and between humans and nature (ANA, 2019e). Two strategic actions have been indicated by the Crisis Chamber and ratified by ANA, IBAMA, and SFRB Committee: adaptation of the river's flow considering seasonality and a River's Day.

Adaptation of the river's flow

The SFRB has a hydroelectric system in place for intra-annual streamflow regulation. With this system, the "reservoirs fill during the wet season (summer and early spring) and during the dry season (winter and autumn), the total water volume level" decreases to half its capacity (Interview N-2/3) (de Jong et al., 2018,p.1541).

However, since 2012, there has not been sufficient rainfall for the reservoirs to refill, and the hydroelectric plants have thus supplied less electricity (Interview N-2/3). As a consequence of the constant droughts, the minimum flow of the São Francisco River was altered to meet the electricity demand (Interview N-2/3). Table 6.8 shows the eight resolutions implemented from 2013 until 2017, modifying the minimum flow of the São Francisco River at Sobradinho Dam. In November 2015 and 2017, the water volume level in the Sobradinho reservoirs fell to 5% of the total capacity for stored energy, which is the lowest level seen since all the dams were completed in 1994 (de Jong et al., 2018). The decline in hydropower production has been substituted mostly by fossil fuel (Interview N-2/3). Thus, the change in the regime flow also affected the ecological status of river ecosystems (Koch et al., 2018).

As a consequence of the continuing drought and through discussions in the Crisis Chamber, ANA, along with the National Energy Operator (ONS) and the Environmental Agency (IBAMA), authorized a flexible approach to the minimum flow of the SFRB river. This entailed adapting the river's flow according to the season, leading to slight awareness of

Table 6.8. The minimum flow of the São Francisco River at Sobradinho Dam (2013 – 2017)

Time	Minimum flow (m^3/s)	Resolution*	Year
Before April 2013	1,300		2013
April 2013 - March 2015	1,100	Resolution 442	2013
March 2015 - June 2015	1,000	Resolution 206	2015
June 2015 - December 2015	900	Resolution 713	2015
January 2016 - October 2016	800	Resolution 66	2016
November 2016 - March 2017	700	Resolution 1,283	2016
March 2017 - April 2017	665	Resolution 347	2017
April 2017 - July 2017	570	Resolution 742	2017
July 2017	550	Resolution 1,291	2017

Source: ANA (2019a)

N.B. The Resolution allows a lower flow, and when droughts are over, another new resolution increases the flow again. IBAMA is responsible for the decision-making related to environmental issues. The Crisis Chamber cannot set up this kind of decision, but it can only suggest to IBAMA possible actions. The final decision is from IBAMA.

water but limited in terms of water-sharing between humans and nature. The decision actually did not account for water-sharing between humans and nature, and changing the river flow resulted in severe negative impacts downstream, including contamination of water resources by saltwater intrusion (see 7.2.2.3).

River's Day

In 2017, following the most severe drought and extensive discussion in the Crisis Chamber, ANA adopted a 'River's Day' as a regulatory instrument (Resolution 45/2018). River's Day prohibited commercial users of the SFRB (i.e., industries and irrigators) from using water resources on Wednesdays from June through November 2017 (Mendonça, 2019). The establishment of River's Day is considered the best solution to preserving water stocks in the SFRB reservoirs and meeting water demands of multiple uses. In fact, it directly resulted in the saving of water during the critical period and increased the level of awareness of many stakeholders about the water crisis and its effects on other parts of the basin (Mendonça, 2019) (Interview B-7). There is still a lack of a national policy, and most of the actions are reactive responses.

The Crisis Chamber instrument offers a high degree of legitimacy in encouraging and enabling the participation of different stakeholders in the decision-making processes of water allocation and re-allocation during severe droughts. It reduces asymmetrical information among the participants and ensures transparency as its meetings take place online and are made available on ANA's website (ANA, 2019e). ANA has also implemented the Crisis Chamber instrument to address water crises from droughts and floods in other rivers, including the Tietê-Paraná, Tocantins, and Madeira Rivers (Mendonça, 2019). Despite different perspectives and specificities of actions, Crisis Chambers can involve public and private actors and civil society organizations with a common goal. However, Brazil and the SFRB still lack preparedness for droughts as environmental degradation is increasing and producing different effects such as desertification, deforestation, and land degradation due to human activities. If I look from a perspective of *inclusive development*, Brazil lacks adequate information about its water permit system.

If considered from an ID lens, the design of the Crisis Chamber, a drought management policy instrument, is considered socially inclusive because it commits to minimizing the risk of water damage. It aims to plan and promote defence against public calamities (Art. 21, XVIII, 1988 Federal Constitution).

The design of this instrument is considered *relationally inclusive* because it indirectly promotes a participatory approach as the Crisis Chamber brought together relevant stakeholders to share information and ideas about alternative actions for improving water security in the affected areas.

However, the design of the instrument is not considered *ecologically inclusive* as it does not adopt a broad definition of reserving water for nature (i.e., environmental sustainability is not ensured). For instance, the minimum flow was reduced (e.g., adaptation of the river's flow), and the needs of nature were not taken into account.

So when I look at the text on paper, in the next round of policy-making, it is essential to consider ecological inclusiveness as one of its criteria.

6.4.6. Minimum flow

In terms of *design*, the minimum flow instrument was established by the 1997 National Water Law as a broad definition. The National Water Agency (ANA) and “the different management bodies of the states and the federal district have different minimum flows of Reference Streamflow (Qmr) and proportional percentages”(da Silva, Pereira & de Oliveira Vieira, 2020, p. 19). The water resources management agencies in Brazil have the autonomy to determine the percentage of Qmr (Q7,10, and Q95%) over which water rights are granted (da Silva, Pereira and de Oliveira Vieira, 2020). In permanent or perennial rivers, the water permit is usually made based on Qmr, and only part of the minimum flow values are granted (da Silva, Pereira and de Oliveira Vieira, 2020). In the case of federal rivers, for example, “the maximum water flow (Qmo) granted by the National Water Agency corresponds to 70% of Q95 and, consequently, minimum residual flows (Qr) downstream of 30% of Q95 after the grant of all consumptive uses” (da Silva, Pereira & de Oliveira Vieira, 2020, p. 23).

It is essential to explain that several times, this value of the residual flow is referred to as the ecological flow. However, 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 the case of the SFRB, the flow adopted as a reference for granting water use is the same flow that guarantees permanence 95% of the time (Q95). This means that the river flow must be guaranteed for 95% of the evaluated time. The National Water Agency (ANA) oversees this regulation. The number of water permits granted depends on the amount of water that can be diverted from the water body, taking into account the percentage of the minimum flow required (Benetti et al., 2004, p.441).

In terms of *operationalization*, ANA is responsible for the definition of requirements for minimum flow and maximum concentration of pollutants in the transition from State domain water bodies to the Federal domain (Art. 17 of Decree 3692/2000). However, during the severe drought from 2016 to 2018 (see the previous section and Table 6.8), ANA, along with the National Energy Operator (ONS) and the Environmental Agency (IBAMA), authorized the flexibilization of the minimum flow of the SFRB river several times.

The minimum flow instrument has been recognized on paper through the 2016 – 2025 São Francisco River Basin Water Resource Plan. In practice, however, during the severe drought, it was unable to guarantee equitable water allocation between users and humans and nature.

Moreover, recent studies on water released from dams in the SFRB indicate that there is not sufficient water to support even aquatic species (Knoppers et al., 2005; Medeiros et al., 2013; de Souza Castro, Moreira & da Silva, 2015). To say the least, there is an urgent need for studies on river flows to support ecosystem services (Interview B-7). Large users in the agriculture and energy sectors were the primary beneficiaries at the expense of the other users, showing that the minimum flow instrument was not successful in addressing the existing prioritization of the economy over the environment.

If considered from an ID lens, the design of the minimum flow instrument is not considered *socially*, *ecologically*, or *relationally inclusive*. On paper, it has a broad definition that does not address environmental sustainability. Hence, not enough water is reserved for nature to support riparian zones, floodplains, and other natural ecosystems (WMO, 2019). So when I look at the text on paper, the next round of policy-making may need to reallocate to ecological, social, and relational issues based on hydrological information and studies.

6.5. Inferences

The São Francisco River Basin is the largest domestic transboundary basin in Brazil at 638,500 km², and is considered a strategic connection between the well-developed Southeast and the economically poorer North-eastern regions of Brazil. Since the 1950s, the SFRB has been part of the national development strategy. Its development process was driven by agricultural expansion and hydroelectric development, two important drivers of the SFRB current water problems. The favourable conditions for hydropower production resulted into the damming process along the river, which seriously affected waterflows and cycles and had detrimental social and environmental effects (i.e. downstream communities especially suffer the worst consequences - see Figure 7.2).

Commercial irrigated agriculture is by far the main water user in the basin. This fact mirrors the federal government's strategy to support agriculture development using the potential of the São Francisco River (see 6.4.3). Almost 78% of the total water withdrawn from the SFRB is for irrigation purposes (see Table 6.4). Irrigation use is the largest surface water consumer (see Table 6.5). Livestock use is more dependent on groundwater when compared with the other uses (e.g., 89% of its water consumption comes from groundwater). Currently, water demand from the SFRB is higher than the supply, therefore urging attention to water-sharing (6.2.3). The SFRB mirrors the water-sharing challenges of the country as a whole.

The São Francisco River Basin has a multilevel (federal, state and basin) governance system as a result of the national legal framework adopted in 1997. The framework allowed for more dynamism at the basin level and stakeholder participation through the creation of the São Francisco River Basin Committee in 2001. Water governance has since shifted from the hydraulic engineering paradigm towards IWRM. This clearly added an extra layer of governance. Overall, this has had a positive effect on water governance in the basin, with several instruments developed at the basin scale. A river that crosses several states clearly needs the basin level of governance to enable more equitable sharing between the different states.

Several policy instruments exist to address the water-sharing problems, including the adoption of priority of use, irrigation systems and hydropower plants, bulk water charges, the minimum river flows, and the Crisis Chamber. The CBHSF appears willing to address key water-sharing challenges in the basin through the 2016 - 2025 São Francisco River Basin Water Resource Plan. The São Francisco River Basin Committee's call for equal sharing of interest through the "Water Pact" an instrument that explicitly shows the potential to solve the transboundary conflicts and protect downstream users from their disadvantaged position. However, since the 2000s, when water governance was rescaled to the basin level, the Committee has been unable to reach an agreement that suits both upstream and downstream states. There is a lack of political will in Bahia to sign the Water Pact Agreement, which focuses on water-sharing instruments between states (see 6.4.1). The state's governors, who are strongly pressured by interests in agribusiness exportation, have argued that the Agreement would limit the state's economic growth. Bulk water charges in particular have presented positive results in the SFRB. Revenues collected from bulk water charges have contributed to financing Municipal Sanitation Plans, Integrated Preventive Inspections, and various hydro-environmental projects. However, the minimum flow of the SFRB was changed several times during the severe drought from 2016 to 2018 (Table 6.8). The flexibilization negatively affected nature and downstream users, and was unable to guarantee equitable water allocation between uses and humans and nature.