



Social Consumption and Production Technologies in the Context of the Landscape of the Hillside Surface in the Municipality of Mucambo-Ce

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The present research aims to study social technology in Mucambo, Pedra de Fogo, and Pajeú, based on an approach to the elements that make up the Coreaú Watershed. The Brazilian Northeast has been a region punished by the lack of water due to irregular rainfall. Such a problem, which has been part of the reality in that region, is, among other factors, accompanied by a population that shows resistance to the difficulties related to water conditions. The manuscript discusses social technology in the Mucambo outback, which stores water during the rainy season to be used by humans and in agriculture in the drought period. This aspect is significant because of the water shortage in the dry season in the location. This way, social technology grant water assistance to the population, providing security for this resource. The results highlight the social technology benefits, being the most significant water source for families living in rural areas. Given the research results, the cisterns are relevant for consumption and production in rural areas since people reported that they store water in good quality.

Keywords: Social technology; agriculture; drought period; evaporation.

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1. INTRODUCTION

The Northeastern semi-arid region lies between the isohyets of 250 to 1000 mm. The potential evaporation (PE) – 2,700 mm/year – characterizes a high water deficit, which results in an average aridity index of 0.30 [1]. The seasons that define the rainfall scheme are a wet season, which lasts three to four months when about 70% of the annual precipitation occurs, and a dry season during the rest of the year whose temperature varies from 24° to 28° C [1]. It is the rainiest semi-arid region in the world with cultural, social, and natural diversity.

Historically, the Brazilian Northeast has been a region punished by the lack of water due to irregular rainfall. Such a problem, which has been part of the reality in that region, is, among other factors, accompanied by a population that shows resistance to the difficulties related to water conditions.

Because of this scenario, numerous projects emerged intending to combat drought. Among the solutions, the most resorted to was the practice of constructing dams, which had as responsible for their construction the Instituto de Obras Contra a Seca (Institute of Works Against Droughts, IOCS), the Instituto Federal contra a Seca (Federal Institute Against Drought, IFOCS), and the Departamento de Obras contra a Seca (Department of Works Against Drought, DNOCS).

In this context, [2] state that such measures were insufficient because of economic issues, such as the construction of dams on private properties intending the irrigation instead of meeting the needs of small farmers. During the actions, the State was responsible for creating and implementing public policies for the semi-arid region. Besides that, the Brazilian government contribution – construction of water infrastructure works, organization of work fronts, and distribution of water and food – revealed a monopoly concerning public policies in the region [3].

Speeches and studies about the semi-arid region resulted from discussions on governmental inefficiency. Thus, the Articulação no Semiárido Brasileiro (Articulation in the Semi-arid Brazil, ASA) emerged in the 1990s from mobilization and consolidation of civil society to defend the water right.

The articulation revealed the impossibility of solving the drought, but sustainable practices assist the coexistence in the semi-arid environment. Therefore, ASA has developed training and social mobilization programs, such as the Um Milhão de Cisternas (One Million Cisterns Program, P1MC), created in 2000, which is a social technology. This program is a form of collecting and storing rainwater for human consumption.

ASA reports [4] that the program Uma Terra e Duas Águas (One Land and Two Water, P1+2) created in 2007 has expanded the water stock of families, rural communities, and traditional populations. Number one means the land, and two is the second water destined for family farming and small animal husbandry.

It is essential not only to consider the semi-arid potentials and limitations but also to develop sustainable technology to deal with natural resources. In this scenario, the social technology implementation such as consumption and production cisterns are suitable for the sustainable management of natural resources. Therefore, discussions on access to water are relevant for a harmonious coexistence between society and nature.

This integrated study approaches the natural and social elements brought by the social technology in Pedra de Fogo and Pajeú villages, which are 10 km away from Mucambo. Both areas have the P1MC and P1+2 programs providing a safe quality of life for the people. Moreover, the social technology for rainwater storage supply eases problems caused by water shortage during the dry season.

The research presents a study on social technology in Mucambo, Pedra de Fogo, and Pajeú, based on an approach to the elements that make up the Coreaú Watershed. The choice for these areas is because they have such a social technology, which delivers a reliable quality of life, and are in a semi-arid environment marked by water scarcity over time.

Map 1 below shows the two communities under analysis in the Mucambo rural area, 10 km away from downtown. Even though most of the houses are masonry covered with cement, others have beaten ground and walls made of wood and clay, an artisanal and historical process.

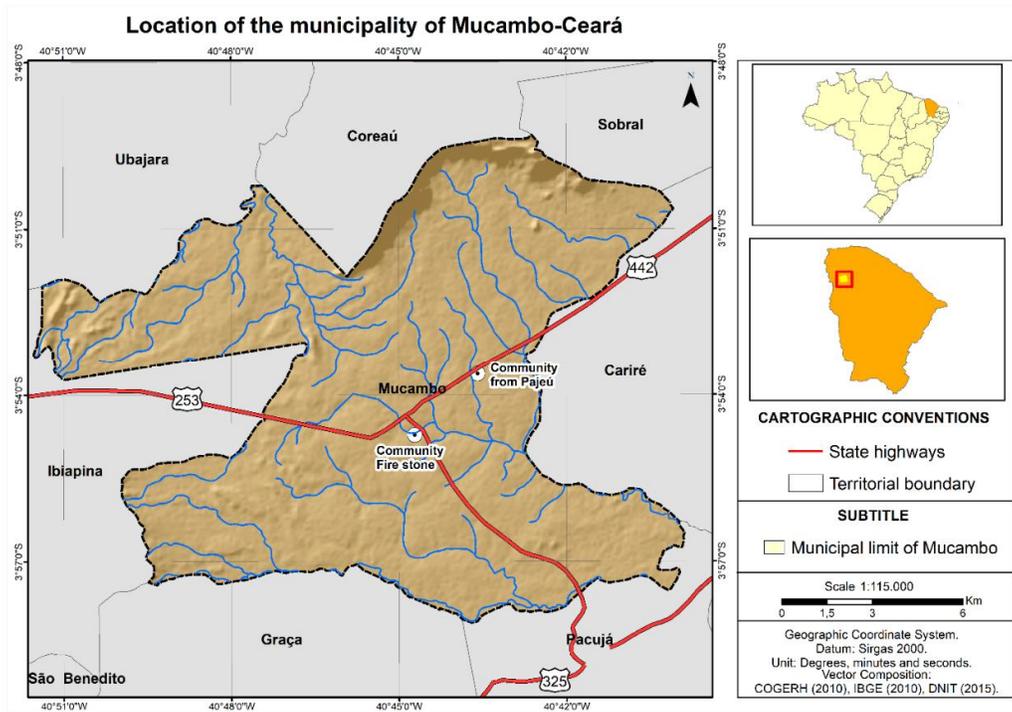


Fig. 1. Location Map of Mucambo / Ce Map 1- Location Map of Mucambo / Ce

Fonte: COGERH (2010), IBGE (2010), DNIT (2015), organizado pelos autores (2018)

From an interaction perspective, the research analyzes the coexistence practices in the semi-arid communities of Pedra de Fogo and Pajeú, covered by the P1MC and P1+2 programs. Besides, it investigates this technology's role and the relationship with the geographical peculiarities of the semi-arid region and the area under study. It also discusses the advantages of social technology, highlighting the impacts on society and interconnecting the relationships with the elements of nature, especially water.

In this context, it is worth understanding that the relationship between nature and society has influenced the landscape design process. Besides, social technology is the result of the conflict between the environment and the social. Thus, technology has motivated the reorganization of the relationships between society and nature [2]. Therefore, the research must be natural and social, considering elements of nature that involve the context.

From this perspective, nature is always related materially and ideally to social activity. [...] life appears and develops in the natural environment, so the history of humanity is the continuation of the history of nature [5]. It is worth

noting that the dynamic between society and nature is essential for the families contemplated with social technology and that live in the semi-arid northeastern region.

Social technology has emerged to manage and restructure relations with the environment. Therefore, addressing how society access water through cisterns is an allusion to an integrated relationship.

The research came from the social technology relevance, which became a public policy to help rural communities affected by drought through water support. Thus, it is essential to discuss water resources in the semi-arid environment, in this manuscript, the forms of collecting and storing water.

The manuscript discusses social technology in the Mucambo outback, which stores water during the rainy season to be used by humans and in agriculture in the drought period. This aspect is significant because of the water shortage in the dry season in the location. In such a case, the proper social technology contributes to access to water and family farming, giving rural farmers a protagonist role.

Therefore, the manuscript has five sections besides the Introduction. The first one is Discussing the Topic, which deals with the concepts about the drought and social technology to support life in the semi-arid region. The second – The Area Characterization – supports the local characteristics and geological and geomorphological aspects. Thirdly, the Material and Methodology approach methodological contributions for the research. The fourth, Result and Discussion, presents the results. Finally, there are the Final Considerations.

2. DISCUSSING THE TOPIC

The drought affecting various continents has to do with the circulation of air masses on the planet and phenomena such as El Niño and La Niña, which alter the rainfall regime in these regions. Due to the drought affecting many countries, some authors have shown their perception of what factors cause this phenomenon in Northeastern Brazil [6,7].

El Niño is the climatic phenomenon influencing the dry season in Northeastern Brazil. According to [1], there is a direct cause and effect relationship between the El Niño phenomenon and drought in Northeast Brazil, at least in the dry period beyond the normal. Also, the anomalous change in the circulation of the upper atmosphere, in the dynamics of the centers of high and low pressure, and in the atmospheric air cells explain the significant droughts in Northeast Brazil.

Additionally, the intermittent watercourses make people use unusual water sources – the same for animals – when the usual ones are not available anymore. Besides impacting the water quality, increasing the cases of diseases, it also aggravates scarcity due to the competition established [8].

For Cavalcante [9], the proposal of living in the semi-arid region represents a positive character for tackling economic and socio-environmental issues. According to the Rede de Tecnologia Social (Social Technology Network, RTS), social technology is products, techniques, or replicable methodologies developed and applied in interaction with a community. It represents solutions for social transformation through the sustainable use of local resources.

Furthermore, social technology for capturing water to assist the semi-arid life is significant to Northeastern Brazil. This kind of technology originates from an innovative process resulting from the knowledge created collectively by the actors interested in its use. In a political and social context, in which interests emerge in the elaboration of inclusive social policies, the processes, techniques, and methodologies developed in interaction with the population represent an alternative to facilitate social inclusion and improvement in the quality of life [10].

Social technology is a method capable of solving some social problem, meeting the requirements of simplicity, low cost, easy applicability, and generation of social impact [1].

Collecting rainwater is an ancient strategy consisting of a fundamental law for life in the semi-arid region. Thus, the social technology that ASA has developed with governmental support has forty projects in test and implementation [1]. Some of them are already programs, as explained below.

The P1+2 (One Land and Two Water), a successful project highlighted in this research, includes the use of land and rainwater capturing [11]. Both communities under analysis possess two kinds of technology.

Concerning challenges and prospects, implementing social technology has been significant to access water in the semi-arid region. In the words [1], it is worth noting that devices to capture and store rainwater for human consumption and food production, contrary to the perspective of combating drought, seek possibilities for living in the semi-arid region and value local potentialities. They provide farmers with a harmonious coexistence with their climate.

A holistic view is essential in this context, requiring the presentation of the relationship among geomorphological aspects, landscape elements, and human activity. The relief forms are responses to the conditioning of the lithology, endogenous and exogenous processes, and evolution. However, it also reconfigures through anthropic action [12].

Social technology, especially consumption and production cisterns, are a new landscape component that has influenced the reorganization of the relationship between

society and nature [13]. Thus, the kinds of social technologies must undergo a systemic perspective.

It is unfeasible to analyze social technology separately but considering all the natural and social elements. [2] mention that it is essential to consider the natural landscape set, which impacts on water resources, such as soil, vegetation, climate, geology, and relief – the stage for human and nature activities, what reflects on landscapes.

3. THE AREA CHARACTERIZATION

Mucambo is in the Northwestern Ceará – about 286 km from Fortaleza, the state capital – in Sobral and Ibiapina macro-region, in the Northwestern mesoregion, and the Sobral micro-region. Its outback surface has low relief, up to 400m, irregular rainfall, shallow soil, rocky outcrop, and Caatinga is the prevailing vegetation [14]. By way of explanation, the State of Ceará (CE), shares a border with the States of Piauí (PI), Pernambuco (PE), Rio Grande do Norte (RN) and Paraíba (PB). Besides, [15] mentions that it is a lowered area among high environments, which corresponds to 92% of Ceará territory.

The region has shallow soil, Caatinga vegetation, thorny deciduous forest, tropical sub deciduous rainforest [15]. The Coreaú watershed, which comprises the area, drains the 10,633.66 km² basin, which corresponds to 7% of state territory. Pedra de Fogo and Pajeú communities are in the Mucambo rural area, possessing the same abovementioned characteristics.

The region presents the outback surface, residual crest, the Ibiapaba peripheral depression, and Ibiapaba klint. It is worth mentioning that the first geomorphological environment has been the stage for the relationship involving rural communities and the implementation of social technology to assist life in the semi-arid region [2].

Mucambo presents the Meruoca granitoid suite predominantly, but also the Aprazível, Pacujá, Parapuí, Coreaú, Trapiá, and Ubajara group. In this sense, the proposal of an integrated study requires observing the landscape considering its natural elements. Thus, the geomorphological and geological aspects approached in this research enable the understanding of the area.

According to [2], the lithological material impacts the process of soil formation. Concerning the strength of the materials, weathering can act in diverse forms in rock fragmentation and decomposition over time. [2] explain that depending on the kind of rock, soil can have more or less sand and clay, and it can be fertile or poor based on the number of nutrients.

Thus, one can notice the influence that the geological potential has on the local landscape aspects according to map 2. The relationship between rock and soil reveals the amount of water infiltrated and stored in the ground, what acts on the vegetation, and the analyzed factors indicate the physical environment in which the social technology is. Furthermore, the relationship and its analysis are essential to identify the use condition of elements in the landscape.

4. MATERIALS AND METHODOLOGY

4.1 Theoretical Aspects

The adopted methodology was initially the literature review about the issue at hand and the social technology importance for families. The theoretical and methodological support had as a basis a systemic view of the area, in which the system is a set of units reciprocally related, articulated among themselves and with the environment, and directed to a defined purpose, Bertalanffy [16].

From this perspective, the systemic approach provides an integrated analysis of the elements and not an isolated one. Therefore, the methodology makes the research more perceptible of reality. From the general systems theory, it is possible to understand the structure of the environment (Mucambo outback surface), delivering a better organization of the object of study and comprehension of its totality.

4.2 Technical Operational Routing

The fieldwork consisted of a survey at the rural workers union to investigate the number of social technology devices (cisterns, mandala vegetable garden, underground dams, and stone tanks), photographic records, and collection of geographical coordinates for the preparation of cartographic products. The fieldwork took place in two communities, Pajeú and Pedra de Fogo, which have two kinds of cisterns. The plate kind is for basic consumption – drinking and cooking –

and the floodwater kind is to irrigate plantations and to the animals. The number of social technology devices in the municipality is twelve hundred.

The twenty interviews conducted in each village focused on social aspects related to the conditions before and after the social technology implementation. The research with the families served for data collection and methodological purposes to know how they use the cistern water and the impacts. The rural workers union was the link to reach these families in March 2018. The interview took place between the heads of the families and the authors of the research.

The questions asked in the interview were as follow:

- How long does your family have the cistern?
- Do all families have cistern in your village?
- Do you share the cistern water with other families?
- How do you use the consumption and production pieces of technology?
- How did you use to get water before having the cistern?
- How many hours did you spend getting water before having the cistern?
- Did you and your family take part in any preparatory course before getting the cistern?
- Did cisterns improve the quality of life of your family?

The open-question interviews focused on social aspects related to the conditions before and after the device implementation. The research with the families served to collect data and to know how they use the water cisterns and the impacts after their construction.

5. RESULTS AND DISCUSSION

In this context, the use of cisterns for consumption and production are simple ways to collect water, which prove to be effective in the use of rainwater. Moreover, these water storage techniques improve the reality of the communities they serve.

In this continuation, it was clear the relevance of social technology since both governmental and civil society actions mitigate the suffering caused by droughts. Besides, communities revealed that social technology devices play a fundamental

role in sustainable development and provide a better quality of life because the P1MC and P1+2 programs ensure food security and sovereignty.

The coexistence alternatives improve the time previously spent fetching water from rivers, cisterns, fountains, wells, among other means, thus ensuring that women and children, who are mainly responsible for this activity, can dedicate themselves to other tasks. It is worth mentioning that the plate cisterns, which can store 16,000 liters, are only for consumption as proposed by the project.

Therefore, the Pedra de Fogo and Pajeú population use the plate cistern water for eight months in the dry season, not needing tank trucks to refill them. The interviewees say that it is because of the awareness provided by the responsible bodies. They also highlight the good-quality water, which reduces diarrhea and dehydration cases, especially among children. On the other hand, the torrent cisterns demand tank trucks since they serve various purposes. Even though the Mucambo dam serves the population, it is not easily accessible [17]. According to this author, the most effective resource is human supply through cisterns for the local reality [17,18,19].

Even though these water reserves are explicit, many families have not yet benefited, not only in Mucambo but in other places in the semi-arid region. Consequently, the benefited ones reported in interviews that they need to share their water reserve, especially those from Mucambo rural area. This fact represents a challenge. About this, Gnadlinger [20] points out that:

If only a few houses have cisterns, then other community members will take water there in the dry period. Soon the cisterns run out of water. Besides the risk of cracks, the population would think that cisterns are not the solution for the lack of water.

Despite the improvement in the quality of life brought by social technology, the remaining challenge is that not all rural families have a device at home. Because of the demands, the programs must continue to benefit the families that do not have any of the rainwater storage cisterns types.

Almeida [13] highlights another challenge, which is precisely the need to continue the technical assistance with the communities served by the

programs, to discuss and reinforce the importance of the proper use of the cisterns, as well as about cleaning and other events that may arise, such as maintenance of the physical structure.

The water shortage in Northeastern Brazil is a historical issue. However, public policies such as dams, cisterns, and deep wells implemented over time mitigate water problems in that region. Despite the few rainy years, it is possible to verify the opposite, as in 2009. Among the following years of rainfall below the average in the region, 2011 stands out as above.

Fig. 4 shows the precipitation and averages in Mucambo from 2009 to 2019, highlighting the historical average and the observed maximums, according to Fundação Cearense de Meteorologia e Recursos Hídricos (Ceará Meteorology and Water Resources Foundation, FUNCEME). (21) had the last highest index, and the precipitation was low in the following years.

The values shown in the graph counted on the FUNCEME website, considering the data from 1981 to 2010.

The rainfall accumulation over the last seven years matches the one proposed for the semi-arid climate. To Souza [14], this volume is due to the geographical position and the proximity of the Ibiapaba Plateau since it intercepts the clouds and provides rain for the region. Besides, the physical characteristics in that environment do not favor the water issue because the shallow crystalline soil hinders the water flow. It also interferes with the supply of water tables and the evaporation caused by the temperature. Therefore, the use techniques must collect and store rainwater.

As previously mentioned, Pajeú was the area chosen for this research. The interviews with those who have cisterns (Fig. 2). Focused on the impacts caused by their construction and their use.

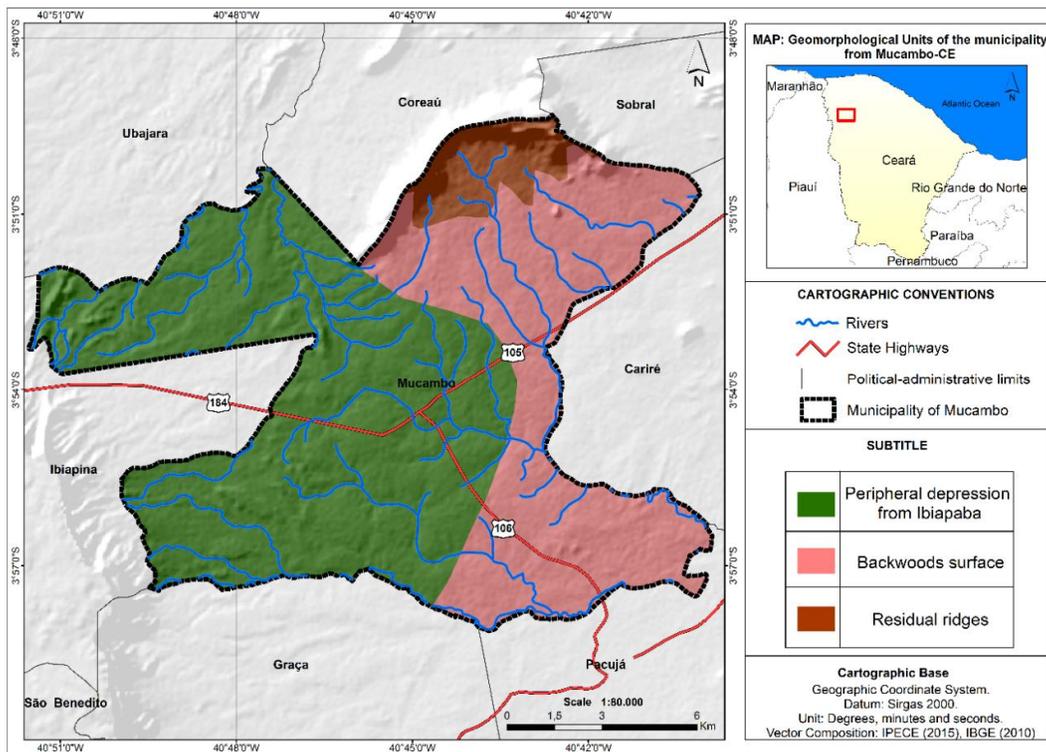


Fig. 2. Geomorphological Units of the Municipality of Mucambo / Ce
Fonte: IBGE (2010), IPECE (2015) organizado pelos autores (2021)

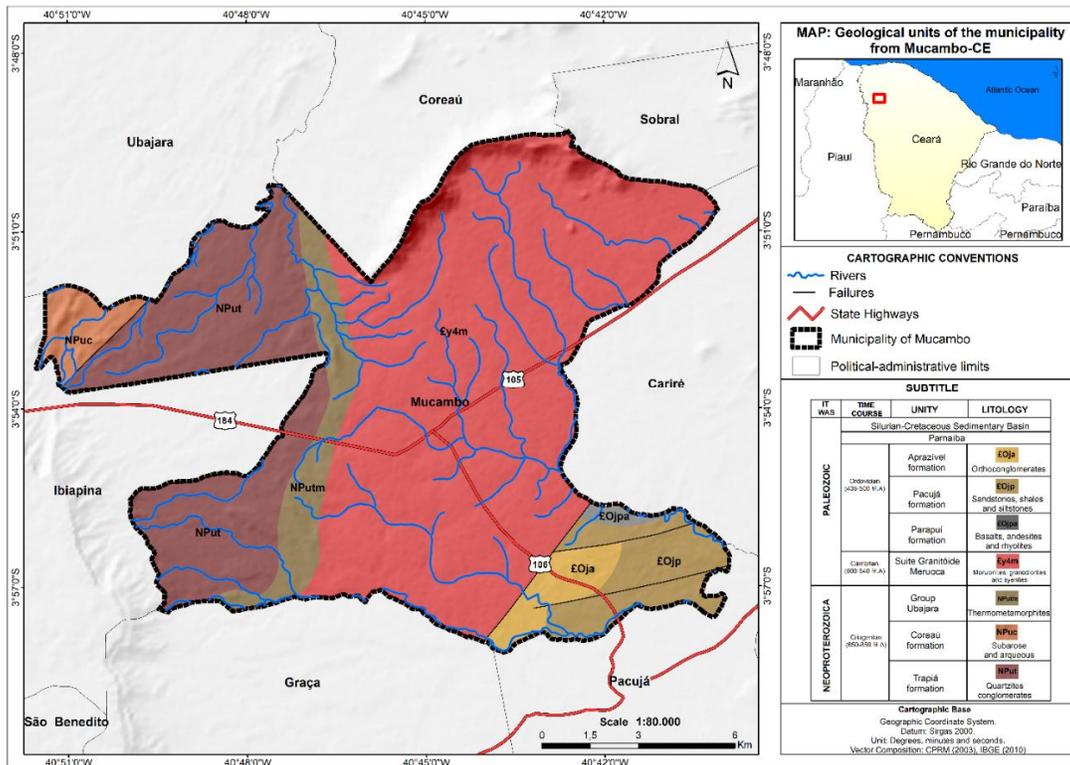


Fig. 3. Geological map of the Municipality of Mucambo / Ce
 Fonte: CPRM (2003), IBGE (2010), organizado pelos autores (2021)

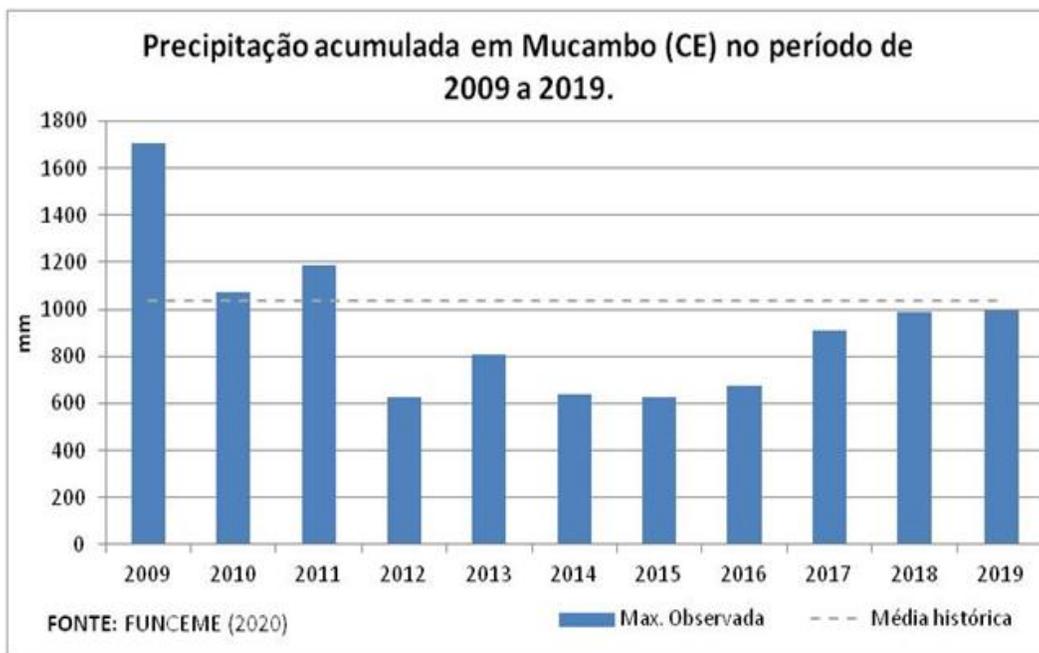


Fig. 4. Rainfall level in Mucambo
 Source: Hydrological portal – FUNCEME [21], adapted by the authors

The Pajeú plate cisterns (Fig. 5(a)). are the primary consumption source for that community according to the local families and fieldwork, which has been in the One Million Cisterns Project (P1MC) for seven years. On the other hand, some families have tanks whose water is brackish, making them use it only for washing and not for drinking. This way, Suassuna [22] approaches the crystalline lithology and the salinization of water resources. Thus, cisterns have been a relevant alternative technology for storing rainwater for consumption during the dry season.

For proper handling of the cistern and water management, one of the family members must participate in a training course – a criterion for receiving the cistern – offered by P1MC, which lasts one and a half days. The theory is finally put into practice since the families use the water for basic needs, such as cooking and drinking.

The rainy season is uncertain in the semi-arid region, and there is variability in time and space. Concerning that, rainfall impacts the life in the field directly – the agricultural production and the water shortage for human consumption in the dry season. Thus, it is essential to evaluate the alternatives for collecting water, including the water torrent cisterns intended for production.

Fig. 6 depicts the positive results of the implementation of technology to assist life in Pedra de Fogo. A backyard crop seemed impossible a few years ago, but it is possible now with cisterns. The techniques to collect rainwater, intended for production (Fig. 6), are essential for farmers since they assist the cultivation of vegetables and medicinal plants. Therefore, despite environmental limitations, it is possible to live in the semi-arid climate and biome. These are sustainable practices since they do not harm the environment.



Fig. 5. (a) A Plate cistern in Pajeú and (b) its protection sign
Source: Made by the authors (2018)



Fig. 6. (a) Coriander plantation (Coriandrum sativum) and (b) water torrent cistern in Pedra de Fogo
Source: Made by the authors (2018)

As shown in Fig. 7(b), one of the countless benefits provided by this social water-catching technology is reflected in the possibility of producing foods such as papaya, tomatoes, gherkins and raising small animals (Fig. 7(a)). It is worth mentioning that families only get this cistern after the approval in P1MC. They report an improvement in their lives since besides consuming, they sell at the fair, and with the money from sales, it is possible to buy other products necessary for food.

Before the technology implementation, the Pedra de Fogo residents collected water from wells and tanks that were far. The SISAR water supplying program does not comprise this location. Although SISAR supplies Pajeú village, its water is saline and improper for consumption and irrigation.

Given the situation of the communities, both of them have cisterns for consumption and production. They assist crops and improve the quality of life despite the bad-quality water supplied by SISAR in Pedra de Fogo. Therefore, the principal water source is a social technology. It has assisted life in such an environment through the productive backyards, generating income to support the family, besides breeding small animals.

The principal activities in Pajeú and Pedra de Fogo are the subsistence agriculture and raising cattle, sheep, goats, pigs, and small poultry. Supported by social technology, these activities are active since there is enough water for animals and productive yards.

The access to the water collection technology represented an improvement in the quality of life, as stated by Malvezzi [23], who emphasized that the advantage of this technology is that it is low-cost and allow for a thorough use of water and soil since there is no waste and no aggression to the environment. The families start mastering the techniques they need, and the quality of their food and water improves with positive effects on health and income.

In the Coreaú Watershed, many dams have already been built [24], among them the Mucambo one (Fig. 8). It is significant for the municipality because it is where tank truckers get water when cisterns get dry.

The dam represents a surface runoff that is artificially controlled by damming a river. It plays a fundamental role as a water source and is an alternative for local communities instead of wells, cisterns, and tanks [2]. In 2017 the dam was dry, which has caused a water shortage in the municipality. However, in the following year, there was a considerable volume of water.

Given the natural characteristics of the semi-arid region, such as the drought, there was the need for government actions to mitigate the effects and store water so people could use it in the dry season. In this sense, it is possible to mention the dam policy implemented by DNOCS, which built dams in the semi-arid region. This action prevailed and is still exceptionally adopted today.



(a)



(b)

Fig. 7. (a) animals around the backyard and (b) a family cropping system

Source: Made by the authors (2018)

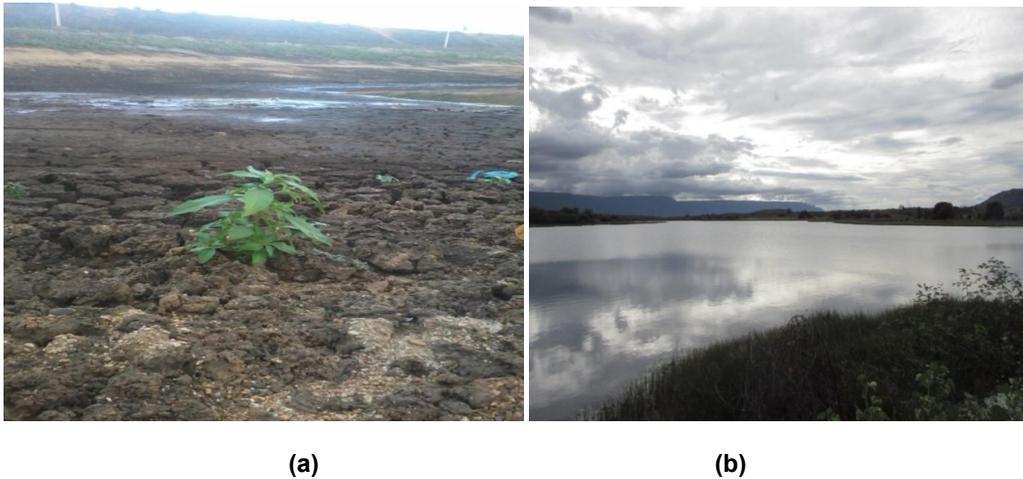


Fig. 8. Mucambo dam in the (a) dry and (b) rainy seasons

Source: Made by the authors (2018)

6. CONCLUSION

In this light, social technology is more than an alternative for living in the semi-arid region since it helps farmers deal with the climate and biome. Therefore, Mucambo has received benefits from such technological devices that deliver alternatives for collecting and storing water, providing security during the dry season.

The results highlight the social technology benefits, being the most significant water source for families living in rural areas. It delivers a better quality of life because the cisterns store water properly over the year. Besides, such policies are necessary for the Northeastern semi-arid region because they show that it is possible to live sustainably in an environment with limitations.

Therefore, one can see the importance of this social technology in human development, social climbing of individuals, and local agricultural support. Besides, the implementation of the devices in the semi-arid region made families confident concerning the water quality.

Thus, it is essential to implement more devices in the communities since not all families have them. There must be more technical assistance projects so that people learn about their region. Also, it would help them to handle cisterns more efficiently to obtain positive agricultural results.

Given the research results, the cisterns are relevant for consumption and production in rural areas since people reported that they store water in good quality. Furthermore, the communities improved in organization and solidarity among the dwellers. Using such technology is a collection and storage form, improving the local quality of life.

CONSENT

As per international standard or university standard, respondents' written consent has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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