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CONTRIBUTIONS OF THE UNDERGROUND DAM TO THE SUSTAINABILITY OF AN AGRO-ECOSYSTEM IN THE SERTÃO OF NORTHEASTERN BRAZIL

CONTRIBUIÇÕES DA BARRAGEM SUBTERRÂNEA NA SUSTENTABILIDADE DE UM AGROECOSSISTEMA DO SERTÃO DO NORDESTE BRASILEIRO

CONTRIBUCIÓN DE LAS PRESAS SUBTERRÁNEAS A LA SOSTENIBILIDAD DE UN AGROECOSISTEMA EN EL SERTÃO DEL NORDESTE DE BRASIL

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ABSTRACT
The underground dam is a social technology for capturing and storing rainwater underground. Its adoption has proven to be an effective strategy for living with the scarcity of rainfall in the Brazilian semi-arid region, reducing the climatic vulnerability of the region's productive units. Despite the growing adoption of underground dams, there are still few studies that systematically evaluate their contribution to the sustainability of family-based agricultural systems. Given this context, the aim of this study was to assess the impacts of underground dams on the economic, environmental and social sustainability of a family agro-ecosystem located in the semi-arid region of the state of Alagoas. The research was carried out with the participation of a farming family and local technicians, using tools from Participatory Rural Diagnosis and the MESMIS Methodology. The results show that the agro-ecosystem analyzed has a solid basis for sustainability, especially with the adoption of technologies for accessing and storing rainwater. However, some indicators revealed weaknesses that require integrated and continuous action in order to promote effective advances in the system's sustainability. As for the contributions of the underground dam, it was found that by integrating technical and local knowledge, it strengthens the cultural identity and protagonism of the rural family, promoting care for the land and the preservation of ways of life. The underground dam, as a social technology, not only improves the economic-ecological conditions of the agro-ecosystem, but also strengthens the social and cultural ties that sustain the family's resilience in the territory.

Keywords: Social water technology. Socio-economic and environmental impacts. Coexistence with the semi-arid region. Storing rainwater.

RESUMO
A barragem subterrânea consiste em uma tecnologia social de captação e estocagen da água da chuva no subsolo. Sua adoção tem se mostrado uma estratégia eficaz no convivio com a esscassez da chuva no Semiárido brasileiro, reduzindo a vulnerabilidade climática das unidades produtivas da região. Apesar da crescente adoção das barragens subterrâneas, ainda são escassos os estudos que avaliem de forma sistemática sua contribuição na sustentabilidade de sistemas agrícolas de base familiar. Diante desse contexto, o presente estudo teve como objetivo avaliar os impactos da barragem subterrânea

na sustentabilidade econômica, ambiental e social de um agroecossistema familiar localizado no Semiárido do estado de Alagoas. A pesquisa foi desenvolvida com a participação de uma família agricultora e de técnicos locais, utilizando-se ferramentas do Diagnóstico Rural Participativo e a Metodologia MESMIS. Os resultados apontam que o agroecossistema analisado apresenta uma base sólida rumo à sustentabilidade, especialmente a partir da adoção de tecnologias de acesso e estocagem da água da chuva. No entanto, alguns indicadores revelaram fragilidades que exigem ações integradas e contínuas, a fim de promover avanços efetivos na sustentabilidade do sistema. Quanto às contribuições da barragem subterrânea, constatou-se que, ao integrar saberes técnicos e locais, ela fortalece a identidade cultural e o protagonismo da família rural, promovendo o cuidado com a terra e a preservação dos modos de vida. A barragem subterrânea, como uma tecnologia social, ela não apenas melhora as condições econômicas-ecológicas do agroecossistema, mas também fortalece os laços sociais e culturais que sustentam a resiliência da família no território.

Palavras-chave: Tecnologia social hídrica. Impactos socioeconômicos e ambientais. Convivência com o Semiárido. Estocagem da água de chuva.

RESUMEN
La presa subterránea es una tecnología social de captación y almacenamiento subterráneo de agua de lluvia. Su adopción ha demostrado ser una estrategia eficaz para convivir con la escasez de lluvias en la región semiárida brasileña, reduciendo la vulnerabilidad climática de las unidades productivas de la región. A pesar de la creciente adopción de represas subterráneas, aún son pocos los estudios que evalúan sistemáticamente su contribución a la sostenibilidad de los sistemas agrícolas familiares. Dado este contexto, el objetivo de este estudio fue evaluar los impactos de las presas subterráneas en la sostenibilidad económica, ambiental y social de un agroecosistema familiar localizado en la región semiárida del estado de Alagoas. La investigación se llevó a cabo con la participación de una familia de agricultores y técnicos locales, utilizando herramientas del Diagnóstico Rural Participativo y de la Metodología MESMIS. Los resultados muestran que el agroecosistema analizado tiene una base sólida para la sostenibilidad, especialmente con la adopción de tecnologías de acceso y almacenamiento de agua de lluvia. Sin embargo, algunos indicadores revelaron debilidades que requieren una acción integrada y continua para promover avances efectivos en la sostenibilidad del sistema. En cuanto a los aportes de la represa subterránea, se constató que al integrar conocimientos técnicos y locales, fortalece la identidad cultural y el protagonismo de la familia rural, promoviendo el cuidado de la tierra y la preservación de formas de vida. Como tecnología social, la represa subterránea no sólo mejora las condiciones económico-ecológicas del agroecosistema, sino que fortalece los lazos sociales y culturales que sustentan la resiliencia de la familia en el territorio.

Palabras clave: Tecnología social del agua. Impactos socioeconómicos y medioambientales. Vivir en la región semiárida. Almacenamiento del agua de lluvia.

1 INTRODUCTION

All agricultural activity involves cultivation and breeding techniques that have been developed in order to meet the growing human demand for food, fiber, and fuel (CÂNDIDO et al., 2015). The way in which this activity is conducted affects to a lesser or greater extent the environment in which it is inserted, always seeking the sustainability of the agroecosystem and society as a whole (CONWAY; BARBIER, 2013).

Through the sustainability assessment, it will be possible to measure the conduct and management of agricultural activities developed within the scope of the agroecosystem, in the social, economic and ecological dimensions, as well as to observe the level of perspectives of farming families in the face of new proposals for cultivation systems, breeding and organization.

Sustainable agriculture is one that contemplates a diverse set of objectives over time, resulting in an evolutionary process, aiming at its multidimensional characteristic (PETERSEN et al., 2021). It is not only about achieving maximum yield, much less the development of economically viable, diversified and self-sufficient agroecosystems, but it comes from new designs of cropping systems that allow management based on local ecological processes, which promote resilience and equity in the food system (MOLINA; TOLEDO, 2011).

In studies based on agroecosystems, it is necessary to break the ideological barriers of traditional science and introduce new assumptions to research. In the perception of ALTIERE (2012), the study of the sustainability of agroecosystems should highlight its various dimensions (environmental, economic, social and cultural) as basic assumptions for the analysis of ecological conditions, the technology/practices adopted and the economic and sociocultural conditions of the actors involved.

Currently, the forms of production have evolved from a merely technical dimension and incorporated other dimensions of a socioeconomic, political, environmental, and cultural nature, which, according to Iaquino (2018), represent the concern about the sustainability of agriculture, whose broader understanding requires a greater understanding of the relationship between the agricultural context and the global environment as a whole, based on the interaction of biophysical, technical and socioeconomic subsystems.

Agroecosystem is understood as a *social unit of appropriation and conversion of ecological goods into economic goods* (PETERSEN et al., 2021). Its physical delimitation is demarcated by the environmental space appropriated by a Social Center for Agroecosystem Management (NSGA). In family farming, the NSGA is usually the family itself. The boundaries of the agroecosystem coincide with the divisions of the family establishment and encompass the ecological assets of these areas (land, water, biodiversity, etc.) (GLIESSMAN, 2009; GOMES: ASSIS, 2013).

In the Brazilian semi-arid region, the underground dam is a social water technology that has contributed to the sustainability of family-based agroecosystems by capturing and storing rainwater in the soil (subsoil). Its objective is to contribute to the sovereignty and water, food and nutritional security of farming families through the exploitation of low-flow agriculture and/or sub-irrigation (LIMA et al., 2018; SILVA et al., 2021a).

Its function is to block the flow of surface and underground water through a wall (impermeable septum) built transversely to the direction of the waters.

This dam allows water to be stored inside the soil with minimal moisture losses (slow evaporation), keeping the land moist for a longer period of time, until almost the end of the dry season in the semi-arid region (September-December), increasing access and its multiple uses (MELO & ANJOS, 2017; LIMA et al., 2018; SILVA et al., 2021b).

For greater efficiency of the technology, it is recommended that in the selection of the appropriate location, the recommended technical criteria/parameters are taken into account, as well as the guidelines for wall maintenance, soil, water and crop management. In recent years, there has been a great increase in interest in the implementation of underground dams in rural agroecosystems in the Brazilian semi-arid region. However, studies on the impacts of this technology on the agroecosystem and on the life of the farming family are few.

In order to provide information on the contribution of the underground dam to the resilience to climate change of a family-based agroecosystem, the present study aimed to evaluate the economic, technical-environmental and social sustainability of an agricultural production system with an underground dam, located in the municipality of Senador Rui Palmeira, in the semi-arid region of the state of Alagoas, in the Northeast region of Brazil.

2 METHODOLOGY

2.1 LOCATION OF THE STUDY AREA

The present study was carried out in an agroecosystem whose NSGA headquarters (Figure 1) is located in Sítio Cacimbinhas, a rural area of the municipality of Senador Rui Palmeira, in the state of Alagoas, with geographic coordinates of 9°24'1.33" S and 37°13'0.86" W, and an average altitude of 302 meters. The agroecosystem adopts sustainable practices aimed at the production of diverse foods, based on the principles of agroecology. Among the social technologies implemented, the underground dam and the use of native seeds adapted to local conditions stand out.

Figure 1. NSGA headquarters, Cacimbinhas Site (A); underground dam after first rains before water infiltrates (B); underground dam after forage cutting (C); underground dam in a dry period (D).

Source: Maria Sonia Lopes da Silva (A, C and D); Rosimeire Melo (B).

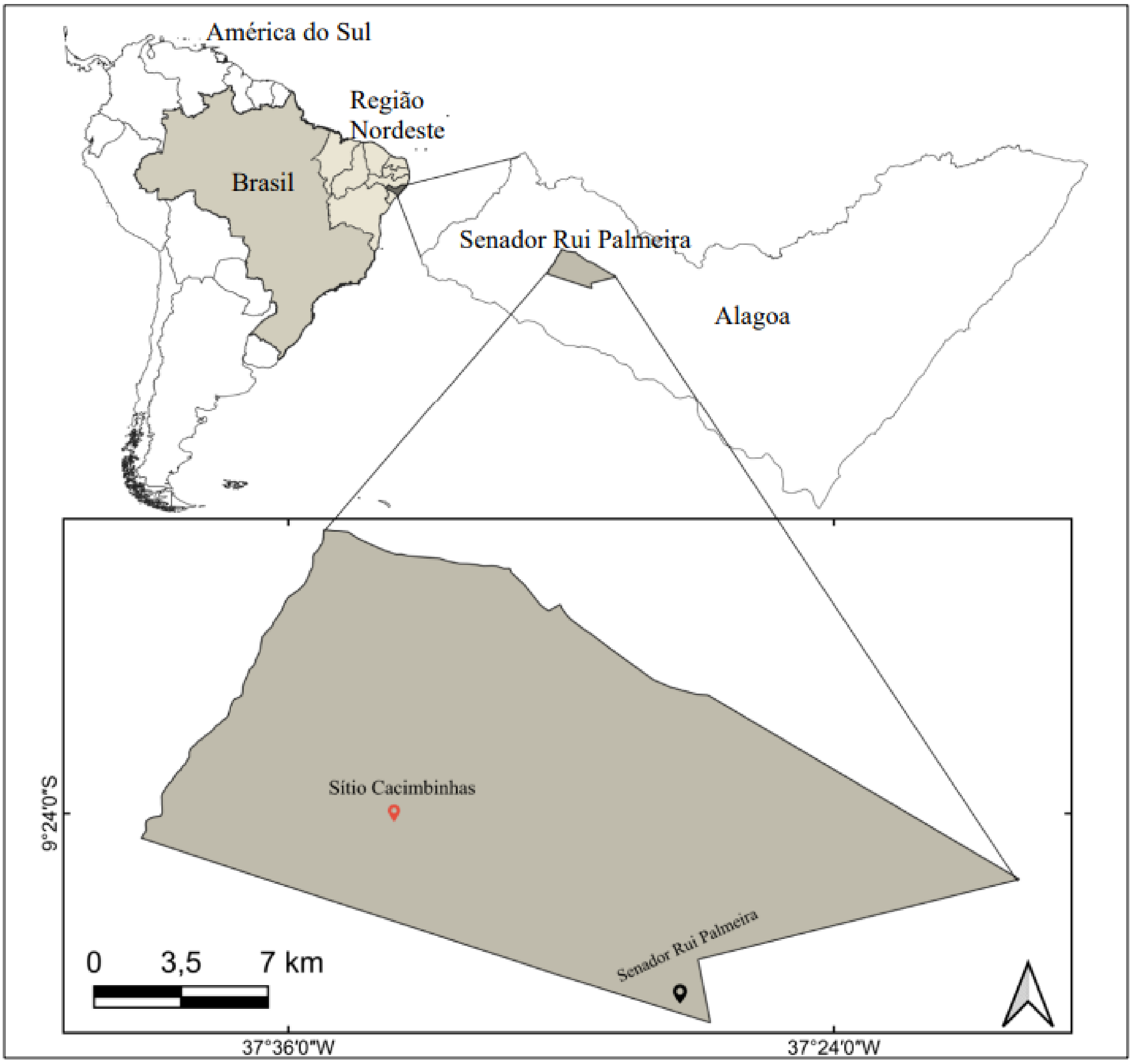
2.2 CHARACTERISTICS OF THE MUNICIPALITY OF SENADOR RUI PALMEIRA

The municipality of Senador Rui Palmeira is located in the west of the state of Alagoas, in the semi-arid region of the Brazilian Northeast (Figure 2). It is limited to the north by the municipalities of Canapi and Poço das Trincheiras, to the south by São José da Tapera, to the east by Santana de Ipanema and Carneiros, and to the west by the city of Inhapi (MASCARENHAS et al., 2005).

The municipal area occupies 359.71 km2 (1.30% of the state) and is inserted in the mesoregion of Sertão Alagoano and in the microregion of Santana do Ipanema. The seat of the municipality has an approximate altitude of 360 m and geographic coordinates of -09º 27' 59" south latitude and 37º 27' 25" west longitude (IBGE, 2025).

Senador Rui Palmeira is located approximately 236 km from the capital, Maceió, and has basic health, education and transportation services. The road infrastructure allows the connection with neighboring cities, facilitating the flow of agricultural production and access to regional markets. The Municipal Human Development Index (MHDI) is 0.518. In summary, Senador Rui Palmeira is a municipality that, despite the socioeconomic and environmental challenges, has potential for sustainable development.

Figure 2. Location of the Cacimbinhas Farm in the municipality of Senador Rui Palmeira, Alagoas.



Source: Authors (2025)

2.2.1 Physiographic aspects

The predominant climate is the semi-arid, characterized by long periods of drought, with low humidity and little rainfall. The rainy season begins in January/February and ends in September, and may last until October. According to Köopen, the climate is classified as BSh, average annual temperature of 24.6 ° C and precipitation of 569 mm (SECRETARIA DE ESTADO DO PLANEJAMENTO...., 2025).

The vegetation is of the Hyperxerophilous Caatinga type, with occurrences also of Subdeciduous and Deciduous Forests. The relief is generally busy, with deep and narrow valleys dissected (IBGE 2025).

The municipality is located in the Geoenvironmental Unit of the Borborema Plateau, formed by massifs and high hills, with an altitude ranging from 650 to 1,000 meters. It is geologically inserted in the Borborema Province, encompassing rocks of the gneiss-migmatitic basement, dated from the Archean to the Paleoproterozoic and the metamorphic sequence arising from tectonic events that occurred during the Meso and Neoproterozoic. It is represented by the lithotypes of the Cabrobó Complex, Indiscriminate Granitoids and Chorrochó Suite (MASCARENHAS et al., 2005).

The predominant soils are of the Ultisol type, on the tops and slopes of the low, well-drained undulating valleys; and in the valley bottoms the Fluvic Neosols predominate, poorly drained and in the residual ridges occur the Litholic soils, poorly drained. With respect to fertility, it is quite varied, with a certain predominance of medium to high fertility (SANTOS et al., 2013).

2.2.2 Socioeconomic activities

The municipality has an estimated population of 12,303 inhabitants, according to the 2022 Brazilian Demographic Census. A territorial area, in 2023, of 338,569 km2 (IBGE 2025).

The main economic activities of the municipality are: commerce, services, agriculture and plant extractivism and forestry activities. In agriculture, family-based agriculture stands out, especially with bean and corn crops, on a smaller scale there is fodder (grass and forage palm) and cassava. Scarcity of rainfall, lack of labor and the use of rudimentary soil preparation techniques pose challenges for the agricultural sector. In the livestock area, it has herds of cattle, pigs, goats, sheep and poultry. It has milk, eggs and honey production (MASCARENHAS et al., 2005).

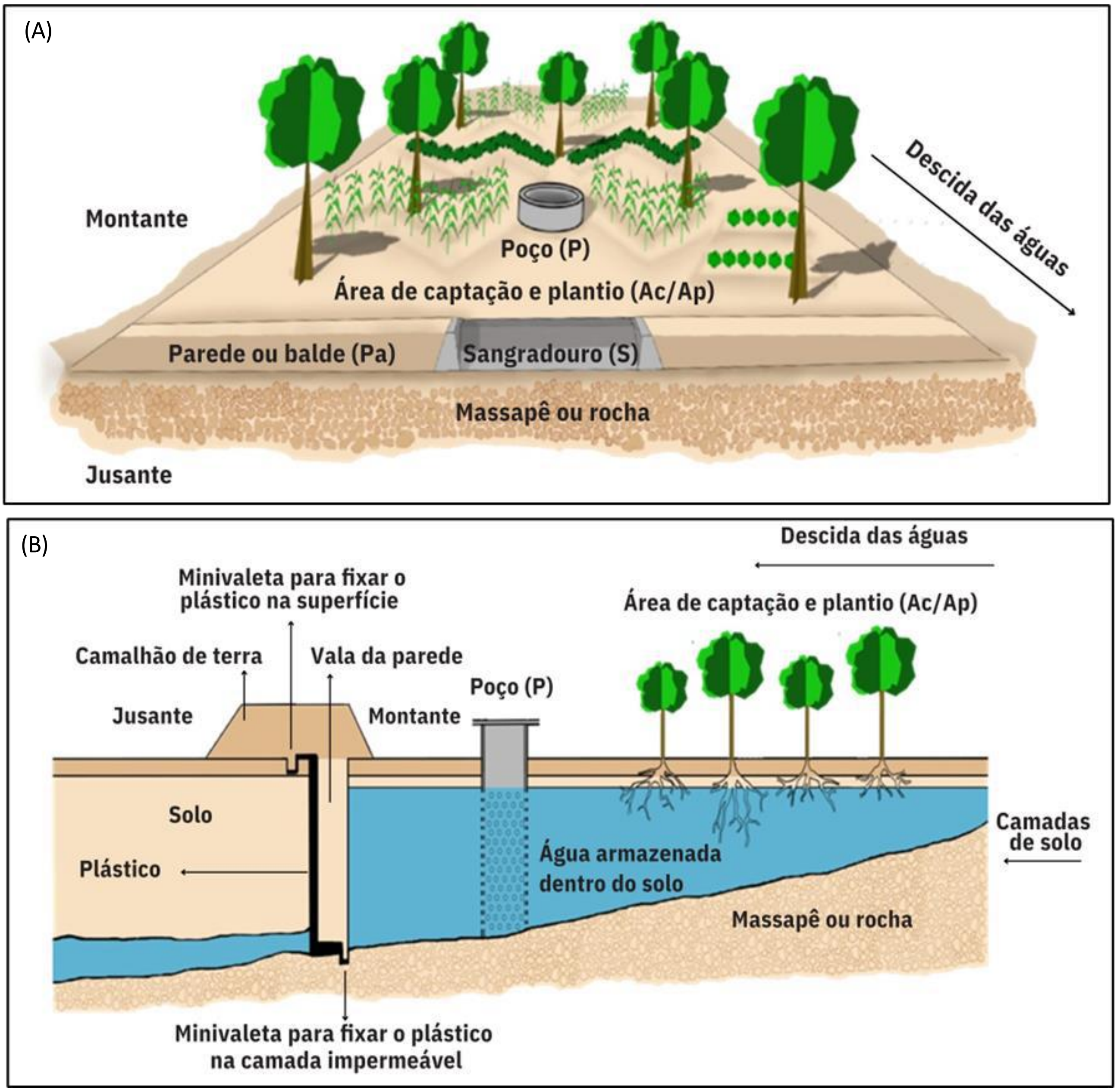
The trade and services sector is limited, with low diversity and concentration in supermarkets, variety stores and building materials. These activities represent about 7% of formal jobs in the municipality (PREFEITURA DE SENAOR RUI PALMEIRA...; 2025)

The municipal government, in partnership with institutions such as SEBRAE and SENAR, has implemented programs to encourage agricultural production and the commercialization of local products. Initiatives such as the Family Agriculture Fair, held weekly, and participation in programs such as the Food Acquisition Program (PAA) and the National School Feeding Program (PNAE) (SENAOR CITY HALL RUI PALMEIRA...; 2025) stand out.

2.3 UNDERGROUND DAM

The underground dam is a social technology for capturing and storing rainwater that has contributed significantly to the better coexistence of farming families with the semi-arid region of Brazil. Figure 3 shows the schematic drawing of the functioning of an underground dam with its respective components: water storage and capacity area, planting area, wall, bleed and well.

Figure 3. Underground dam with its components (A); cross-sectional showing the operation of the underground dam (B).



Source: Silva et al. (2021a)

By enabling access and multiple uses of water, whether for irrigation, animal watering or complementary domestic consumption, this practice reduces the risks of agriculture dependent exclusively on rainfall, promoting greater productive stability and water security in family-based systems. The underground dam has been characterized as a guiding cultural technology that has contributed to the development of the improvement of the living conditions of farming families and to the promotion of citizenship, through environmentally appropriate socioeconomic and technological initiatives (Melo; ANJOS, 2017).

Despite the growing use of underground dams in agroecological experiments and rural development programs, there are still few studies that systematically evaluate their impacts on the sustainability of agroecosystems. This gap hinders the consolidation of technology as a structuring public policy and prevents the improvement of its implementation in different socio-environmental contexts.

Thus, the present work seeks to evaluate the contribution of the underground dam to the sustainability of a family-based agroecosystem, with emphasis on environmental, economic and social aspects. From an integrated approach, it seeks to understand how this social technology can strengthen the resilience of family farming systems in the face of climate change and water insecurity, promoting a more harmonious and productive coexistence with the semi-arid region.

2.4 STUDIES CARRIED OUT AND METHODS USED

2.4.1 Participatory Rural Diagnosis (DRP)

For the characterization and monitoring of the agroecosystem, the Participatory Rural Diagnosis (DRP) was used, according to Verdejo (2006), using the following tools:

i) Transverse walking: consists of walking through a certain geographical space, observing and recording the characteristics of the place. It is commonly used in the initial phase of PKD.

(ii) Participant observation: - this is a qualitative method that involves the participation of the technician in the activities of a social group, with the objective of understanding and describing the culture, behavior and social relations of the group.

(iii) Semi-structured interview: interview method that is based on a script of pre-prepared questions, but which allows a more natural and dynamic dialogue between interviewer and interviewee, where ideas are explored, detailed information is obtained and facilitates the interviewee's spontaneous participation.

In order to observe the life trajectory of the farming family and its relationship with the environment in which it lives, as well as seeking to characterize its agroecosystem, six themes were collectively defined for the interview script: 1. family history and production area; 2. access to water);

3. management systems used (necessary inputs, inputs and outputs of the agroecosystem, types of crops); 4. social participation (in unions, associations, cooperatives, non-governmental organizations, religious movements, festive celebrations, among others); 5. family income; 6. Organization of work in the family nucleus.

(iv) Timeline - consists of the collective construction of the trajectory, evolution, structuring and functioning of the agroecosystem, aiming to understand the strategies that have been constituted over time.

v) Construction of an agroecosystem map: consists of the design of the agroecosystem map by the NSGA, which allows the sharing of information about the subsystems and improvements of the agricultural system, as well as discussing the reality of space and the use of environmental resources.

2.4.2 Sustainability assessment - MESMIS methodology

For the evaluation of sustainability, the MESMIS methodology was used - Framework for the Evaluation of Natural Resource Management Systems Incorporating Sustainability Indicators, with adaptations made by Ferreira (2011) and others made by the team.

By considering the different ecological, social, and economic contexts in which the systems are inserted, the MESMIS methodology has high flexibility and applicability, being widely used in sustainable rural development projects and in research focused on agroecology, food sovereignty, and conservation of natural resources.

It is a systemic, participatory and interdisciplinary approach, whose central objective is to diagnose, monitor and promote sustainability through the identification of indicators adapted to the specific characteristics of each production system. Its participatory nature also favors the direct involvement of farmers and other local actors in the evaluation process, promoting community empowerment and social appropriation of the results, fundamental aspects for the construction of sustainable and resilient agroecosystems.

The sustainability of the agroecosystem under study was evaluated based on seven attributes: productivity, equity, stability, resilience, reliability, adaptability/flexibility and autonomy, according to Masera et al. (1999).

The definition/construction of the critical points was carried out with the family, rural development agents and Ater technicians, based on the seven sustainability attributes and diagnostic criteria. For Masera et al. (1999), diagnostic criteria are characteristics of the system that can be measured through the use of specific indicators and that show trends of change in a relatively short time. The indicators describe a specific process or a control process and must be comprehensive, flexible, easy to measure and understand, and appropriate to the level of aggregation of the system under analysis (MASERA et al., 1999).

To identify the characteristics of the agroecosystem, monitoring was carried out for 18 months, aiming to obtain data on the evolution and dynamics of the agricultural system. This process allowed the realization of some adaptations, which provided the identification of the specificities of the agroecosystem under study. These adaptations were important, because from them, it was possible to observe the particularities, allowing a more realistic assessment of sustainability.

The indicators were constructed for three dimensions — technical-environmental, social, and economic — following the guidelines of the MESMIS method and contemplating the elements that make up the agroecosystem and that were influenced by both anthropic action and the construction of the underground dam.

The family's perception was prioritized throughout the process — from the transversal walk and monitoring to the evaluation of sustainability (Figure 4) — which highlighted the importance of rain both for the agroecosystem and for their lives.

Figure 4. Transverse walking (A); construction of maps, seasonal calendar, tables and graphs by the family (B).

Source: Maria Sonia Lopes da Silva

The soil and water indicators were qualitatively evaluated by the family. All activities were recorded in specific forms, audio recordings, images and digital photographs. The recommendations and conclusions were inferred from the graphs constructed based on tables 1, 2 and 3, elaborated by dimension, and from the dialogical reflection carried out.

Table 1. Attributes, descriptors, diagnostic criteria and technical-environmental indicators used in the evaluation of the sustainability of the agroecosystem of Sítio Cacheirinha, in Senador Rui Plameira, a semiarid region of the state of Alagoas.

Technical-environmental dimension			
Attributes	**Descriptors**	**Diagnostic criteria**	**Indicators**
Productivity	Production and management system	Yield, efficiency	1. Area yield (productivity)
Self-dependence (self-management)		Energy efficiency	2. Inputs and outputs
		Use of external inputs	3. External dependence
		Biological diversity	4. Crop diversity
		Fragility of the system	Technologies Social of living with drought
Stability, resilience, reliability	Soil	Resource conservation	6. Cover/erosion of the soil
			. Soil quality (physical, chemical properties a nd biological)
	Water		. Water quality (human consumption and animal)
	Fauna and flora		9. Conservation Nati ve area
		Biological diversity and resource conservation	. Diversity of fauna and flora

Source: Authors (2025)

Table 2. Attributes, descriptors, diagnostic criteria and social indicators used in the evaluation of the sustainability of the agroecosystem of Sítio Cacheirinha, in Senador Rui Plameira, a semiarid region of the state of Alagoas.

Social Dimension			
Attributes	**Descriptors**	**Diagnostic criteria**	**Indicators**
Equity	Organization of the work	Participation, organization and decision-making	1. Distribution of tasks by gender and age
		Fragility of the system	2. Decision-making power
Stability, resilience and reliability	Organization of the system of production	Fragility of the system	3. Ability to overcome severe events
	Access to services	Quality of life	4. Access to school, housing, water, medical services, basic sanitation, electricity, transportation, among others. other services.
		Access to culture and leisure	5. Culture and leisure
		Education	6. Education level
	History of the land	History of occupation and permanence on the land	7. Prospects for young people to remain on the land
	Training	Participation in training	8. Knowledge generation

Adaptability	and assistance	and access to the media	and access to information
Self-dependence (self-management)	Countryside /city offer	Control of relations with the external environment	9. Time spent on off-property activities
	External organization	Organization and participation	10. Type, structure and decision-making process in local organizations

Source: Authors (2025)

Table 3. Attributes, descriptors, diagnostic criteria and economic indicators used in the evaluation of the sustainability of the agroecosystem of the Cacheirinha Farm, in Senador Rui Plameira, a semiarid region of the state of Alagoas.

Economic dimension			
Attributes	**Descriptors**	**Diagnostic criteria**	**Indicators**
Productivity and stability	Economic stability	Efficiency (cost-effectiveness)	1. Gross Production Value/Annual Cost total 2. Worker's annual cost 3. Recovery period of investments
Productivity, equity of products marketed and		Efficiency (profitability); Fair price	4. Cost/benefit ratio
Stability, resilience, reliability, adaptability	Marketing	System fragility, risk reduction	5. Diversification of markets and goods 6. No. of products sold
	Diversity of activities		7. Number of activities developed in the property
	Financial resources		8. Use credit lines or other financing
Adaptability	Social dynamics and External organization	Risk reduction	9. No. of non-agricultural activities carried out outside the property
Self-dependence (self-management)	External organization	Participation	10. Participation and economic operations carried out in groups (associations, cooperatives, unions)
	Food safety	Self-sufficiency	11. Percentage of products consumed by the family from the agroecosystem

Source: Authors (2025)

To measure the level of sustainability of the agroecosystem, scales from 0 to 5 were considered, according to the family's perception: 5 corresponds to the ideal level of sustainability; 4, Well level; 3, reasonable or regular level; 2, Low; 1, Very low level; and 0 refers to a situation of unsustainability.

3 RESULTS AND DISCUSSION

3.1 CHARACTERIZATION OF THE AGROECOSYSTEM

The collective and dialogical construction through the transversal walk, the elaboration of the property map and the seasonal calendar, allowed the collection of information on the conditions of natural resources, improvements, the economic, social situation and other aspects relevant to the NSGA studied. In the collection of information about the life history and its relationship with the environment, the family had an active participation as a subject of the process, which enabled an in-depth and systemic dialogue.

The family's trajectory highlights the importance of their reproduction in the countryside, characterizing their permanence on the land. Ownership of the property was initially acquired by inheritance from the couple, who, over time, expanded its extension through new acquisitions. After the death of the matriarch and, later, the patriarch's second marriage, three of the couple's daughters - known as "The Three Marias" - remained residing in the family's headquarters.

In addition to the "Três Marias", the family nucleus is composed of the father, who lives on a neighboring property, and two brothers, one residing in São Paulo and the other in the seat of the municipality.

In addition to Três Marias, the family is composed of the father, who lives on a neighboring property, and two brothers - one who lives in São Paulo and the other in the seat of the municipality.

3.1.1 Timeline

The timeline of the agroecosystem, built together with the family, highlights an important milestone from 2007 onwards. In that year, there were implementations of social technologies promoted by public policy programs of the federal government, such as the One Million Cisterns Program and the P1+2 Program.

With the commercialization of the products resulting from the expanded access to water, the family was able to make improvements in the garden and in the residence, in addition to acquiring some goods from the income obtained. In addition, the family has access to electricity and running water.

3.1.2 Seasonal calendar

The seasonal calendar was elaborated with a gender perspective and constituted a participatory tool that made it possible to identify and represent the organization of agricultural, domestic, social and economic activities throughout the year, differentiating the responsibilities attributed to women and men. By analysing the division of labour, the calendar made it possible to understand the periods of greatest workload and scarcity of rainfall. It also highlighted the accumulation of tasks assigned to women, which extend throughout all months of the year, regardless of the occurrence of rainfall. In the analysis of the seasonal calendar (Table 4), it is observed that the first item recorded was the period of occurrence of rainfall, which demonstrates the centrality of this element for the safety and sustenance of the family.

According to reports, the rains begin in January, with the first thunderstorms, and occur more effectively between the months of April and July. It was observed that agricultural activities - especially soil preparation, planting and crop management - are concentrated in this period, showing that these practices depend exclusively on rainwater, which reveals the inexistence of other water sources on the property.

Table 4. Seasonal calendar of activities developed in the agroecosystem

Calendário de atividades

Atividades	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez
CHUVA	•			•	•	•	•					
ARAÇÃO	• H M			• H M	• H M	• H M	• H M					
PLANTIO (MILHO E FEIJÃO)				• M	• M	• M	• M					
PLANTIO (PALMA E ALGODÃO)	• H M						H M					
PREPARO CANTEIRO				• M	• M	• M	• M	• M	• M			
PLANTIO DA ORTALIÇA				• M	• M	• M	• M	• M	• M			
COLHEITA ORTALIÇA						• M	• M	• M	• M	• M		
MILHO							• H M					
FEIJÃO						• H M	• H M					
PALMA											• H M	• H M
ALGODÃO											• H M	• H M
CAPRINO	• M	• M	• M	• M	• M	• M	• M	• M	• M	• M	• M	• M
AVES	• M	• M	• M	• M	• M	• M	• M	• M	• M	• M	• M	• M
BOVINO	• H M	• H M	• H M	• H M	• H M	• H M	• H M	• H M	• H M	• H M	• H M	• H M
VENDA DE OVOS	• M	• M	• M	• M	• M	• M	• M	• M	• M	• M	• M	• M
CONTROLE DE PRAGAS				• H M	• H M	• H M	• H M	• H M	• H M	• H M		
ATIVIDADE EXTERNA (P		• M	• M	• M	• M	• M	• M	• M	• M	• M	• M	
ATIVIDADE DOMESTICA	• M	• M	• M	• M	• M	• M	• M	• M	• M	• M	• M	• M
ATIVIDADES ESCOLARES		• M	• M	• M	• M	• M	• M	• M	• M	• M	• M	

Source: Prepared by the farming family

In the seasonal calendar, the central role of women in the productive and reproductive dynamics of the agroecosystem deserves to be highlighted, evidencing the accumulation of responsibilities they assume when dividing themselves between agricultural work and domestic tasks - the latter often invisible.

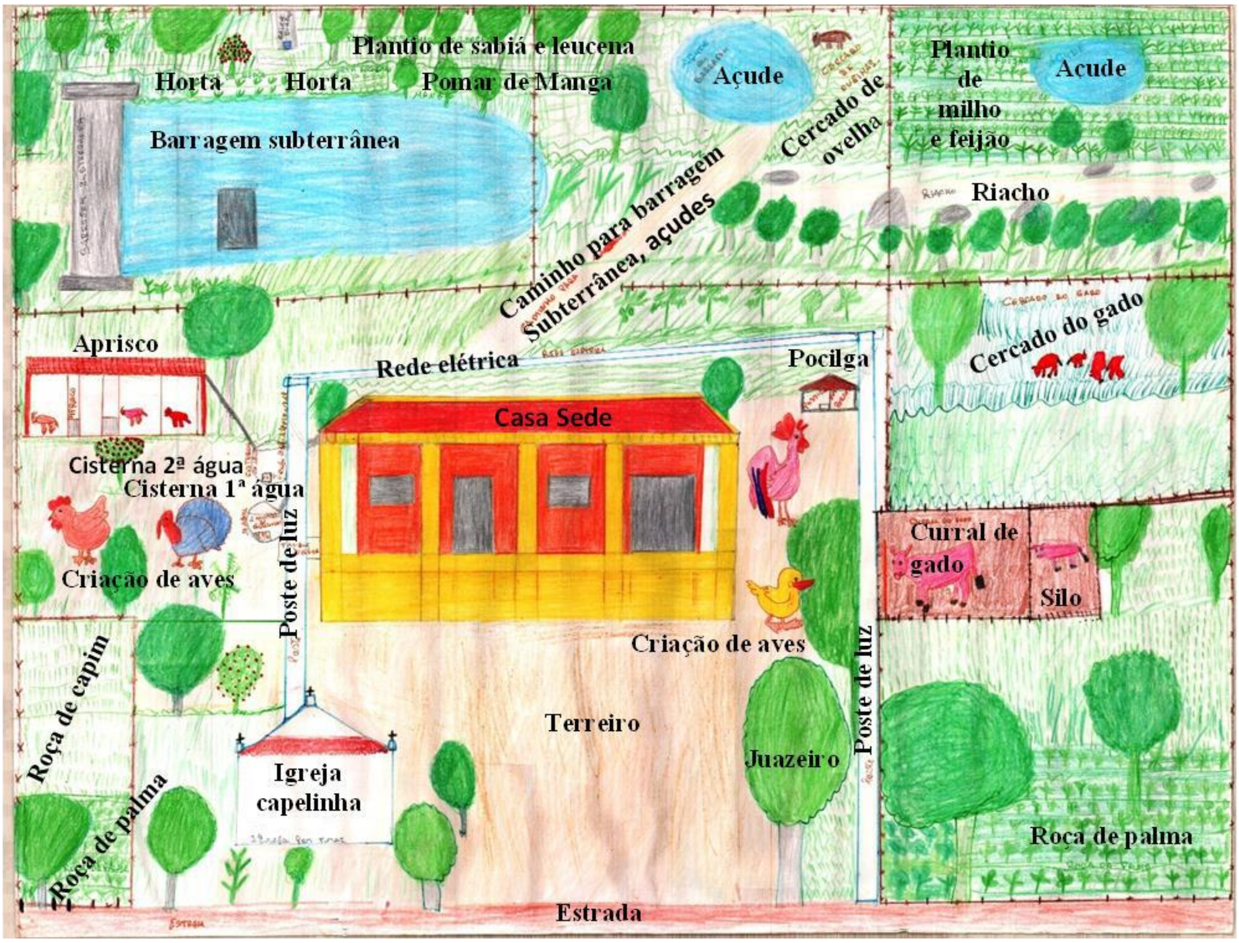
It is therefore evident that women play a multifaceted role, assuming essential functions both in agricultural production and in the maintenance of domestic life. This overlapping of tasks reveals a division of labor marked by gender inequalities, often naturalized in rural daily life. They work continuously in productive activities – such as planting, harvesting and handling animals – as well as in reproductive activities, such as taking care of the house, preparing food and paying attention to the well-being of family members. This accumulation of responsibilities throughout the year highlights the overload of work that falls on women. Such tasks, although often made invisible, are fundamental for the sustainability of the agroecosystem.

3.1.3 Agroecosystem map

As a result of the implementation of social technologies, especially those aimed at access to water, the family now has several mediators/improvements and infrastructures that have contributed significantly to the improvement of conditions and quality of life. Among the goods purchased, a motorcycle, a cart and a Fiat car stand out. Important constructions were also carried out, such as a chapel in the yard of the house, a fenced corral, a pigsty, a sheepfold, a chicken coop and a silo (Figure 5).

The main house underwent renovations, including the expansion of the kitchen, the placement of ceramic tiles on the entire floor and the construction of a complete bathroom inside the residence, equipped with a water tank and flushing system.

Figure 5. Map built by the family showing the mediators/improvements and the subsystems of the agroecosystem.



Source: Prepared by the farming family

With regard to improvements/mediators for water storage, the family has structures aimed at both human consumption and agricultural production and animal watering. The "first water", intended for domestic consumption, is guaranteed by the cistern for human consumption, with a capacity of 16 thousand liters. For animal watering, the family has a second cistern and two dams. The "second water" — aimed at food production — is made possible by an underground dam, located approximately 1 km from the main house, and by a tank located around it, used for the irrigation of medicinal plants and the garden.

The underground dam represents a strategic improvement in the agroecosystem. Built in 2007, in the ASA (Brazilian Semi-Arid Articulation) model, submersible type, with waterproof plastic wall/septum, measuring 38 meters in length and bleeding of approximately 8 meters. It also has a well, upstream, which allows the irrigation of the planting area of the underground dam, as well as the areas around it, in addition to meeting the thirst of animals during periods of drought.

Its implementation was a milestone in the family's trajectory and in the strengthening of the agroecosystem, by providing access to water for food production. The dam significantly reduced the dependence on water trucks, favored productive diversification (with vegetable, fruit and forage crops) and made it possible to generate income through the sale of surpluses at local fairs and markets. In addition, it resulted in improvements in the family's diet, with varied and better quality products, and contributed to the empowerment and autonomy of the family, by strengthening its capacity to cope with climate change and make sustainable decisions.

Although the underground dam currently has leakage problems in its structure, it still plays a fundamental role in the agroecosystem. The pasture continues to be sufficient for feeding the animals and the well associated with the dam still provides water for watering. However, the production of vegetables is temporarily suspended, due to the shortage of family and external labor, aggravated by the cost of the daily rate, which exceeds the family's financial capacity.

For a coexistence more adapted to the reality of the semi-arid region, the family develops important productive subsystems (Figure 5). In the field of livestock, it breeds cattle, sheep, pigs and poultry (chickens, turkeys and guineas/coats). In agriculture, he maintains vegetable gardens (around the main house), grain crops (corn and beans), an orchard, as well as fodder (grass and palm). When the climatic and working conditions allow, he also grows manioc and cassava.

Animal production aims at both family consumption and the commercialization of meat, eggs and milk in the regional market. Management is carried out in a semi-extensive system, combining grazing with the cultivation of forage — such as buffel grass and palm — and food supplementation with leftover vegetables and corn silage produced on the property itself.

The cultivation of corn and beans is carried out with native seeds — varieties developed, selected and conserved by family farmers and traditional communities over generations, with characteristics adapted to the local environment. Corn is intended for family consumption and animal feed, and its aerial part is used in the manufacture of silage. Beans are intended for their own consumption, and their aerial part serves as food for sheep. In the garden, when in activity, lettuce, coriander, chives, sweet pepper and peppers are grown.

3.2 SUSTAINABILITY ASSESSMENT

The sustainability assessment was based on the identification of critical points of the agroecosystem, which were determined from the analysis of positive and limiting factors that were influencing its autonomy, considering the aspects of management, organization and management of production systems. According to Masera et al. (1999), critical points are understood as the aspects or processes that limit or strengthen the ability of systems to remain sustainable over time.

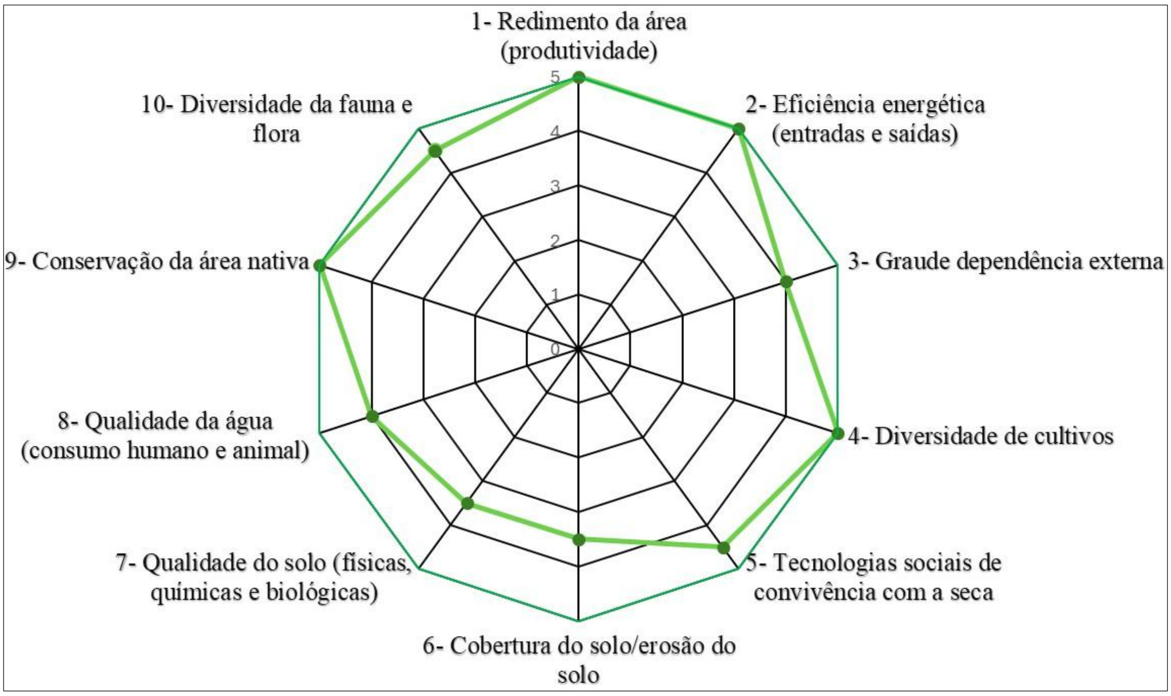
To measure sustainability, radar-type graphs (also known as spider web graphs) were used, a visual tool that allows the simultaneous analysis of multiple indicators, enabling a comparative evaluation between them. In the present study, the graphs evaluated 10 to 11 indicators distributed among the technical-environmental, social and economic dimensions.

The contribution of the underground dam was analyzed in the context of the agroecosystem based on the tools of the Participatory Rural Diagnosis (DRP) and radar charts, allowing a more integrated understanding of its effects on the various aspects of sustainability

3.2.1 Technical-environmental dimension

Figure 6 presents the results of the evaluation of the technical-environmental sustainability of the family agroecosystem, showing expressive performance in several key indicators. Indicators 1 (Productivity), 2 (Energy efficiency), 4 (Crop diversity) and 9 (Conservation of the native area) stand out, all classified at the maximum level of sustainability (level 5). These results indicate the existence of an efficient production system, based on sustainable practices, with high agricultural diversity and a strong commitment to environmental conservation. Such performance reinforces the ecological resilience and self-sufficiency of the agroecosystem, essential elements for its long-term sustainability.

Figure 6. Assessment of technical-environmental sustainability



Source: Authors (2025)

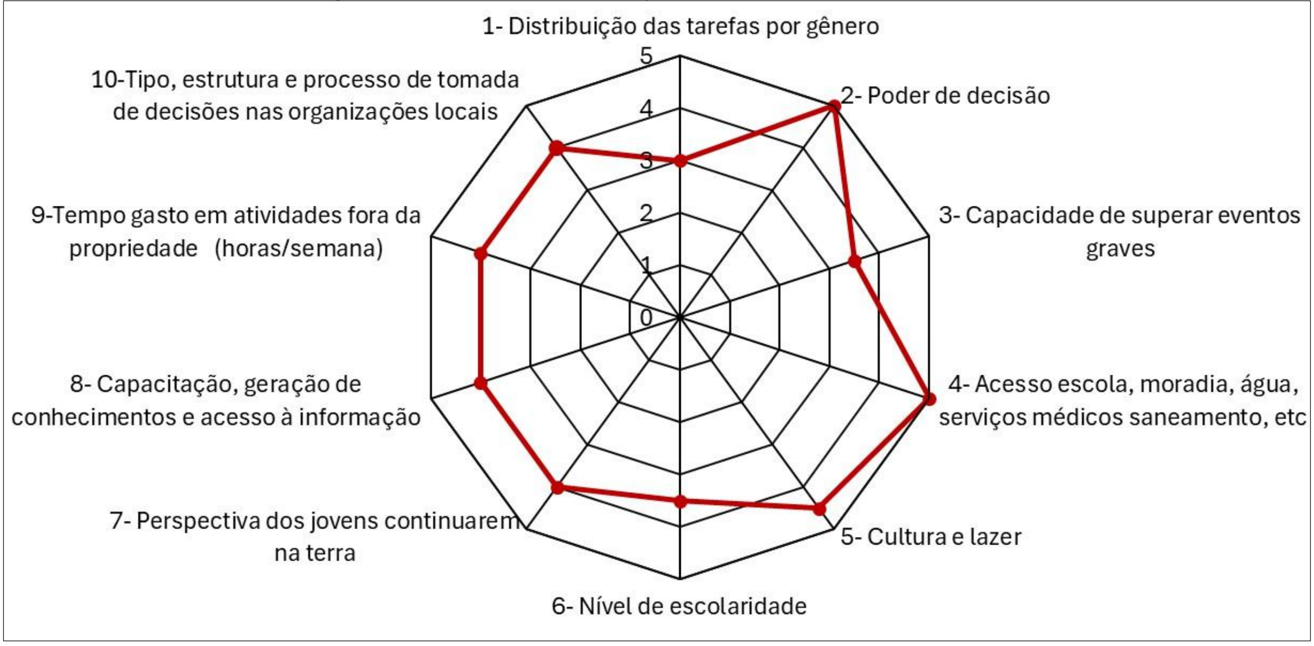
However, indicators 6 (Soil cover/erosion) and 7 (Soil quality), both evaluated at level 3.5, show weaknesses related to soil management and conservation. The existence of areas with insufficient vegetation cover and signs of erosion, as well as limitations regarding soil fertility and structure, point to the need for specific interventions. The implementation of practices such as permanent vegetation cover, organic fertilization and crop rotation is essential to reverse this scenario and ensure the sustainability of the system in the long term.

In summary, the data indicate that the agroecosystem has a solid foundation of technical-environmental sustainability, with well-consolidated agroecological practices, although it still faces technical challenges that require constant monitoring and improvement. The strengthening of soil management strategies, combined with the conservation of biodiversity and the rational use of water resources, will be essential to consolidate an environmentally balanced, productive and lasting agricultural model.

3.2.2 Social dimension

The analysis of Figure 7 reveals that the family agroecosystem evaluated presents expressive elements of social sustainability, highlighting indicators 2 (Decision-making power) and 4 (Access to basic services), both evaluated with the maximum level of sustainability (5). These results indicate consolidated family governance, with active participation of family members in decision-making processes, in addition to an adequate social infrastructure. Guaranteed access to education, health, housing and sanitation is an essential factor for promoting the quality of life in rural areas and for the permanence of families in the countryside, reinforcing social cohesion and territorial roots.

Figure 7. Social sustainability assessment



Source: Authors (2025)

Indicators 5, 7, 8, 9 and 10, with sustainability levels ranging between 4.0 and 4.5, also reveal a positive scenario, although there is still room for improvement. The tendency for young people to remain in rural areas, access to training and information, leisure, the balance between internal and external activities, as well as participatory organization in local instances, are indicative of social dynamism and strengthening of community bonds. However, limitations related to access to innovation, equitable representation in decision-making spaces, and the time spent on external activities persist, which highlight the urgency of strategies that expand opportunities, promote inclusion, and ensure greater equity and autonomy in the rural context.

On the other hand, indicators with intermediate levels of sustainability - between 3.0 and 3.5

- such as 1 (Distribution of tasks by gender), 3 (Ability to overcome serious events) and 6 (Level of education), point to gender inequalities, weaknesses in social resilience and deficiencies in the level of education. These factors negatively impact family well-being, individual autonomy, and the ability to respond to adverse situations, reinforcing the need for public policies aimed at social empowerment, valuing local knowledge, and encouraging continuing education for all.

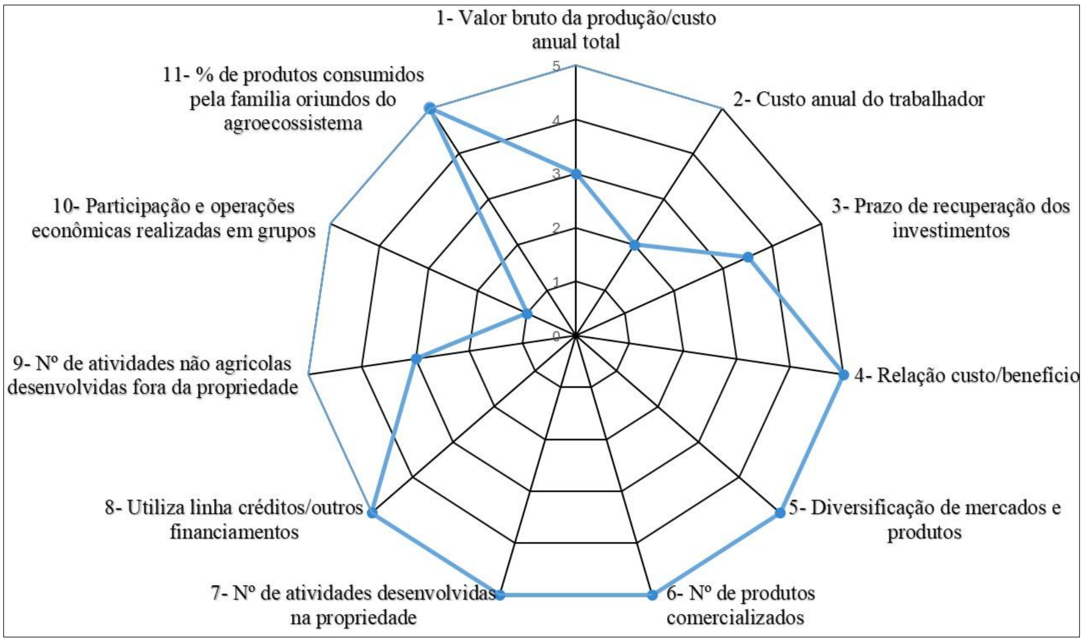
The joint analysis of the social indicators shows that the sustainability of the family agroecosystem is in the process of consolidation, but still depends on the implementation of structuring and strategic actions. Such actions should promote the correction of historical inequalities, expand access to opportunities and ensure the dignified permanence of families in rural areas. Moving in this direction requires strengthening family protagonism in communities, recognizing local practices and knowledge, and committing to more inclusive, fair, and sustainable rural development models.

3.2.3 Economic dimension

The analysis of the economic dimension, as shown in Figure 8, shows a structure with consolidated positive aspects, but also with significant weaknesses that require attention. The performance was excellent in indicators 4, 5, 6, 7, 8 and 11, related to the cost-benefit ratio, diversification of markets and products, number of items sold, activities developed on the property, use of credit and food self-sufficiency. These results indicate productive resilience, management capacity, and good use of local resources — essential characteristics for long-term economic sustainability.

Indicators 1 (gross value of production), 3 (recovery period of investments) and 9 (activities outside the property) showed intermediate levels of sustainability (between 3.0 and 3.5). These results reflect a system with growth potential, but which still faces difficulties in generating consistent economic returns and achieving full self-sufficiency. Overcoming these challenges requires strengthening marketing chains, adding value to products, and implementing public policies aimed at valuing family farming, which promote access to targeted rural credit, agroecological-based technical assistance, and encouraging young people to stay in the countryside, as a way to ensure rural succession and productive innovation. Thus, economic indicators lack structuring stimuli to achieve greater financial autonomy and stability, without giving up the principles of sustainability and social justice.

Figure 8. Evaluation of the economic impact on the agroecosystem.



Source: Authors (2025)

On the other hand, significant economic weaknesses are observed in indicators 2 and 10, both with low levels of sustainability (2 and 1, respectively). The high cost of local labor compromises economic viability, especially in systems with low mechanization and predominantly aimed at self-consumption. In addition, the absence of participation in collective economic operations weakens the bargaining power of the family and restricts access to fairer and more efficient markets. These limitations highlight the need for structuring actions, such as encouraging appropriate mechanization for family farming and fostering solidarity economic organization.

3.3 CONTRIBUTIONS OF THE UNDERGROUND DAM TO THE SUSTAINABILITY OF THE AGROECOSYSTEM

The evaluation of the agroecosystem, considering the ecological, social, economic and cultural aspects, showed that it is progressively moving towards sustainability over time. It was evident that the implementation of social technologies for capturing and storing rainwater resulted in positive impacts on the agroecosystem and the living conditions of the farming family. These technologies have made it possible to supply water for human consumption, food production and animal husbandry, even during prolonged periods of drought, characteristic of the region.

Specifically in relation to agricultural production, the underground dam stood out for its ability to store water underground, promoting the maintenance of soil moisture for extended periods. This characteristic has been decisive for the continuity of productive activities in contexts of water scarcity, by reducing the vulnerability of crops to irregular rainfall. The maintenance of soil moisture for longer has enabled productive diversification throughout the year, allowing the implementation of more complex and resilient agricultural systems. Such diversification has contributed significantly to the strengthening of food sovereignty and to the food and nutritional security of farming families, by ensuring continuous and autonomous access to a variety of nutritious foods adapted to local conditions.

From the perspective of socio-productive inclusion, the presence of the underground dam has played a strategic role in enabling the dignified permanence of the family in the countryside, through the expansion of its productive capacities and access to essential natural resources in a sustainable way. By ensuring greater stability in living and production conditions, this social technology has favored the insertion of the family in local and regional productive circuits, promoting its economic autonomy and strengthening solidarity marketing networks.

In the socioeconomic aspect, the underground dam has strengthened the autonomy of the family by enabling production both for self-consumption and for the commercialization of surpluses. This new productive scenario generated an increase in family income and greater economic stability, in addition to favoring family-based agricultural practices, adapted to local environmental conditions. The raising of small animals and the cultivation of vegetables and fruit trees were also intensified, which expanded the supply of healthy and diversified foods.

In this way, the underground dam has been consolidated as a strategic social technology for coexistence with the semi-arid region, by promoting structural transformations in the rural territory and expanding the possibilities of socio-productive inclusion of farming families. Its positive impacts are reflected in the improvement of the quality of life, the strengthening of dignity in the countryside and the promotion of socio-environmental and economic sustainability, through safe access to water, the increase of productive autonomy and the generation of income on a sustainable basis.

4 CONCLUSIONS

The integrated analysis of the social, economic and environmental dimensions of the family agroecosystem reveals a system with important advances towards sustainability, but which still faces specific challenges that require strategic attention.

In the environmental dimension, a positive scenario is observed with a high level of productivity, crop diversity, biodiversity conservation and efficient use of energy and water. Such sustainable practices reflect a clear commitment to the preservation of natural resources and ecological resilience. On the other hand, indicators related to vegetation cover and soil quality warn of the need for improvements in conservation management, such as crop rotation, organic fertilization and erosion control.

With regard to the social dimension, the strong participation of the family in decision-making processes, access to essential services and the presence of democratic community structures stand out, which favor social cohesion and permanence in the countryside. However, inequalities persist in the distribution of tasks by gender, limitations in schooling, and weaknesses in the ability to face critical events, which requires policies of inclusion, education, and strengthening of support networks.

Finally, in the economic sphere, the agroecosystem demonstrates good performance in indicators such as productive diversification, use of credit, cost/benefit ratio, and food self-sufficiency, evidencing resilience and organization of production. However, the high dependence on expensive labor and the low participation in collective economic activities reveal weaknesses that compromise financial autonomy and economic efficiency, requiring incentives for cooperation, adequate mechanization and the valorization of local marketing chains.

In summary, the agroecosystem evaluated presents a solid basis for sustainability, based on technologies for accessing and storing rainwater, but its improvement depends on integrated and continuous actions, which articulate public policies, community strengthening and agroecological innovations. The balance between these three actions will be decisive to ensure the viability, social justice and resilience of the agroecosystem in the long term.

Specifically in relation to the contribution of the underground dam to the sustainability of the agroecosystem, it can be stated that this technology plays a strategic role in promoting the storage of rainwater underground, ensuring the continuity of productive activities in periods of drought, reducing water vulnerability and strengthening the food and nutritional security of families.

By articulating technical knowledge with local knowledge, this technology values peasant culture and promotes the role of families in caring for the territory and preserving their ways of life. In this process, it contributes not only to the improvement of ecological and economic conditions, but also to the strengthening of social ties and cultural identity in rural communities.

In addition, the underground dam played a decisive role in the socio-productive inclusion of the family. By enabling diversified production, income generation, and permanence in the countryside, it expanded access to economic and social opportunities in a sustainable and autonomous way, contributing to transforming realities marked by exclusion and scarcity into experiences of resilience, dignity, and belonging.

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The collective involvement and mutual trust between researchers, farming families and partners were essential for the development of this assessment and reinforce the importance of collaborative, participatory and co-developed work in the promotion of more sustainable, fair and resilient agroecosystems.

REFERENCES

Altieri, M. (2012). Agroecologia: Bases científicas para uma agricultura sustentável. Expressão Popular.

Candido, G. A., Nobrega, M. M., Figueiredo, M. T. M., & Maior, M. M. S. (2015). Avaliação da sustentabilidade de unidades de produção agroecológicas: Um estudo comparativo dos métodos IDEAS e MESMIS. Ambiente & Sociedade, 18(3), 99–120. https://doi.org/10.1590/1809-4422ASOC756V1832015

Conway, G. R., & Barbier, E. B. (2013). After the Green Revolution: Sustainable agriculture for development. Earthscan.

Ferreira, G. B., Costa, M. B. B. da, Silva, M. S. L. da, Moreira, M. M., Gava, C. A. T., Chaves, V. C., & Mendonça, C. E. S. (2011). Sustentabilidade de agroecossistemas com barragens subterrâneas no semiárido brasileiro: A percepção dos agricultores na Paraíba. Revista Brasileira de Agroecologia, 6(1), 19–36. https://periodicos.unb.br/index.php/rbagroecologia/article/view/49168/37332

Gomes, J. C. C., & Assis, W. S. de (Eds.). (2013). Agroecologia: Princípios e reflexões conceituais (Coleção Transição Agroecológica, Vol. 1). Embrapa.

Gliessman, S. R. (2009). Agroecologia: Processos ecológicos em agricultura sustentável (1a ed.). Editora da UFRGS.

González de Molina, M., & Toledo, V. M. (2011). Metabolismos, naturaleza e historia: Hacia una teoría de las transformaciones socioecológicas. Icaria Editorial.

Iaquininto, B. O. (2018). A sustentabilidade e suas dimensões. Revista da ESMESC, 25(31), 157–178. https://doi.org/10.14295/revistadaesmesc.v25i31.p157

Instituto Brasileiro de Geografia e Estatística. (2025). Cidades e Estados: Senador Rui Palmeira, Alagoas. https://www.ibge.gov.br/cidades-e-estados/al/senador-rui-palmeira.html

Lima, A. de O., Lima-Filho, F. P., Dias, N. da S., Reis Júnior, J. A. dos, & Sousa, A. de M. (2018). GPR 3D profile of the adequateness of underground dams in a sub-watershed of the Brazilian semiarid. Revista Caatinga, 31(2), 523–531. https://periodicos.ufersa.edu.br/index.php/caatinga/article/view/6762/pdf

Mascarenhas, J. de C., Beltrão, B. A., & Souza Junior, L. C. de. (2005). Diagnóstico do município de Senador Rui Palmeira, estado de Alagoas. CPRM/PRODEEM. https://rigeo.sgb.gov.br/jspui/bitstream/doc/15348/1/rel_cadastros_senador_rui_palmeira.pdf

Masera, O., Astier, M., & López-Ridaura, S. (1999). Sustentabilidad y manejo de recursos naturales: El marco de evaluación MESMIS. Mundi Prensa.

Melo, R. F. de, & Anjos, J. B. dos. (2017). Barragem subterrânea: Alternativa de captação e armazenamento de água de chuva. Cadernos do Semiárido: Riquezas & Oportunidades, 11(11), 27–31. https://www.infoteca.cnptia.embrapa.br/infoteca/bitstream/doc/1098685/1/CADERNODOSEMIARIDO2731.pdf

Petersen, P., Silveira, L., Fernandes, G. B., & Almeida, S. G. (Eds.). (2021). LUME: Método de análise econômico-ecológico de agroecossistemas. AS-PTA - Agricultura Familiar e Agroecologia. https://aspta.org.br/files/2015/05/Lume_Port_V_Final-1.pdf

Prefeitura Municipal de Senador Rui Palmeira. (n.d.). Prefeitura de Senador Rui Palmeira incentiva a produção agrícola por meio da feira da agricultura familiar. Retrieved April 14, 2025, from https://www.senadorruipalmeira.al.gov.br/portal/artigo/prefeitura-de-senador-rui-palmeira-incentiva-a-producao-agricola-por-meio-da-feira-da-agricultura-familiar?utm_source=chatgpt.com

Santos, J. C. P. dos, Araújo Filho, J. C. de, Barros, A. H. C., Accioly, L. J. de O. V., Tavares, S. C. C. de H., Silva, A. B. da, Leite, A. P., Nascimento, A. F. do, Amaral, A. J. do, Cavalcanti, A. C., Gomes, E. C., Marques, F. A., Silva, F. H. B. B. da, Luz, L. R. Q. P. da, Oliveira Neto, M. B. de, Silva, M. S. L. da, Ribeiro Filho, M. R., Lopes, O. F., Lima, P. C. de, Parahyba, R. da B. V., Cunha, T. J. F., Tabosa, J. N., Varejão-Silva, M. A., Lopes, H. L., Silveira, H. L. F. da, Silva, E. A. da, Silva, J. A. da, Alves, E. da S., Menezes, A., Silva, D. F. da, Fonseca, J. C. da, & Botelho, F. P. (2013). Zoneamento agroecológico de Alagoas. Secretaria de Estado da Agricultura e do Desenvolvimento Agrário; Embrapa Solos - UEP Recife.

Secretaria de Estado do Planejamento e do Desenvolvimento Econômico. (2014). Perfil Municipal: Senador Rui Palmeira (No. 2). https://dados.al.gov.br/catalogo/dataset/267a1b30-b240-4815-9375-db3f1c44a72b/resource/53afc1bb-587c-41a8-b25e-641a13c8a031/download/municipalsenadorruipalmeira2014.pdf

Silva, M. S. L. da, Marques, F. A., Nascimento, A. F. do, Lima, A. de O., Ribeiro, C. A., Barbosa, A. G., Oliveira Neto, M. B. de, Amaral, A. J. do, Melo, R. F. de, & Parahyba, R. da B. V. (2021). Barragem subterrânea: Acesso e usos múltiplos da água no Semiárido brasileiro. Embrapa.

Silva, M. S. L. da, Ribeiro, C. A., Ferreira, G. B., Silva, J. S. da, & Barbosa, A. G. (2021). Barragem subterrânea: Sustentabilidade socioecológica e econômica de agroecossistemas do Semiárido do Nordeste brasileiro. In F. de B. P. Moura & J. V. Silva (Eds.), Restauração na Caatinga (2a ed. rev. e ampl., pp. 201–218). Edufal. https://www.alice.cnptia.embrapa.br/alice/bitstream/doc/1130957/1/Barragem-subterranea-sustentabilidade-socioecologica-e-economica-2021.pdf

Verdejo, M. E. (2006). Diagnóstico Rural Participativo. MDA/Secretaria da Agricultura Familiar. http://jararaca.ufsm.br/websites/deaer/download/VIVIEN/Texto01/ManualDATER.pdf