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“TECNOLOGIAS SOCIAIS” AND THE NORTHEAST BRAZILIAN SEMI-ARID: A Study on the Cisterns’s Program

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ABSTRACT

Some initiatives of "tecnologias sociais" (TS) have led to public policies of a social nature and are examples of experiences that have emerged without the help of the public sector, but whose practices have been improved and disseminated through their incorporation into the policy, such as the Cistern's program that emerged of active community action to provide better living conditions for the inhabitants of the semi-arid regions of Brazil (preferably). Against this background, this paper aims to analyze the role of the Cisterns's program as a generator of social technologies in the semi-arid region of northeastern Brazil. A qualitative, descriptive and exploratory study was performed, using a single case study and data collection through interviews and document analysis in the Cisternas Program. The results show that the social technologies designed by the Cistern's program have positive impacts beyond access to potable water. These include mitigation of desertification and articulation and mobilization between communities, among others. Such findings corroborate the understanding of the Cisterns's Program as a "supplier" of social technologies and its relevance to the advancement of the regions where it operates, mainly in the northeastern semi-arid region.

Keywords: **"***Tecnologia Social*". Cisterns's Program. Northeast Brazilian semi-arid.

1 INTRODUCTION

Greater inequality in income distribution, an increase in poverty and the number of unemployed, environmental degradation and public health are just some of the problems of modernity that make public policy a fundamental element for the development of society (MATOS JÚNIOR, 2021). However, decision-making in public policies can be carried out by other actors besides governments, such as civil representatives, individuals, groups, associations or organizations that influence the design of these policies (MACEDO et al., 2016), with the aim of creating initiatives that benefit society (SOUZA; SAUER; BENINI, 2019).

Among these initiatives is "*tecnologia social" (tecnologias sociais* – plural form) (social technology (TS) / social technologies - TSs), written in Portuguese (original form) in this paper to avoid misinterpretation with technologies based on new social media. This technology is the result of a paradigm shift characterized by scientific and technological initiatives whose focus is not on economic profitability (as with traditional technologies), but on improving the quality of life, inclusion, autonomy and social transformation of society (ANDRADE; VALADÃO, 2017) in communities facing economic, political, legal and social difficulties (NUNES et al, 2021). In this scenario, "*tecnologia social"* has acquired a strategic status to solve problems related to sanitary conditions, water supply, food insecurity, education, health, and housing (SOUZA; POZZEBON, 2020).

Considering that TS is also a tool to cope with adversity in water supply, its study becomes relevant in the context of the northeastern brazilian semi-arid region, which has had this problem as one of its main challenges for decades (GIL et al., 2020). In this context, the Cisterns's Program stands out, a public policy for the implementation of TSs to capture, store and use rainwater. This program includes *"tecnologias sociais"* that emerged from the active action of the local community (people living in the semi-arid regions of Brazil) to create better living conditions, strengthen the region, and generate jobs and income through social empowerment (DUTRA; ROZENDO, 2019).

Considering the discussions presented, this study addressed the following problem: What is the role of the *"tecnologias sociais"* of the Cisterns's Program in the northeastern brazilian semi-arid region? In order to answer the problem presented, this study aimed to analyze the role of the Cisterns's Program as a generator of *"tecnologias sociais"* in the semi-arid region of the Brazilian Northeast. Specifically, it aimed to identify the *"tecnologias sociais"* that constitute this program, to recognize the TS elements that make up the Cisterns's Program, and to identify the results (impacts) obtained through its implementation.

It should be noted that although there are legal records of the implementation and benefits of initiatives based on TSs, such as the Cisterns's program (MATOS JÚNIOR, 2021), the reality in the northeastern brazilian semi-arid is still water scarcity and there is room to expand the use of these technologies (AGUIAR et al., 2019). Moreover, it is an emerging topic that originated in South American studies (POZZEBON; TELLO-ROZAS; HECK, 202) and still requires further academic exploration and conceptual-empirical consolidation (ARAÚJO; CÂNDIDO, 2017) to understand this phenomenon and its impact on the transformation of disadvantaged social settings (SOUZA; POZZEBON, 2020).

It is also appropriate to add (according to a brief review in the databases SPELL and Scielo[i]), that the study and development of "tecnologias sociais" have been applied in various contexts, such as promoting rural entrepreneurship (SOUZA; POZZEBON, 2020), cultural entrepreneurship (CAMPOS; DAVEL, 2017); innovative means of fighting poverty and social exclusion (POZZEBON; TELLO-ROZAS; HECK, 2021), educational methodologies (ANDRADE, VALADÃO 2017); network of family farmers (FRANZONI; SILVA, 2016) and entrepreneurial training for fish farming, poultry and vegetable farming (COSTA et al., 2014), with limited in-depth discussion of its elements and results in the context of the northeast Brazilian semi-arid region, as proposed in this study .

2 *"TECNOLOGIA SOCIAL"*: Concept and elements

Unlike conventional technologies, which are focused on commercialization and the generation of profits (NUNES et al., 2021), the "*tecnologia social"* is based on the search for solutions to environmental, economic, social, and political problems (DAGNINO, 2004). Thus, TS is seen as a set of transformation techniques and methods designed and/or used in interaction with and appropriated by the population, reproducing solutions for social inclusion, improvement of living conditions (ITS, 2004) and poverty alleviation (SOUZA; POZZEBON, 2020), starting from the use of production techniques that optimize the use of resources and maximize the well-being of individuals (DAGNINO, 2014).

Consequently, the "*tecnologia social"* must have a central element, a device or tool (hard technology) or a technique or methodology (soft technology), that is, it has something concrete whose characteristics and limits can be clearly described (POZZEBON; TELLO-ROZAS; HECK, 2021). In this way, these technologies develop products, processes, techniques, methods (NASCIMENTO; BENINI; PETEAN, 2021), tools and organizational arrangements (SOUZA; POZZEBON, 2020) based on strategies to create and implement solutions to economic and socio-environmental problems that lead to social inclusion, sustainability (THOMAS, 2009) and well-being (JESUS; LUFT, 2021).

In this context, TS has been given formative characteristics to facilitate its identification, such as social participation in the technological decision-making process, low cost of products/services and simplicity (DAGNINO, 2009). Moreover, this technology is the result of

innovative experiences oriented to the defense of the interests of the majority (BAVA, 2004) and, among other possibilities, is the result of the appreciation of tacit knowledge, where the different actors that make up civil society (citizens, associations, NGOs, social movements, among others) can and should contribute to the development, appropriation and/or adaptation of technologies that benefit society (JESUS; COSTA, 2013).

Garcia (2007) goes further and proposes a grouping of four guiding axes based on the results of the studies conducted by Social Technology Institute - ITS (2004; 2007) on the principles and parameters that form TS, organizing them into four dimensions: (1) knowledge, science, technology, and innovation; (2) participation, citizenship, and democracy; (3) education; and (4) social relevance. Regarding the dimension of knowledge, science, technology and innovation, TS consists of the application of knowledge (scientific, popular, and technological) as a link between social problems and their respective solutions, with the main characteristic being the search for innovations solutions to problems society.

In the dimension of participation, citizenship and democracy, the functioning of TS is the result of citizens' participation in decision-making, elaboration, implementation and diffusion, that is, the users themselves assume a social protagonist role (LEMOS; DECHANDT, 2019) in the process of selection (SCHIRAY; CARVALHO; AFONSO, 2017) and construction of "*tecnologias sociais"* (JESUS; CUNHA; SANTOS, 2021). In the dimension of education, the ways of knowledge production and learning are shown. In the dimension of social relevance, the results obtained through the elaboration and implementation of TS are perceived as solutions that have an impact on improving the lives of citizens (GARCIA, 2007).

Another characteristic aspect of "*tecnologia social"* is the identification and description of its functioning, i.e., in order to identify a TS, it is necessary to describe its modus operandi, resources, and key mechanisms, i.e., the processes that are leveraged by practices that allow social transformations (SOUZA; POZZEBON, 2020). In addition, the procedures, and tangible components, such as tools, equipment, and local spaces, as well as intangible components, such as knowledge, experience, and methods, must be identified (POZZEBON; TELLO-ROZAS; HECK, 2021), i.e., a methodology is needed to systematize and implement the TS.

Analyzing the dimensions proposed by Garcia (2007) and ITS (2004, 2007), they can be summarized in innovation (knowledge, science, technology, and innovation), social participation (participation, citizenship, democracy) and results (impacts and social relevance). Innovation is the result of local needs and the integration of scientific, technological, and informal knowledge leading to new products/services and/or improvements to existing solutions; social participation results from the mandatory involvement of users and representatives of civil society, which strengthen the democratic process of ST; and results assume the role of confirming the benefits and application needs of "*tecnologia social"*.

The education dimension does not appear as a specific element, because it is assumed that learning and knowledge sharing are naturally integrated into the processes and mechanisms of the other aspects. Thus, innovation, social participation, and outcomes are mediated through the application of methods that specify the ways and procedures for designing, implementing, and disseminating TS.

Considering the explanation presented and recognizing the existence of other aspects for the characterization/discussion of "*tecnologia social"* (POZZEBON; TELLO-ROZAS; HECK, 2021), also seeking optimization for the discussion of this topic in academic articles, the methodology (method), innovation, social participation, and results (impact) were adopted as

fundamental elements for the operationalization of TS and consequently for the empirical phase of this study.

3 METHODOLOGICAL DESIGN

In the light of that academic research must be classified according to its nature, its objectives, its research strategy and the tools used to collect and analyze the results (FONTELLES et al., 2009), it is considered that, by its nature, this is a qualitative study that explores the field of action based on subjectivism, in order to understand and interpret the facts and phenomena studied, based on the attitudes and opinions of the people studied (VERGARA, 2006).

In terms of objectives, this study is exploratory and descriptive. Exploratory because it aims at an in-depth analysis of the scenario under study, to develop, clarify and modify concepts and ideas (COLLIS; HUSSEY, 2005), through the theoretical study at TS combined with the information gathered in the field research (analysis of documents and interviews). It is descriptive because it describes characteristics, factors, elements, and methods that contribute to the occurrence of TSs in the analyzed scenario (VERGARA, 2006).

The research strategy chosen was the single case study, which allows a deep and exhaustive study of the complexities of a particular reality (STAKE, 2005). These cases can consist of individuals, groups, organizations, regions, states, cities, communities, and programs, i.e., any event that is delimited and specific (PATTON, 2002). The instrumental single case study was chosen, which in its analysis tries to obtain results that go beyond the case investigated and provide answers to theoretical questions through the empiricism studied (STAKE, 2005).

In addition, the single case study is indicated in scenarios where the chosen case is critical, peculiar, common, revealing, or longitudinal, where the specificity of the event studied and its contribution to the phenomenon analyzed are important guidelines that support the choice of this research strategy (YIN, 2015). In this study, the single case is developed from the Cisterns's Program in the semi-arid region of the Brazilian Northeast. More information about the choosing this case can be found at the end of this section.

Since this is an instrumental case study, it was necessary to define the unit(s) of analysis (PATTON, 2002). Considering that TS has as a prerequisite the participation of users (LEMOS; DECHANDT, 2019) and representatives of civil society (JESUS; COSTA, 2013), these groups of actors became the analysis units of this study. For users, the condition for participation was that they had benefited from the Cisterns's program, lived in the rural area of the northeastern brazilian semi-arid, and owned/enjoyed some of the TS that make up the program under study. For civil society representatives, in a variety of modalities, the condition was to have at least 3 years of experience in the organization, to live in the northeastern brazilian semi-arid (rural or urban), and to have an active connection with the organization.

Considering that the three main methods of data collection in qualitative research are observation, interview, and document analysis (FLICK, 2013), the latter two were used, being based on the categories of analysis established in the theoretical framework of this study, namely: methodology, innovation, social participation and results. In addition to these categories, the identification of *"tecnologias sociais"* in the Cisterns's program was introduced as a category of analysis.

Among the documents consulted are Federal Law No. 12.873/2013 (Measures for the reform, modernization, expansion or construction of storage units for the storage and preservation of agricultural products), Decree No. 9.606/2018 (Regulates the National Program to Support Rainwater Harvesting and Other Social Technologies for Access to Water - Cisterns's Program),

Intergovernmental Panel On Climate Change (IPCC, 2019), SESAN Operational Instruction 02/2017 (Implementation of Services for the Implementation of Social Technologies for Access to Water), and ASA Notebook (Proposals from Civil Society).

Table 1 shows the 08 (eight) interviewees that make up the research corpus, namely 04 (four) representatives of beneficiary communities and 04 (four) representatives of civil society organizations.

Table 1 - Selected Respondents

GROUP	STATE	IDENTIFICATION	INSTITUTION
CIVIL SOCIETY ORGANIZATION	Pernanbuco	EO-01	Avina Fundation
	Pernanbuco	EO-02	Brazilian Semiarid Articulation - ASA e Sabiá Center
	Ceará	EO-03	Grassroots Christian Association - ACB
	Ceará	EO-04	Center for Labor Studies and Support to Workers – CETRA
BENEFICIARY	Bahia/Sergipe	EB-01	Not applicable
	Ceará	EB-02	
	Ceará	EB-03	
	Pernanmbuco	EB-04	

Source: Prepared by the authors (2022).

It is worth noting that the definition of the number of respondents shown in Table 1 was based on the criterion of data saturation (GLASER; STRAUSS, 1967). It is also worth mentioning that, considering the geographic context in which the analyzed program operates (10 Brazilian states), we tried to select representatives of the states that have a greater importance in terms of population and percentage of rural population (target group of the TSs under study) - Bahia (30%), Ceará (21%) and Pernambuco (13%) (ASA, 2019) - in order to obtain a representative panorama of the northeastern brazilian semi-arid. In order to optimize the presentation of the results, only the speeches summarizing the groups perceptions of the respondents were transcribed in this paper.

The analysis of the evidence was based on the analysis of the categorical content through the organization, classification and grouping of the text (description of the interviews and the content of the documents) according to the categories established for the research (BARDIN, 2016).

3.1 Single case: Cisterns's Program in the Northeastern Brazilian semi-arid

The topic examined in this study is "*tecnologias sociais"* for drinking water supply in drought-affected regions. The TS initiatives studied here were initially promoted by the Brazilian Semiarid Articulation (ASA) and later integrated into the National Program of Support for Rainwater Harvesting and Other Social Technologies – Cisterns's Program (in Portuguese, "*Programa Nacional de Apoio à Captação de Água de Chuva e Outras Tecnologias Sociais - Programa Cisternas"*), established by Law No. 12.873/2013 and regulated by Decree No. 9.606/2018. This program is the case analyzed in this article.

One of the reasons for choosing this program as a single case for this research is its legal classification (in the title of the program) as a "*tecnologia social"* that offering concrete solutions - cisterns - to improve the quality of life of the population (POZZEBON; TELLO -ROZAS; HECK,

2021). Besides this, this program has a broad geographic presence, operating in 10 (ten) brazilian states.

The semi-arid area in the Brazilian Northeast was chosen because it is one of the most important semi-arid areas in the world and is classified as one of the places with the highest index of climatic vulnerability due to drought, desertification, and global warming (IPCC, 2019). These circumstances make access to drinking water essential in this region, and therefore the presence of TS, offered by the Cisterns's Program, is of great benefit.

Moreover, during its existence, this program has already built about 1.3 million TSs (cisterns) and other equipment in its different operational models for domestic and productive consumption (crops and livestock), focusing on the 16,000-liter cisterns that have already reached about 1.1 million families (ASA, 2021). On the other hand, the current scenario in terms of investment and release of funds dedicated to the implementation of the program has been declining in recent years, which threatens the continuity of this initiative.

In this scenario, a survey conducted by ASA (2021) showed that the number of TSs (cisterns) built under this policy decreased dramatically in 2020, reaching the lowest number of implementations in the entire history of the program - only 8,310 devices were built, a 73% decrease from the previous year (2019), which until then was the lowest number in the history of the program (MADERO, 2021).

Due to its territorial amplitude, amount of TSs implemented in the Brazilian semi-arid region, time in operation and presence of formative requirements (concrete aspect, social participation and quality of life), also in view of the drastic reduction in TSs delivered to the semi-arid Brazilian population in recent years (MADERO, 2021), it is believed that this program has a critical role and peculiarities that give rise to its analysis as a single case study in this research.

4 PRESENTATION AND ANALYSIS OF RESULTS

To facilitate the presentation and analysis of the results, this section is organized according to the categories of analysis established in this study, namely: *"tecnologias sociais"* (types), methodology, innovation, social participation, and outcomes.

4.1 Types of "tecnologias sociais" of the Cisterns's Program

From the speeches collected and the documents analyzed, it appears that the main TSs established under the Cisterns's Program are the following: Consumption cistern (or first water cistern), which has a storage capacity of 16 thousand liters of rainwater (TS, which launched the program); Production cistern (or second water cistern), which has a storage capacity of 52,000 liters of water intended for food production and water supply for small and medium animals; and among the second water cisterns, the "*calcadão"* cistern and the "*enxurrada"* cistern are the most common. In addition, there are other TSs in a less meaningful amount, but mentioned by the respondents, such as: "*barreiro trincheira, barraginha, tanque de pedra, barragem subterrânea, cisterna escolar* e *bomba popular"*.

About this TSs the respondents reported that they are classified as family TS and community TS. The first is the responsibility of a family that is supplied with the stored water, such as the cistern of the First Water Plate and the *"Calçadão" cistern;* the second type is represented by the TSs that supply a number of families in a given community, such as the "*Bomba Popular,*

Tanque de Pedra, Cisterna Escolar" and others. Regarding the availability of these types of ST, one of the interviewees said that:

> In the case of my family, it was the cistern for human consumption [of 16 thousand litres], [...] accompanied by the gutter that it puts on the roof, and it also has the PVC pipe pump to remove the water from the cistern. But here in the region there is also the production cistern ["*enxurrada"* cistern] and the "*calçadão"* cistern (EB-02).

This finding was confirmed in the SESAN Operational Instruction 02/2027, which emphasizes the importance of these other equipments for the functionality of the cisterns. In describing the components associated with ST, the interviewee also reiterates the understanding that these technologies require the use of specific devices and equipment that condition their proper functioning, reinforcing the technical concrete aspect of "*tecnologia social"* (POZZEBON; TELLO-ROZAS; HECK, 2021).

4.2 Methodology

Regarding the methodology to implement the Cisterns's Program, the interviewees addressed aspects of how the beneficiary families are selected, as well as the elements of the process of creation and construction of the TSs, which are part of the program. Regarding the criteria for selecting beneficiaries and the method for implementation, the criteria established at the beginning of the program and those adopted later are highlighted in the following statements, as explained by the interviewee EO -01:

> In the early 2000s, there were four main criteria. They were houses of families headed by women, with children up to six years old, with disabled and elderly people. [...] Then came the government's CadÚnico[ii] on the social welfare system. The government already has information about who the people are, the profile of families in poverty, in extreme poverty, and these criteria are already included [in] the NIS[iii], which is precisely this register based on the Social Assistance of the State (EO -01).

Detailing the methodology of the implementation of the TS of the Cisterns's program, this interviewee also said that:

> Once the beneficiary families are defined, they go through a training process in which they are trained on the importance, right of access and care in the use of water, the importance of agroecology, coexistence with the semi-arid region, non-use of pesticides, non-deforestation, and practices to combat desertification [and on] care in the use of the cistern. In the case of the first water cistern, the training is called GRH [Management of Water Resources]; in the case of the second water cistern, two courses are offered, SISMA [Simplified Water Management System] and GAPA [Management of Water for Food Production]. In addition, there are also inter-city and inter-state exchange programs that allow the exchange of experiences between farmers, and here we are talking about the movement of knowledge, which an important process for the development of communities and their territories (EO -01).

In this discussion, respondent EB-03 said that:

> They [government officials and civil society organizations] had already established the criteria, [...] the neediest people, those who really did not have water, those who had children with disabilities, then there was a whole process and I, as a community leader,

> mobilized people and we had a meeting. Then a registration was done and we sent them to CETRA, who together with ASA carried out the project (EB-03).

Interviewee EB-03 also explained that:

> Then came the training, which was a three-day course - first 40 cisterns came, then 40 families came together for this course. In that three-day course, they built my cistern and also trained the masons. They not only taught the people how to use water, but they also trained the masons how to build the cisterns (EB-03).

The reports of these respondents, referring to the methods of the Cisterns's Program, are supported by the documents analyzed, such as Decree 9.606/2018, which regulates the program, and also in the materials published by ASA (2021), which deal with the methodological principles of this policy and the phases of its operationalization, namely: a) mobilization and registration; b) qualification and training; and c) construction and implementation of TS.

The focus on the courses offered shows that the potential of this type of technology depends on the training of the participating actors (DAGNINO, 2014). On the other hand, even if these courses are provided by formal institutions, here is underlined the need that all the knowledge about the developed technology, even if improved by official bodies, must be widely disseminated among the local population (POZZEBON; TELLO- ROZAS; HECK, 2021). In addition, the recruitment and training of workers in the region confirms the result of TS as a tool for generating employment and income (SILVA et al., 2021).

On the other hand, some reports have shown that, despite the existence of a defined method for the implementation of the program, third parties, here called "middlemen," may appear, interfering in the procedures for selecting beneficiaries and implementing and creating TSs.

> I have already worked with a situation where a councilman said he did not have a cistern and with threatening tones said he wanted the cistern anyway [...] and these cases are more common than you can imagine, because unfortunately there is a terrible political influence, and the smaller the municipality, the greater this influence, but we have always tried to preserve the criteria (EO -01).

Another interviewee said that:

> There has already been a political deal where we got a list of families that would benefit [with TSs]. I asked some people who received [the cisterns] if they attended classes or participated in events, and they told me that the cisterns had already come from City Hall or from somewhere, without being able to say what criterion was used. The families that received the cisterns received them, and those that did not benefit did not receive any justification. [Thus] some people who had the profile to participate in the program did not receive the TS. (EB-01).

This is an important point that, although not foreseen in the research design, emerged during the interviews and deserves attention because it reveals a reality - political interference and corruption - that is not compatible with the scope of the program. Moreover, this political interference can damage the Cisterns's Program, as it prevents it from fulfilling its purpose, avoid the access of the true beneficiaries, and promotes the lack of maintenance of the implemented TSs (cisterns).

These results also show the absence or inadequate application of clear criteria for the management, monitoring and control of the procedures for identifying and selecting beneficiaries (families) of the TS. This is not to say that the mechanisms created by the current legislation are

inefficient, but that without monitoring (with autonomy for regulators and civil society organizations) these mechanisms lose an essential part of their purpose.

In relation to the methodology of implementation of TS, the interviewees mentioned partnerships for the operationalization of the Cisterns's program. One of them said that:

> There is a partnership with the community, with associations, with NGOs that are already working with other collectives that are also discussing public policies, so I see that there are multiple actors involved in this process. Since it is a policy designed by ASA at the national level, that is, the government is in charge with this program, ASA has the role of mediation and articulation and ASA the NGOs act as program executors in the communities. In our municipality, CETRA is the executing agency, but there are other institutions such as Centro *Sabiá, Cátedra Diocesana* and others in other states and regions (EB-02).

The speech of this interviewee reflects the aspects established in Decree No. 9.606/2018 on partnerships in the elaboration, analysis, and implementation of the TSs of the Program. In addition, the methodology shows that the action of the community, together with its representatives, in partnership with the State and other stakeholders, allows the program to promote social welfare and reach a greater number of beneficiaries.

Thus, it is assumed that to improve the expected outcomes of *"tecnologias sociais"*, a broad institutional diversity with the engagement of different actors such as users, universities, governmental and nongovernmental institutions (NGOs), and social movements is recommended (JESUS; CUNHA; SANTOS, 2021).

4.3 Innovation and Social Participation

In terms of innovation, the types of TSs implemented by the Cisterns's Program represent the innovations introduced by the program, since until its inception there were no effective and accessible solutions to the poorest people for the scarcity of water resources and the capture, storage and use of rainwater in the semi-arid region. Considering the understanding of innovation as improvement of existing solutions (LI; HUANG, 2019), it can also be said that derived cisterns (*barreiro trincheira, barraginha, tanque de pedra, barragem subterrânea, cisterna escolar e bomba popular*) of the original types (consumption plate cistern and production cistern) represent incremental innovations in the TSs of the studied program.

In the context of innovation in the form of improvements, respondent EB-03 reported that when he received a second delivery in his community, he noticed that "the first delivery had a strainer in the gutter that kept some dirt out, but with the second delivery, in addition to the strainer, there is already a filter in place and the water already goes into the filtered cistern" (EB-03). Similarly, respondent EO -01 reported that the improvements were not only in the technical aspects of the TS, but also in the execution and implementation processes. He related the following:

> At the very beginning of the program, the families had a great counterpart to get the cisterns, they had to give the sand, dig the hole, and still provide the mason with food during the week of construction, and then you had families in extreme poverty who needed the cisterns but were not able to meet the requirements. Today the project is more complete, the family receives the money to buy the food for the mason, the excavation is already included in the project and is done by machines [and] the family receives water to use the cisterns (EO -01).

Based on this report, the respondent also highlighted aspects related to the participation of the population in the implementation of ST:

> And these [improvements] are the result of the work of organizations that have helped to implement these improvements over time. So today you do not have the difficulties that families used to have. Today the family brings practically nothing in terms of material resources, the family contributes by helping the masons and the mason's helpers, today even have resources for mason's helpers and food preparation (EO -01).

Further evidence of the innovations resulting from participatory development in this process of implementation and evaluation of TS is the emergence of *"tecnologias sociais"* from the identification and adaptation to the specific needs of a particular community (POZZEBON; FONTENELLE, 2018), i.e., TSs resulted from beneficiaries' proposals, such as the *Telhadão* cistern, described by users as "an evolution of the *Calcadão* cistern" (EO -01), and the *Chapéu do Padre Cícero* cistern, an improvement of the *Calcadão* cistern (EO -03).

In this sense, it can also be concluded that the improvements and adjustments in the TS are not only innovative aspects, but also symbolize methodological aspects, since they are idealized (to adapt to the needs of the community served) as methodological procedures of the TSs of the Cisterns's program.

4.4 Cisterns's Program: TS and its results

Regarding the results, it is appropriate to state that given the diversity and possibilities of operationalization and the problems to be solved by the TS, the results presented here specifically reflect the "*tecnologias sociais"* that are part of the Cisterns's program.

When talking about the results of TS resulting from the implementation of this program in the microregions that make up the northeastern brazilian semi-arid, there is an improvement in access to drinking water for human use (EB-01), which is the main motivation for the institutionalization of the program cisterns, as established by Federal Law No. 12.873/2013 (BRASIL, 2013).

Consequently, access to quality drinking water has had an impact on strengthening public health in the region by reducing childhood illness and death caused by consumption of unsuitable water (EB-02, EB-04). Another positive impact promoted by the implementation of the TS was the increase in the productive capacity of the inhabitants of the semi-arid region, who were provided with second water cisterns (EB-02, EB-04) to ensure access to water for food production, livestock and irrigation (BRASIL, 2018).

This productive capacity brought other benefits, such as the generation of income, which in turn improved the living conditions of families in this region (EB-04, EO -02). All these changes contributed to the promotion of another very important impact for the development of the semi-arid region of Brazil, that is, the reduction of rural exodus and, moreover, the contribution to the reinforcement of urban exodus, as a movement of return of citizens from urban areas to the rural environment of their origin (EO -02, EO -01, EB-01). This movement of greater permanence and return of people to their place of origin, motivated by the causes already mentioned, differs with the reality presented by Souza Neto and Escobar (2019) when they present rural exodus as one of the main problems of the Brazilian semi-arid region.

In addition, the articulation and mobilization between communities promoted by participatory social engagement and exchange between families during the implementation and use

of TS is another positive outcome that not only confirms the formative requirement of "*tecnologia social"*, but also strengthens representativeness and political union (in search of improvement) in the region (EO -02, EO -01). Community empowerment was also reflected in greater empowerment of women, as the implementation of the TS promoted women's self-organization in managing and maintaining productive backyards in the region (EO -04).

Another positive outcome with environmental and sustainability relevance is the mitigation of desertification (EO -01), as water storage and availability is one of the strategies to mitigate this climate effect (VENTURA; GARCIA; ANDRADE, 2019). Reaching and involving users, even those who live in distant, remote locations and are poorly served by public policies (EO -01, EO -02, EO -03) is another positive outcome that should not be overlooked. Another important milestone was the strengthening of food sovereignty (EB-04, EO -03), as the TS provided families with healthy, clean and pesticide-free food.

In light of these positive results, respondent EO -01 drew a compelling conclusion about the benefits offered by the TSs of the Cisterns's program:

> For me, the benefits lie in guaranteeing the water supply, whether for consumption or production, in the generation of income, in the participation of the community in the project, and then you can work both associatively and cooperatively, in collective efforts, in the commitment of the community itself. [...] Access to public policies, access to qualification, because [in] all *"tecnologias sociais"*, families go through training and education to benefit from it. All this contributes to the empowerment of the farmer (EO -01).

Due to the diversity of findings of this study, a summary of the results is presented in Table 2.

Table 2 - Summary of results

CATEGORY	FINDINGS
TYPES OF "TECNOLOGIAS SOCIAIS")	• Main TSs (cisterns) identified: *Cisterna de Placas, Calçadão, Enxurrada, Barreiro Trincheira, Barraginha, Barragem Subterrânea, Tanque de Pedra, Cacimbão, Cisterna Escolar, Bomba Popular*
METHODOLOGY	• CadÚnico registration of the Federal Government (Families in poverty) • Definition of families • Training Process • Intercity and interstate courses and exchanges - exchange of knowledge • Community leadership • Construction and Implementation of Cisterns/TSs • Principles of Participation and Social Mobilization • Changes and Updates to some actions, over time • Presence of political intermediaries
INNOVATION AND SOCIAL PARTICIPATION	• Original TSs: plate and production cistern • Insertion of Improvements in the TSs (filter and pump coupled to the cistern, among others) • Changes and Updates in some actions over time (adoption of machines, subsidy for meals, training for the groups involved) • Telhadão cistern and Chapéu de Padre Cícero cistern • Participation and Social Mobilization
RESULTS	• Improved access to drinking water • Strengthening public health in the region (reducing diseases and even deaths caused by the consumption of improper water, especially by reducing child mortality) • Increasing productive capacity

	• Income Generation • Reduction of the rural exodus • Strengthening articulation and mobilization among communitiess • Woman empowerment • Mitigation of Desertification • Scale and scope of the Cisterns's program.

Source: Prepared by the authors (2022)

It is important to highlight that many of the elements mentioned by respondents, such as participation and social engagement (identifying problems, proposing solutions, and integrating into the community), ownership (understanding the program and how it works, participation in courses and training) and empowerment (improvements in the offer of TSs and belonging to the region), taking into account the peculiarities and diversity of forms of TS, find a theoretical basis that supports them in authors such as Dagnino, Brandão and Novaes (2004), Rodrigues and Barbieri (2008), Pozzebon, Tello- Rozas and Heck (2021), and Andrade and Valadao (2017).

5 FINAL CONSIDERATIONS

The results of this study allow some reflections and conclusions, such as the observation that *"tecnologias sociais"* can take different forms and processes. When focused on water supply in communities in the northeastern brazilian semi-arid, are divided into the family TS and the community TS. This distinction shows that these technologies are not limited to solving individual (family) problems, but also offer alternatives that have a positive impact on the socioeconomic and environmental conditions of the region, as was noticed in the community TS, represented by second water cisterns. This finding also underscores the understanding that these technologies achieve better results when offered in an integrated manner and with interdependent functions (first and second order cisterns) that promote family strengthening (family TS) and local empowerment/development (community TS), among other consequences.

Regarding the elements of TS, which constitute the Cisterns's Program, it was found in the methodology that the governmental action established selection beacons and optimized this process through the use of computerized governmental registration systems. On the other hand, although this measure is administratively recommendable, it is important to consider that in Brazil there are still families that are "invisible" in the state registries (GONZALEZ; BARREIRA; PEREIRA, 2020). This fact highlights the importance of partnering with civil society entities to minimize the risk of excluding potential beneficiaries, including those living in geographically distant and difficult-to-access locations, who could be "prevented" from accessing these TSs by centralizing the selection process with the state power.

In addition, it is important to strengthen the performance of civil society organizations, which could be entrusted with the inspection activities (with the support of legal oversight bodies), in order to prevent the performance of "middlemen" and political interferences.

In the context of the data on the decrease in investment in the program, it was noted that TSs components of the Cisterns's program depend on the government funding and that without these contributions, the number of families at social and environmental risk due to water scarcity could increase. For this reason, and for the continuity of the distribution of these TSs, it is considered necessary that the government establish a financing and development fund, not only for the implementation of new TSs (cisterns), but also for the maintenance of those that are already in use.

Considering that qualification and social participation are fundamental elements for operationalizing ST, it is noteworthy that universities and secondary schools were not portrayed by the participants of this research. In this scenario, it is recommended to build partnerships with these institutions to further qualify the trainings conducted and educate the community about the mechanisms, opportunities and forms of social participation in the design and implementation of TS.

Another aspect that should be mentioned in terms of methodology is the role of community leaders to guide the community and accelerate the procedures (by arousing the commitment of the population) for the training and implementation of the TS. In this context, the dissemination of "*tecnologia social"*, especially in the context of the Cisterns's program, involves the identification and dialogue with these leaders.

Given the semi-arid region of the Northeast and the presence of TS (cisterns) in small cities, it is believed that one way to optimize the results achieved is through inter-municipal and intergovernmental collaboration to disseminate best practices and jointly solve potential challenges to maintaining these "*tecnologias sociais"*.

In the context of TSs, partnerships in their various forms need to be strongly promoted in order to increase the performance of civil society organizations, disseminate benefits and results, expand the scope of services, and spread the existence of *"tecnologias sociais"*, including with the aim of attracting supporters/financiers.

In terms of innovation and social participation, it was noted that TS must not only focus on grandiose novelties such as the first cisterns, but also consider improvements and adaptations to processes, production and use (based on perceptions and user-reported outcomes/difficulties) to ensure the durability of the benefits and solutions offered.

As for the results (impacts) from the implementation of TS (cisterns) in the northeastern brazilian semi-arid, it is not necessary to restate them in this section, but to emphasize that they are multiple and include benefits from access to drinking water, social empowerment, mitigation of desertification, improvement of production in drought-affected regions, and even reversal of rural exodus. These results highlight the need for continuity of initiatives, projects and policies whose main objective is the adoption, use and diffusion of *"tecnologias sociais"*.

Given the discussions and results presented, it is believed that this research will open opportunities for new studies, such as identifying opportunities and challenges for implementing other TSs in the northeastern brazilian semi-arid; the role and potential of the TSs of the Cisterna program as a public policy tool; and identifying robust financial alternatives for funding these technologies. Given the potential of the TS (cisterns) studied as tools for mitigating desertification, new studies can explore the role of "*tecnologia social"* in studies of sustainability transition theory.

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[i] Academic repositories that provide free access to publications from Brazilian scientific journals.

[ii] Brazilian federal government registration system aimed at identifying all low-income families in the country for inclusion in social assistance and income redistribution programs.
[iii] The Social Identification Number (NIS) is a registry established by the Brazilian federal government to determine whether a citizen is a participant (beneficiary) of any government social program.