



2nd Water Cisterns: Social technologies promoting adaptive capacity to Brazilian family farmers

Cisternas de 2^a Água: tecnologias sociais promovendo capacitação adaptativa às famílias de agricultores brasileiros

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ABSTRACT: Brazil is the tropical region of the world that heated up the most during 1901-2012. Over the years, in face of the constant shocks related to the drought periods in the Brazilian semiarid region, the governments have leaned on two distinct policy responses - to fight against drought and cope with drought, the latter mainly characterized by the expansion of social technologies related to rainwater harvesting. Among those, the water reservoir called “cistern” has been changing small farmers’ lives since the early 1990s, when the discussion about “Coexistence with the Semiarid” started by the Brazilian civil society. This research focuses on the Cisterns Program, more specifically to the 2nd Water Cisterns, a social technology that aims to improve productive capacity and reinforce food security of beneficiaries. The research goals are: 1) To present the main impacts of the 2nd water cisterns in three semiarid states: Pernambuco, Bahia and Ceará and 2) To discuss the impacts of cisterns in the promotion of adaptive capacity through social learning. The conceptual theory is based on social learning and adaptive capacity, and it is argued that farmers acquire extensive knowledge about coexistence with the semiarid, which will possibly benefit them in a climate change scenario. The assessment is based on document analysis, fieldwork and open/semi-structured interviews, 39 households and five rural technical assistance workers responsible to implement the cisterns were interviewed. The findings suggest the positive impacts of 2nd water cisterns extend beyond water infrastructure, with relevance for food security and

adaptive capacity through social learning activities as farmers presented an increased confidence in their own knowledge and capabilities as a result of the cisterns implementation process.

Keywords: semiarid; adaptive capacity; cisterns; social learning.

RESUMO:

O Brasil é a região tropical do mundo que mais aqueceu durante 1901-2012. Ao longo dos anos, diante dos constantes choques relacionados com os períodos de seca na região semiárida brasileira, os governos adotaram duas respostas políticas distintas –combater a seca e cooperar com a seca, sendo que a última é caracterizada principalmente pela expansão das tecnologias sociais relacionadas com a captação de água da chuva, entre elas o reservatório de água chamado “cisterna”, que tem mudado a vida dos pequenos agricultores desde o início dos anos 90, quando a discussão sobre “Convivência com o Semiárido” começou na sociedade civil brasileira. Esta pesquisa concentra-se no Programa Cisternas, mais especificamente nas Cisternas de 2ª Água, uma tecnologia social que visa melhorar a capacidade produtiva e reforçar a segurança alimentar dos beneficiários. Os objetivos desta pesquisa são: 1) apresentar os principais impactos das Cisternas de 2ª Água em três estados do semiárido: Pernambuco, Bahia e Ceará; e 2) discutir os impactos das cisternas, promovendo a capacidade adaptativa por meio da aprendizagem social. A discussão é baseada na teoria da aprendizagem social e da capacidade adaptativa e argumenta-se que os agricultores adquirem conhecimentos vastos sobre a coexistência com o semiárido, o que possivelmente os beneficiará num cenário de mudança climática. A pesquisa se baseia na análise de documentos, no trabalho de campo e em entrevistas abertas/semiestruturadas, onde entrevistamos 39 famílias e cinco Técnicos de Assistência Técnica e Extensão Rural responsáveis pela implementação das cisternas. As conclusões sugerem que os impactos positivos das Cisternas de 2ª Água vão além da infraestrutura hídrica e a sua relevância é para a segurança alimentar e a capacidade de adaptação por meio de atividades de aprendizagem social, uma vez que os agricultores apresentaram uma maior confiança nos seus próprios conhecimentos e capacidades como resultado do processo de implementação da cisterna.

Palavras-chave: semiárido; capacidade adaptativa; cisternas; aprendizagem social.

1. Introduction

Smallholder farmers will have to adapt to a world of increasing climate change. Climate models indicate that semi-arid regions around the world are likely to experience increased rainfall variability and longer droughts in the coming years (PBMC, 2014). In addition to Brazil being the tropical region with the highest increase in temperature during 1901-2012 (IPCC, 2014), IPCC global scenarios (RCP4.5 and RCP8.5) suggested a warming of 0.5-2,0°C for the Brazilian Northeast region between 2016 and 2035 (IPC-IG, 2016). The likelihood of more intense and frequent extreme events in this

region will have direct and indirect impacts on natural and social systems, especially due to the elevated reliance on scarce and seasonally variable water resources of inhabitants of rural areas (Burney *et al.*, 2014; Lindoso *et al.*, 2014).

Individuals dependent on climate-sensitive activities (*e.g.*: agriculture) will be exposed to irreversible productive losses, which may increase their vulnerability and force them to abandon their land and migrate to urban and marginal areas (Krol & Bronstert, 2007). Rain-fed farming is more vulnerable to drought impacts compared to irrigated farming (Krol *et al.*, 2006), even though these farmers may have some degree of coping capacity, their ability to adjust and thrive in changing conditions (adaptive ca-

capacity) is what determines their resilience in the long term (Burney *et al.*, 2014). Among the variables that influence individuals' capacity to recover from the many impacts related to drought, i.e. socioeconomic and environmental ones, are the public policies aimed to manage risks, protect and improve livelihoods and reduce vulnerability (Shiferaw *et al.*, 2014).

In this context, Brazil has historically implemented two distinct policy responses to deal with drought impacts, fight against drought, and cope with drought (Campos, 2015). Fight against drought comprises mainly policy responses to drought based on large reservoirs to deal with the impacts of drought and emergency actions to help during crises (Nys *et al.*, 2016). Cope with drought, in its turn, in this research derive from the ideas of 'coexisting with the Semiárido' supported by a social movement (Articulação Semiárido Brasileiro, ASA) and defined as "the lifestyle and production choices that respect local knowledge and culture by using technologies and procedures appropriate to the environmental and climatic context" (IRPAA, 2005). This last approach gained prominence by the expansion of social technologies (ST). In the Brazilian Semiárido context, one of the examples are the water reservoirs to harvest rainwater known as "Cisternas" (in Portuguese). As a core component of the 'cope with drought' policy responses, the cisterns started within the scope of civil society and later became a public policy fostered by the federal government (Machado & Rovere, 2017).

A public policy that increased the implementation of the water reservoirs, the Cisterns Program – Law No. 12.873/2013 (Brasil, 2013), regulated by Decree No. 9.606/2018 (Brasil, 2018) – has been over the years responsible for the expansion of 1st and 2nd Water Cisterns broadly in Brazil (Costa

& Dias, 2013). The first, known as consumption cisterns, aims to improve the access of water for human consumption, while the latter, the production cisterns, aims to support small-scale productive activities. Both technologies were created with the ultimate aim of helping farmers and other vulnerable populations in attaining food and nutritional security, through access to water in an amount and quality appropriated for family consumption (*e.g.*: cooking and drinking) and water sufficient to keep the activity of subsistence agriculture in their backyards or in the field.

The existing body of research on cisterns focus mainly on the 1st Water Cisterns or considers both cisterns. For example, previous research has established that social vulnerability is reduced at the local level driven by the 'cope with' strategies (Silva & Barros, 2016; Gualdani & Sales, 2016; Lindoso *et al.*, 2018; Escórcio & Dutra, 2018). Others, with focus only on the 2nd Water Cisterns, showed the importance for food production (Gonçalves *et al.*, 2013; Ferreira *et al.*, 2015).

However, given a research gap identified in understanding to what extent the impacts of the Cisterns Program goes beyond the water infrastructure and promotes adaptive capacity through social learning, this research aimed to fill those gaps with an assessment based on document analysis, fieldwork and open/semi-structured interviews with farmers and rural technical assistance workers in the Brazilian Semiárido. As an innovative research due to its focus on the 2nd Water Cisterns, there are two primary aims: 1) To present the main impacts of the 2nd Water Cisterns in three Semiárido states: Pernambuco, Bahia and Ceará and 2) To discuss the impacts of cisterns promoting adaptive capacity through social learning.

2. Conceptual framework

Originally, social learning referred to the learning of individuals in a social environment by observation and imitation of others (Bandura, 1977). A major step in reaching more conceptual clarity has been proposed by Reed *et al.* (2010) defined social learning as a change in understanding, that goes beyond the individual and occurs through social interactions. The interactions considered in this study are the training activities of the Program, that are described later in this section.

In previous studies on social learning, Rodelas' (2011) systematic review indicated that three research approaches to social learning have been developed in the natural resource management literature. The first is an individual-centric perspective, where learning is seen as transformative, resulting from individuals' participation in learning activities, and resulting in changes in individual behavior. The second perspective is network-centric, where learning is experiential and leads to changes in established practice and ways of relating among members of a common network or community. The third perspective is system-centric and sees learning as a process emerging from engagement with or around social-ecological systems and resulting in more systemic transformations that improve the sustainability of these systems. Ensor and Harvey (2015) argue these are closely related to the work on adaptive co-management of social-ecological systems (Folke *et al.*, 2005), and are exemplified in the work undertaken by Browning-Aiken *et al.* (2014) as a tool to build adaptive capacity. In this research, we agree with this latter standpoint, whereby argues that social learning can be viewed as an adaptable and flexible learning mechanism.

Beyond those three perspectives presented by Rodela (2011), we further structure our analysis also considering the interplay between social learning and adaptive capacity (AC) proposed by Thi Hong Phuong *et al.* (2017). They suggest a perspective that considers social learning as an important component of AC. Social learning is one mechanism among others (*e.g.*: collaborative learning and experiential learning) that can help develop AC.

Adaptive capacity can be widely interpreted as the ability of people and institutional systems to cope with incremental and rapidly changing conditions (Smit & Wandel, 2006), for instance by shaping actors' abilities to plan and implement adaptation, as well as their capacities to overcome multiple types of sociopolitical constraints (Biesbroek *et al.*, 2013). Vulnerability and adaptive capacity are closely linked concepts: adaptive capacity is one of the determinants of vulnerability, in addition to exposure and sensitivity. This paper only focuses on adaptive capacity in simple terms as the ability to adapt, situated in line with the ideas of coexistence with the semiarid and adaptation to climate change (Cunha & Paulino, 2014). Recent evidence suggests that cisterns are appropriate technologies to increase the adaptive capacity of households in the Brazilian Semiarid (Lindoso *et al.*, 2018).

2.1. Social technologies are facilitators of social learning

Facilitation is a central attribute of social learning (Steyaert & Jiggins, 2007; Muro & Jeffrey, 2008) and is considered a critical pathway for extending knowledge about farm management (Pretty & Chambers, 2003). Facilitating social

learning is the capacity to design a process in which different stakeholder groups engage diverse forums and activities so that knowledge is generated, and ideas, values, and perspectives are shared and can be contested. The art of facilitating social learning is to create situations where people can learn collectively how to improve their livelihood (Bouwen & Taillieu, 2004).

Social technologies are instruments of social transformation and can be products, techniques, or methodologies that arise from the interaction among the community (Rodrigues & Barbieri, 2008), and which aim to solve problems through the use of simple or practical techniques from accessible knowledge. The concept of ST is defined by “set of techniques, transforming methodologies, developed and/or applied in interaction with the population and appropriated by it, which represent solutions for social inclusion and improvement of living conditions” (ITS, 2004, p. 130, translated by authors). The implications of the ST concept is correlated to three axes, with the first related to the relationship between the production of science and technology and society, emphasizing the need to include social demands as a subject for scientific investigations. Secondly, it focuses on knowledge for the solution of social problems encountered by the population. Finally, relates to a particular way of intervening on concerning social issues.

Considering the 2nd Water Cisterns, the object of this study, farmers who are selected to be beneficiaries are included in all process of technology implementation. The process is manifold, first with a training named water management for food pro-

duction (GAPA, in Portuguese), which takes place before the construction of cisterns and addresses issues related to production, involving agroecological principles and sustainable management of stored water. The second training is the simplified water for production system (SISMA, in Portuguese), which takes place after the construction of cisterns and where families set up a simplified watering system based on water savings. Finally, the third stage promotes exchanges between beneficiaries, on occasions where farmers share experiences about management and storage of their yield (Souza, 2014). All these trainings are based on the perspective of coexistence, which requires and implies a cultural and educational process, generating new learning about the Semiarid environment, as well as its limits and potentials (Silva, 2003).

In addition to the courses, another component is a production kit to ensure that the cisterns meet the expectations of improving production capacity integrated with the family food production system. The production kit or productive project—the terms are used interchangeably as a meaning to items that enables to strengthen the production of fruits and vegetables or the rearing of small animals such as poultry, goats and sheep—, among other productive project options that help increase production, income and food security of families.

The implementation of the kits happens with the support of rural technical assistance workers (RTAW)¹ who are responsible for seven individual assistance activities to monitor the production project and provide technical guidance. The families have an active role throughout the whole imple-

¹ Translation for Ater – Técnicos de Assistência Técnica e Extensão rural, in Portuguese

mentation process, as they are expected to help to build the cisterns, and to provide or prepare food for the workers during the construction (Brasil, 2017).

Here, we argue the cisterns are social technologies that are facilitators of adaptive capacity through social learning. Along with the social technologies farmers have training activities, which we believe are situations that facilitate social learning and where farmers can learn collectively how to improve their livelihood (Bowen & Taillieu, 2004), share experiences and learn about coexistence with the Semiarid conditions.

3. Study area and research methods

The Northeast region extends over 1,600,000 km² of the Brazilian territory and has 62% of its area in the Polygon of Droughts, a semiarid region of 940,000 km², that covers nine states in the Northeast (86% of the region). This area faces a recurrent problem of water shortage, with rainfall below 800 mm per year (Marengo, 2008).

From 2011/2012 to 2017 an extended drought period hit the region, and was considered one of the most significant droughts in Northeastern Brazil in the last 50 years (WMO, 2014). This region is home to approximately 27 million people (CONDEL, 2017), with a population that corresponds to 13.4% of the total in Brazil, and has 60% living in urban areas and 40% in rural lands.

This exploratory study was conducted by researchers, who were accompanied by RTAW from institutions responsible for implementing policies at the local level. This study used qualitative methods to explore context-specific conditions addressing research questions. We employed a multiple case-

study approach to explore learning in rural communities that had access to the cisterns associated with training activities. One limitation of this study was having the RTAW with the research team, which might have intimidated the farmers to give non-biased answers about their performance on the job.

Two fieldwork activities occurred in November/2017 and September/2018. The study communities were purposively sampled since the RTAW were familiar with the families, and also because most of the families included in the policy programs are from the Northeast region. We interviewed family farmers from seven municipalities in three different states (Ceará, Pernambuco, and Bahia) (Figure 1).

We also interviewed RTAW who worked directly in the Program at the local level. They work for civil society organizations that are certified by the Ministry of Citizenship (former Ministry of Social Development) to implement the Program.

The questionnaires covered different topics, such as changes in assets, main challenges faced, status of family agriculture in the region, emergency initiatives, drought management, cisterns implementation processes, and climatic impacts. Some questions were explored in more detail during the fieldwork in Ceará due to the improvement in knowledge about the Program throughout the development of the research. Also, all participants signed a term of informed consent before responding to the interviews.

The responses to both types of the questionnaire were annotated in the field and subsequently transcribed by the researcher who conducted the interview, as well as the questionnaires with the field technicians. The questionnaire of beneficiaries had a high sample number (N = 39), for this reason, it was also explored quantitatively.

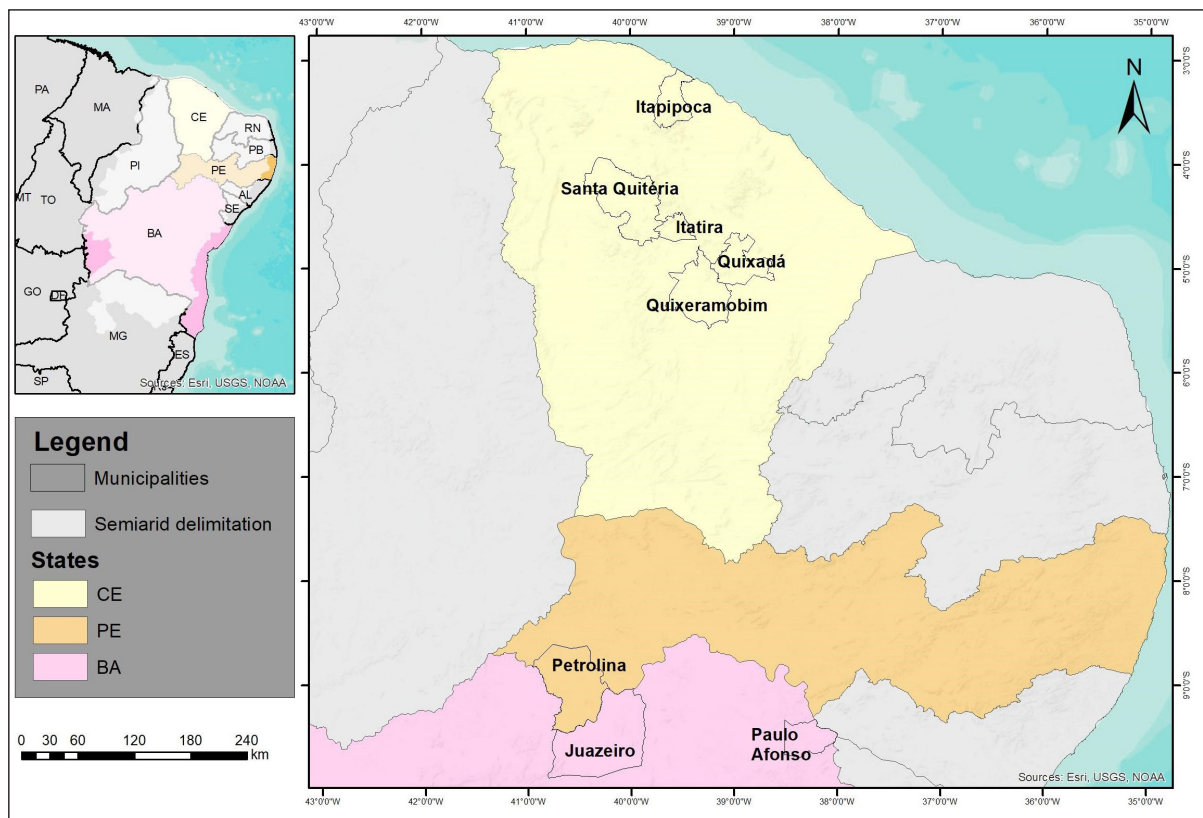


FIGURE 1 – Study area.

The responses tabulation consisted of organizing qualitative data into categories and questions where it was possible to identify presence/absence (yes/no). Therefore, the analysis involved a reading of the statements and subsequent classification by the responsible researcher. Since some questions were open, in some cases the interviewees choose not to answer. In the data analysis below it was chosen to maintain the representation of the percentage of answers over the total number, including the

doesn't know/no answer (DK/NA), so that results were not inflated in some alternatives.

Lastly, as some alternatives were answered with more than one response category (e.g., variety of topics they learned during trainings on Table 2), the 'N count' indication was used, which expresses the percentage of the total number of counts of all the categories answered, by total respondents in each question.

4. Results

Overall, we visited 39 households (N) in three different states (Bahia, Pernambuco, and Ceará) and interviewed 50 farmers. Their ages varied between 50-59 years (28% of farmers), 60-69 years (22%) and 40-49 years (18%).

The majority of families (38%) had the 2nd Water Cistern for a period of one to three years. Farmers with the shortest time had it for a year or less (28%), whereas the longest had it between seven and nine years (3%). Before the cisterns, the water source for food production was mainly rainwater (38%), small water reservoir for domestic uses (15%), and rustic wells (*cacimba*, in Portuguese) (10%).

The majority of farmers (85%) mentioned there were problems due to the lack of water for production before the cisterns, such as the distance to access water (18%), a difficulty for cultivating crops (15%) and the absence of a reservoir to store water (6%). 58% did not specify the problems they faced (Table 1). In general, the interviewees perceived negative impacts that emerged from the limited access of water for production, with impacts on food (67%) and well-being (61%), followed by income (48%) and health (30%). As mentioned by two interviewees: *“for washing clothes, for everything [used to lack] ...”*; *“affected everything ... without water [we] are nobody ... [we didn't have it for even] to have a shower... “*.

After the implementation of cisterns, the social technology became the main source of water for production. Considering only the 16 farmers interviewed on Ceará state, cisterns' water was used mainly for irrigation (88%), for animals (38%), domestic uses (19%), to drink and cook (6%), and

TABLE 1 – Problems caused by lack of water before the 2nd Water Reservoir.

Problems caused by lack of water (N _{yes} = 33)		
	N	%
Distance to access the water	6	18
Unable to plant	5	15
No reservoir to store the water	2	6
Cost of purchasing water	1	3
DK/NA	19	58

other uses, such as fish farming and private water storage (13%). Farmers started to produce new varieties of vegetables (67%), with 58% of this starting to produce more than five varieties of vegetables, and 31% between two and five types.

Also, considering the 16 interviews, as for the productive kits that are received with the cisterns, 69% received it in full – which means, for example, bricks for building vegetable gardens, hose pipe for the drip system, dark fences for shading and vegetable seeds. The type of productive project was not chosen by the farmers in 87% of cases (13% have not answered). The production kits were mainly composed of seeds for the vegetable gardens (69%) and fruit seedlings (6%). Among those who received the production kit with seeds and seedlings, 75% were successful and managed to plant, with 89% still having part of the seeds to plant on other occasions.

In general, the interviewees were satisfied with the type of productive project they have received. Most stated that they would not have chosen other items (63%), whereas 9% mentioned they would have liked to have chosen a hennery. For 94% of the beneficiaries, the productive kit was delivered at the same time as the cistern.

As for the construction of cisterns, 50% reported receiving some assistance (food baskets or cash) to help with feeding the masons and servants. Regarding the construction of cisterns, 49% reported the construction was with a task force with neighbors, 41% by hired servants, and 3% only with the help of their relatives.

As a measure of income increase, farmers were asked whether they obtained income after selling products yielded, if they had bought goods for the household and if they were spending less on food purchases. Of the 39 interviewed farmers, 38% mentioned the water reservoir changed family income, followed by 33% saying they were able to buy structure for the vegetable garden, buy seeds (20%), or renovating their homes. Related to savings in food purchases, 41% spent less money on groceries.

Regarding training activities (GAPA and SISMA), 82% reported that courses were essential. Some interviewees mentioned (Table 2) gaining knowledge about how to plant and harvest (35%) and water management (25%). About organic pesticides and fertilizers, 11% made use, with one participant mentioning “*I learned to produce herbicide in the trainings. They taught me a natural mixture of neem leaves and tobacco so ants go away*”. The experience related to the exchanges among farmers was positive, however only 63% had this experience. Of those, it was mentioned they had learned about agricultural practices with hands-on activities and some theoretical topics. One farmer cited the exchange was important because it was possible to learn with other farmers alike him. “*I saw the experience of others, then I will make my own experience*”.

TABLE 2 – Topics learned in trainings.

Topics learned in trainings (<i>N = 71 among beneficiaries who answered N = 32</i>)*	N_count%
Plant and harvest	35%
Water management	25%
Water reservoir maintenance	13%
Organic pesticides and fertilizers	11%
Animals care	8%
Harvest storage	1%
Examples of farmers elsewhere	1%
Earn Income	1%
Avoid the use of chemical pesticides	1%
Other uses of water reservoir infrastructure (<i>e.g.: to dry seeds</i>).	1%

**More than a valid answer per interviewee; N count% - number of answers.*

None of the interviewees perceived the courses as unnecessary. Regarding the informative materials distributed in the courses, 75% had received some material, and 42% of those mentioned they were still of some use.

The productive projects were considered still in progress by 87% of farmers. However, they mentioned some aspects that could help to improve production, such as 1) more financial resources (32%): “*[yes, it is going forward], but needs more resources ... money to expand, buy more seedlings, expand bees and fish ... I have expanded my production little by little*” and “*there is still a lot to improve... I wanted to expand the area with a fence to plant more... if we plant outside, chicken spoils*”. 2) structure to protect from the sun (15%): “*the hot sun weakens and burns the garden, I have to buy a canvas to make shade and protect from the hot sun... the coriander burns*”. Another response to this question was the need for more water (15%), and others, such as the permanence of technical assis-

tance for a longer period. One interviewee argued she tries to grow her flowerbeds, and sometimes, she has some questions that would be worth to have someone to ask, she said: “*you have to have more knowledge...[we] try one way and another, but it doesn't come out...*”. 5% of farmers mentioned productive projects were not progressing because of the lack of RTAW or that they needed some equipment, such as a tractor. Another 8% of interviewees did not have an opinion.

The challenges to earn a living from their production was emphasized by 77% of the interviewed farmer, with the most expressive being water scarcity (63%), strong solar irradiation (13%) and lack of technical training (10%) (Table 3).

TABLE 3 – Challenges to live from production.

Presence of challenges to live from production (N=39)			Type of challenge (N_yes*=30)		
	N	N%		N	N%
Yes	30	77%	Water scarcity	19	63%
No	5	13%	Lack of financial resources	2	7%
DK/NA	4	10%	Strong solar irradiation	4	13%
			Lack of RTAW	3	10%
			Unfair prices	1	3%
			DK/NA	1	3%

*percentage based on the affirmative answers.

Interestingly, when questioned if having a cistern could contribute to the coexistence with the Semiarid and dealing with extreme droughts, some felt that cisterns increase the ability to coexist with the Semiarid (67%), while others considered that the cisterns might help but it is not a determining factor (26%) (Table 4).

TABLE 4 – Cisterns, coexistence with the Semiarid and coping with extreme events.

Coexistence with Semiarid and coping with extreme events (N=39)	N%	Ways in which coexistence is increased (N_yes=26)	N%
Yes	67%	Permanence in their land	50%
No	0%	Water storage	15%
Maybe*	26%	Production	19%
DK/NA	8%	DK/NA	15%

* N=3 – helps, but if the person genuinely wants, otherwise they will move elsewhere; N=3-helps, if the person is willing to work.

Table 5 provides results on the beneficiaries’ perception related to impacts from the Program. Among the interviewees it was highlighted a perception of improvement in their quality of life (82%), food (77%), greater willingness to stay on the land (75%), greater confidence as producers (64%) and greater technical knowledge (62%). The role of women was highlighted as having shown improvement in 81% of the households visited. Of those who reported improvements in food, 19% mentioned improvements linked to the greater quantity of food consumed, higher quality (without agrochemicals) (19%), and greater consumption of vegetables (16%) (Table 6).

TABLE 5 – Perception of impacts by beneficiaries.

Sector (N=39)	Better	Worse*	Equal	DK/NA
Life quality	82%	0%	18%	0%
Food	77%	0%	23%	0%
Income	46%	0%	38%	15%
Technical knowledge	62%	0%	23%	15%
Health	23%	3%	56%	18%
Relationship with family	33%	0%	54%	13%
Relationship with community	21%	0%	72%	8%
Confidence as a producer	64%	0%	21%	15%
Willingness to stay in land	75%	0%	19%	6%
Role of women in production	81%	0%	0%	19%

* Unrelated to the cisterns.

TABLE 6 – Impacts related to food.

Category (Ncount in N_yes= 30; Ncount=32)	N%
More fruits	3%
More vegetables	16%
More meat	6%
Greater amount	19%
Improved quality (organic)	19%
DK/NA	38%

4.1. Rural technical assistance workers

Of the five interviewed RTAW, all of them attended training activities provided by the institutions they belong before starting the work with the implementation of cisterns. The courses had theoretical and hands-on components, aiming to strengthen their capacities to teach farmers, and according to the objectives of the Program.

The rural technicians believed the courses (GAPA and SISMA) were essential for farmers succeeding with the cisterns and the productive project. It was argued that in the training activities, beneficiaries began to have more awareness about the role of cisterns in coping with the semiarid conditions, as well as with the main goals of the public policy. During those moments, farmers had questions answered, and were provided with anticipation of problems that could happen during the implementation process or later.

Despite the positive impacts of courses, concerns were expressed about the family member who used to attend the meetings: “...sometimes the husband goes, but the one who has vocation is the one who is there [in the backyard]”. In these specific cases, it was argued that in some cases men attended the training activities, while women were the ones

with more skills or availability (since they used to stay more at home) to work with the backyard garden or small livestock (goats and sheep).

Regarding the motivation of beneficiaries, different behaviors were identified. In some cases, most of the beneficiaries were motivated in the first place and kept it through the process and over the years. Others were motivated in the beginning but were discouraged by the associated costs and work related to the reservoir. This view was echoed by another informant who mentioned: “*motivation in the 1st year is high ... from one year to a year and a half, it decreases a little. If it doesn't rain, the water runs out and then the water trucks have to deliver some water*”. Another field technician mentioned that about 80% of those who received the technology was able to “*go forward*”, however not all technologies or policies are suitable to all farmers, and that there were even cases of farmers who were not interested in the Program. Finally, it was mentioned that some farmers who were motivated at the beginning were discouraged along the way, perhaps because they realized the technology was not suitable for a certain use they had in mind, or even just considered to use the cistern as a reservoir for domestic uses.

About the impact of the 2nd Water in the coexistence with the Semiarid and with extreme droughts, one interviewee mentioned that obstacles to living in the region were mostly related to lack of water, which could lead to the abandonment of properties. It was complemented that “*if you have a cistern, you stay because you have the water to drink*”. Another exemplified “*before [the cisterns] when was a one-year drought, people moved to another city [or community] where there was a dam (Açude, in Portuguese) nearby*.”; “*Some left in 2015... five fam-*

ilies from one community left because of the drought but when it rained again they came back and now are producing with the 2nd Water cistern”. All technicians interviewed agreed somehow that cisterns, in addition to the production kit, positively impact beneficiaries in relation to the coexistence with the Semiarid and extreme droughts. However, there was a divergent opinion mentioning the greatest impact for the semiarid coexistence as expressed by the 1st water cistern, for the domestic uses. The Program is contributing to alleviate conditions of poverty and extreme poverty faced by farmers in the region.

The inclusion of the youngest people in the Program had common opinions. One technician mentioned a greater interest of young people in participating in activities with the family: “a young man who used drugs was integrated with his family” and “one young man was thinking about moving away and decided to stay...”. Other mentioned younger people who participated in the Program were deciding to stay in rural areas, instead of migrating to the city in search of work (e.g.: in shoe factories nearby) and that it was giving one more opportunity to people. Despite many people still not included in the Program, it was, in general, helping farmers who want to stay in rural areas: “the sertanejos want to stay in the sertão...”. An observation about the inclusion of younger people on the Program was that opportunities should arrive when this public is around 15 years old, when it is still possible to inspire them to stay in the rural area.

5. Discussion

The main pieces of evidence of social learning are acknowledgements regarding the importance

of trainings by farmers and RTAW, especially the influence of new technical knowledge on the production of food and agroecological practices adopted by farmers.

In all the household units visited, the production was already agroecological, the fertilizers used were all self-made (47% used fertilizers and 53% herbicides) and in most cases they were learned in the training sessions. The RTAW commented that there are improvements in technical knowledge for the beneficiaries who apply the lessons and are inquisitive. A comparison of the findings with those of other studies confirms the use of sustainable fertilizers is an adaptation strategy verified in other semiarid regions in Asia (Sivakumar *et al.*, 2005). In addition to that, in our study was observed a few changes related to the environment because farmers are preventing burning garbage and are changing their opinion about the harms caused by chemical pesticides.

Another important finding was that the impacts of trainings would be greater if farmers had access to a longer period of rural technical assistance. A permanent rural technical assistance was also mentioned as one of the necessary aspects for the productive project to persist over time. Despite this, 62% of the beneficiaries interviewed mentioned that technical knowledge improved after the arrival of cisterns, 23% said it remained the same, while 15% did not know or did not answer. A longer term relation between farmers and the RTAW would allow an increased number of meetings where farmers could try and adopt new techniques, and have concerns or questions answered. This would possibly increase their adaptive capacity through social learning as an adaptable and flexible learning mechanism of trials and errors.

The training activities influenced beneficiaries, both through the exchange of knowledge among them and through the techniques taught by the RTAW. Ferreira *et al.* (2015) pointed that the courses transmit knowledge about production techniques in the semiarid region, in addition to strengthening the bonds of families, while Gonçalves *et al.* (2013) found that the production cisterns contributed to the transition of a conventional agriculture to an agroecological agriculture and also to the replanting of native species. It is encouraging to compare this finding with smallholders in Peru, where training contributed to increasing social cohesion and technical communication among farmers, strengthening their social capital and innovation performance (Hartmann *et al.*, 2019).

The adaptive capacity of farmers is related to their capacity to adapt, take advantage of new circumstances and improve their livelihoods. The increase in productive assets was acquired with the farmer's savings. While beneficiaries are not buying food because they are producing with the cistern water, they can buy goods for home, for production or personal uses. Furthermore, the cistern is a valuable possession, since after the construction of the infrastructure it adds value to the property, increasing the chances to the farmers remain in the region. This is also in line with other observations, which showed that family assets increases with the acquisition of the reservoir to store water and the productive project (Ferreira *et al.*, 2015). This also aligns with observations which showed the potential for selling the surpluses and generating extra income in other case studies (Santos, 2017; Silva *et al.*, 2013; Gonçalves *et al.*, 2013).

A comparison of the purpose of the production before and after the cistern reveals that the number

of products designed for sale has increased. Before the cistern, 67% of the cases were for consumption, while consumption, and occasional sale, exchange or donation 26%, and only sale in 5%. After the cistern, the production designed only to consumption decreased to 33%, while production for consumption and occasional sale increased to 54% of the cases, and consumption and sale 13%. Despite this increase, it was still reported that 62% of the cases had difficulties to sell the products, which may be an obstacle to the increase of rural entrepreneurship. The beneficiaries claimed three main difficulties, the absence of transportation, of buyers, and insufficient production. They also mentioned unfair competition with conventional producers (those not producing organics), the introverted personality to attend markets, and the lack of sanitary certification for selling products in the formal markets.

Other benefits of cisterns were related to an increase in well-being, reported by 82% of the beneficiaries interviewed, with 23% also reporting improvements in health. As well-being is a subjective issue, there were several comments when investigating this issue, such as about beneficiaries no longer having to work for other people and getting water in distant locations, and being able to wash their hair while bathing. In a study focused on the production cistern in Pernambuco, Ferreira *et al.* (2015) also found that cisterns provided an improvement in farmers' quality of life.

One unanticipated finding was that all the positive changes in the family cannot be attributed only to the cisterns. The RTAW highlighted there were a set of public policies (*e.g.*: *Bolsa Família*, *Garantia Safra*, and rural technical assistance) that gave families access to information and allowed

them to shift their strategies and to guarantee an increase in income.

The increased water availability for food production corroborates with the findings of previous work in Paraíba, in the São Miguel community, where it was only possible to start growing vegetables, fruits and medicinal plants with the production cisterns (Araújo *et al.*, 2015). In our research, before the production cistern, 38% of the beneficiaries depended on rainwater for production, while after the cistern beneficiaries started growing new foods (67%), of which 58% started producing more than five varieties of vegetables and 31% of them, between 2 and 5 varieties. The lack of water to produce impacted the diet of most of the interviewees, however, the production cisterns solved these problems and allowed the increase and diversification of food production.

The increase in water storage has increased production capacity, as farmers were taught to manage water, produce, and stimulate agroecological practices. The RTAW emphasized that it is a satisfaction to see the farmer storing water and thus improving their food and, in some cases, selling surplus of production. The increase in water availability was seen as a trigger for this series of improvements, generating autonomy for families and reducing their political dependency.

The most interesting finding was that cisterns can contribute to the coexistence with the Semiarid and dealing with extreme drought, however, it is not a determinant factor, it triggers other changes that help farmers live in the region. One mentioned that the willingness to work is an important feature when combined with the cistern, “*it helps ... if you dare to work, it helps*”. The circumstance in which the cistern increases the coexistence with the Semiarid

was related to the likelihood of staying in the countryside for half of the farmers interviewed. One said: “*it is a pity to abandon the things we own with so much arduous work*”. As mentioned in the literature review, social learning is considered to be a device for fostering adaptive capacity since implementing climate change adaptation depends largely on the capacities of individuals, organizations, and communities (Thi Hong Phuong *et al.*, 2017).

6. Final considerations

This study found that in general the 2nd Water Cisterns are not a determinant factor, however, it helps substantially living in a Semiarid region. The contribution of this study has been to confirm that water availability is the main constrain in the Semiarid region and the social technologies triggers the adaptive capacity of farmers. With the support of social learning and adaptive capacity conceptual frameworks, we found that the positive impacts 2nd Water Cisterns goes beyond the water infrastructure. The relevance is also for food security, which means the policy addresses the problem for which it was designed, the guarantee of food and water security.

The training activities (GAPA and SISMA), which are part of the 2nd Water Cistern implementation, create social learning situations where people can learn collectively how to improve their livelihoods living in the Semiarid. Regardless, there are critiques to the social learning concept concerning its clarity and the difficult to measure. Our results support the idea that the 2nd Water Cisterns triggers new learning about the Semiarid environment, its limits and potentials, with participants presenting an increased confidence in their own knowledge and

capabilities as a result of the involvement process, contributing to their adaptive capacity.

The cisterns have a great potential in the face of climate change, as it contributes to many of the factors that increase the adaptive capacity of farmers and the agricultural system. However, the impacts can be amplified if, mainly, training activities and practices that facilitate social learning are planned and executed with the climate change factor in consideration.

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