

Brazilian Semi-Arid: Potentialities and Diversity of Uses

Dr. José Falcão Sobrinho
Larissa Ingrid Marques Linhares
Bruna Lima Almeida
Vanessa Campos Alves

Semi-Arid Research and Extension Laboratory/LAPES
State University Vale do Acaraú/UVA, Sobral, Ceará, Brazil

Dra. Cleire Lima da Costa Falcão
State University of Ceará, Fortaleza, Brazil

Abstract

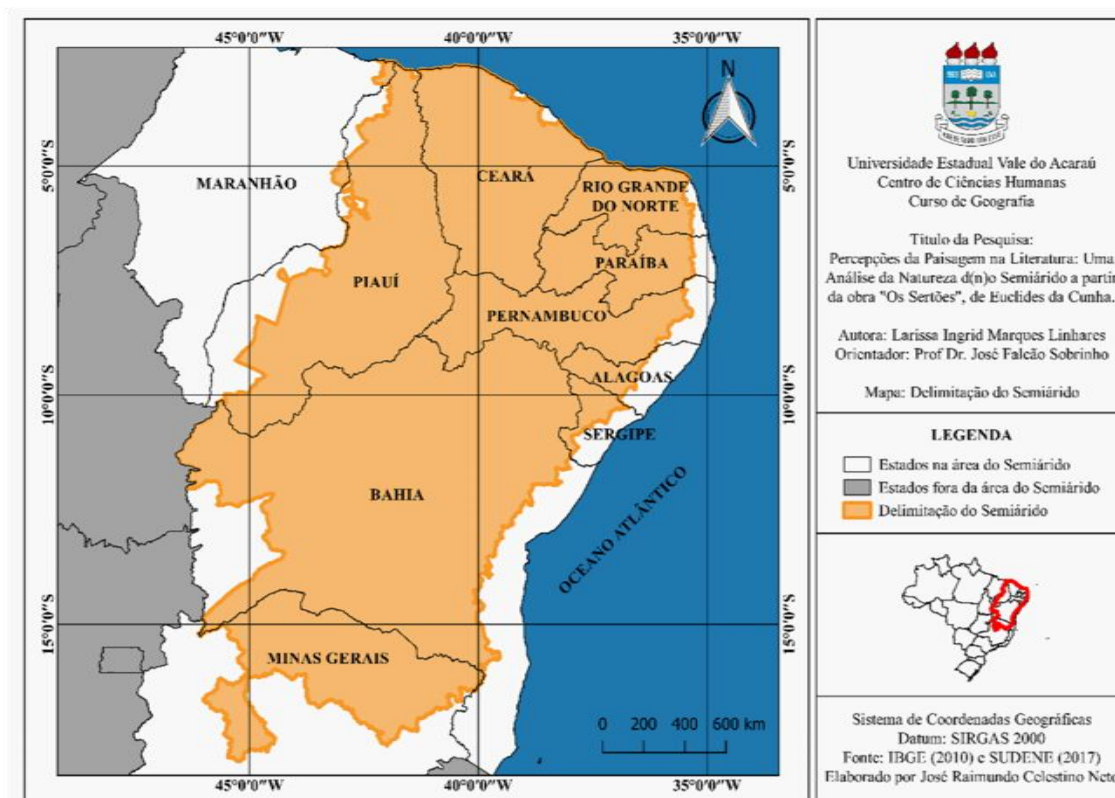
The Brazilian semiarid region is a rustic environment because of the natural characteristics related to the gray vegetation and the shallow and dry soil during droughts. However, the perceptions are clippings of scenarios that do not explain the natural dynamics and do not go further in the richness and exploration potential. Because of it, what follows is atheoretical reflection and methodologies applicable to living in this environment.

1. Semiarid region: introductory notes

When discussing the semiarid region, it is necessary to understand that it is articulated in the Northeastern Brazil – comprising the states of Piauí, Ceará, Pernambuco, Rio Grande do Norte, Paraíba, Alagoas, Sergipe, Bahia, and Northern Minas Gerais. Thus, it is essential to understand the local potentials and peculiarities since the semiarid receives an erroneous classification of a climatic reference by Teixeira (2006). It marks a characteristic of the ecosystem of this region – the low rainfall index, less than 800mm per year.

Then, discussing the semiarid region is to understand that the climate is not the only articulation, but also the specific relationships that make it peculiar, given its singularities. Malvezzi (2007) says the Brazilian semiarid region is not only climate, vegetation, soil, sun, or water, but it is people, music, festivals, art, religion, politics, and history. It is a social process that anyone cannot understand from just one angle. Therefore, the analysis must start from an exponential geographic look, qualifying and quantifying elements of this nature and understanding that the semiarid region and the hinterland emerged initially in the thematic scenario as discursive constructions. They were to be natural, and not political nor historical, highlighting the subjects in the discourse – the media, science, political and governing classes, school, and literature (MOTA, 2008). Thus, when discussing the complexity, one must consider soil, vegetation, and physical, chemical, and biological processes to understand its capabilities.

In this perspective, it is worth mentioning that even though Northeastern Brazil suffers from droughts and other artifacts that make it miserable, it has the highest rainfall rates with about 750 mm per year on average (with its variations within its regions). The soil has 70% of shallow crystalline rock, which inhibits the formation of natural reservoirs, reduces the water potential, and most of the time is saline. Thus, the Ministry of National Integration delivered in 2005 a new territorial delimitation and measures that could reallocate this area to the Brazilian semiarid region. According to the Intergovernmental Panel on Climate Change (IPCC, 2007), the warming in the region may reach 4°C in the second half of the 21st century.



Source: The authors

It is essential to highlight that the semi-arid region has historical, artistic, political, and natural issues that make it complex. Then, it is necessary to understand the perspectives and punctualities in development. Besides talking about it, it is appropriate to transpose the elements found. Describing the semi-arid region means talking about the vegetation, soil, use and management, culture, perceptions of the geographic analysis on the landscape, and its articulation concerning nature. According to Ab'Saber (1965):

The subequatorial and tropical semi-arid zone has a unique azonal position. The extension is of second order, varying between 700 thousand and 850 thousand square kilometers. Region of interplanaltic depressions reduced to true erosion plains due to the great extension of the pediplains and to the relatively recent final perfection of the so-called modern hinterland pediplain.

The semi-arid context goes from the transposition of the São Francisco River to the Cratéus hinterlands. Some situations encompass and make it so peculiar, but its discussion by Brazilian classical literature gives the idea of a land scourged and cursed by God (Castro, 1987). It would not be the fruit of natural processes dialogued with consensual perspectives. In other words, spreading the peculiarities of the semi-arid region from a perspective of perception alone does not translate the real reasons for such events.

It is necessary to understand that semi-arid is not something stationary, static, or much less a dead landscape. Cunha (1902), for example, states that now, the Northern hinterlands, despite minor sterility in contrast to this natural criterion, feature perhaps the singular point of regressive evolution, a context that reveals the diversity of elements dynamically articulated.

Thus, it is necessary to understand that Ab' Saber (1965) argued that the Northeast region is an odd and rustic morphological and phytogeographical landscape. Therefore, it is essential to go over the fundamental aspects of nature, the landscape, and its peculiar factors. Also, the guidelines give a notion of the semi-arid region in Northeastern Brazil and its characteristics.

2. Vegetation: white or gray forest, Geography from the Caatinga

Ab' Saber (2003) states that the morphoclimatic domain is a spatial set of great extension that can vary from thousands to millions of square kilometers and presents relief, soil, vegetation, and climatic-hydrological conditions. Therefore, the integrated landscapes and ecological features form a homogeneous and extensive complex.

Thus, when enlightening the caatinga domain, one can notice the intensity of elements involved in the process of belonging to that space and its peculiarities.

Thus, the Caatinga vegetation is in 17 landscape units distributed in 105 geoenvironmental units (RODAL, SAMPAIO 2002). What contributes to this event is the relief, elevation, and slope. To Silva (2000), the average altitude is between 400 m and 500 m and may reach 1000 m, surrounded by 37% of hillsides in which 4% to 12% represents inclination. It reveals the strong presence of erosive processes.

Caatinga comes from the Tupi-Guarani language meaning white forest, which describes the vegetation aspect during the dry season when the leaves fall and white and shiny trunks of trees and bushes remain (ALBUQUERQUE; BANDEIRA, 1995). Then, the elements that trigger such compartmentalization must be the object of researches and elementary for society. To Barros (2003), the Caatinga is an exclusive Brazilian biome, comprising the Northeastern region and part of Minas Gerais, an ecosystem of great relevance. The rustic shrubs and flora are adaptable to semiarid conditions.

To understand the semiarid zone, one must consider the vegetation elements, from its size to its foliage. Thus, Ab' Saber (1999) says that vegetation is almost entirely deciduous—gray and calcinated in the dry season and exuberantly green in the rainy months—with some intrusions of full xerophytism represented by several species of cactus: mandacaru, *Melocactus zehntneri*, *Pilosocereus pachycladus*, *Pilosocereus polygonus*, and other spreading thistles. In reflection, the semiarid flora does not have size and foliage well developed by the process of environmental adaptation, still with Ab' Saber (1999):

A flora made up of species with a long history of adaptation to heat and dryness, incapable of restoring under the same grouping pattern after mechanical scarification of their edaphic support. The Caatinga scrubs—*Croton sonderianus*, *Combretum leprosum*, and *Mimosa hostilis*—prove how hard it is to return to their original vegetation. On the other hand, the land used for road construction reveals the quickness of the xerophytic spreading and the irreversible prevailing conditions.

By understanding the Caatinga, one can notice the geological and geomorphological processes and the human action that transformed it over time. Durval Muniz de Albuquerque, in the book *The Invention of the Northeast*, points out the problem roots in the colonization process of the Northeast region, having in mind the natural exuberance reported by the settlers. Besides, the classic literature approaches drought, monotonous landscapes, and other elements with roots in the semiarid region. Thus, for Casteleti et al. (2004):

In the literature, the Caatinga is poor and shelters few endemic species, but recent studies have revealed a considerable number registered for the region. Because it is a poorly studied ecosystem, there is regular registration of new species of endemic flora and fauna, indicating little knowledge of its biodiversity and ecological processes.

When listing the Caatinga as the most representative biome of this region, one must realize that it harbors countless diversities of fauna and flora, understanding the adaptation factors. It does not obey a homogeneous logic but has its peculiarities. That is, it is not only one Caatinga, but various. Analyzing its phyto-physiognomy, one can see aspects related to the arboreal Caatinga, characterized by large trees, the shrubby Caatinga, which is of small size and has as its principal representatives the *Pilosocereus polygonus*, the dry forest, which does not lose its foliage so voraciously, and the Carrasco, shrubby vegetation difficult to penetrate found in the West of the Ibiapaba Plateau and the South of the Araripe Plateau.

In the magazine *Dossier on the Dry Northeast* (1999), Ab' Saber stated that characterizing the semiarid region is the consummation of morphoclimatic and physiologic processes that have occurred. The postulation of facts arises by perception and not by the physio-geographical processes established over geological time. Thus, the Caatinga had to adapt to the unique local factors, and its vegetation has undergone several adaptation processes, especially in periods of drought. Therefore, the foliage of this biome is xerophytic, being the most remarkable form of survival during drought times.

Concerning the adaptation of the Caatinga vegetation, it is a way to survive in extended drought periods. By observing native plants from Caatinga, one can notice thorns instead of leaves, as is the case of the mandacaru. Some species germinate, proliferate, and die to stay alive in the dry season. They have a kind of potato to store water for hard times.

To elucidate perspectives that involve the Caatinga is necessary to analyze the natural issues around this biome, understanding that these artifacts remain connected. The Caatinga physiognomy shares bonds to the soil structure, encompassing geomorphological, pedological, and geological characteristics.

To elucidate perspectives regarding the Caatinga, one must analyze the natural issues involved in this biome, understanding that these artifacts remain connected. The Caatinga physiognomy shares bonds to the soil structure, encompassing geomorphological, pedological, and geological properties.

3. Semiarid soil

Considering the vegetation, the dynamic in the semiarid region does not have a large size and potentialities because of the local soil. Ab' Saber (1999) stated that the land that constitutes the Northeastern semiarid region, in areas of slopes and interfluvies of the hinterland hills, has a complex regional association of soils, totally different from all other existing sets in the country. Its specificity derives from the presence of soil equally distant from both saline and excessively carbonate. On the other hand, they rarely come close to the characteristics of oxidized soils, which contain concentrations of iron and alumina sinusoids (oxisol, latosol). The latter is restricted only to the humid highlands.

The crystalline soil, especially those containing gneiss, granite, migmatite, and schist (JACOMINE, 1996), is the leading type in the geomorphological composition of the semiarid region. That is why the area does not retain water because the old and hard matrix rock does not allow waterproofing. Even though the crystalline rock is present in an accentuated degree, the sedimentary material is noticeable in the composition of the semiarid landscape. To Rougerie and Beroutchachvili (1991), the landscape is an integrating link that seeks to show the spatial distribution and the existing relations between the elements that compose the natural picture, aiming to describe and sometimes explain the harmony of nature. The facts before the geomorphological attributions start from the assumption that, over time, the landscape suffers modification by natural factors such as climate (temperature, rainfall, humidity, and winds). As a result of these modifications, one can highlight the diversity of formations of reliefs, from the hinterland surface (Falcão, 2007) to the other geomorphological compartments.

Araújo (2002) states that soils result from the combined action of formation factors, that is, the material of origin (geology), climate, relief, the activity of organisms, and time, making the semiarid soil vary from shallow and few fertile to deep and more fertile. The morphological environment consists of a set that differs even in small distances and is the outcome of chemical, physical and biological processes that shape and differentiate the semiarid landscape over time. To Ab' Saber (1977), the landscape is a heritage from physiographic and biological processes, comprising exogenous and endogenous factors.

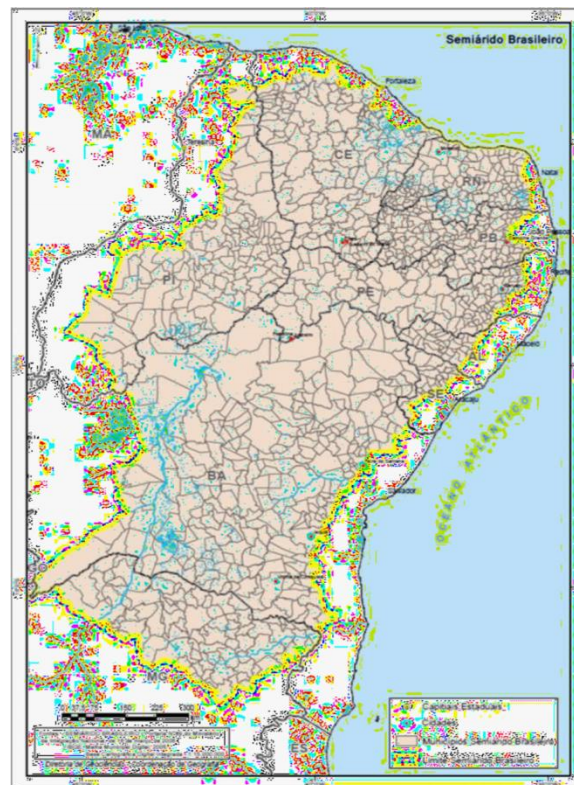
When studying the entire structure of the soils, it is noticeable the issues within the semiarid context, such as infertility, poor and shallow soil, variety in soil, residual and sedimentary soils. In the Northern side of the massifs, where the rain favors the chemical weathering, there are indications of alteration (BRASIL, 1981) (LEITE, 2000). In the alluvial plain, there is an association of strophic Fluvisol Neosol A moderate, indistinct texture, hyper-xerophytic Caatinga floodplain, and the riparian forest, comprising a significant agricultural potential (BRANDAO, 2003). Four (Latosol, 19%, Litholic Neosol, 19%, Acrisol, 15%, and Luvisol, 13%) out of the 15 soil orders occupy 66% of the Caatinga area, although they are spatially fractioned. According to Silva (2000), 82% of the region has soil with low productive potential, either by fertility limitations, depth of profile, or the drainage and high levels of exchangeable Na (CUNHA et al., 2008; SALCEDO; SAMPAIO, 2008).

4. from fighting drought to living in the semiarid region

The public policies that support Northeastern Brazil are not recent. The drought from 1877 to 1879 is the initial milestone of the concern regarding the climatic phenomena that devastated that region. Besides, the incipient public strategies did not prioritize policies that included essential elements – economy, culture, politics, nature, and society – for development.

Thus, from the beginning of the 20th century to the present day, it was established the Departamento Nacional de Obras Contra as Secas (National Department of Works Against Droughts, DNOCS) in 1946, the Inspeção de Obras Contra as Secas (Inspectorate of Works Against Droughts, IOCS) in 1909, and the Inspeção Federal de Obras Contra as Secas (Federal Inspectorate of Works Against Droughts, IFOCS) in 1919. Together they have been building an immeasurable extension of medium to large-sized dams. In this perspective, the preliminary measures of the government interventions were the hydraulic solution, that is, the construction of reservoirs to accumulate rainwater for the dry season. From 1936 to 1989, this region was the so-called Drought Polygon.

In this light, this strategy of damming water evolved and became the principal subsidy mechanism for irrigated agriculture. So, from 1970 on, the irrigation policies gained success and became the target of government interests, causing the agricultural production to create agricultural poles, jobs, and income for most of the population.



Source: IBGE (2017).

5. Six decades of coexistence

It is necessary to go over the six decades of assistance to the semiarid region, not that it currently succeeded, but there has been considerable progress. Besides, it is indispensable to elucidate the advance in the last sixty years, highlighting uses and situations over time.

By creating the Superintendência do Departamento do Nordeste (Superintendence of the Northeast Department, SUDENE) in 1950, the government started implementing strategic planning actions for the region. Also, the Grupo de Trabalho para o Desenvolvimento do Nordeste (Work Group for the Development of the Northeast, GTDN), created in 1956 under the Juscelino Kubitschek government, sought strategies for the local development. The guidelines and programs aimed at an industrial park to foster agriculture in the Northeastern area since the actions pursued the regional economy. Structuring programs, irrigation advancement, and pedological, hydrological, and meteorological studies caused SUDENE to develop. Such factors assisted the selection of areas to develop irrigated agriculture.

However, in the 1960s, irrigated agriculture demanded technology that did not match the situation in Northeastern Brazil. The solution was to create the Planos e Programas de Emergência de Seca (Emergency Drought Plans and Programs) still in the 1960s, which underwent several modifications that modified the concepts and the very assignment of these public policies. These actions did not inhibit the drought effects, nor did they contribute to the infrastructure of coexistence in the semiarid region.

From the 1970s in, some measures sought to strengthen the Northeastern identity – Northeast Pole (Program for the Development of Northeastern Integrated Areas), Hinterland Project (Special Program of Support to the Development of the Northeast Semiarid Region), Programa de Recursos Hídricos do Nordeste (Program of Northeastern Water Resources, PROHIDRO), Programa de Apoio ao Pequeno Produtor Rural (Program of Support to the Small Rural Producer, PAPP), and Northeast Project (Program for the Development of the Northeast Region). However, fighting drought was the thinking behind such discussions since it is natural and the problems result from political usurpation. Later, the logic of living in the semiarid region had consolidation from the 1980s on.

6. in the semiarid region

The areas depressed among highlands because of the adversities affecting the hinterland depression, also named as hinterland surface by Falcão Sobrinho (2008).

This geomorphological compartmentalization corresponds to 92% of the total area of Ceará. The analysis assumption is issues affecting the semiarid region, such as social aspects, land issues, migration, misery, poverty, high mortality and birth rates, and principally the drought.

Starting from an assumption of historical analysis, one can perceive the process of dispersion of a miserable identity of Northeastern Brazil for a long time in dialogue with political and oligarchic perspectives. The poverty, drought, and soulless land got proportion through the classic Brazilian literature, in the novels of Rachel de Queiroz, Graciliano Ramos, Euclides da Cunha, and other authors that reported the natural condition of the semiarid environment highlighting incontestable aspects.

Because of problems and attempts to emancipate Northeastern Brazil from drought, some governmental measures have tried to act in a very significant way. According to the Panel on Climate Change (IPCC), the area is one of the most vulnerable arid and semiarid regions worldwide. Thus, given all the natural issues, the latest climate changes can further accentuate these factors.

To Ribot Najam and Watson (1992), a semiarid region has an arid climate, water deficit, unpredictable rainfall, and its soil is not rich in organic matter. Thus, the discourse of drought remained for a long time as the identity of this region and added to this, technological and economic backwardness factors only reinforced such problems. Therefore, the semiarid area still has a low economic dynamism, whose social indicators are below the national and regional averages, and environmental degradation, affecting its fragile ecosystems (Santos, 2008).

To mitigate the impacts of droughts or accentuated periods of drought, some mechanisms developed by various bodies brought to light measures that ensured the maintenance of the semiarid area. Given these setbacks, the actions assisted life in such zones, which became the principal measure of applicability to mitigate the results of this local natural state. In other words, living in the semiarid region meant steps for its development, reducing migration, deaths, and diseases arising from the lack of public policies towards food and drinking water. According to Nascimento (2008), the idea of living in the semiarid area does not represent only a response to drought but also brings with it fundamental elements to obtain successes and perspectives for the local region. Thus, the local life represents the fight against desertification, the promotion of access to land, funding, technical assistance, education, and water (Neves, Medeiros, Silveira, and Morais, 2010).

To Gnaldlinger (2000), the rainwater collection emerged independently around the world thousands of years ago, with adaptations that depended on specific conditions and cultures to solve local problems. In other words, the coexistence with the semiarid region is not recent but the result of a process of adaptation and survival of those who have always been hostages of the local natural state. Malvezzi (2010) states that the materialization of coexistence represented learning about popular wisdom and the rescue of an established technology.

Thus, life in the semiarid region does not aim to combat drought, a slogan widely used for a long time that offered a solution to this problem. However, it represents a new logic of thinking, acting, and conducting debates about an appropriate development model for the semiarid region (Carvalho, 2010: 8). It is not an end to the problem but support for life in this area. It is an aid to the natural state of this area to enable the construction of human guidelines to understand the dynamics of nature.

The beginning of more substantive solutions to the problems of humans and society in the hinterlands depends on the level of knowledge of the regional reality. There is no use in salvific ideas elaborated by a bourgeois and distant mentality, feeding popularity-seeking arguments and crushing resources that should have a more generous social destination. The cause of the Northeastern hinterlands deserves a true crusade of Brazilian intelligence without embarking on elitist and insincere fads (A'b Saber, A. N., 1999).

The slogan Combat Drought went on for a long time, giving the idea of a solution to the problem. When realizing the impossibility, more measures gained space along with programs that aimed at the same clauses. Such programs arose at the 3rd Conference of the Parties to the Convention to Combat Desertification of the United Nations, held in 1993 in Recife, Pernambuco. The One Million Cisterns (P1MC) is an initiative from social organizations and the government. Although created in 2000, the P1MC became a public policy of the federal government only in 2003 when signed the Partnership Agreement 001/2003 with the Ministry of Social Development (SOUZA PASSADOR and LUÍS PASSADOR, 2010) and *Articulação no Semiárido Brasileiro* (Articulation in the Brazilian Semiarid Region, ASA). The P1MC and the Programa Uma Terra Duas Águas (One Land Two Waters Program, P1+2) were the first mechanisms to assist life in the semiarid region.

In this prerogative, there must be a gradual consolidation of the actions. To Silva (2006), to happen a transformation in the semiarid reality, it is necessary new rationality that constitutes a fundamental imperative for the sustainability of development.

Therefore, coexistence must start from the assumption of understanding nature and the regional dynamics so that the attributes put forward are substantial and can ensure the development of this region. Thus, coexistence is manifested in the territorial structure to enable the construction of good relations between humans and nature, aiming at the quality of life of families living in semiarid regions. Such a view dismisses the guilty parties and nature as the enemy of this region, making it possible to perceive the local potentialities, limitations, and peculiar characteristics.

Thus, the evolution of the semiarid region has as a booster the prefatory aspects of knowing the environmental uniqueness and modifications in the practice and use of the local resources. To Silva (2006, p. 226), the fundamental challenge to the new orientations of sustainable development in the Brazilian semiarid region is to build a sense of coexistence. With recent methodologies, distorted views on semiarid places lost ground, and later the dimension of this area will appear and remove the drought paradigm.

7. Techniques for coexistence with the semiarid region

Out of all the semiarid regions on earth, Brazil has the highest rainfall rates, making it the rainiest country. Thus, measures that can develop this region have always been quite significant, highlighting that these actions contribute positively and foster the development process of these regions. [...] From the economic viewpoint, coexistence is to sustainably use the potential from nature in productive activities in the environment (SILVA, 2006, p. 234). Also, the Brazilian semiarid region presents a rich natural diversity, such as flora, fauna, and cultural issues of resistant people. It is of utmost importance to value the traditional knowledge and the innovation from coexistence techniques.

In this sense, the public policies for living in the semiarid region seek to promote measures that help in the process of social, political, and economic ascension that minimize the effects of drought or limited resources. Therefore, the actions aim at a collective good and promote aspects concerning the maintenance of activities that seek to live with the most diverse local singularities and fragilities. Thus:

Living in the semiarid region requires values and patterns of production, such as alternatives based on agroecology, sustainable management of the Caatinga, small animal husbandry, and associative and cooperative projects, which express a solidary economy (SILVA, 2006, p. 235).

Therefore, the analysis is on the contributions from policies of coexistence with the semiarid environment and the benefits from these techniques over time. Besides, there is the elucidation of the actions in the semiarid context.

Among the actions, it is worth mentioning the social technology for life in the semiarid region, both for consumption and production and based on simple and accessible methodologies easily handled by farming families. It is essential for guaranteeing the right to water and contributing to food and nutritional security.

According to Magalhães, Costa Falcão, and Falcão Sobrinho (2012), an alternative for better use of the potentialities of the semiarid region would be the encouragement of family farming. Such potentialities are mentioned below through water capture and storage systems.

Several techniques have been promoting and making feasible the assistance to the semiarid region, such as plate cisterns, which capture and store rainwater, seeking to provide drinking water for consumption and basic needs, promoted by the PIMC.

The model of each cistern can store sixteen thousand liters of water, covering the supply of a family of five people during the eight months of drought, bearing in mind that the water is intended exclusively for human consumption, which consists of drinking and cooking. (FALCÃO SOBRINHO, 2020a,b).

Falcão Sobrinho adds that such a claim should occur throughout the semiarid region, guaranteeing quality water for the consumption of approximately five million people. According to the ASA report (2002), the program provides rural communities with training aiming at sustainable coexistence that intends to involve one million families. The coexistence technology offers a better quality of life and access to quality drinking water.

Figure 1 – Plate cistern in Taboleiro, Reriutaba, Ceará.

Source: The authors (2018).

In addition to P1MC, ASA has been promoting P1+2, aiming at increasing the water stock of families, rural communities, and traditional populations. Number one means the land, and two is the second water destined for family agriculture and small animal husbandry for production. The proposal for social mobilization is the access to water for sustainable management to ensure food security for rural families in the semiarid region. What follows below is some social technology for coexistence with the semiarid environment.

Flood cisterns store water for food production, medicinal plants, animal husbandry and enhance the productive backyards.

The rainy season is uncertain in the semiarid region, presenting variability in time and space. Concerning it, there is a direct influence of rain on the lives of rural people, both for agricultural production and the lack of water for human consumption in the dry season. Therefore, it is necessary to evaluate the alternatives for water catchment, including flood cisterns intended for production, which depends on precipitation.

Figure 2– Floodcistern.

Source: The authors (2018).

Family farming in the backyard, which once seemed impossible, is now a reality. The capture of rainwater through cisterns is intended for production, as shown by Figure 2. It is a crop of coriander and chives, which are of extreme importance for the small farmer since it is possible to grow vegetables, medicinal plants, greens, among other crops. These practices make it evident that despite the limitations imposed by the environment, it is possible to live with the semiarid climate and biome. These practices are sustainable since they do not harm the environment.

The underground dam is a technique that stores rainwater within the soil profile and serves small irrigations of grass, vegetables, cassava, potatoes, and other crops (Figure 4).

The underground storage system is an effective instrument to complement water needs in semiarid climate regions and, in some cases, the solution for providing water for families (LIMA, 2012).

Figure 3 – Underground dam in Taboleiro **Figure 4** – Vegetable planting



Source: The authors (2018)

Lima (2012) declares that underground dams are alternative low-cost construction and maintenance technology in the semiarid region for rainwater harvesting. The water serves humans, animals, and agriculture and ensures food and nutritional security for families.

A mandala system is a sustainable form of family farming. It is a model organized in the form of concentric circles. Given the sustainability and active role of the farmer through this system, it provides the cultivation of bananas, vegetables, and poultry. These crops provide the farmer with an additional income.

Figure 5 – Mandala system in São Domingos, Sobral, Ceará.



Source: The authors (2018).

Given the advantages of the mandala implementation, Mesiano and Dias (2008) mention the reduction of dependence on inputs from outside the property, diversification of production, efficient use, rationalization of water resources, and achievement of sustainability.

As explained by Magalhães, Costa Falcão, and Falcão Sobrinho (2012), the format mandala system shape is a new form of irrigation. The round reservoir in the middle of the planting makes better use of space since the project is for small farms. Food production is diverse, such as vegetables, fruits, and other crops (MESIANO; DIAS, 2008).

The benefits from the mandala system are the supply and livelihood of small farmers, promoting a protagonist role. Moreover, it contributes to the sustainable use of the environment and the non-degradation of natural resources. The improvement in food and family income stands out because it favors the social inclusion of the participating farming families since the technology is low-cost, which values and respects traditions and local knowledge.

Besides the water collection and storage techniques – which assist crops, small animal husbandry, flowerbeds, and green backyards –there is also the digester as an alternative to manage renewable energy sources. The Paulo Freire Project, support by the Government of Ceará and the International Fund for Agricultural Development (IFAD), implemented the digesters. This equipment promotes the fermentation of organic matter by anaerobic digestion, producing biogas for stoves. It reduces the expense since it is not necessary to buy gas cylinders. It also allows alternative management for organic, previously dumped outdoors, polluting the environment and damaging the soil (Figure 1).

Figure 6 – Digester in Trapiá, Massapê, Ceará.



Source: The authors (2019).

The final product of digesters after anaerobic fermentation serves as fertilizer farmers to control pests. After filtered or decanted, the liquid produces a solid mass that serves as organic fertilizer for the soil, dispensing external agricultural inputs.

The reuse water technology integrates into the environment to reuse gray water from bathrooms, sinks, and kitchens. After having the impurity filtered, the water goes to the grease tank, worm farm – which acts as a biological filter – and then to the well serving to irrigate the plants. The organic fertilizer produced on the property supplies the worm farm, generating income for the owner by selling hummus and worms.

Figure 7 – Worm farm in Trapiá. **Figure 8** – Well for the reallocation of gray water.



Source: The authors (2019).

Using this technology, in general, constitutes a fundamental role as a means of social development in the semiarid region.

Other techniques also provide significant performance, such as salvation irrigation, which uses water from nearby reservoirs during the rainy season without disturbing the human and animal supply, and drip irrigation, which is an equal distribution of water, keeping the roots of plants moist, avoiding water waste.

In this prerogative, there are other means that promote the survival and permanence of the inhabitants in the context of the semiarid region, which goes from the small-scale breeding of animals – goats, sheep, pigs, and poultry –and other processes, such as cooperatives and the use of the flora, characterized as plants that give the possibility of extraction and commercialization. Together, these actions constitute ways of living harmoniously in a semiarid area, highlighting the support of public policies.

The presented framework of experiences of coexistence makes possible a broad reflection on the reality of the semiarid region and possibilities and perspectives of living with the Caatinga climate and biome in an agroecological way. The experiences create the conditions for a dignified life, food sovereignty, and better quality of life.

Despite the support of public policies and non-governmental organizations that aim at helping the semiarid region, there is still a lack of applications, such as families that do not have social technology like cisterns, mentioning that such policies should start from the systemic premise of social and economic development, preservation, and potentization.

Given the framework presented, there must be greater integration between the work done by the family, through their representations, and NGOs, with research and extension conducted by public universities and research centers. Therefore, there will be effective and consolidated sustainability of techniques for living in the semiarid region (LIMA, 2012).

Referências

- AB' SABER, A. N. Da participação das depressões periféricas e superfícies aplainadas na compartimentação do Planalto Brasileiro. São Paulo, (tese livre-docência), 1965.
- AB' SABER. O domínio morfoclimático semiárido das caatingas brasileira. Geomorfologia, n. 43, p.1 -3, 1974.
- AB' SABER, A. N. Potencialidades paisagísticas brasileira. In: AB'SABER, A. N. "Os domínios da natureza no Brasil." 9-26, 1977.
- AB' SABER, A. N. **Sertões e sertanejos**: uma Geografia Humana sofrida. Estudos avançados. São Paulo, v.13, n 36, p. 7-59, 1999.
- AB'SÁBER, A. N. **Os domínios de natureza no Brasil: potencialidades paisagísticas**. Ateliê editorial, 2003.
- ALBUQUERQUE, S. G.; BANDEIRA, G. R. L. **Effect of thinning and slashing on forage phytomass from a caatinga of Petrolina, Pernambuco, Brasil**. Pesquisa Agropecuária Brasileira, Brasília, DF, v. 30, p. 885-891, 1995.
- ARTICULAÇÃO DO SEMIÁRIDO BRASILEIRO (ASA). **Programa da Formação e Mobilização Social para a Convivência com o Semiárido**: um milhão de cisternas rurais (P1MC). 2002. Recife, sumário executivo, 47p.
- BRASIL. Projeto RADAMBRASIL. Folhas AS. 24 Fortaleza; geologia, geomorfologia, pedologia, vegetação e uso potencial da terra/ Projeto RADAMBRASIL: Rio de Janeiro, 1981. 488 p (Levantamentos dos recursos naturais).
- BRANDÃO, R. L. Zoneamento geoambiental da região de Irauçuba-CE. Texto explicativa, Carta Geoambiental. Fortaleza: CPRM, 2003.
- CARVALHO, L. D. **Ressignificação e reapropriação social da natureza: práticas e programas de "convivência com o semiárido"** no território de Juazeiro-Bahia. Tese de Doutorado em Geografia. Centro de Educação e Ciências Humanas da Universidade Federal de Sergipe. 342p.(inédito). 2010.
- CASTELLETI, C.H.M.; SILVA, J.M.C. TABARELLI, M.; SANTOS, A.M.M. 2000. Quanto ainda resta da caatinga? Uma estimativa preliminar. In: SILVA, J.M.; TABARELLI, M.; FONSECA, M.T.; LINS, L.V. (Orgs.) Biodiversidade da Caatinga: áreas e ações prioritárias para a conservação. Ministério do Meio Ambiente/Universidade Federal de Pernambuco, Brasília, 2004, p. 91-100.
- CAVALCANTI, E. P.; SILVA, E. D. V. **Estimativa da temperatura do ar em função das coordenadas locais**. In: CONGRESSO BRASILEIRO DE METEOROLOGIA, 7.; CONGRESSO LATINOAMERICANO E IBÉRICO DE METEOROLOGIA, 2., 1994, Belo Horizonte. Anais... Belo Horizonte: Sociedade Brasileira de Meteorologia, 1994. p. 154-157.
- CUNHA, Euclides da. **Os Sertões**. Rio de Janeiro: Ediouro, 2003
- CUNHA, T. J. F.; PETRERE, V. G.; SÁ, I. B.; CAVALCANTI, A. C.; SILVA, A. H. B. B. da; ARAÚJO FILHO, J. C. de. A pesquisa em ciência do solo no Semiárido brasileiro. In: ALBUQUERQUE, A. C. S.; SILVA, A. G. da. (Ed.). **Agricultura tropical**: quatro décadas de inovações tecnológicas, institucionais e políticas. Brasília, DF: Embrapa Informação Tecnológica, 2008. v. 2, cap. 5, p. 453-491.
- FALCÃO SOBRINHO, J. **Relevo e Paisagem** – Proposta Metodológica. Ed. Sobral. Sobral. 2007.
- FALCÃO SOBRINHO, J. **Semiárido**: diversidades naturais e culturais. Fortaleza, Expressão Gráfica, 2008.

- FALCÃO SOBRINHO, J. **Waterresourcesavailableatcisterns in theacaraúriverbasin, Ceará, Brazil**. Interespaço: Revista de Geografia e Interdisciplinaridade, v. 6, p. 1-25, 2020a. Disponível em: <<http://dx.doi.org/10.18764/2446-6549.e202028>> Acesso em: 05 de Junho de 2021.
- FALCÃO SOBRINHO, J. A Natureza do Vale do Acaraú: um olhar através das sinuosidades do relevo. Série Geografica do Semiárido, v.7. Sobral-CE: Serão Cult, 2020b.Doi: 10.35260/87429137-2020.
- GNADLINGER, J. **Colheita de Água de Chuva em Áreas Rurais**. Juazeiro – BA: IRPAA, 2000.40p
- INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC). **Impacts, Adaptation and Vulnerability.Working Group II Contributions to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Summary for PolicymakersandTechnicalSummary**. 2007
- JACOMINE, P. T. K. Solos sob caatinga: características e uso agrícola. In: ALVAREZ V., V. H.; FONTES, L. E. F.; FONTES, M. P. F. **O solo nos grandes domínios morfoclimático do Brasil e o desenvolvimento sustentado**. Viçosa, MG: Sociedade Brasileira de Ciência do Solo: Universidade Federal de Viçosa, 1996. p. 96-111
- LEITE, F. A.B; CARVALHO, G. M. B. S; SANTOS, S. M. Diagnostico geoambiental do município de Irauçuba-CE. Fortaleza: Semace, 2000.
- LIMA, A. O. **Nova abordagem metodológica para locação, modelagem 3D e monitoramento de barragens subterrâneas no semiárido brasileiro**. 2012. 244 f. Tese (Doutorado em Geodinâmica e Geofísica: Área de Concentração Geodinâmica) - Universidade Federal do Rio Grande do Norte, Natal, 2012.
- MALVEZZI, R. (2010). **“Personagens das Águas. Água nos Agrossistemas: aproveitando todas as gotas”**. Revista Agriculturas: experiências em agroecologia, 7, 3, 4-6.
- MALVEZZI, Roberto. **Semiárido - uma visão holística**. – Brasília: confea, 2007. 140. - (pensar Brasil).
- MAGALHAES, L. C. M. ; FALCÃO, C, L, da Costa ; FALCÃO SOBRINHO, J. **O sistema Mandala como alternativa para uma melhor convivência com o semiárido, implantado no assentamento são João no município de Sobral-ce**. Revista Homem, Espaço e Tempo, v. 1, p. 12-24, 2012.
- MESIANO, Â; DIAS, R. **A Tecnologia Social como estratégia para o desenvolvimento sustentável: o caso da Mandalla**. In: VII ESOCITE. Jornadas Latino-Americanas de Estudos Sociais das Ciências e das Tecnologias. Rio de Janeiro, 2008. Disponível em :<<http://www.necso.ufjf.br/esocite2008/resumos/36047.htm>>. Acesso em: 28 maio 2021.
- NASCIMENTO, H. M. **Convivência com o Semiárido e as Transformações Socioprodutivas na Região do Sisal –Bahia**: por uma perspectiva territorial do desenvolvimento rural. Congresso da Sociedade Brasileira de Economia, Administração e Sociologia Rural, 46ª Edição, 16 a 18 de julho de 2008, Rio Branco. Anais XLVI Congresso da SOBER, Rio Branco.
- NEVES, R. S.; MEDEIROS, J. C. A.; SILVEIRA, S. M. B.; MORAIS, C. M. M. **“Programa Um Milhão de cisternas: guardando água para semear vida e colher cidadania”**. Agriculturas. 7, 3, 7-11. 2010.
- PASSADOR, C. S.; PASSADOR, J. L. **Apontamentos sobre as políticas públicas de combate à seca no Brasil: cisternas e cidadania?** Cadernos Gestão Pública e Cidadania v. 15, n. 56. São Paulo, 2010. ISSN 1806-2261.
- RIBOT, J. C.; NAJAM, A.; WATSON, G. **Variação Climática, Vulnerabilidade e Desenvolvimento Sustentável nas Regiões Semiáridas**. Trabalhos da Conferência Internacional sobre Impactos de Variações Climáticas e Desenvolvimento Sustentável em Regiões Semiáridas –ICID. Volume IX. Estudos de Abrangência Geral. Fortaleza. 1992.
- RODAL, M.J.N. & E.V.S.B. SAMPAIO. 2002. A vegetação do bioma caatinga. p.11-24 In: **Vegetação e flora das caatingas** (SAMPAIO, E.V.S.B., A.M.; GIULIETTI, J. VIRGÍNIO & C.F.L. GAMARRA-ROJAS, ed.). APNE / CNIP, Recife, PE.
- SANTOS, J. M. Estratégias de convivência para a conservação dos recursos naturais e mitigação dos efeitos da desertificação no semiárido. Em: Brasil, Ministério de Ciência e Tecnologia (MCT) **Desertificação e mudanças climáticas no semiárido brasileiro** (pp. 165-184). 2011, Campina Grande, PB: Insa-PB.
- SILVA, J. R. C: Erosão e produtividade do solo semiárido. In: OLIVEIRA, T. S de; ASSIS JR. R .N& ROMERO, R.E. eds. **Agricultura, sustentabilidade e o semiárido**. Capítulo 10 Fortaleza; UFC, Viçosa: Sociedade Brasileira de Ciência do Solo, 169-213, 2000.
- SILVA, R. M. A. **Entre o Combate a Seca e a Convivência com o SemiÁrido**: transições paradigmáticas e sustentabilidade do desenvolvimento. (Tese de Doutorado). Brasília: UNB, 2006, 298.
- ROUGEIRE, G. & BEROUDCHACHVILI. N. **Geosystemes et Paysages**:Bilian et Méthodos.Paris: Armand Colin Éditeur. 1991.