The generation of "tecnologias sociais" and public policy: A study of the Cistern Program in the Brazilian Semi-arid Region

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Generación de "tecnologías Sociais" y Políticas Públicas: Un Estudio del Programa de Cisternas en el Semiárido Brasileño

Geração de *Tecnologias sociais* e políticas públicas: Um estudo do Programa Cisternas no Semiárido Brasileiro

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ABSTRACT

Purpose: To analyze the role of the Cisterns Program as a generator of "*tecnologias sociais*" in the Brazilian Semi-Arid.

Theoretical framework: The theoretical framework was established based on the characteristics, mechanisms and requirements of "*Tecnologia social*", summarized in methodology, innovation, social participation and results (impact and social relevance).

Design/methodology/approach: Qualitative and exploratory research was carried out with a single instrumental case study. Data was collected with document analysis, and an interview script was applied to 8 representatives of civil society organizations and program beneficiaries during 2021. Categorical content analysis was the technique for examining evidence.

Findings: As a public policy, the results show that the "*tecnologias sociais*" developed by the cistern program have positive impacts beyond access to drinking water. These include, among others, mitigation of desertification and articulation and mobilization between communities. Such findings corroborate the understanding that the Cisterns Program as a "supplier" of "*tecnologias sociais*" and its relevance to the advancement of the regions where it operates, mainly in the Brazilian semi-arid.

Originality: This study deepens analyzes of the component elements of "*tecnologia social*", ways of acting by the groups involved and social implications (results), aspects with little discussion in the literature on the subject.

Theoretical and practical contributions: The study summarizes the forms of action, the groups involved, the mechanisms, the bottlenecks in the process, and the impacts related to "*tecnologias sociais*" in a set of elements that can serve as a guide for the implementation of "*tecnologias sociais*" in other places. It also identifies mechanisms for creating/strengthening actions and public policy to scale up, disseminate, and optimize these technologies.

Keywords: "*Tecnologia social*". Public policy. Cisterns Program. Brazilian semi-arid.

RESUMO

Objetivo: Analisar o papel do Programa Cisternas como gerador de "*tecnologias sociais*" no Semiárido nordestino.

Enquadramento teórico: O referencial foi estabelecido a partir das características, mecanismos e requisitos da "*Tecnologia social*", sintetizados em metodologia, inovação, participação social e resultados (impactos e relevância social).

Desenho/metodologia/abordagem: Foi realizada uma pesquisa qualitativa e exploratória com estudo de caso único instrumental. A coleta de dados foi efetivada com análise documental e um roteiro de entrevistas aplicado a 8

representantes de organizações da sociedade civil e beneficiários do programa, durante o ano de 2021. A Análise de conteúdo categorial foi a técnica para exame de evidências.

Resultados: Os resultados mostram que as "*tecnologias sociais*" desenhadas pelo Programa Cisternas, enquanto política pública, têm impactos positivos além do acesso à água potável. Estas incluem, entre outras, a mitigação da desertificação e a articulação e mobilização entre as comunidades. Tais achados corroboram o entendimento do Programa Cisternas como "fornecedor" de "*tecnologias sociais*" e sua relevância para o avanço das regiões onde atua, principalmente no semiárido brasileiro.

Originalidade: Este estudo aprofunda análises dos elementos componentes da "*tecnologia social*", formas de atuação dos grupos envolvidos e implicações sociais (resultados), aspectos pouco discutidos na literatura sobre o assunto.

Contribuições teóricas e práticas: O estudo sintetiza as formas de atuação, os grupos envolvidos, os mecanismos, os gargalos do processo e os impactos relacionados às *tecnologias sociais* em um conjunto de elementos que podem servir de guia para a implementação de *tecnologias sociais* em outros locais. Também identifica mecanismos para criar/fortalecer ações e políticas públicas para ampliar, disseminar e otimizar essas tecnologias.

Palavras-chave: "*Tecnologia social*". Políticas Públicas. Programa Cisternas. Semiárido Brasileiro.

RESUMEN

Propósito: analizar el papel del Programa Cisternas como generador de "*tecnologias sociais*" en la región semiárida del nordeste de Brasil.

Referencial teórico: El marco teórico se estableció con base en las características, mecanismos y requerimientos de la "Tecnología Social", sintetizados en metodología, innovación, participación social y resultados (impactos y relevancia social).

Metodología: Se realizó una investigación cualitativa y exploratoria con un estudio de caso único instrumental. La recolección de datos se realizó con análisis documental y guion de entrevista aplicado a 8 representantes de organizaciones de la sociedad civil y beneficiarios del programa, durante el año 2021. El análisis de contenido categórico fue la técnica para el examen de evidencia.

Hallazgos: Los resultados muestran que las "tecnologías sociais" diseñadas por el Programa Cisternas, como política pública, tienen impactos positivos más allá del acceso al agua potable. Estos incluyen, entre otros, la mitigación de la desertificación y la articulación y movilización entre comunidades. Tales hallazgos corroboran la comprensión del Programa Cisternas como "proveedor" de "*tecnologías sociais*" y su relevancia para el progreso de las regiones donde actúa, principalmente en el semiárido brasileño.

Aportaciones prácticas y teóricas: El estudio resume las formas de acción, los grupos involucrados, los mecanismos, los cuellos de botella en el proceso y los impactos relacionados con las tecnologías sociales en un conjunto de elementos que pueden servir de guía para la implementación de tecnologías sociales en otros sitios. También identifica mecanismos para crear/fortalecer acciones y políticas públicas para escalar, difundir y optimizar estas tecnologías.

Originalidad: Este estudio profundiza en los análisis de los elementos componentes de la "*tecnologias sociais*", formas de actuar de los grupos involucrados e implicaciones sociales (resultados), aspectos con poca discusión en la literatura sobre el tema.

Palabras clave: "Tecnología Social". Políticas públicas. Programa Cisternas. Semiárido brasileño

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 the public policy a fundamental element for the development of society (Matos Júnior, 2021). In this scenario, public policy is considered as the set of activities and strategies that governments implement to maintain equilibrium for the different social groups (Rosa et al., 2021). Thus, it is the process by which a government's goals are translated into programs and policies that produce practical results to meet the needs of the population (Souza, 2006).

Decision-making in public policies can be carried out by other actors besides governments, such as civil representatives, individuals, groups, associations and organizations that influence the design of these policies (Macedo et al., 2016), to create initiatives that benefit society (Souza et al., 2019). From the same perspective, social participation and collaboration among citizens in formulating and managing public policies bring benefits in terms of legitimacy, transparency, and social control of government initiatives (Brito, 2017).

Among these initiatives is "*tecnologia social*" *(TS)*, written in Portuguese (original form) in this paper to avoid misinterpretation with technologies based on new social media. In addition, some TS have led to public policies of a social nature and are examples of experiences that were created without the help of public authorities but whose practices were improved and disseminated when they were included in the policy (Matos Júnior, 2021).

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, environmental, political, legal, and social difficulties (Nunes et al., 2021).

In this context, it should be explained that the concept of "*tecnologia social*" is related to social innovation. In fact, TS is a tool with the potential for social innovation to happen (Souza & Pozzebon, 2020). Moreover, social innovation, as an expression of collective social actions and practices that promote transformations based on changes in attitudes, behaviors, perceptions, and innovative solutions (Rocha et al., 2019), aims to expand the scope of "*tecnologia social*" developed and used by communities, providing empowerment to actors participating in the governance process, and promote gains in social improvements (Medeiros et al., 2017).

In the context of the need for initiatives to improve the quality of life in society (Maciel & Fernandes, 2011), TS has gained importance as one of the possible responses to social demands (Maciel et al., 2013). 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 environmental adversity and water supply, its study becomes relevant in the context of the Brazilian semi-arid, which has had this problem as one of its main challenges for decades (Gil et al., 2020). In this respect, it is clear that water scarcity in the Brazilian semi-arid region is not the same for everyone and that a movement to democratize access to water, including for dispossessed populations in rural and urban areas, must be launched or strengthened (Cunha, 2020).

In this context, the Cisterns Program stands out as a public policy for implementing TS 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 aimed to analyze the role of the Cisterns Program as a generator of *"tecnologias sociais"* in the Brazilian semi-arid. Considering the discussions presented, this study aimed to analyze the role of the Cisterns Program as a generator of "tecnologias sociais" in the Brazilian semi-arid. Specifically, this research sought to identify the TS that makes up this program, the TS elements that integrate the cistern program and the results (impacts) achieved through its implementation.

It is also appropriate to add that in the national environment (according to a brief overview in the databases SPELL and Scielo), although it is a recent expression inserted in an emerging conceptual-empirical framework (Araújo & Cândido, 2017), the study and development of "*tecnologias sociais*" has been applied in different contexts, such as in the promotion of entrepreneurship in the rural (Souza & Pozzebon, 2020) and cultural sectors (Campos & Davel, 2017); innovative means to fight poverty and social exclusion (Pozzebon et al., 2021), pedagogical methods (Valadão et al., 2017); family farmers' networks (Franzoni & Silva, 2016) and entrepreneurial training for fish farming, poultry farming and olive growing (Costa et al., 2014), with limited discussion of elements and outcomes in the context of the Brazilian semi-arid, which adds to the gap for conducting this study.

It should be noted that the reality of Brazilian semi-arid areas is still characterized by water scarcity and there is room to expand the use of these technologies (Aguiar et al., 2019). Moreover, it is an emerging topic that has its origins in South American studies (Pozzebon et al., 2021) and still requires further academic exploration and conceptual-empirical consolidation (Araújo & Cândido, 2017) to understand this phenomenon and its implications, also as a public policy (Bonilha & Sachuk, 2011), in the transformation of disadvantaged social environments (Souza & Pozzebon, 2020).

To make this article easier to understand, it has been divided into five sections. In the first, the concept and relationship between "*tecnologias sociais*" and public policy are introduced. The second section expands on the discussions of TS, looking at the concept, elements, and integration into public policy. Then, the methodological path used is presented. The fourth section presents the findings and compares them to the literature, highlighting the theoretical contributions and research opportunities that emerge from the study. The final considerations summarize the findings, new research suggestions, and research limitations.

2 "*TECNOLOGIA SOCIAL*": Concept, elements, and integration with Public Policies

"*Tecnologia Social*" is a Latin American expression that emerged in Brazil at the beginning of the 21st century from the work of the Social Technology Network (RTS)[i] (Dagnino et al., 2014). The general meaning of the term "social technology" refers to the creation and use of knowledge by doubly disadvantaged populations (due to the lack of access to modern scientific knowledge and the loss of the most favorable conditions for the reproduction of their traditional knowledge) to promote the economic sustainability and the cultural and political empowerment of these communities (Garcia, 2014).

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 et al, 2004). Thus, TS is seen as a set of transformation techniques and methods designed and used in interaction with and appropriated by the population, reproducing solutions for social inclusion, improving living conditions (Institute of "*Tecnologia social*" - ITS, 2004), and poverty alleviation (Souza & Pozzebon, 2020). These TS use production techniques that optimize resource use and maximize individuals' well-being (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 et al., 2021). In this way, these technologies develop products, processes, techniques, methods (Nascimento et al., 2021), tools, and

organizational arrangements (Souza & Pozzebon, 2020) based on strategies to create and implement solutions. These solutions soften the effects of economic and socio-environmental problems and 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 technology decision-making process, low cost of products/services, and simplicity (Dagnino, 2010). 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, non-governmental organization (NGO), social movements - can and should contribute to the development, appropriation, and/or adaptation of technologies that benefit society (Jesus & Costa, 2013).

Based on a comprehensive study, various researchers (Garcia, 2007; ITS, 2004, 2007) have classified ST into four axes: (1) knowledge, science, technology, and innovation; (2) participation, citizenship, and democracy; (3) education; and (4) social relevance. The characteristics of these axes are explained in more detail in Figure 1.

Figure 1
TS axes and definitions

AXES	DEFINITIONS	BASE AUTHORS
Knowledge, science, technology and innovation	Every technology is characterized by applying knowledge in the search for a solution to a real problem. When we refer to TS, this knowledge is applied to solve community problems and needs. TS consists of the application of knowledge (scientific, popular, and technological) whose main characteristics are the search for the solution of social problems with a high degree of innovation.	Garcia (2007); ITS (2004, 2007).
Participation, citizenship and democracy	This dimension concerns the process of social construction, i.e., the functioning of TS is the result of the democratic participation of citizens in decision-making, elaboration, implementation and dissemination. Users assume the role of protagonists in the process of selecting and constructing "tecnologias sociais".	Garcia (2007), ITS (2004, 2007); Lemos and Dechandt, (2019); Medeiros et al., (2017); Schiray et al., (2017).
Education	This dimension identifies the forms of knowledge production and learning and has as its characteristics the pedagogical process, the dialogue between knowledge and appropriation/empowerment. They include defining different environments for the distribution and training of TS users.	Franzoni and Silva, (2017); Garcia (2007), ITS (2004, 2007).
Social relevance	The results obtained are perceived as solutions that have an impact on improving the lives of citizens. They include aspects of effectiveness, sustainability and social change.	Duque and Valadão (2017); Garcia (2007); ITS (2004, 2007).

Source: Prepared by the authors based on Duque and Valadão (2017); Franzoni and Silva, (2017); Garcia (2007); ITS (2004, 2007); Lemos and Dechandt, (2019); Medeiros et al., (2017); Schiray et al., (2017).

Another distinctive aspect of "*tecnologia social*" is the identification and description of its functioning, i.e., to identify a TS, it is necessary to describe its modus operandi, resources, and key mechanisms (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 et al., 2021), i.e., a methodology is needed to systematize and implement the TS.

In analyzing the dimensions proposed by Garcia (2007), which are derived from the studies of ITS (2004, 2007), and taking into account the understanding of Franzoni e Silva (2017), Lemos and Dechandt (2019), Medeiros et al., (2017), Schiray et al., (2017), Souza and Pozzebon (2020) and Pozzebon et al., (2021), it was found that they can be grouped into innovation, social participation, results and methodology.

Considering the characteristic aspects of TS, explaining its relationship with the public policy concepts is appropriate. In this scenario, public policy is developed based on a demand from society and is of great importance to social development (Souza et al., 2019), as it allows the resolution and mitigation of problems through mechanisms that promote social justice and, consequently, the survival of a large part of the population (Madeira, 2014).

In this sense, Bonilha and Sachuk (2011) highlight the role of TS as public policy tools to support local development. Also, Dagnino (2008) already considered that TS would be increasingly integrated into public policies and government actions, especially because of its potential for social inclusion. Complementing this, the "*Tecnologia social*" Network (RTS, 2008) reports that TS can be promoted and extended through public policies to meet the population's needs, especially in the human and social dimensions. This way, the integration between public policies and TS can be seen in the proposed model.

Figure 2
Public Policy and "*Tecnologia social*": A Proposal for Integration
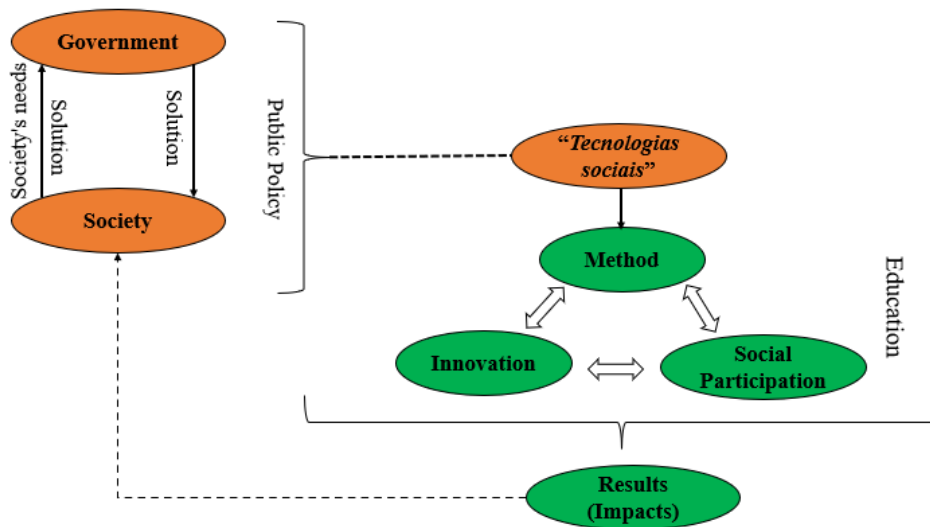
Source: Prepared by the authors (2023)

According to the proposed model, government and society are in constant interaction, with society expressing its needs and proposing solutions, and government offering results in the form of public policies (Matos Júnior, 2021). Similarly, social and community initiatives can also emerge without government support and be leveraged by transforming them into public policies, such as the Cisterns Program (Matos Júnior, 2021). These technologies, as mentioned earlier, are based on elements of method, innovation, and social participation that, when integrated, bring positive benefits to society.

Innovation, resulting from the dimension of knowledge, science, technology and innovation (Garcia, 2007), leads to the construction of innovative solutions based on local needs and results from the integration of scientific, technological and informal knowledge that leads to new products/services and improvements to existing solutions. The innovation discussed here can be

radical or incremental. Radical innovation is based on completely disruptive solutions that involve significant changes in skills, knowledge, design, production techniques, equipment, and organizational investments. In contrast, incremental innovation represents a lesser deviation from current standards (Koc & Bozdag, 2017).

Social participation, associated with the dimension of participation, citizenship and democracy (Lemos & Dechandt, 2019; Medeiros et al., 2017), results from the mandatory involvement of users and representatives of civil society that strengthen the democratic process of TS. According to this understanding, social participation results from sharing TS planning, monitoring, and evaluation activities that generate the protagonism and engagement of stakeholders and beneficiaries (Franzoni & Silva, 2016).

The method (Duque & Valadão, 2017; Pozzebon et al., 2021) describes operationalizing the TS considering the elements and procedures essential to its design and implementation. Therefore, the method promotes innovation in creative solutions and encourages social participation mechanisms in a continuous and integrated process. The results confirm the usefulness and necessity of applying TS (Garcia, 2007), considering its role in social inclusion, quality of life, socio-economic and environmental sustainability, poverty alleviation, access to water resources, and education.

It is explained that although the education dimension does not appear as a specific element, it is assumed that learning and knowledge sharing are naturally integrated into the processes and mechanisms of the other aspects since education fosters the use of knowledge to generate innovation, is a mechanism that facilitates social participation and promotes better use of the results. This way, this research understands that innovation and social participation are mediated through the application of methods (methodology) that specify the forms and procedures for the design, implementation, and dissemination of TS i.e., to produce social impacts (outcomes) that benefit society.

3 METHODOLOGY

This qualitative study explores the field of action based on subjectivism to understand and interpret the facts and phenomena investigated 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). It is descriptive because it describes characteristics, factors, elements, and methods that contribute to the occurrence of TS 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), including individuals, organizations, regions, communities, and programs (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).

The single case study is indicated in scenarios in which the chosen case is critical, peculiar, common, revealing, or longitudinal, whose particularity of the studied event and its contribution to the phenomenon analyzed are important precepts that support the selection of this research strategy (Yin, 2015). Additional information about the reasons for choosing this case (Cisterns Program) is presented 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 civil society representatives (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 Program, lived in the rural area of the Brazilian semi-arid, and owned/enjoyed some of the

TS that make up the program under study. For civil society representatives in various modalities, the condition was to have at least three years of experience in the organization, to live in the Brazilian semi-arid (rural or urban), and to have an active connection with the organization.

Considering the three main methods of data collection in qualitative research, interview, and document analysis (Flick, 2013) were used, being based on the categories of analysis established in the theoretical framework: methodology, innovation, social participation, and results. In addition to these categories, identifying *"tecnologias sociais"* in the Cisterns Program was introduced as a category of analysis, making the grid of categories in this study mixed (Vergara, 2005). It should be noted that the interview script consisted of "open-ended" questions in order to obtain as much detail as possible from the interviewees and not restrict the subjects that could be addressed in each category of analysis; therefore, the elements/subcategories of analysis emerged as the results were processed. Interviews were conducted during the first half of 2021 and lasted an average of 1h30min each.

Among the documents consulted are Federal Law No. 12.873/2013 (2013), Decree No. 9.606/2018 (2018), Intergovernmental Panel on Climate Change (IPCC, 2019), SESAN Operational Instruction 02/2017 (2017) and ASA Notebook (Proposals from Civil Society). These documents were analyzed mainly to validate the information obtained in the interviews and confirm the legality of the cistern program as a public policy tool. Figure 3 shows the 08 (eight) respondents that granted interviews for this research: 04 (four) representatives of beneficiary communities and 04 (four) representatives of civil society organizations.

Figure 3
Selected Respondents

GROUP	STATE	IDENTIFICATION	INSTITUTION
CIVIL SOCIETY ORGANIZATION	Pernambuco	EO-01	Avina Foundation
	Pernambuco	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	
	Pernambuco	EB-04	

The definition of the number of respondents was based on the criterion of data saturation (Glaser & Strauss, 1967). Moreover, considering the geographic context in which the analyzed program operates (10 Brazilian states), we tried to select representatives of the states that have greater importance in terms of population and percentage of the rural population (target group of the TS under study) - Bahia (30%), Ceará (21%) and Pernambuco (13%) (Brazilian Semi-arid Articulation - ASA, 2019) - in order to obtain a representative panorama of the Brazilian semi-arid.

The analysis of the evidence was based on the categorical content analysis through the organization, classification, and grouping of the text according to the categories established (Bardin, 2016). In this way, the content of the interviews was transcribed, keeping the language form of the interviewees. Later, it was organized by separating excerpts with evidence to meet the guiding objectives of this article. This outline was followed by a preliminary classification into predefined categories of analysis (methodology, innovation, social participation, and outcomes) based on the proposed framework and the objectives of this study (Bardin, 2016; Eisenhardt, 1989).

Thus, the categories of analysis were defined as dimensions for the study of the TS. However, given the variety of forms and characteristics that the TS can take, the elements/subcategories of analysis were not determined in advance. They were identified only during the data analysis. Finally, the

excerpts and speeches were classified into the established categories based on cross-evaluation and integrated agreement between the researchers.

3.1 Single case: Cisterns Program in the Brazilian Semi-arid

The TS initiatives studied here were initially promoted by the Brazilian Semi-arid Articulation (ASA) and later integrated into the "*Programa Nacional de Apoio à Captação de Água de Chuva e Outras Tecnologias sociais - Programa Cisternas*", established by Law No. 12.873/2013 (2013) and regulated by Decree No. 9.606/2018 (2018). This program is the case analyzed in this article because it offers concrete solutions - cisterns - to improve the population's quality of life (Pozzebon et al., 2021) and has a broad geographic presence, operating in 10 (ten) Brazilian states.

The Brazilian semi-arid 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 Program, is of great benefit.

Moreover, during its existence, this program has already built about 1.3 million TS (cisterns) in its different operational models for domestic and productive water consumption (crops and livestock) (ASA, 2021). On the other hand, the number of TS (cisterns) built under this policy decreased dramatically in 2020 (ASA, 2020). However, the Brazilian federal government announced new investments in this public policy, issuing public notices for more than R$500 million and expanding implementation beyond the semi-arid region to areas of the Brazilian Amazon (Brasil, 2023).

Due to its territorial amplitude, number of TS implemented in the Brazilian semi-arid region, time in operation, and presence of formative requirements, also given the drastic reduction in TS delivered to the semi-arid Brazilian population in recent years (ASA, 2020), and the restimulation of this public policy (Brasil, 2023), this program has a critical role and peculiarities that warrant to its analysis as a single case study.

4 PRESENTATION AND ANALYSIS OF RESULTS

4.1 Types of "*tecnologias sociais*" of the Cisterns Program

The main TS established under the Cisterns 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 TS 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 these TS, 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 TS that supply several families in each 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:

> In my family's case, it was the cistern for human consumption [of 16 thousand liters], 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).

The SESAN Operational Instruction 02/2017 (2017) emphasizes the importance of these other types of equipment for the functionality of the cisterns. In describing the components associated with ST, the interviewee also reiterates the understanding that these technologies require specific devices and equipment that condition their proper functioning, reinforcing the concrete technical aspect of "*tecnologia social*" (Pozzebon et al., 2021).

4.2 Methodology

Regarding the methodology, the interviewees addressed aspects of how the beneficiary families are selected and the elements of the creation and construction of the TS, 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 interviewee's speech 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 older people. Then came the government's CadÚnico[ii] through the social assistance 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]. This register is precisely based on the Governmental Social Assistance system (EO -01).

The selection mechanisms based on families' social and economic vulnerability reinforce that TS should be directed to families, producers, and consumers with low economic power to meet their human needs (Novaes & Dias, 2009).

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, practices to combat desertification and care in the use of the cistern.

> In the case of the first water cistern, the training is called Management of Water Resources; in the case of the second water cistern, two courses are offered, Simplified Water Management System and Management of Water for Food Production. In addition, inter-city and inter-state exchange programs allow farmers to exchange experiences. Here we are talking about the movement of knowledge, an important process for developing communities and their territories (EO -01).

In this discussion, respondent EB-03 said:

> Government officials and civil society organizations had already established the criteria, the neediest people, those who did not have water and had children with disabilities. 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 [*Centro de Estudos do Trabalho e de Assessoria ao Trabalhador*], 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, taught the people how to use water and trained the masons how to build cisterns (EB-03).

The reports of these respondents, referring to the methods of the Cisterns Program, are supported by the documents analyzed, such as Decree 9.606/2018 (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 this type of technology's potential depends on the participating actors' training (Dagnino, 2014). On the other hand, even if formal institutions provide these courses, there is a need for knowledge about the developed technology, even if improved by official bodies, to be widely disseminated among the local population (Pozzebon et al., 2021). In addition, the recruitment and training of workers in the region confirm the result of TS as a tool for generating employment and income (Silva et al., 2021).

On the other hand, although there is a method 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 TS.

> 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. These cases are more common than you can imagine because, unfortunately, there is a terrible political influence. The smaller the municipality, the greater this influence, but we have always tried to preserve the criteria (EO -01).

Another interviewee said:

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

This is an important point and deserved 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 Program. It prevents it from fulfilling its purpose, avoids the access of the true beneficiaries, and promotes the lack of maintenance of the implemented TS (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 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. Regarding the implementation methodology of TS, the interviewees mentioned:

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

The speech of this interviewee reflects the aspects established in Decree No. 9.606/2018 (2018) on partnerships in the elaboration, analysis, and implementation of the TS 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 more 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 non-governmental institutions, and social movements is recommended (Jesus et al., 2021).

4.3 Innovation and Social Participation

In terms of innovation, the types of TS implemented by the Cisterns 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 an 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 (Koc & Bosdag, 2017).

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.

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 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).

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), 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).

4.4 Cisterns 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 Program. When talking about the results of TS resulting from the implementation of this public policy in the microregions that make up the 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 (Federal Law No. 12.873/2013).

Consequently, access to quality drinking water has impacted the region's public health by reducing childhood illness and death caused by the consumption of unsuitable water (EB-02, EB-04). Another positive impact 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 benefits, such as the generation of income, which in turn improved the living conditions of families in this region (EB-04, EO -02), corroborating the role of TS as an instrument to make enterprises economically viable, as popular cooperatives, agrarian reform settlements and family farming (Novaes & Dias, 2009).

All these changes contributed to the promotion of another important impact on the development of the semi-arid region of Brazil, that is, the reduction of rural 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 from 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.

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 the greater empowerment of women, as the implementation of the TS promoted women's self-organization in managing and maintaining productive backyards (EO -04).

Another outcome with environmental relevance is the mitigation of desertification (EO -01), as water storage and availability are strategies to mitigate this climate effect (Ventura et al., 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 strengthening food sovereignty (EB-04, EO -03), as the TS provided families with healthy, pesticide-free food. Considering these positive results, respondent EO -01 synthesized:

> 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. 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 all "*tecnologias sociais*", families go through training and education to benefit from it. All this contributes to the farmer's empowerment (EO -01).

Due to the diversity of findings of this study, an integrated summary of case results is presented in Figure 4.

Figure 4
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 communities • Woman empowerment • Mitigation of Desertification • Scale and scope of the Cisterns Program.

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 TS and belonging to the region), taking into account the peculiarities and diversity of forms of TS, find a theoretical support in authors such as Andrade and Valadao (2017), Dagnino et al., (2004), Pozzebon et al., (2021), Rodrigues and Barbieri (2008).

4.5 Theoretical contributions and future research directions based on the results

Based on the assumption that the theoretical contribution is based on the presentation of new concepts and theories, as well as the review, application, and refutation of existing theories based on analysis and reflection arising from empirical data (Bispo, 2023), the theoretical contribution of this research arises from the analysis of the evidence obtained to expand the theoretical approach to TS and their integration into public policy.

Thus, the results offer an empirical picture of how a public policy (Cisterns Program) promotes the creation of TS in a water scarcity scenario and complements theoretical approaches on the subject. In this context, even given the diversity of possibilities that TS can represent, they adopt classifications of family TS and community TS. This distinction, not found in the literature consulted and cited in this text, 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.

This judgment also underscores the finding that these technologies achieve better results when offered in an integrated fashion and with interdependent functions that promote family strengthening (Familiar TS) and community empowerment/development (Community TS). This classification, not identified in the literature, can even be explored in new research and in scenarios different of the Brazilian semi-arid region, such as the Brazilian Amazon, due to the expansion of the cistern program for this region (Brazil, 2023). In addition, this classification can compose the definition of public policy for TS.

Regarding the link with public policy, although the government sets selection criteria and streamlines the process through computerized government registration systems, this action may limit access to TS, especially in emerging countries such as Brazil, where many families are still "invisible" in some government databases (Gonzalez et al., 2020). This aspect, which has not been explored in other research in this area, underscores the importance of partnering with civil society entities to minimize the risk of exclusion of potential beneficiaries, including those living in geographically distant and hard-to-reach locations who may be "prevented" from reaching this TS due to the exclusivity of the selection process in government hands.

Public policies aimed at TS should then promote to partnerships, including strengthening the role of civil society organizations, which could help with oversight activities (with the support of public bodies of legal oversight) to avoid the activity of "intermediaries" and the interference of parties and public officials. These political interferences in the TS design and implementation process were also not noticed in the literature consulted. They offer a theoretical addition to the method element in TS and deserve better discussion in future studies. New research can also analyze the existing government mechanisms and policy proposals to limit/eliminate these interventions.

Considering that in many initiatives of TS, government funding prevails (Bonilha & Sachuk, 2011; Costa & Vidal, 2008; Tahim et al., 2022) and the financial resources of the state are limited, the government must establish a financing and development fund, not only for the implementation of new TS but also for the maintenance of those already in place. Thus, it is not enough to provide resources with "limited deadlines"; a government plan (not a plan of government manager) must be created for this purpose.

Considering that qualification and social participation are fundamental elements for operationalizing TS, it is worth mentioning that participants in this research should have mentioned universities and secondary schools. Consequently, in the TS theory, these institutions should be adopted/reinforced as an environment for qualifying and stimulating the implementation of TS (training and providing knowledge). Likewise, public policies aimed at TS should identify the activities of these organizations and promote partnership mechanisms and integrated work.

Another aspect that should be mentioned in the context of "*tecnologias sociais*" in terms of methodology is the role of community leaders in managing the community and accelerating procedures (awakening the commitment of citizens) for the training of the population and the implementation of TS. In this context, the dissemination of the "*tecnologia social*", especially in the framework of the cistern program, means the identification and dialogue with these leaders. Since the role of community leaders in the theory of "*tecnologia social*" needs to be clarified, this theoretical contribution should also be better discussed in the new research, including its positive and negative implications.

Because "*tecnologia social*" typically serves communities with specific needs, one way to optimize its outcomes is through inter-community and intergovernmental collaboration to disseminate best practices and jointly address potential challenges. Although the laws dealing with the cistern program provide for this cooperation among government agencies, it should be better explored of its role the consequences of its ineffective implementation, and the obstacles to its satisfactory

occurrence. New research should also analyze whether these partnerships have been established and how the TS elements (methodology, innovation, social participation, outcomes/impact) are addressed.

In the context of TS, therefore, partnerships in their various forms (users, universities, governmental and non-governmental institutions, and social movements) need to be strongly promoted in order to increase the activities of civil society organizations, disseminate the benefits and outcomes, expand the scope of services, and spread the existence of public policies based on "*tecnologia social*", including to attract supporters/funders. In addition, public policies for this purpose can be planned based on public-private partnerships, as with initiatives to address social needs in other countries (Akbulaev et al., 2019; Choi & Park, 2021).

It should also be noted that although innovation is a characteristic aspect of "*tecnologia social*" (Franzoni & Silva, 2016; Souza & Pozzebon, 2020), not only radical solutions should be considered, but also those resulting from improvements and adaptations of processes and applications, including those reported by users, to ensure the durability of the benefits and solutions offered. In addition, public policy tools should establish mechanisms for identifying TS initiatives and developing dissemination strategies in regions with similar problems. In this sense, new research can explore the role of incremental innovation in the context of "*tecnologias sociais*" and the role of public policies in developing this type of innovation in TS initiatives.

Finally, this study offers the proposed model as a theoretical contribution that confirms that TS public policies can emerge from popular initiatives, such as the cistern program. As the proposed model shows, innovation and social participation are mediated, in an integrated process, through the application of methods (methodology) that optimize forms and procedures to design, implement and disseminate "*tecnologia social*", that is, to generate social impacts (outcomes) that benefit society.

5 FINAL CONSIDERATIONS

This research aimed to analyze the role of the Cisterns Program as a generator of "*tecnologias sociais*" in the Brazilian semi-arid region. The results show that although the program emerged from a community action, it gained expression and scope when it was incorporated into a public policy by the Brazilian government. The results also show that elements such as methodology, social participation, innovation, and results (social impact) are characteristic aspects of TS that promote its implementation and facilitate the achievement of its goals in inclusion and social change.

In this sense, the analyzed case has shown that the inclusion and social change resulting from TS can be perceived in the access to drinking water, the containment of desertification, the improvement of production in drought-affected regions and even the reversal of rural exodus. These findings underscore the need for continuity in initiatives, projects, and policies whose primary goal is the adoption, use, and diffusion of "*tecnologias sociais*".

Like any research, this study has some limitations; the first is related to the qualitative case study method. Although it is impossible to establish generalizations, the case has revealed aspects that complement the theoretical approach of "*tecnologia social*" and their relationships with the concept of public policy, integrating these constructs and stimulating their discussion in new research. Furthermore, the analyses were based on the perceptions of civil society organizations and beneficiaries, limiting the state's approach to the documents consulted. For this reason, new studies can evaluate the role of public policies in creating "*tecnologias sociais*" based on the understanding and performance of state actors.

Aware that government is an important actor in the process of transition to sustainability (Derwort et al., 2022) and that "*tecnologia social*" are tools for sustainable development (Nunes et al., 2017; Santos & Rocha, 2021), new research could address the role of TS public policies in promoting environmental sustainability, including from the perspective of Sustainability Transitions Theory.

Finally, considering the scenario of the resumption of the cistern program in the semi-arid region and its extension to the Brazilian Amazon (Brazil, 2023), the results of this research may be useful

for civil society organizations, beneficiaries, and government officials involved in this process. Thus, the aspects presented in this study reinforce the theoretical postulates on the subject, can be explored in new research, and confirm the role of the cistern program as a public policy that generates "*tecnologia social*".

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[i] The "Rede de Tecnologia Social" (RTS) was founded in Brazil in 2005 and brings together governmental and non-governmental institutions involved in initiatives for the technological promotion and support of social projects. It is based on the perception of a series of obstacles to the effectiveness of actions to compensate public policies for the social issue in the country, which is characterized by high levels of inequality in the distribution of employment and income, education, information and culture, housing, health, the fight against hunger, access to drinking water and basic sanitation (RTS, 2008).

[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.