Alternative Systems for Water Security in the Brazilian Semiarid Region

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Abstract

The Brazilian semiarid region faces the challenge of guaranteeing water security for rural communities, especially with the COVID-19 outbreak. The chapter presents how small-scale water system initiatives like the 1 million Cisterns Program and the Freshwater Program contribute to the access to water, pointing out its strengths and weaknesses. The methodology consisted in a thorough document analysis. These programs adopted a posture of coexistence with the

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drought and included rural populations as protagonists in the planning, installation and monitoring processes of the systems. Their continuity depends on the government's willingness. Although they ease regional structural problems, they do not solve them.

Keywords

Brazilian semiarid · Water security · Alternative water systems · Freshwater

Introduction

Ensuring water security for rural communities in arid and semiarid areas is a major challenge to guarantee the human right to water. The emergence of COVID-19 highlights the importance of access to water to prevent and fight the virus, whether through hand washing, cleaning of goods, clothing and masks, or guaranteeing healthy environments.

Although Brazil is known for holding 12% of the world's freshwater reserves (Ana 2019) and sharing large transboundary basins and aquifers (such as the Amazon Basin, the Prata River Basin and the Guarani Aquifer), it also comprises one of the largest and most populous semiarid regions on the planet – the Brazilian semiarid (Mdr 2019). The combination of climate variability and governance problems has made this region known for its low human development index (HDI), water scarcity, and migration resulting from drought and poverty (Campos 2015).

Public policies for access to water were reactive to the occurrence of major droughts and were structured based on investments for the construction of water infrastructure, mainly dams or reservoirs. The focus of those infrastructures was to meet the specific demands of cities, industry, and irrigation, without much attention for the water security of low-income families living in rural areas (Santana et al. 2011).

In this context, the Freshwater Program (*Programa Água Doce* - PAD) and 1 million Cisterns Programs (*Programa 1 Milhão de Cisternas* – P1MC) aim, in an innovative and autonomous way, to ensure access to water for individuals and small communities, guaranteeing access to quality water through alternative small-scale water supply systems. In the case of the pandemic, these initiatives took on greater relevance, as preventive actions are the main alternative for these communities. Among the municipalities, 99% have a low health development index, with a deficit of health care professionals and primary care services of basic, medium, and high complexity (Damasceno et al. 2018).

This chapter presents how small-scale water system (SSWS) based programs can contribute to promoting water security in the rural semiarid region, pointing out the strengths and weaknesses of the PAD and the P1MC. The methodology used was document analysis from the National Water and Sanitation Agency (ANA) and the Ministry of Regional Development (MDR) involved in the implementation of these programs.

Water Security of Rural Communities in Arid and Semiarid Regions in the Context of COVID-19

The search for universal access to water and sanitation has been a challenge on the international agenda since the so-called International Drinking Water Supply and Sanitation Decade promoted by the United Nations, between 1980 and 1990. The approval of the Millennium Goals (MDGs) leveraged this commitment, as the MDGs 7 – Ensure Environmental Sustainability (Target 7.c) intended to "reduce by half, by 2015, the population without permanent and sustainable access to drinking water and to sanitation." Despite 147 out of 215 countries achieving the target, inequalities continued, particularly in rural areas (UNICEF and WHO 2015).

According to General Comment n. 15, issued by the United Nations Committee for Economic, Social and Cultural Rights (CESCR), access to water would be classified as a human right (United Nations 2002). This was the basis for the United Nations General Assembly to declare the human right to water and sanitation, by Resolution n° 64/292/2010 (United Nations 2010). Its main objective is to ensure "that everyone has sufficient, safe, acceptable, physically accessible and reasonably priced water for personal and domestic use," representing a milestone in the public policy agendas in the water, sanitation, and development sector (Brown et al. 2016).

The universalization of this right gained strength with the 2030 Agenda for Sustainable Development of the United Nations, which comprises 17 Sustainable Development Goals (SDG) and 169 targets. The SDG 6 – Drinking water and Sanitation – aims to promote management and achieve universal access to water and sanitation by 2030. This challenge faces greater difficulties to materialize in developing countries that have problems related to access to health care, housing, and education, particularly in arid and semiarid regions (United Nations 2021).

These initiatives generated improvements in the years 2000 to 2017, which allowed the reduction of the number of people without access to safe drinking water from 1.1 billion to 785 million, while the lack of access to sanitation went from 2.7 billion to 2 billion (UNICEF and WHO 2019). There is a lack of data about hygiene in most world countries; however, it is estimated that 3 billion people do not have adequate handwashing facilities, either because of the lack of such structure in the home or because of problems with lacking water and soap (UNICEF and WHO 2019). In the case of Brazil, in 2004, more than 50 million people did not have access to piped water (Moraes 2014). By 2020, the numbers had dropped to 34 million (16.3% of the population) (Ana 2020). The sanitation situation in Brazil is still critical as 96 million (46%) do not even have access to sewage collection services (Ana 2020).

These numbers mask inequality as little progress has been made in water distribution in rural areas, traditional communities, informal settlements, and slums, where the poorest and most vulnerable groups live (Meeks 2018; Cetrulo et al. 2020). These populations are more exposed to public health problems resulting from waterborne diseases; diseases that are spread by the lack of sufficient amounts of water to carry out personal hygiene; vector-related diseases or diseases caused by drinking contaminated water (WHO 2003).

In this context, guaranteeing water security to these communities is essential. There is no consensus on this concept, which incorporates debates related to military, food, energy, environment, livelihood, and health security (Brauch et al. 2009; Cook and Bakker 2012). One of the most widespread concepts of water security is the one developed by the Global Water Partnership (2000, 12), through which it must be ensured that "every person has access to enough safe water at an affordable cost to lead a clean, healthy and productive life, while ensuring that the natural environment is protected and enhanced." This definition includes the human right to water but goes even further, as it seeks to ensure: meeting basic needs; food production; protection of ecosystems; equitable sharing of water resources; risk management (drought and floods); assigning a value to water; and water resources management (Cook and Bakker 2012).

The pandemic highlighted the importance of meeting water human needs and seeking innovative solutions, without major construction and with the involvement of communities that are directly affected (Linton 2012). Without access to water it is not possible to achieve many other SDGs, such as: SDG 1 – No poverty; SDG 2 – Zero hunger; SDG 3 – Good health and well-being; SDG 5 – Gender equality; SDG 10 – Reduced inequalities; SDG 11 – Sustainable cities and communities. The SDGs and targets are compartmentalized, but they can only thrive with a governance infrastructure capable of implementing them in an integrated manner by institutions, policies and management practices that include various social actors (Bernstein 2017).

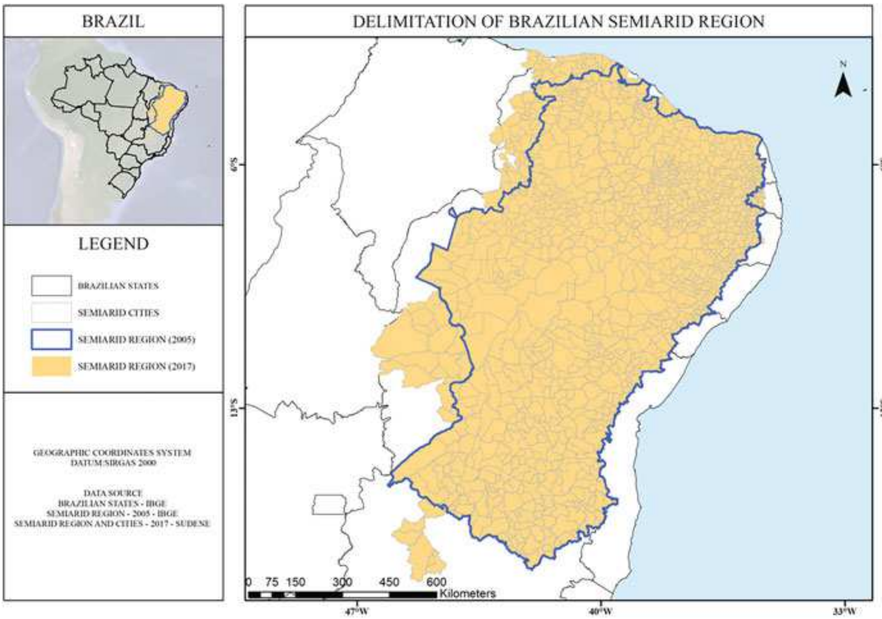
Rural communities face the challenge of obtaining safe, accessible and low-cost water, as well as having a voice in public policies, because urban areas, whose population density and social mobilization are greater are prioritized (Li et al. 2019). Also, in rural areas the centralized infrastructure of water and sewage networks does not represent an effective solution, as there are: (a) low numbers of household connections; (b) dispersion of residences in the space; (c) extension of rural areas; and (d) difficulties in accessing the installation, operation, and maintenance of networks (Barde 2017). These difficulties explain why only 29% of rural areas have a piped water network (Joint Monitoring Programme 2014).

The problem of access to water becomes more dramatic in arid and semiarid rural areas, due to the availability of limited water reserves, making these localities become increasingly subject to prolonged droughts. Tackling this problem requires institutional, economic, social, and engineering approaches (Kahil et al. 2016). The strategies adopted focus on: reducing water entitlement rights; transferring water from other basins; adopting economic instruments, or technologies that encourage low consumption; small-scale water systems (SSWS); joint use of surface and groundwater, as well as other alternative sources, such as rainwater, stormwater and atmospheric harvesting, desalination (sea water or brackish groundwater), and recycled water (Kahil et al. 2016).

For small rural communities in water-stressed regions, solutions must consider the local reality and foster the strengthening of social capital and arrangements that enable the empowerment of these rural communities, with effective opportunities for its development (Dean et al. 2016). Therefore, it is not enough to implement water infrastructure construction, as it was done in the past.

Water Scurity, Rural Area of the Brazilian Semiarid Region, Public Water Policies and COVID-19

The Brazilian semiarid (Map 1) has an area of 1,128,697 km^2 and covers 1262 municipalities in ten Brazilian states (Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Rio Grande do Norte, Sergipe and Minas Gerais) (SUDENE Resolutions n^o 107, of July 27, 2017 and n^o 115, of November 23, 2017), with a population of approximately 27,870,241 people (Mdr 2019). Updated data on the rural population are lacking, but according to the 2010 Demographic Census there were 8.5 million people living there, corresponding to the lowest urbanization rate in the country (IBGE 2010). This region is characterized by an average annual rainfall of less than 800 mm; a Thorntwaite aridity index equal to or less than 0.50 and a daily percentage of water deficit equal to or less than 60%, considering every day of the year (SUDENE Res. n° 107/2017). Irregular rainfall, low precipitation rates, intermittent rivers, low availability of groundwater, high temperatures, strong



Map 1 Map of the Brazilian semiarid region (IBGE 2017). (Prepared by the authors. Source: Superintendence for the Development of the Northeast,. From here: Instituto Brasileiro de Geografia e Estatísticas (IBGE) (2017) 'Mapa do semiárido' 1:12000000. Available at: https://geoftp.ibge.gov.br/organizacao_do_territorio/estrutura_territorial/semiarido_brasileiro/Situacao_23nov2017/mapa_Semiarido_2017_11_23.pdf)

insolation, and high evapotranspiration rates, linked with the social and environmental vulnerability framework, are a challenge for management and make it difficult to guarantee the right to water.

In the Semiarid region, only 32% of rural households had access to treated water in 2012, and 68% of the population had to resort to alternative sources of water (De Lira Azevêdo et al. 2017). The main sources of water are: reservoirs known as weirs, underground dams, rainwater cisterns, wells, waterholes, bottled water, and water tanks (De Lira Azevêdo et al. 2017). In the absence of public water networks, access to water is made possible via direct extraction from either the water body, wells, distribution through a network built by residents' associations, or transported by means of water tanker trucks, cars, motorcycles, animals, or people (De Lira Azevêdo et al. 2017).

The region has the highest percentage of population with some degree of vulnerability (69%) (Ana 2020), the highest proportion of low-income families (more than 6.3 million) and low levels of human development (0.613) (Santana et al. 2011). Another regional challenge is the unequal relationship between land and access to water (Arsky 2020). Water access in the semiarid region is an issue that transcends the "water supply paradigm." Water is a scarce resource, but the way in which it is distributed reveals structural inequalities marked by injustices, and both gender and ethnic-racial differences, that permeate human relations in this territory (Campos 2015). The lack of access to water, sanitation, education, infrastructure, and health care creates a cycle of poverty that often lasts for generations, or forces people to leave their land. In the case of the pandemic caused by Covid-19, access to water was not enough to maintain adequate, health conditions.

Of the families that have individual or community facilities for accessing water, 53.5% live more than 5 km from the nearest primary care center, while 60% are more than 10 km from high-complexity care centers that provide care for COVID-19 (Benevenuto et al. 2019). The distance and lack of transport discouraged or prevented this population from seeking health services, putting their lives at risk, especially in the case of COVID-19, or other serious illnesses.

From the end of the 1990s onwards, instead of seeing drought as an obstacle to be overcome, policies have begun reinforcing the population's resilience against regional natural conditions that tend to worsen due to climate change (Campos 2015). Public policies for the Brazilian semiarid region can be divided into five periods: contact with the semiarid region (1583–1848); the search for knowledge (1849–1877), hydraulic solutions (1877–1958), regional-based development policy (1959–1991) and the last phase, which started in 1992 and concerns social policies based on solutions that increase water management and the improvement of the population's quality of life (Campos 2015). For Moura et al. (2021), the main challenge is promoting investments in public policies for access to water which, preserve the natural biodiversity of these regions and promote the participation of the population. Table 1, adapted from Machado et al. (2017), presents an overview of the main public policies related to mitigating the effects of drought in the Brazilian Semiarid Region.

Table 1 Evolution of public policies in the Brazilian semiarid region

Period	Main public policies aimed at combating the drought
1948–1956	Creation of the Federal Institute of Works Against Drought – IFOCS (1948), Northeast Bank (1952) and the Working Group for the Development of the Northeast-GTDN (1956).
1959	The Northeast Development Council (CODENO) was created, and the Northeast Development Superintendence (SUDENE) was instituted.
1970–1976	Regional development programs to promote irrigation: National Integration Program (PIN), North and Northeast Land Redistribution and Incentive to Agroindustry Program (PROTERRA), 1971, incorporated into the I National Development Plan (I PND) and the Special Program for the São Francisco Valley (PROVALE), 1972, and the Northeast Integrated Areas Development Program (POLONORDESTE), 1974; and SERTANEJO Project.
1977–1984	Northeast Water Resources Program (PROHIDRO), later renamed PROÁGUA (1977). National Irrigation Policy (1978). PROVÁRZEAS Program (in charge of the States) dedicated to provide assistance to small farmers (1981). Agreement between the Ministry of Integration (MI) and the International Bank for Reconstruction and Development (BIRD) to allow the implementation of medium-sized companies in irrigation projects (1984).
1987	The Northeast Irrigation Program - PROINE (1986), which was expanded to the National Irrigation Program - PRONI (1986), which established the Northeast Project I, in which only the Support Program for Small Rural Producers (PAPP) in the semiarid region prospered.
1990–1993	Emergency Food Distribution Program - PRODEA, (1993). This program gave rise to the Bolsa Renda Program in 2001 and the Bolsa Família in 2004. In 1997, the irrigation model was created, with family plots for settlement projects and public irrigation projects fully occupied by companies.
1998	Creation of the Federal Program to Combat the Effects of Drought, coordinated by SUDENE, to help those affected by the drought. To avoid the dismantling of public irrigation projects, in December 1999, SUDENE, the Superintendence of the Amazon (SUDAM), the National Department of Works Against Droughts (DNOCS) and the São Francisco and Parnaíba Valleys Development Company (CODEVASF) were linked to the Ministry of Integration (created in September 1999). In July 1999, the National Civil Defense Council (CONDEC) prepared the Manual for the Decree of Emergency Situations or State of Public Calamity
2001–2006	Creation of the 1 million Rural Cisterns Program (P1MC), within the Training and Social Mobilization Program for Living within the Semiarid, from the Articulation in the Semiarid (ASA) NGO, created in 1999. The P1MC becomes a public policy of the federal government upon signing the Partnership Agreement n° 001/2003 with the Ministry of Social Development (MDS). SUDENE was dissolved in May 2001, having been renamed the Northeast Development Agency (ADENE) in June 2004. SUDENE was recreated in 2007. Creation in 2003 of the One Land and Two Waters Program (P1+2), a program about living within the semiarid that intends to assure the rural population access to land and water. The National Semiarid Institute (INSA) was created in 2004.
2011	Creation of the Water for All Program (*Program Água para Todos*) and the Cisterns in Schools Project, which are integral parts of the Brazil without Poverty Plan (*Plano Brasil Sem Miséria*).

Prepared by the authors
Source: Machado et al. (2017)

Despite the policies and investments, the situation of rural socio-environmental vulnerability persists. The public policies carried out either did not focus on small landowners or were discontinued. Federal Law n° 11.445/2007 and the changes made in 2020 perpetuate the exclusion of access to water for the rural population, centralizing their actions to the urban environment. Ignoring the deadline of SDG-6, Law n° 14.026/2020 established that universalization will only be achieved in 2033, but it did not bring strategies for rural supply. The National Water Security Plan (Ana 2019) allocated most of its investments to the Northeast region, with emphasis on increasing water availability in the Semiarid region (R$ 15.7 billion, corresponding to 58% of the total). However, this investment is intended to supply cities, never reaching the rural population. Against this trend, the PAD and the P1MC stand out by seeking to provide water and alleviate inequality.

Water Security for Rural Populations Through Small-Scale Water Systems (SSWS): The Case of the 1 Million Cisterns Program (P1MC) and the Freshwater Program (PAD)

The P1MC and PAD are examples of small-scale water systems (SSWS) based on alternative water sources (Barde 2017). SSWS are individual or collective supply solutions, designed to guarantee water for individuals or, small communities of users (Rickert et al. 2016). SSWS allow greater adaptability to the social and water particularities of communities, but their installation faces challenges such as: (a) structural problems in the implementation of infrastructure that compromise its operation; (b) choice of inappropriate technologies for the location; (c) lack of investments and maintenance; (d) centralized decisions that do not take into account local needs or particularities; (e) lack of engagement of the local community in the decision-making process for choosing and installing the technology; (f) lack of training programs for the community to properly operate and maintain the system; (g) free distribution of water, which would harm the system's operation; (h) attribution of price to the service, which would exclude the poorest; (i) lack of quality control; and (j) control of the system by a group that restricts access to others (Whittington et al. 2009; Barde 2017; Mapunda et al. 2018). The success of these initiatives depends on the choice and implementation of technology or infrastructure appropriate to the local situation, community involvement in the overall process, post-construction support from the State or on other social actors (Schweitzer and Mihelcic 2012; Dean et al. 2016).

With the interiorization of COVID-19 in the semiarid region and the increase in cases from 2020 onwards, preventive measures are the only coping strategy available in this area. The health of these communities depends on taking proper measures for social isolation and hygiene. Public authorities did not idealize any program to protect rural populations on the region from the COVID-19 contagion. In this sense, the P1MC and the PAD are not only the main guarantors of access to water in this region for the most vulnerable groups, but also the main strategy to prevent COVID-19.

1 Million Cisterns Program (P1MC)

The P1MC uses cisterns as the main means of guaranteeing water for rural populations. The construction of masonry reservoirs in the Semiarid region started in 1988 in Bahia. From the 1990s onwards, through a partnership between civil society (Articulation in the Semiarid - ASA) and public authority, the technique was improved, transforming it into a public policy (Silva and Borja 2017). This partnership produced two types of cisterns in terms of storage capacity: (i) storage of 16 thousand liters of water, mainly destined for consumption and food and (ii) capacity of 52 thousand liters, applied toward agricultural production (Embrapa 2015). The system consists of a cylindrical structure, with the lower part buried in the ground, which is supplied with rainwater collected from the roofs of houses, or from inclined surfaces that allow the flow of water to this masonry structure. In addition to being a water source, the cistern represents also the social management of the natural resource, as the financial resource is directed to the community, which will be responsible for building it collaboratively (Soares Júnior and do Fátima Andrade Leitão 2017).

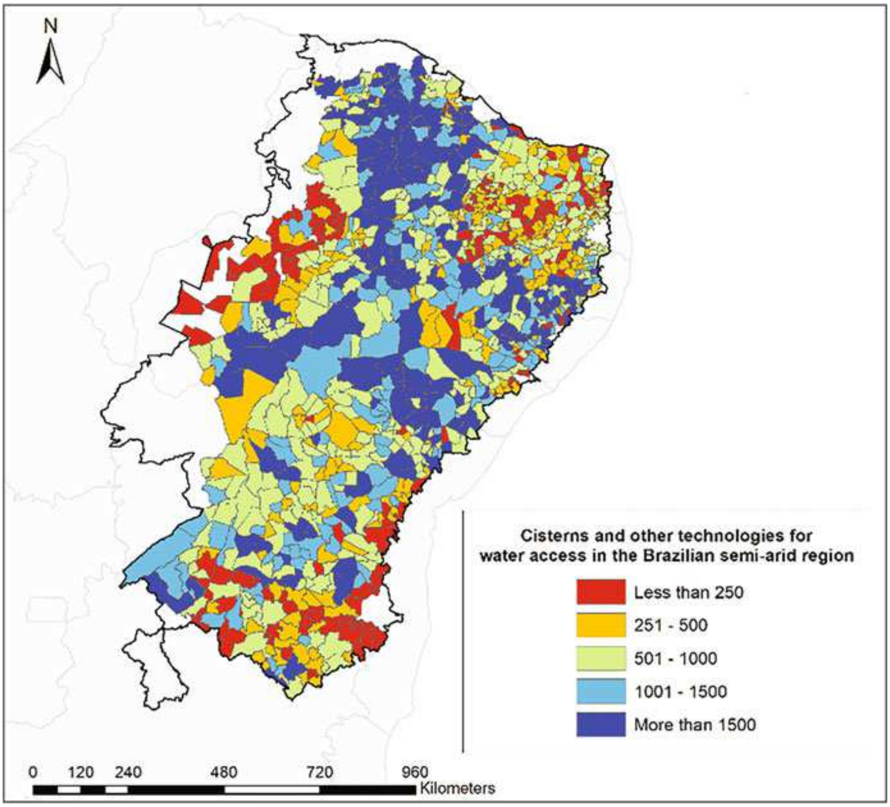
In 2000, the ASA launched the Training and Social Mobilization Program for Living within the Semiarid: 1 million Rural Cisterns (P1MC), with support from the federal government, through the Ministry of Social Development and Combating Hunger (MD) (Cunha 2020). This policy was included in the “Brazil Without Poverty Program”, which also included the PAD. This initiative clashed with large water infrastructure projects characterized by large reservoirs that did not always benefit rural populations in the Northeast.

The P1MC proposed a water autonomy project, in which rural residents began to reserve and manage their own water, which they were previously never able to do. The central strategy was cooperation and self-management, or co-management. The resources for the construction of these structures came from non-governmental organizations or public authority, but the organization and construction were controlled by the local population, which created an awareness of belonging and was fundamental to the success of the program.

The cisterns provided a better coexistence of the rural population with the semiarid region, but water quality is a still concern, as there is not always correct handling and treatment, which can make it a vector of disease transmission (Machado et al. 2021). However, simple sanitary changes, such as the use of PVC equipment to capture rainwater from roofs would bring improvements in turbidity, the dissolution of solid materials, and the reduction of the presence of coliform bacteria (de Carvalho et al. 2018). Despite this, the quality of water stored in the cistern is better than that stored in larger reservoirs such as weirs, or dams (Farto and Da Silva 2020).

The implementation of this innovative and successful public policy breaks the secular logic of the rural population’s dependence on a decision by the public manager, focused on large water infrastructure projects whose results did not reach the field. About 1.3 million people have benefited from this program, specifically farmers who had never been the object of a water policy, resulting from the partnership between the State and civil society (Arsky 2020). The cisterns also benefited more than 6000 schools that were without water access with the conventional system, thereby improving the health conditions of the environment. Map 2 shows the number of cisterns received by Brazilian municipalities, where it can be seen that all municipalities in the semiarid region received this technology.

The possibility of storing water reconfigures the families' strategy in a productive aspect, as it enables management to be used for their survival. In addition to building the cistern, the community also undergoes some training to transform locals into amateur farmers, who experiment with new production technologies. The continuation of this program in the following years – named "Second Water" – was fundamental for food security and for community engagement through social learning activities, thereby giving farmers greater confidence in their own knowledge and skills, as a result of installing the cistern (Cavalcante et al. 2020).



Map 2 Diagnosis of implanted cisterns in Brazil, with an emphasis on the semiarid region. (Prepared by the authors. Source: Embrapa 2021. From here: Embrapa (2021) Inclusão produtiva no seu município, 'Cisternas e outras tecnologias sociais de acesso à água'. Shapefiles. Available online: http://mapas.cnpm.embrapa.br/mds/?layers=1. Accessed on June 3rd 2021)

In addition, the cistern contributed to women's empowerment. The provision of water prevents women from traveling long distances to fetch water for household chores, allowing them to become involved in other community activities (Brandão et al. 2020). In 10 years (2000–2010), 306,000 cisterns were built in 1000 municipalities in the semiarid region of the Northeast. By 2021, 628,355 cisterns were built, with an eventual target of 1 million reservoirs (Asa 2021). This strategy transforms and reinforces the resilience of communities in multiple life aspects, including sanitation, having reduced incidence of diarrheal infections in children aged between 0 and 4 years (da Silva 2015).

Behind this program lies a political articulation that resulted in an increase in water security for communities that are excluded from conventional water supply in cities. In addition, ever since the choice of the communities until the installation of the cistern, there has been a political formation based on the self-management of this resource. Despite the program's success, since 2016 the resources allocated by the Federal Government have significantly decreased, thereby compromising its expansion, which contributes to the permanence of exclusion, thus facing the violation to the human right to water by the population, in this region.

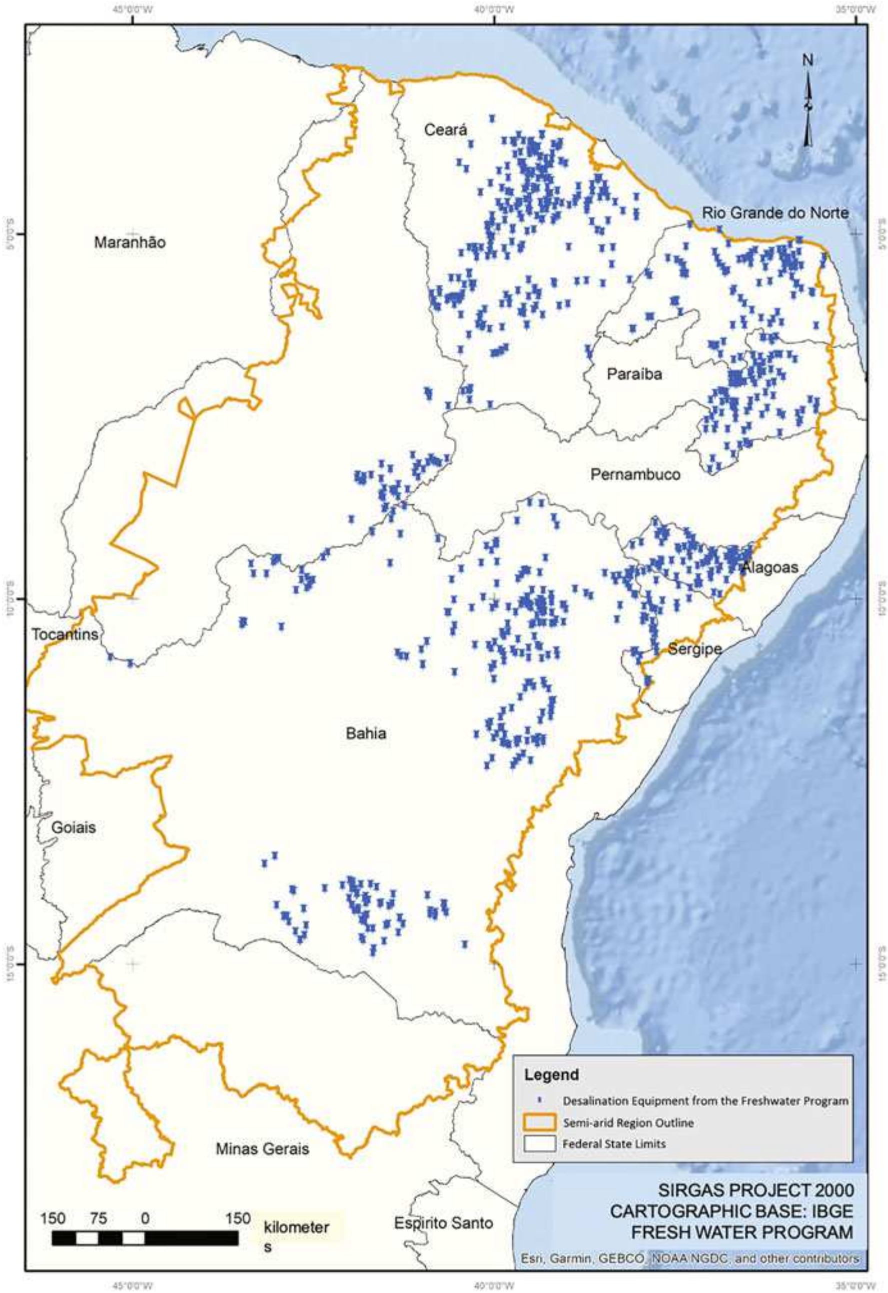
Freshwater Program (Água Doce Program)

The PAD emerged as a way to take advantage of the region's abandoned wells due to the groundwater's salinity, which is a characteristic of the Crystalline Aquifer, and to overcome the shortcomings of the "Good Water Program" (PAB). In some locations of the semiarid region, groundwater is the only available source of water. However, it is estimated that 70% of the wells have brackish, or saline water; furthermore, several of the 160,000 thousand tube wells registered in the region were abandoned for this reason (Cprm 2021).

As a way of seeking a solution to this problem, the Federal Government implemented the "Good Water Program" (*Programa Água Boa*) Program in the 1990s whose objective was to install desalination systems in rural communities to use the wells. However, the management model was not adequate for the chosen technology, and many implemented systems lacked technical, social, and environmental care, which resulted in its abandonment by the population.

In light of this situation, the Água Doce Program (PAD) was created in 2003 with the objective of recovering abandoned systems, albeit on new bases. This time, the adopted methodology established solid structures of cooperation and social participation in the management of desalination systems. In addition to the Federal Government, through the Ministry of Regional Development (MDR), PAD's actions were implemented in partnership with all Northeastern states (Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Rio Grande do Norte, and Sergipe) and Minas Gerais, with federal government, states, municipal institutions, and especially local communities (Map 3).

It is worth highlighting the work of the Federal University of Campina Grande (UFCG) for their social engagement procedures, the Geological Services of Brazil



Map 3 Diagnosis of desalination systems installed and in process of installation in the Northeastern semiarid. (Source: Ministério do Desenvolvimento Regional (2019) '*Boletim informativo Ministério da Cidadania n°28, novembro' Programa Cisternas* it is publicly available and no permissions required)

(CPRM) for information on groundwater, and the Brazilian Agricultural Research Corporation (EMBRAPA) for their Methodology for the reuse of desalinated water (Ferreira et al. 2017).

The first municipalities served by the PAD desalination systems were those located in areas that are most susceptible to the desertification process. The other technical criteria that guided the cities' choices were: lower Human Development Indices, high percentages of infant mortality, low rainfall, and difficulty in accessing water resources. In this sense, the Index of Access to Water in the Semiarid Region (ICAA) was developed based on the crossing of these same indicators (de Azevêdo 2017).

The shared management of desalination systems, with the effective participation of communities and representatives of municipalities, states, and the federal government, is a distinction of the Program. From this structural change, it was possible to make advancements in the implementation of the Program. In each community, shared management agreements are created as legal documents that define the responsibilities of each part in their management.

Periodic monitoring of the Communities by state teams is essential, especially in the first months when the operators of the desalination system and the residents are still appropriating the methodology and proper handling of the equipment. There is still a need for the periodic presence of representatives from the institutions involved – Federal, State, and Municipal Governments – in order to reinforce care as well as the management of the desalination systems. This management includes permanent institutional effort and resources (Saia 2018).

The objective of the PAD is, therefore, to establish a permanent public policy for access to quality water for human consumption through the sustainable use of brackish and saline groundwater, all while incorporating technical, environmental, and social care in the implementation and management of desalination systems in the Brazilian semiarid region.

Communities that have wells with flow rates greater than 5000 l/h and soils deeper than 1.00 m can receive an integrated production system. The system was developed by Embrapa and uses the resulting effluent from the desalination process for the production of tilapia and irrigation of cultivars adapted to the salinity of the water, products that will be able to feed local herds (Ferreira et al. 2017). In addition to making potable water viable, the PSD works on developing an environmentally appropriate destination for the effluent generated in the desalination process.

As of 2011, the PAD has become part of the Water for All Program (*Programa Água Para Todos*), with resources from the Food and Nutritional Security Program. The State plans for the Freshwater Program were then implemented, and the program was institutionalized by the state governments, which implemented state management and coordination centers. The agreements between the Federal Government and the ten states involved are in the execution phase, with an investment of approximately R$ 210 million, to supply drinking water to 320,000 people in rural communities in the region. The desalination systems implemented so far have an installed capacity to produce around 2 million liters of drinking water per day.

So far, 3677 communities have been identified in 300 of the most critical municipalities of the Brazilian semiarid region. About 2400 system operators have also been trained. The desalination systems implemented have the potential to serve 358 thousand people and produce 3.5 million liters of desalinated water daily. There are 895 desalination systems in operation today, each with their management agreements formalized, and 212 thousand people benefit from this infrastructure.

The implementation of the program in each state is divided into three phases:

- Carrying out diagnoses to define, through technical criteria, flow tests, physical-chemical analyses of the water from the wells and socio-environmental characterization of the communities, in order to identify which ones will be served
- Implementation of desalination systems
- Maintenance and monitoring of systems

The shared management implemented by the PAD defines that a member of the community must assume operation of the equipment, with the electricity costs being taken on by the municipality, or by the community itself. To this end, each community is encouraged to create a reserve fund to cover operating costs (electricity and operator compensation) and small repairs, with each community establishing a monthly amount to be paid per family.

Considering the minimum reference flow for the use of a deep well that will supply a PAD system of approximately 1000 l/h, which represents a large part of the wells located in the Brazilian semiarid region, a PAD system has the potential to produce up to 4000 l of desalinated water per day, which allows the supply of 10 l/day of drinking water per person, to serve up to 400 people living in rural communities, daily.

Yet, there is the challenge of making advancements in the use of Solar Energy to feed the desalination systems implemented by the program. There is also the possibility of advancing the use of biosaline agriculture, through the PAD Demonstration Units with the dissemination of crops appropriate to the Brazilian semiarid region, adaptable to saline or brackish water in the irrigation process.

The success of the PAD methodology was recognized by the International Desalination Association (IDA), during the World Desalination Congress held in October 2017 in the city of São Paulo/SP, Brazil. Also noteworthy of mention was the participation of the Freshwater Program in a parallel event at the UN Economic and Social Council held in May 2017 in New York, where the program was recognized as an initiative that adopts an integrated approach to sustainable development and combating poverty.

According to de Azevêdo (2017), referring to a survey conducted among users of desalination systems, all 600 respondents linked the desalination system (as well as the P1MC) to improvements in living conditions and highlighted access to better quality water rather than traditional sources (rivers, weirs, mud ponds, shallow and deep wells, and water trucks) and the ease of having water next to their house.

Reports described the cistern and desalination plant as assets that reduced hard work and time spent fetching water. Other improvements were also pointed out, such as in health, in the economy with water transport, and in water security. In fact, the implementation of desalination systems results in an increase in the supply of drinking water with a territorial amplitude that covers the region and also in the strengthening of cooperation in the communities; all the while projecting new possibilities for the implementation of projects of an economic and social nature, since it has given opportunities for a collective sense of belonging in the communities, especially in the self-esteem of local residents.

Conclusion

The P1MC and PAD mark a differential in public policies applied to the Brazilian semiarid region with regard to guaranteeing access to water. This difference is that, for the first time in centuries, the methodology of these programs has involved rural populations who have started playing a leading role in water security actions, thereby participating in the planning processes, installation, and monitoring of systems.

The possibility of participating in the implementation of these policies brought self-confidence to the communities, especially through training programs linked to these innovative experiences. Considering the situation of exclusion (education, health, employment, among other factors) in which local communities live, the programs presented represent hope for economic and social development. Perhaps for the first time, these people are no longer invisible and are experiencing the possibility of acting, together with other actors, in the realization of a right – the human right to water.

The programs do not solve all the issues that afflict the semiarid rural population, such as the lack of access to education and health care. However, these experiences leave the mark of local empowerment, guaranteeing not only quality water, but also the confidence that it is possible to advance in achieving the human right to water. However, there are challenges to face. It is necessary to register new salinization plants and build cisterns, all while verifying where it is still necessary to continue these actions. It is necessary to permanently monitor the quality of the elements that are part of the programs – water quality, operation of the equipment used, and impacts of the training of local communities on the operation of the systems.

Therefore, human and financial resources must be allocated to monitor the evolution that has taken place over time and, above all, to measure this evolution in light of the number of people served, together with the changes observed in their economic and social development.

Therefore, such experiences, although they constitute state policies, still depend, in practice, on the decisions of the public authority, which is a risk, because according to the thinking of the government in power, these populations can have more or less attention. The COVID-19 pandemic demonstrates that these rural communities are still invisible to health care polices and to the fluctuations of water political programs. Instead of promoting actions to expand these water programs as a coping strategy to COVID-19, the government followed a policy of cutting investments and ignoring the sanitary risks.

As a way of guaranteeing the continuity and permanence of the programs, as well as the visibility of this part of the Brazilian population, it is essential to have, in addition to public authority, the support of civil society and the private sector.

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