The **sun** is no longer the *villain* in the **Semiarid region of Paraíba**

PROCASE
PROJETO DE DESENVOLVIMENTO SUSTENTÁVEL DO CARIRI, SERIDÓ E CURIMATAÚ

IFAD
Investing in rural people

Procasur
Harvesting Innovations, *Spreading* Opportunities

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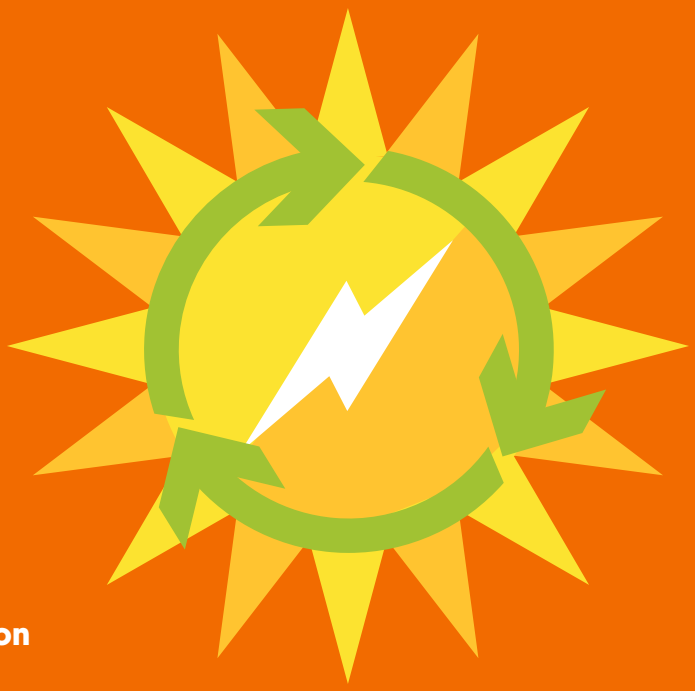
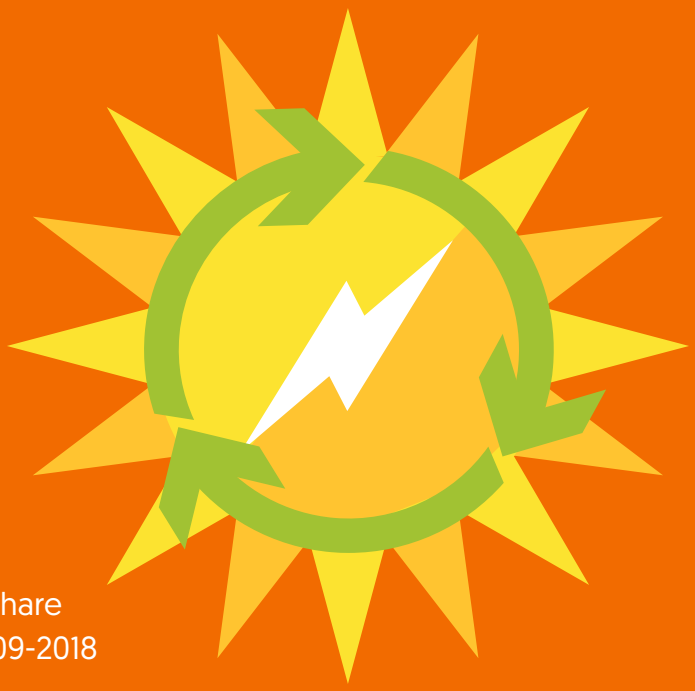
Summary





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Procase presentation

This publication systematizes the experience of the Cariri, Seridó, and Curimataú Sustainable Development Project – PROCASE, supported by the International Fund for Agricultural Development – IFAD, in solar energy agreements signed with associations and cooperatives in the semiarid region of Paraíba, streamlining and strengthening production chains goat farming, handicraft, fruit growing, etc.

Investments of approximately R$ 2 million were made in six agreements *(CAPRIBOM, COOPEAVES, ARTEZA, COAASC, ASCOMCAB, and COAPECAL)* in the period 2017 to 2019 for the implementation of photovoltaic solar energy production systems. These agreements contribute to environmental issues, such as carbon sequestration, producing clean and sustainable energy, and providing a significant reduction in electricity consumption in the enterprises of associations and cooperatives by up to 80%, enabling new investments and encouraging strengthening value chains.

The implementation of solar energy in processing units supported by PROCASE is a strategic part of the productive actions, strengthening the marketing for public purchase programs of food from family agriculture to generate assets and strengthen associations.

This initiative is a partnership between the PROCASUR Corporation and IFAD to disseminate good practices in renewable energy promoted by PROCASE with partners. This publication is permeated by careful historiography that points out the challenges of drought in the Northeast region and the potential generated by climatic conditions, especially in the Semiarid and Caatinga biome, as well as essential reports and a vibrant role, especially of women and young people involved with the production in these enterprises. The photographic records made especially for this publication attest to the outstanding quality of the professionals involved in the conception, organization, and publication of this systematization, which is part of the history of good practices by IFAD, PROCASE, and PROCASUR.

Wallene de Oliveira Cavalcante (PROCASE Environmental Management Manager)

Procasur presentation

Non-conventional renewable energy (ERNC) offers multiple benefits for rural families, communities, and the environment. As they are necessary for all stages of the food chain (planting, growing, and harvesting; manufacturing and transport of inputs; packaging and distribution of final products), they can improve agricultural production and post-production activities, in addition to being used for pumping water, drying products, processing agricultural products, refrigerating, and cooking. From a territorial point of view, they can contribute to the development of rural economies and improve the livelihoods of the poor because of their affordable cost and promote new sources of income and employment, business opportunities, fostering innovation, and empowering communities.

ERNCs contribute to the reduction of greenhouse gas emissions and provide added value for climate resilience in agriculture through at least three different mechanisms: first: although their initial cost is sometimes higher compared to traditional sources, they can increase efficiency and reduce costs in the long run, improving productivity and benefits for family farmers and rural micro, small, and medium-sized enterprises, as they provide a reduction in energy costs of up to 65%.

Second, ERNCs positively influence agricultural value chains from the household to the broader distribution system and the food chain. For example, concerning photovoltaic solar water pumps, biomass for power generation, solar dryers, and biofuels for transporting goods. ERNCs increase productivity and reduce the time and cost of preparing products for sale. As each step of the value chain offers a different opportunity (or challenge), taking a holistic approach is required to fully understand the indirect effects of renewable energy adoption, considering different institutions and organizations (such as cooperatives) involved in agricultural production value chains.

Third, ERNCs bring well-being to rural communities and families. Properly implemented, they trigger complex local dynamics that contribute to communities' resilience. Energy provides access to communication technologies that improve farmers' access to market information and provide, for example, access to the Internet or lighting for schools. Cooling technologies allow vaccines and other medical supplies to be kept in remote locations. ERNCs reduce deforestation due to the use of traditional solid biomass. Their benefits include improving health, soil quality, and nutritional value, protecting biodiversity, food safety, and improving rural communities' livelihoods and quality of life.

ERNCs are gender and youth-sensitive. They are more attractive to rural women by offering the opportunity to earn income from their productive use and employment in activities they induced in rural economies. While there is a tendency to underestimate women's economic potential and their role in the informal economy, they are responsible for most energy-intensive household chores. Thus, projects that adopt ERNCs must consider gender aspects, integrating them into national policies and regulatory frameworks. For rural youth, renewable energies can offer significant opportunities in areas that generate employment for young people, all the more so as they are particularly attracted to new technologies and open to change and the adoption of new practices.

Global investments in renewable energy have increased from less than $50 million a year in 2004 to about $300 billion in 2019, shifting towards emerging markets. Although private sources provide the majority of investment in ERNCs worldwide (over 90% in 2016), developing countries represent a significant opportunity for public and private investment, as public spending plays a crucial role in implementation in early-stage funding. As rural areas do not usually benefit from the microfinance industry, policies that address the lack of access to finance by rural communities and harness the potential of public and private investments from their adoption are very beneficial.

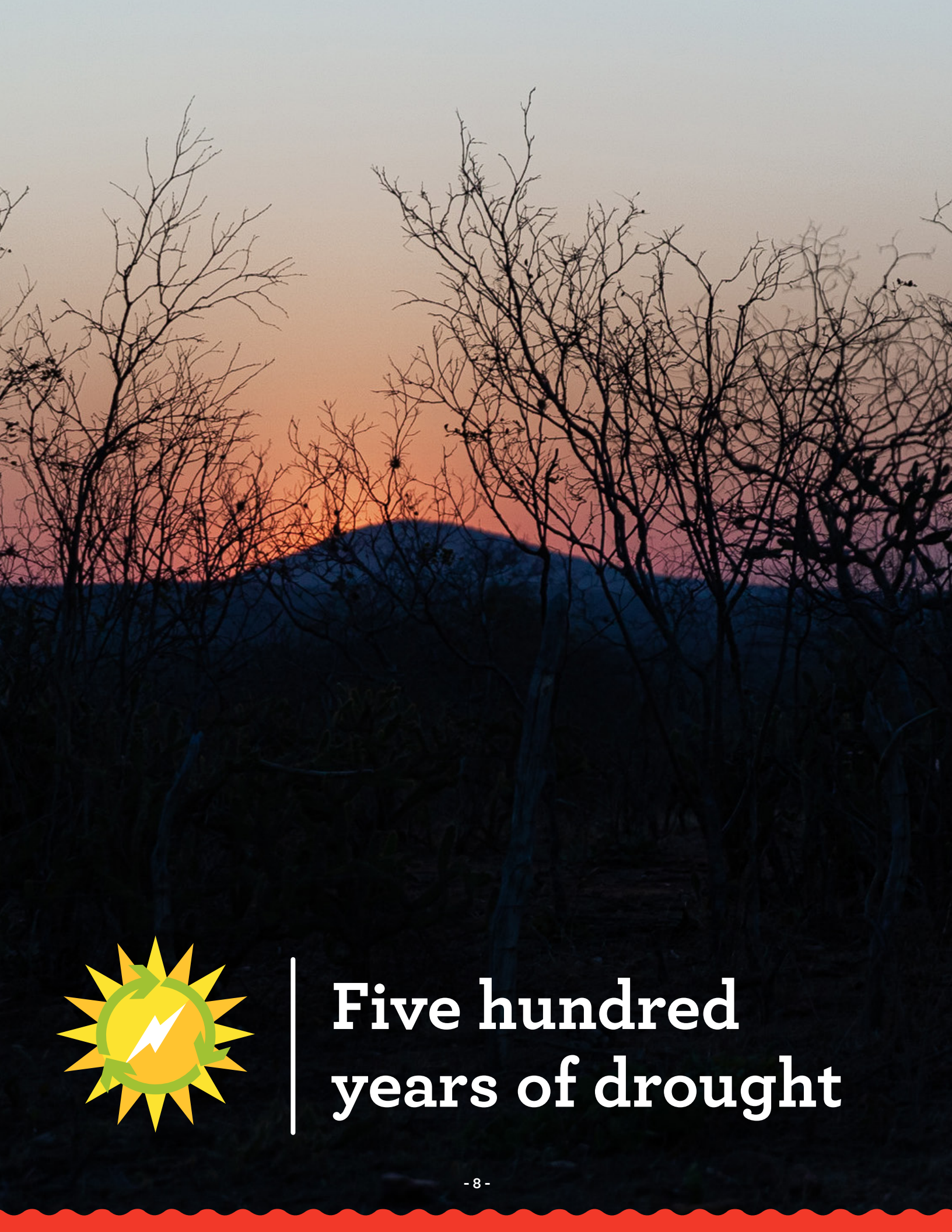
As ERNCs have a positive return on investment, but their initial cost is high, at least 14 countries in Latin America and the Caribbean, including Brazil, have created public funds to finance projects of this type on a large scale or have offered tax incentives to do so. Green microfinance represents a dynamic market. However, there is a lack of specific funds dedicated to ecological microfinance institutions that implement pilot programs capable of expanding projects and capitalizing on their experiences. Including environmental dimensions in microfinance projects turns financial and environmental vulnerabilities into market opportunities by supporting more cost-effective value chains.

Despite the great potential of ERNCs, some barriers delay their expansion due to: (i) lack of adequate political and regulatory frameworks; (ii) lack of funding sources for the projects; and (iii) limited instruments for their financing. Although public and private financing possibilities have been expanded, there is a limited supply of financial instruments, which is accentuated in rural areas, especially in the small-scale business sectors, the primary recipients of development projects supported by IFAD.

For all these reasons, the experience of including ERNCs in the production and transformation processes of products in the Brazilian semiarid region documented and systematized in this publication is gratifying, also because their results and impacts benefit cooperative organizations and their partners.

PROCASUR strives to share lessons and lessons that, together with the multiple participants in these initiatives, will improve governments' ability to diversify and increase the impact of their investments in rural territories across the region.

Juan Moreno Belmar, PROCASUR Corporation President



Five hundred years of drought

For centuries, the sun and lack of rain were the torments of the northeastern population. The first record of drought and its disastrous consequences for the region's inhabitants dates back to 1553. However, it must be remembered that the occupation of the Northeast by the Portuguese only took place 30 years after Pedro Álvares Cabral's fleet landed in Bahia.

Although the population of Portuguese origin was small, the third drought recorded had such a serious social impact that even the original populations were forced to migrate. "In 1583, a drought became known for forcing the displacement of approximately 5,000 Indians from the Cariris Velhos region, the rural and backlands to the coast, in search of food, according to the Jesuit Fernão Cardim."[1]

During the next three centuries, the records became more frequent, not least because they were better observed, and the social and economic consequences more severe, mainly because the territorial and demographic occupation gradually expanded.

Extensive ranching and cotton growing became increasingly important. The fiber experienced an upsurge in the 19th century when production in the southern United States collapsed due to the Civil War in that country. The southern states of the US were big producers, but the conflict practically suspended exports, which led to an ephemeral "boom" in other countries, including Brazil. The drought had mainly an economic effect on livestock due to the death of the herd. In the case of cotton, whose production was intensive in labor, more than the economic loss, what occurred was a catastrophe without parallel in the history of Brazil.

"The Great Drought," as will be seen later, would go down in history as the greatest Brazilian humanitarian tragedy (although not consistently recognized as such). For this very reason, however, it would become a landmark in how the National State would face regional issues: drought became an object of public policies.

Throughout the 20th century, these policies followed two axes: a) public works, mainly the construction of dams and the creation of "work fronts," through which those affected by the drought were incorporated into the construction of roads, for example, enterprises not always of public interest; b) welfare, basically water distribution by water trucks.

Public policies to combat the effects of drought were reoriented at the end of the 20th century. The work fronts ceased to have priority, and other emergency actions gave way to projects focused locally to improve the population's living conditions, such as the construction of cisterns.

Another line of government action was the dissemination of techniques for the conservation of scarce water resources through underground micro-dams and the promotion of rural activities less susceptible to being affected by water scarcity, such as the conversion of extensive cattle raising into goat and sheep farming, the introduction of forage palm and the cultivation of plant species resistant to climate and water stress.

[1] Lima, J.R. and Magalhães, A. Secas no Nordeste: registros históricos das catástrofes econômicas e humanas do século 16 ao século 21. Parcerias Estratégicas (CGEE). Brasília, v. 23, n. 46, p. 191-212, Jan - Jun 2018.

The construction of underground dams to avoid accumulating rainwater (which, in addition to being scarce, often causes flash floods) to avoid evaporation due to the dry and hot climate is not a new technology. However, researchers disagree as to who was responsible for the pioneering spirit. According to the authors of the book "Tecnologias de Convivência com o Semiárido Brasileiro-2019", published by Banco do Nordeste do Brasil:

"The first news of an underground dam in Brazil was in the Northeast region. However, there is disagreement as to the time and place where the first units were installed. For Brito et al. (1989), there is evidence in the literature that one of the first underground dams built was in 1887, on private property in the State of Rio Grande do Norte. However, Silva (1998) states that the first underground dam was built in 1919, in the semiarid region of Paraíba, with the exploration of sugar cane and rice. In the reports of Silva and Rego Neto (1992), and Costa (1998), the first underground dams were built in the 1920s by farming families in the region of Seridó, RN, who used packed mud as a waterproofing material on the wall and cultivated forage species in the ebb tide agriculture system."[2]

What is certain is that from the 1980s onwards, experiences to develop underground dam technology suitable for different conditions have intensified. They were led by two groups of specialists, "the one from the Federal University of Pernambuco (UFPE) led by the professor Waldir Duarte Costa, and the Embrapa Semiarid group led by researcher Aderaldo de Souza e Silva." Since then, although there was no specific government program to finance the construction of these dams, they have multiplied in the Northeast.

[2]Ximenes, L; Lopes da Silva, M.S.; Lima Brito, L. (Editores). Tecnologias de convivência com o Semiárido brasileiro. Fortaleza: Banco do Nordeste do Brasil, 2019. 1116 p. Available in digital version at https://www.alice.cnptia.embrapa.br/alice/handle/doc/1112171

Forage palm - Riacho do Sangue Community, Barra de Santa Rosa municipality/PB

There are several obstacles to economic development and to improve the quality of life in the Semiarid region regarding the difficulty in obtaining electricity: the impossibility of hydraulic generation due to the seasonality of the semiarid rivers (except for the São Francisco river, whose sources and main tributaries are located outside this northeastern region), the financial cost, and the environmental impact of thermal generation, added to the lack of rain and the lack of underground potable water.

This situation has changed significantly in recent years. Significant advances in technology (forms of renewable energy generation, such as photovoltaic and wind power, and low-cost desalination of brackish groundwater) and enhanced knowledge about the region's biome and climate have drastically modified the possibilities for sustainable development in the Semiarid region.

The knowledge responsible for such a difference in the perspectives of the Semiarid region for a little over 20 years was closer to science fiction than to actual knowledge. In 1998, for example, Celso Furtado, an economist from Pombal, Paraíba, and one of the world's leading authorities on issues related to the development and the fight against poverty, creator of the Superintendency for the Development of the Northeast (Sudene) and Minister of Planning, was convinced that the semiarid situation would only be overcome if part of its population emigrated.

"Drought is a business. In Paraíba, for example, there were fortunes made by the drought; several fortunes in Campina Grande were due to public advantages" [of the funds destined to fight droughts], Furtado said in a small book-interview entitled "Seca e Poder," of 1998.[3] *More than denouncing the corruption of sectors that benefited from the "drought industry," he had a firm position on the conditions necessary to overcome the scourge of drought in the Semiarid region: "...there is no doubt that the future of the Northeast is to create jobs outside the semiarid zone. The problem will not be solved by conserving this entire population in the semiarid zone, subject to the inclement weather".*[4]

For this reason, through the introduction of technologies that favor sustainable development, young people like Vitor Ferreira, aged 19, will not have to choose between hunger and exodus. He envisions an alternative from goat's milk that he delivers to the *Cooperativa dos Produtores Rurais de Monteiro Ltda* (CAPRIBOM, Cooperative of Rural Producers of Monteiro Ltda), one of the agro-industries that participated in the project to install photovoltaic electricity generation systems with resources from the International Fund for Agricultural Development (IFAD) and managed via the Cariri, Seridó, and Curimataú Sustainable Development Project (PROCASE), of the government of the State of Paraíba, mentioned in this report.

[3] Furtado, C. Seca e Poder: entrevista com Celso Furtado. São Paulo: Editora Fundação Perseu Abramo, 1998. p. 25

[4] Idem, p. 31

"Until the last Crown jewel"

In the 19th century, there were 13 periods of drought. The one that started in 1877, which coincided with severe droughts in other regions of the planet such as India, was the most serious, especially in the then province of Ceará. It lasted until 1879 and became known as "The Great Drought." Estimates are that, from thirst, hunger, and related diseases, at least 500,000 northeastern people died and about 200,000 emigrated – the total population of Ceará was estimated at 800,000.[5] The capital of Ceará, with 21,000 inhabitants, received successive waves of backlanders begging for food and some help. In a few months, it reached a population of 130,000 people.[6] Across the region, looting occurred by desperate migrants.

In 1880, Emperor D. Pedro II visited the Northeast and, moved, promised that "There will not be a single jewel left in the Crown, but no northeastern person will die of hunger." No pieces were sold, and the declaration was taken as concession of the monarch to plebeian demagoguery.

[5] Silva, V; Patrício, M.C.; Ribeiro, V.; Madeiros, R. O desastre da seca no Nordeste Brasileiro. Polêmica, Rio de Janeiro, v.12, n,2. Apr-Jun, 2013.

[6] Lima, J.R. e Magalhães, A. Secas no Nordeste: registros históricos das catástrofes econômicas e humanas do século 16 ao século 21. Parcerias Estratégicas (CGEE), Brasília, v. 23, n. 46, p. 191-212, Jan - Jun 2018.

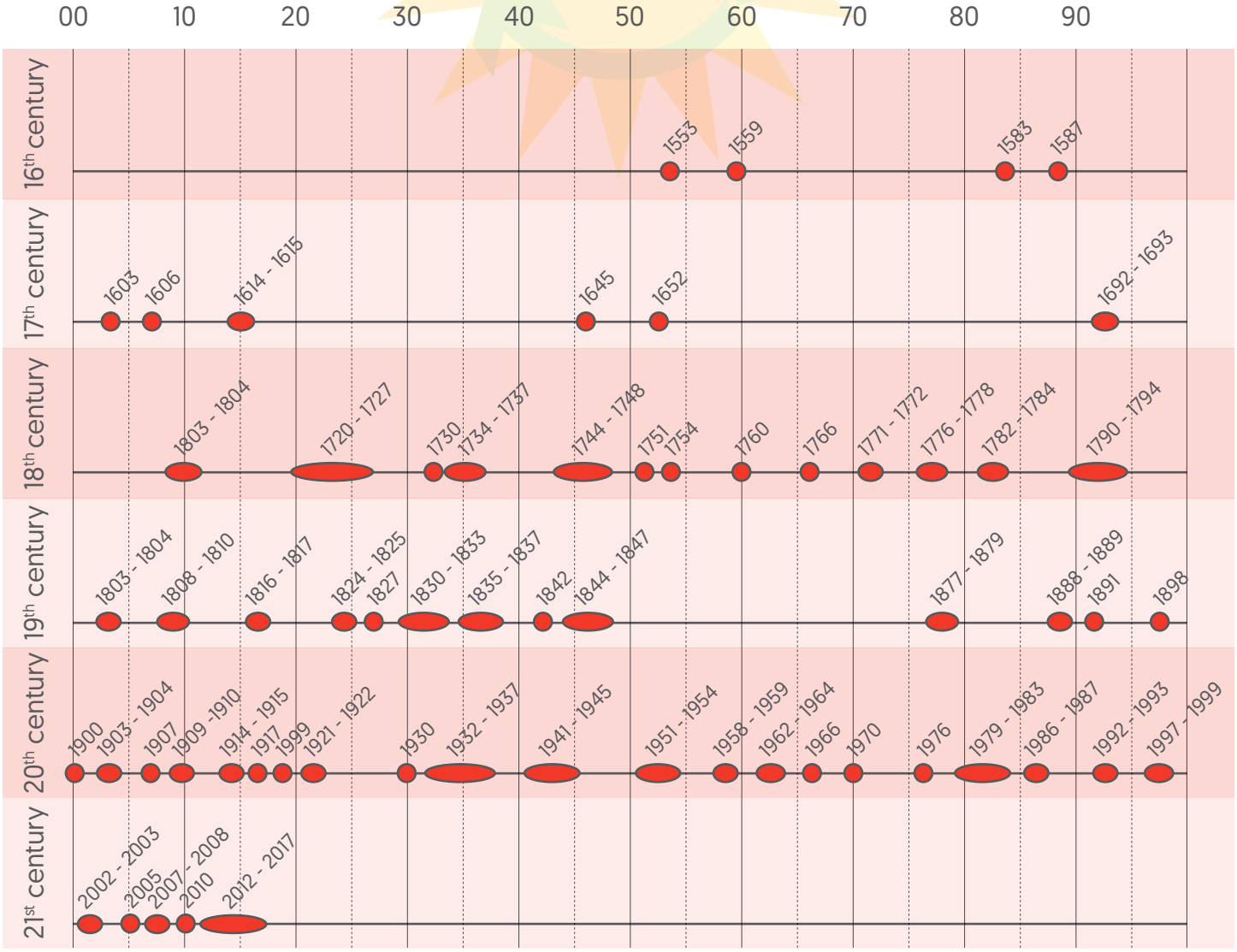
Maybe D. Pedro II realized that the measure would be more symbolic than practical in financial terms. What is certain is that the Emperor sought technical solutions by sending a commission of engineers to the region to study the situation and propose solutions to the problem of drought.

Some measures, undertaken since then, such as public works employing local labor in constructing weirs and roads, had some effectiveness, at least reducing extreme poverty and hunger in the short term. Among the proposals was the transposition of water from the São Francisco River, a project that would only be undertaken more than a century later. Other initiatives have resulted in glaring failure, accompanied by allegations of corruption, such as the importation of camels from Egypt.[7]

During the 20th century, drought cycles became more frequent and prolonged (see Graph 1), in many cases repeating the human tragedy of the "Great Drought."

[7] Barreto, P.H. História - Seca, fenômeno secular na vida dos nordestinos. Desafios do Desenvolvimento (IPEA). Brasília, year 6, ed. 48, March 10, 2009.

Graph 1. **Timeline of droughts in the Northeast: droughts throughout history in the Northeast**



Source: Reproduced from Lima and Magalhães (2018)[8]

Duration of the drought

[8] Lima, J.R. e Magalhães, A. Secas no Nordeste: registros históricos das catástrofes econômicas e humanas do século 16 ao século 21. Parcerias Estratégicas (CGEE), Brasília, v. 23, n. 46, p. 191-212, Jan - Jun 2018.

In the 1915 drought and especially in 1932-37, the government went to the extreme creation of concentration camps (an expression used by the Ceará governor at the time[9]) in an alleged attempt to contain disordered migration, looting, and deaths from hunger.

Writer Raquel de Queiróz reported the raw reality of the first experience from Ceará in the book "O Quinze" in which she tells what happened in the countryside located in the place called Alagadiço, in the current neighborhood of São Gerardo.[10]

In the second of them, seven camps were set up "strategically on migration routes through the State of Ceará, thus preventing the arrival in the capital. They were installed near the railways, through which migrants tried to reach Fortaleza. At the train stations, they were sent to the fields with the promise of work. With no other option, they followed the route", reports journalist Marina Rossi, from the Brazilian website of the Spanish newspaper El País. A total of 73,000 migrants were confined there.[11]

"For the second time, regions surrounded by barbed wire and guarded daily by soldiers were built to confine Northeastern people affected by the drought. Thin bodies, with shaved and numbered heads crowded together in heaps inside the enclosures of Senador Pompeu, Ipu, Quixeramobim, Cariús, Crato (or Buriti, where more than 65,000 people passed by) and the well-known Otávio Bonfim, the largest human corrals installed in Brazil...", reports economist Talita Lopes Cavalcante.[12]

The humanitarian tragedy remained relatively forgotten until 2019 when what was left of the only concentration camp to leave traces was incorporated into the municipal historical and cultural heritage (sic), the "Patu concentration camp," in Senador Pompeu, a municipality located at 270 km south of Fortaleza.

[9] Albuquerque, C. A trágica história dos "campos de concentração" do Ceará. Deutsche Welle. July 20, 2019. Available at https://www.dw.com/pt-br/a-tr%C3%A1gica-hist%C3%B3ria-dos-campos-de-concentra%C3%A7%C3%A3o-do-cear%C3%A1/a-49646665.

[10] Nascimento, T. Campo de concentração onde 'flagelados da seca' eram aprisionados é tombado no Ceará. G1, July 20, 2019. Available at https://g1.globo.com/ce/ceara/noticia/2019/07/20/campo-de-concentracao-onde-flagelados-da-seca-eram-aprisionados-e-tombado-no-ceara.ghtml

[11] Idem

[12] Cavalcante, T. A grande seca do Nordeste. Museu de Imagens, July 18, 2014. Available at https://www.museudeimagens.com.br/grande-seca-do-nordeste/

The Northeast Semiarid Region

According to the National Semiarid Institute (INSA), an agency linked to the Ministry of Science, Technology, Innovation and Communications:

The Brazilian Semiarid Region (SAB) is a geographical delimitation of the national territory, officially defined in 2005 by the Ministry of National Integration (MIN), through Ordinance No. 89, for administrative purposes. In this document, the Semiarid region corresponds to a set of municipalities meeting at least one of the criteria below:

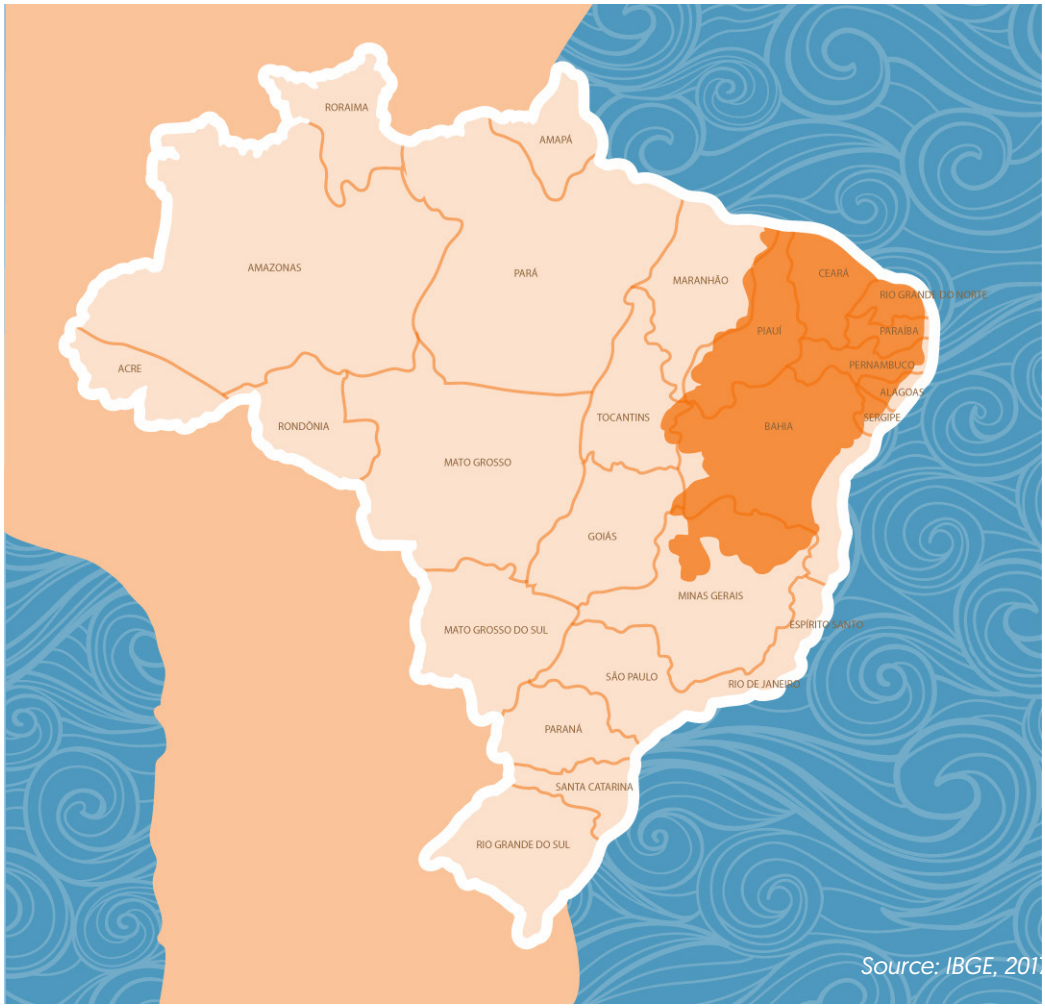
1. Average annual rainfall less than 800 mm;

2. Aridity index of up to 0.5 calculated by the water balance relating rainfall and potential evapotranspiration, in the period between 1961 and 1990;

3. Risk of drought or extension of the dry season, from one year to another, greater than 60%, based on 1970-1990.

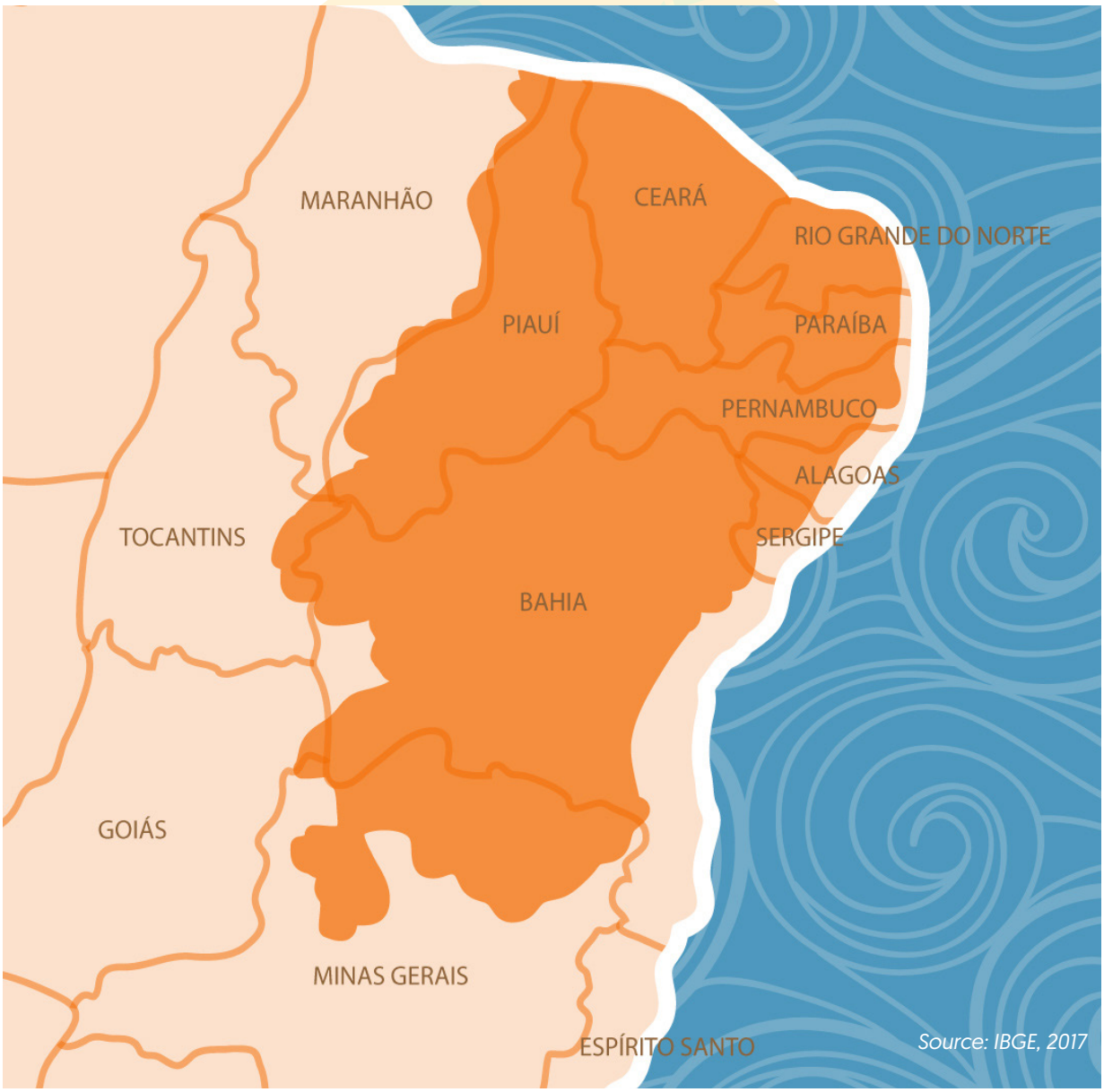
The Semiarid region, according to Sudene Resolution No. 115, of November 23, 2017:

Figure 1. **Map of the Semiarid Region in Brazil**



Source: IBGE, 201

Figure 2. **Map of the Semiarid Region**



The Semiarid region comprises 1,262 municipalities in the Northeast, according to Resolution No. 115, of November 23, 2017, by Sudene (Brazil has 5,570 municipalities). Bahia is the state with the highest number (278), followed by Paraíba, which, despite having a much smaller surface, has 194 municipalities in the Semiarid region.[13]

[13] Brasil. Sudene. Resolution No. 115, of November 23, 2017.

With the expansion, the Brazilian Semiarid region now has the following number of municipalities with the corresponding areas, population, and demographic density, according to the National Semiarid Institute[14]:

Table 1. **Municipalities, population area, and demographic density of the Semiarid region**

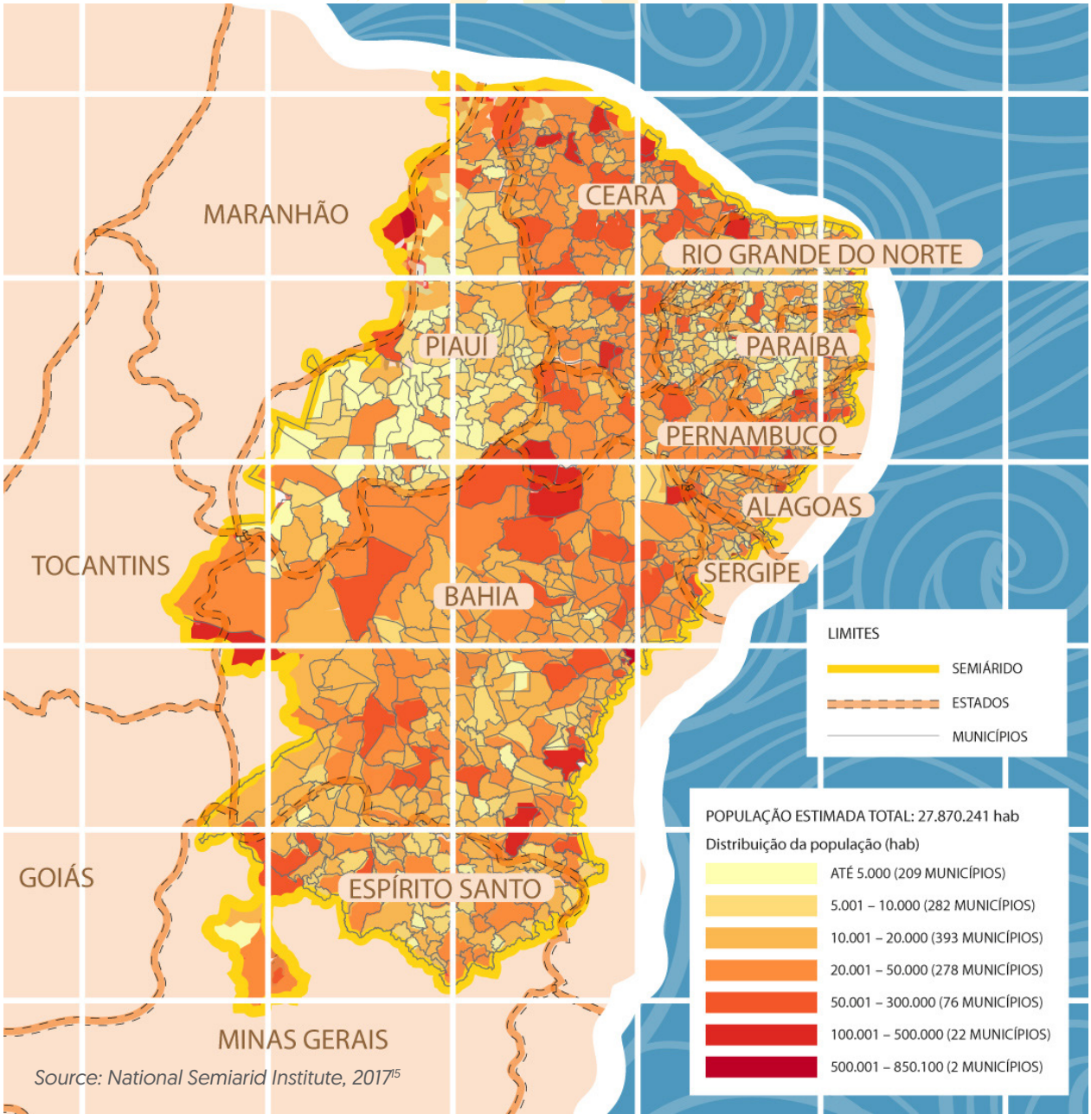
Semiarid	No. of municipalities	Area (km2)	Number of inhabitants	Density (inhabitant/km2)
Alagoano	38	12.646	962.641	76
Baiano	278	445.613	7.675.656	17
Cearense	175	146.945	5.827.192	40
Maranhense	2	3.547	213.693	60
Mineiro	91	121.215	1.492.198	12
Paraibano	194	51.335	2.498.117	49
Pernambucano	123	86.145	3.993.975	46
Piauiense	185	200.301	2.805.394	14
Potiguar	147	49.098	1.922.440	39
Sergipano	29	11.106	478.935	43
TOTAL	**1.262**	**1.127.953**	**27.870.241**	**25**

Source: INSA, 2017

[14] INSA. Nova Delimitação Expande o Semiárido até o Maranhão: 73 Novos Municípios Foram Incluídos. November 29, 2017. Available at https://portal.insa.gov.br/noticias/1070-nova-delimitacao-expande-o-semiarido-ate-o-maranhao-73-novos-municipios-foram-incluidos

The 25 inhabitants per square kilometer that live in the territory make the Brazilian Semiarid region the most populated ecosystem of its kind in the world. Geographically, this population is distributed over the 1,262 municipalities as shown in the following map:

Figure 3. **Estimated population of the Brazilian Semiarid region (2017)**



Source: National Semiarid Institute, 2017[15]

[15] Sistema de Gestão da Informação e do Conhecimento do Semiárido Brasileiro – SIGSAB. 2017. Available at https://portal.insa.gov.br/images/imagens-noticias/2017/11/MAPA_POPULACAO_2017.pdf

In these municipalities, rainfed agricultural exploitation predominates, which is unstable and has low productivity. The zone defined as semiarid is divided into natural areas called Caatinga, Sertão, Seridó, Carrasco, Cariris Velhos, Curimataú.[16]

The Brazilian semiarid region has irregular rainfall (between 800 mm/year and less than 400 mm/year in drier regions. Rains, when they occur, are concentrated in the so-called "winter" (3 or 5 months a year).[17] Temperatures are high – "annual average around 26 ºC to 27.5 ºC. In the driest months the soil temperature reaches 60 ºC".[18] During part of the year the insolation is very strong (2,800 hours/year), with low relative humidity.

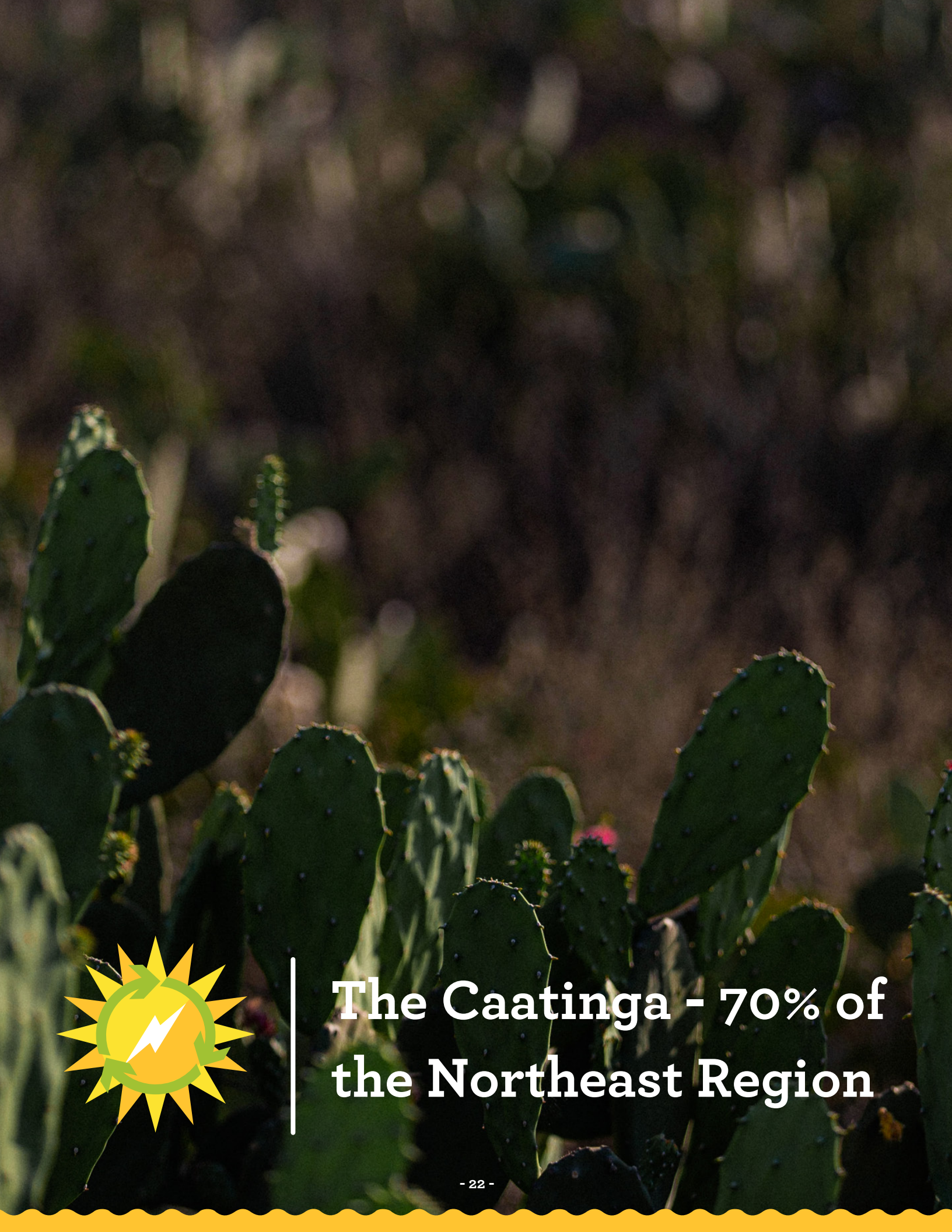
The Semiarid soils originate from crystalline rocks, predominantly shallow, poorly permeable, subject to erosion and of reasonable natural fertility, with a predominance of Caatinga vegetation, which covers about 1.0 million km2 and with a succession of vegetation indicative of the process of environmental degradation, according to a document of Banco do Nordeste (2001).[19]

[16] Ramalho, A; Da Silva, S; Cândido, G. Aproveitamento Sustentável das Potencialidades Energéticas do Semiárido Paraibano. Polêmica, Rio de Janeiro, vol.12, n 3, Jul-Aug-Sep, 2013.

[17] Idem

[18] Beserra de Moura, M. Temperatura e umidade relativa -Bioma Caatinga. Agência Embrapa de Informação Tecnológica. Available at http://www.agencia.cnptia.embrapa.br/gestor/bioma_caatinga/arvore/CONT000g798rt3p02wx5ok0wtedt3n17xgwk.html

[19] Ramalho, A; Da Silva, S; Cândido, G. Aproveitamento Sustentável das Potencialidades Energéticas do Semiárido Paraibano. Polêmica, Rio de Janeiro, vol.12, n 3, Jul-Aug-Sep, 2013.



The Caatinga - 70% of the Northeast Region

According to the Brazilian Agricultural Research Corporation (EMBRAPA), the Caatinga is the predominant ecosystem in the Semiarid region. "It corresponds to 11% of the Brazilian territory and 70% of the Northeast region. This extension includes the states of Ceará, Rio Grande do Norte, most of Paraíba and Pernambuco, southeast of Piauí, west of Alagoas and Sergipe, central region of Bahia, and part of northern Minas Gerais". With an area of 826,411km^2.[20]

Also, according to EMBRAPA, "The Caatinga is considered one of the Brazilian ecosystems most degraded by human activities. An estimated 45.3% of its total area already is altered, which places it as the third most modified Brazilian biome, being surpassed only by the Atlantic Forest and the Cerrado. On the other hand, it is considered the least protected, with only 8% of its area maintained in 123 Conservation Units, of which 41 are Full Protection, and 82 are Sustainable Use".

The environmental degradation of the Caatinga has numbers. "More than 1 million and 260,000 km^2 in 1,440 municipalities in eight states in the Northeast region and the north of Minas Gerais. This is the dimension of extreme soil degradation, vegetation cover, biodiversity, and loss of productive agricultural activities in a vast extension of land in the country. In other words: susceptible to

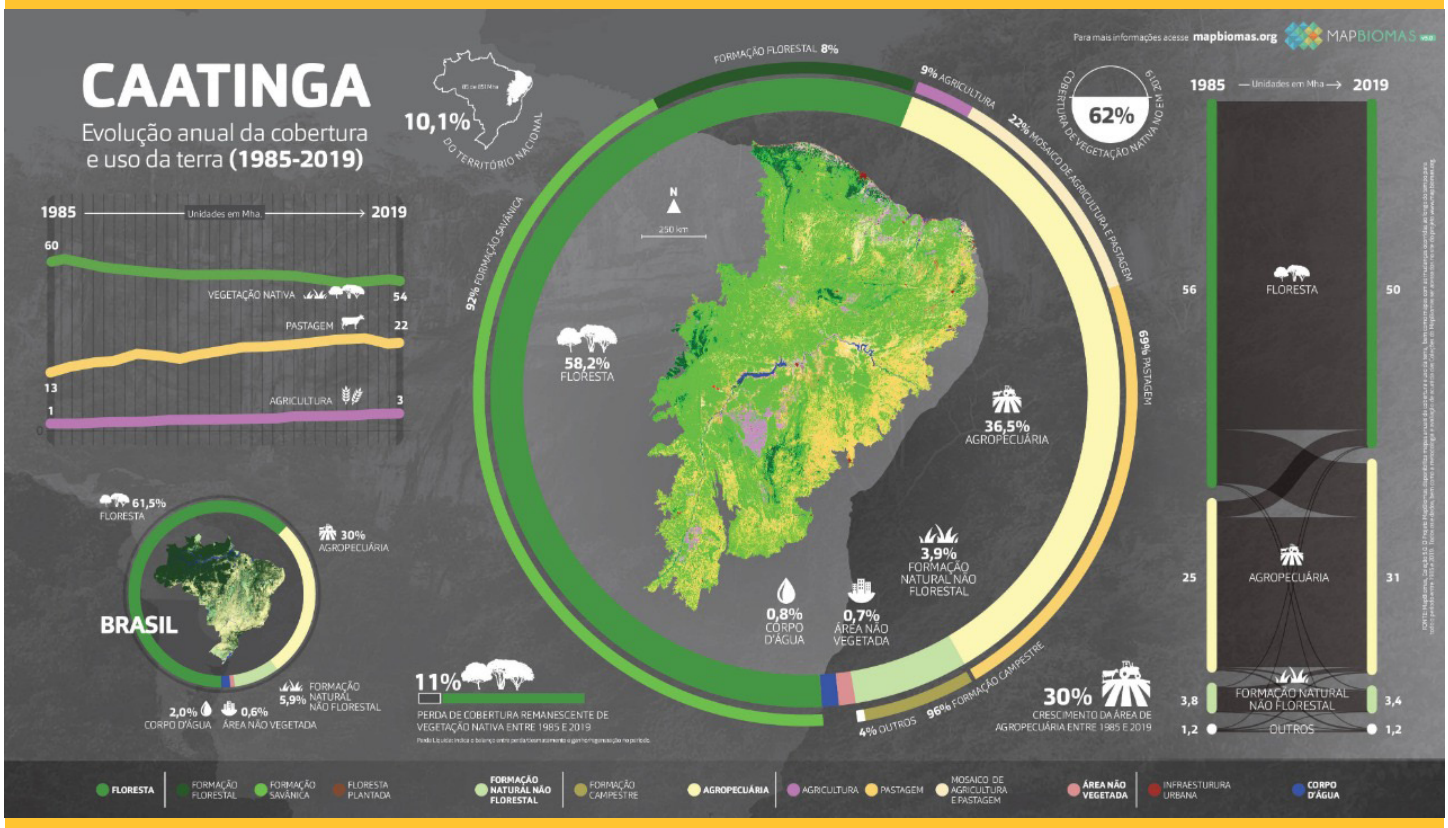
[20] Kill, L.H. Bioma Caatinga, introdução. Agência Embrapa de Informação Tecnológica. Available at http://www.agencia.cnptia.embrapa.br/gestor/bioma_caatinga/arvore/CONT000glz1ehqv02wx5ok0f7mv200nvg0xn.html

Municipality of Cabaceiras, headquarters of ARTEZA.

desertification, according to researcher Iêdo Bezerra Sá, of Embrapa Semiarid."[21] The information is related to 2015, therefore, outdated. Even so, in the previous ten years, deforestation in the Caatinga "reached an area equivalent to Portugal size, to the point where, today, almost 50% of its territory is affected by accentuated and severe desertification processes".[22]

According to the Annual Land Cover and Land Use Mapping Project in Brazil, the situation in 2019 was as described in the infographic below. Noteworthy is the loss of 11% of the remaining native vegetation since 1985 and the concomitant increase of 30% of the agricultural area.

Figure 4. **Caatinga Annual evolution of land cover and use – 1985-2019 – Mapbiomas**



Source: Mapbiomas[23]

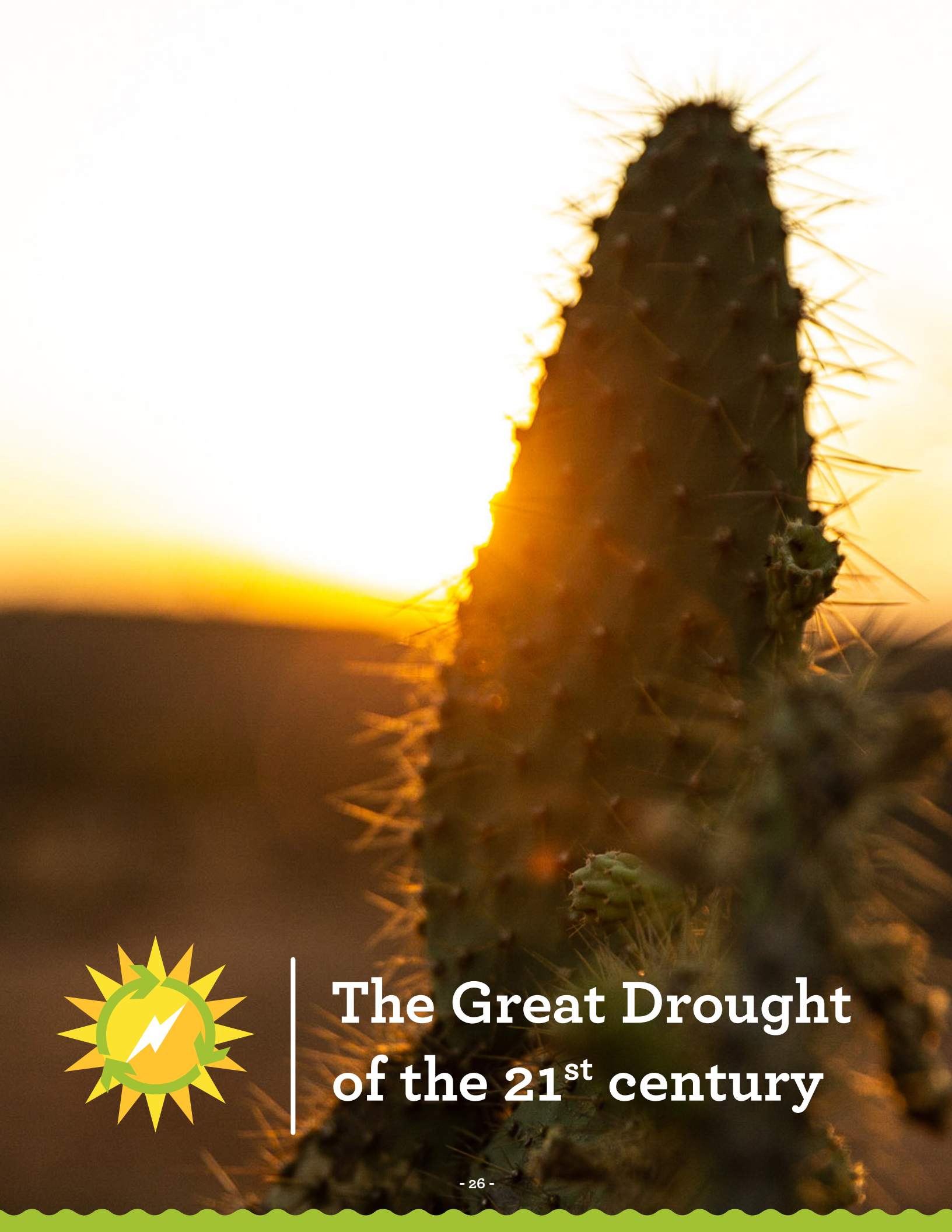
[21] Ribeiro, M. Desertificação atinge grandes áreas do Semiárido. Notícias Embrapa, May 27, 2015. Available at 27/05/15 https://www.embrapa.br/busca-de-noticias/-/noticia/3240771/desertificacao-atinge-grandes-areas-do-semiarido

[22] Idem

[23] https://mapbiomas-br-site.s3.amazonaws.com/Infograficos/Colecao5/MBI-Infografico-caatinga-5.0-BR.jpg

An increase in the number and duration of recorded drought periods is attributed to deforestation of the Caatinga, over-exploitation, and/or inadequate exploitation of fragile and poorly permeable soils, aggravated by climate change. In the 19th century, there were 13 cycles. In the 20th century, they increased to 23, and in the current, there are five cycles, but the press identifies a relevant aspect: "In 173 years, there were eight periods of prolonged drought... Apart from these periods, there were several years of intense drought, but not in consecutive years. A dry period of five consecutive years was recorded four times: at the end of the 19th century (1876-1880), the beginning of the 20th century (1901- 1905), 1929-1933, and 1979-1983. The bienniums 1955-1956 and 1997-1998 and the four years from 1990 to 1993 complete the list of droughts lasting more than a year..."[24]

[24] Rebello, A. Seca de 2012 a 2017 no Semiárido foi a mais longa na história do Brasil. Notícias Uol. March 03, 2018. Available at https://noticias.uol.com.br/meio-ambiente/ultimas-noticias/redacao/2018/03/03/seca-de-2012-a-2017-no-semiarido-foi-a-mais-longa-da-historia.



The Great Drought of the 21st century

The same report mentioned, however, highlights that: “The drought that hit the Brazilian Semiarid from 2012 to 2017, especially the Sertão do Nordeste, was the worst in the history of Brazil, according to a survey by Inmet (National Institute of Meteorology) obtained exclusively by UOL... there had never been six consecutive years with below-average rainfall and prolonged drought in the region...”[25]

[25] Idem

In Paraíba, the drought in the mentioned period caused significant losses in rural production (in livestock, the reduction was "approximately 40% of the state herd, according to data from the Federation of Agriculture and Livestock of Paraíba (Faepa)". At the same time, according to the State's civil defense, affected people increased from 934,711 in 2012 to 1,915,660 in 2016. The situation also severely affected the water supply in cities. Of the 223 municipalities in the state, at the end of 2016, 77 were under rationing, and 23 were in collapse. [26]

According to the National Water Agency (ANA), the situation of reservoirs (dams and weirs in the Northeast – including the region of Minas Gerais that integrates the Semiarid region – was as follows on December 31, 2017, the situation being more serious in Ceará and Paraíba:

Table 2. **Number of reservoirs by UF in the Northeast Region, with accumulated capacity and volume**

Data de referência: **31/12/2017**

State	Reservoirs	Equivalent Capacity (hm³)	Accumulated Volume (hm³)	Accumulated Volume (%)
Alagoas	22	12,26	6,75	55,06
Bahia	43	4.327,64	1.609,90	37,20
Ceará	155	18.248,70	1.284,99	7,04
Maranhão	1	-	-	-
Paraíba	126	3.950,72	379,56	9,61
Pernambuco	104	1.716,52	348,72	20,32
Piauí	25	1.818,96	716,21	39,37
Rio Grande do Norte	54	4.180,44	535,62	12,81
Sergipe	10	-	-	-
Northeast	**504**	**34.255,24**	**4.881,75**	**14,25**
Minas Gerais (Semi-arid)	1	529,59	86,32	16,30

Source: ANA, 2017

[26] Medeiros, A.M. e Cavalcanti de Brito, A. A seca no Estado da Paraíba – Impactos e ações de resiliência. Parcerias Estratégicas CGEE, Brasília. Vol 22, n 44 – Jan. Jun 2017, p. 139 -154.

Despite the seriousness of the 21st century's first great drought, there has not been a humanitarian crisis like those registered in the great droughts of the 19th and 20th centuries. Not even the looting practiced by desperate backlanders took place. This happened for the last time in the 2001 drought, as reported by the Folha de S. Paulo newspaper on July 11 of that year.[27]

This is due to a series of factors, from those related to infrastructure (construction of dams and weirs over the decades – 70,000 units, which dam about 30 billion m³ of water according to some sources[28]–, well drilling, construction of cisterns – 1.3 million built in the Semiarid region, 1.1 million of which destined for human consumption since the implementation of a government program for this purpose in 2003[29]– and installation of desalination units, etc.) to the adoption of emergency measures such as the supply of populations affected by water trucks and social policies such as retirement for rural workers and family allowances.[30]

Rainfall is scarce, and surface water sources are often not perennial in the Semiarid region, as mentioned above. On the other hand, there is abundant underground water. This water, however, is brackish and, in its natural state, unfit for consumption. The solution is to desalinate.

The installation of desalination units is of particular importance because the most used technology currently, reverse osmosis (passage of water through filtering membranes), has been adapted to Brazilian conditions by the Desalination Reference Laboratory (Labdes), of the Department of Chemical Engineering at the Federal University of Campina Grande (UFCG), in Paraíba. It is more efficient than the traditional one in obtaining drinking water through evaporation. "With reverse osmosis, it is possible to spend only R$ 1 to desalinate a thousand liters of brackish water", says Professor Kepler Borges França, Labdes coordinator.[31]

Providing drinking water obtained through equipment that uses reverse osmosis technology to municipalities where water is scarce is the objective of the Água Doce Program, created in 2004 by the Ministry of Environment (MMA). It is currently coordinated by the Ministry of Regional Development (MDR), in partnership between the federal government and the states. According to official publicity material published on 03/08/2020, since implementation, 830 desalination systems have been implemented, capable of serving 330,000 people. In 2020, another 55 systems are expected to be delivered.[32]

[27] Folha de S.Paulo. Flagelados da seca promovem saques no Nordeste. July 10, 2001. Available at https://www1.folha.uol.com.br/folha/brasil/ult96u22173.shtml

[28] Barreto de Melo, J; Pereira, R.; Neto, J. Atuação do Estado brasileiro no combate à seca no Nordeste e aplicação das vulnerabilidades locais. Qualitas (electronic journal), vol. 8, n. 2, 2009. Available at

http://revista.uepb.edu.br/index.php/qualitas/article/view/387/334

[29] Madeiro, C. Sob Bolsonaro, programa construiu menor número de cisternas de sua história. Uol, February 12, 2020. Available at https://noticias.uol.com.br/politica/ultimas-noticias/2020/02/12/bolsonaro-menor-numero-cisternas-desde-origem-programa.htm

[30] Lima, J.R. e Magalhães, A. Secas no Nordeste: registros históricos das catástrofes econômicas e humanas do século 16 ao século 21. Parcerias Estratégicas (CGEE). Brasília, v. 23, n. 46, p. 191-212, Jan – Jun 2018.

[31] Brasil. Senado Federal. Em Discussão. Dessalinizar a água é cada vez mais viável. s/d. Available at https://www12.senado.leg.br/emdiscussao/edicoes/escassez-de-agua/leis-e-propostas-quem-cuida-das-aguas/dessalinizar-a-agua-e-cada-vez-mais-viavel

Providing drinking water obtained through equipment that uses reverse osmosis technology to municipalities where water is scarce is the objective of the Água Doce Program, created in 2004 by the Ministry of Environment (MMA). It is currently coordinated by the Ministry of Regional Development (MDR), in partnership between the federal government and the states. According to official publicity material published on 03/08/2020, since implementation, 830 desalination systems have been implemented, capable of serving 330,000 people. In 2020, another 55 systems are expected to be delivered.[32]

In Paraíba, in 2020, the start of operation of 40 units is predicted, which will bring the number of systems in operation to 93, in 42 municipalities, benefiting 7,448 families directly and about 30,000 people indirectly, in schools, daycare centers, Family Health Program units, hospitals, municipal administration bodies, and churches.[33]

Despite the benefits, the implementation of the systems implies overcoming problems, according to a report in the Folha de S. Paulo newspaper, of 02/17/19. If a city hall or institution not covered by the federal government program intends to do so on its own, it must assume investments, which depend on the size of the equipment and can be relatively high. Also, energy costs, although these can be amortized mainly through the installation of photovoltaic electricity generation units. These costs, however, may also be beyond the financial capacity of the municipality or institution.

According to the report, for systems such as the eight installed in Riachão do Jacuípe (BA), each one produces around 400 liters of drinking water per hour, sold to the population for R$ 1.00 per hour 20-liter bottle. The volume is equivalent to 30% of the raw water taken from the well. The other 70% will form the tailings, pumped into tanks where they will evaporate, which means an environmental problem to be faced, although there are ways to recycle this waste. According to a report by Agência Senado, reverse osmosis enables us to spend only R$ 1 to desalinate a thousand liters of brackish water.[34]

[32] Brasil. Ministério de Desenvolvimento Regional. Programa Água Doce, do MDR, é reconhecido por associação internacional. September 14, 2020. Available at https://www.gov.br/mdr/pt-br/noticias/programa-agua-doce-do-mdr-e-reconhecido-por-associacao-internacional#:~:text=Programa%20%C3%81gua%20Doce%2C%20do%20MDR%2C%20%C3%A9%20reconhecido%20por%20associa%C3%A7%C3%A3o%20internacional,-Iniciativa%20foi%20destaque&text=Bras%C3%ADlia%2DDF%2C%203%2F8,MDR)%2C%20foi%20reconhecido%20internacionalmente.

[33] Paraíba *online*. Governo inaugura 40 sistemas de dessalinização em 27 municípios da Paraíba - Secom/PB. June 22, 2020. Available at https://paraibaonline.com.br/2020/06/governo-inaugura-40-sistemas-de-dessalinizacao-em-27-municipios-da-paraiba/

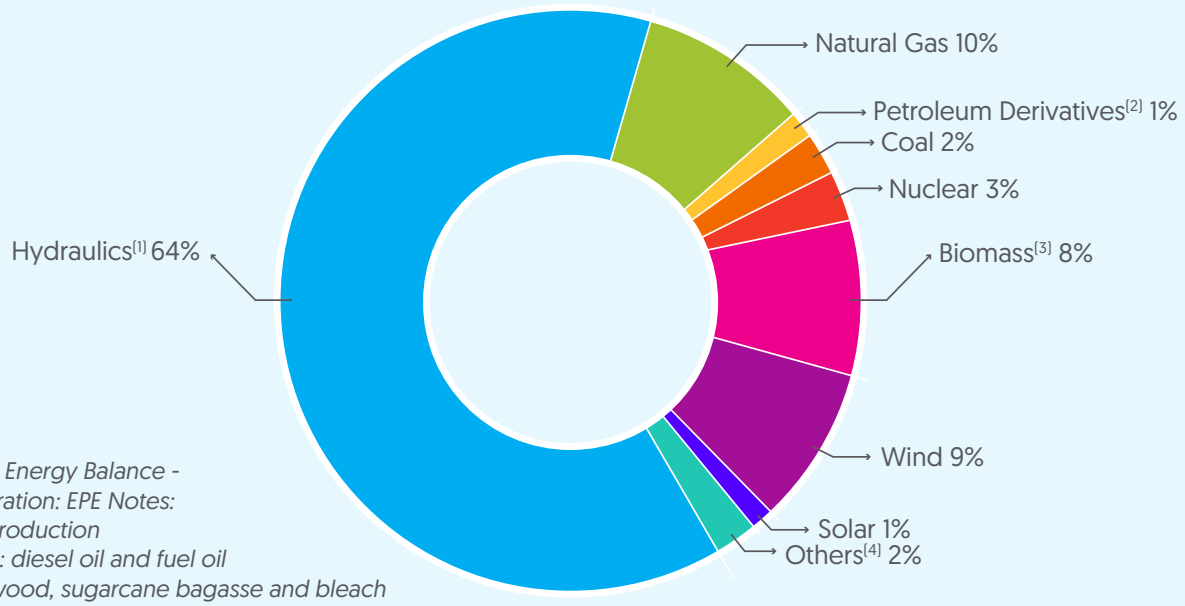
[34] Brasil. Senado Federal. Em Discussão. Dessalinizar a água é cada vez mais viável. s/d. Available at https://www12.senado.leg.br/emdiscussao/edicoes/escassez-de-agua/leis-e-propostas-quem-cuida-das-aguas/dessalinizar-a-agua-e-cada-vez-mais-viavel

The electric matrix in Brazil and energy in the Semiarid region

The electric matrix (set of sources available only for the generation of electric energy in a given territory, different from the energy matrix, which includes energy used to get around using transport)[35] in the Northeast region is different from the Brazilian electric matrix for geographical reasons that are easy to understand.

According to the National Electric Energy Agency (ANEEL), Brazil reached the end of 2019 with a regulated electric power generation capacity of 170,071 megawatts (MW), with more than 75% coming from renewable sources[36]. This capacity, according to the Energy Research Office (EPE), comes from the following sources:

Graph 2. **Electricity generation by source in Brazil – Share in 2019 (%)** [37]



Source: National Energy Balance - BEN 2020; Elaboration: EPE Notes:
i) Includes self-production
ii) Oil derivatives: diesel oil and fuel oil
iii) Biomass: firewood, sugarcane bagasse and bleach
iv) Others: recoveries, coke oven gas and other secondary

Source EPE, 2019

[35] Centro Brasileiro de Infra Estrutura (CBIE). O que é Matriz Energética? June 5, 2020. Available at https://cbie.com.br/ARTIGOS/O-QUE-E-MATRIZ-ENERGETICA/

[36] ANEEL. Brasil alcança 170 mil megawatts de capacidade instalada em 2019. January 30, 2020. Available at https://www.aneel.gov.br/sala-de-imprensa-exibicao/-/asset_publisher/XGPXSqdMFHrE/content/brasil-alcanca-170-mil-megawatts-de-capacidade-instalada-em-2019/656877?inheritRedirect=false

[37] Anuário Estatístico de Energia Elétrica 2020 ano base 2019 https://www.epe.gov.br/sites-pt/publicacoes-dados-abertos/publicacoes/PublicacoesArquivos/publicacao-160/topico-168/Anu%C3%A1rio_2020_sp.pdf

These data indicate that Brazil has one of the "cleanest" electrical matrices globally, as most of it comes from renewable sources, with a predominance of hydraulic generation (hydroelectric plants). The composition of this matrix has been changing in recent years, not least because the locations of possible large-scale hydroelectric use are increasingly remote, with more significant environmental impacts and higher construction costs – generally located in the Amazon. Despite this, between 2018 and 2019, the installed electricity generation capacity in Brazil was expanded by 4.5%. According to EPE, the largest contribution still comes from hydraulic generation,[38].

However, the "cleanliness" and the environmentally correct dimension of the Brazilian electricity matrix, especially concerning its hydroelectric component, is questioned by specialists such as Marcel Bursztyn, one of the leading scholars on its sustainable development.

> *"Hydroelectricity has been a myth associated with the Brazilian economic (and energy) model and, in particular, with the industrial process that started after the Second World War. Using hydraulic power to drive the turbines was the mainstay of a developmental discourse that praised the unique character of our "clean" energy matrix. A few decades passed before impacts in the socio-environmental sphere became evident and present on the political agenda: the drama of the displacement of riverside populations, the flooding of extensive areas of forests, the process of eutrophication of dams, and its effects on water quality and carbon emission. More recently, already under the effect of changes in climate dynamics, the very security of energy supply (and also water for agriculture and domestic supply) has been putting into question the reliability and constancy of the supply of hydroelectricity."*[39]

According to the same publication by the Energy Research Office (EPE), however, the "greater proportional expansion occurred in solar generation, which ended 2019 with an increase in installed power of 37.6% than the previous year. This occurred despite an increase [in solar generation] of almost 100% in 2018 compared to 2017".[40]

Electricity generated in Brazil from new renewable sources, undergoing rapid technological development and reducing equipment costs, had the highest percentage growth: solar (+92.1%) and wind (+15.5%).

In international terms, "compared to other electricity production options, photovoltaics had the best performance over the past few years: an 86% reduction in the average production cost, between 2009 and 2017, in average LCOE values - Levelized Cost of Energy Analysis - per MWh. The second largest drop, in the same period, was that of wind energy: 67%.[41]

[38] Idem
[39] Bursztyn, M. Energia solar e desenvolvimento sustentável no Semiárido: o desafio da integração de políticas públicas. Estudos Avançados (online), vol. 34, n. 38, 2020. pp.167-186.
[40] Idem
[41] Idem

Brazil took a long time to take advantage of its great solar potential, says journalist Mario Osava from the Inter Press Service (IPS) news agency, noting that the initial impulse came in 2012 when the country adopted the rules on distributed generation. More recently, growth has been exponential, says Bárbara Rubim, vice president of the Brazilian Association of Photovoltaic Solar Energy (Absolar), heard by Osava. According to her, the Covid-19 pandemic effect was less than expected, and the installed capacity increased 30% in the first half of 2020". . Still according to sources consulted by Osava, in rural areas, the growth was 120% in the same period.

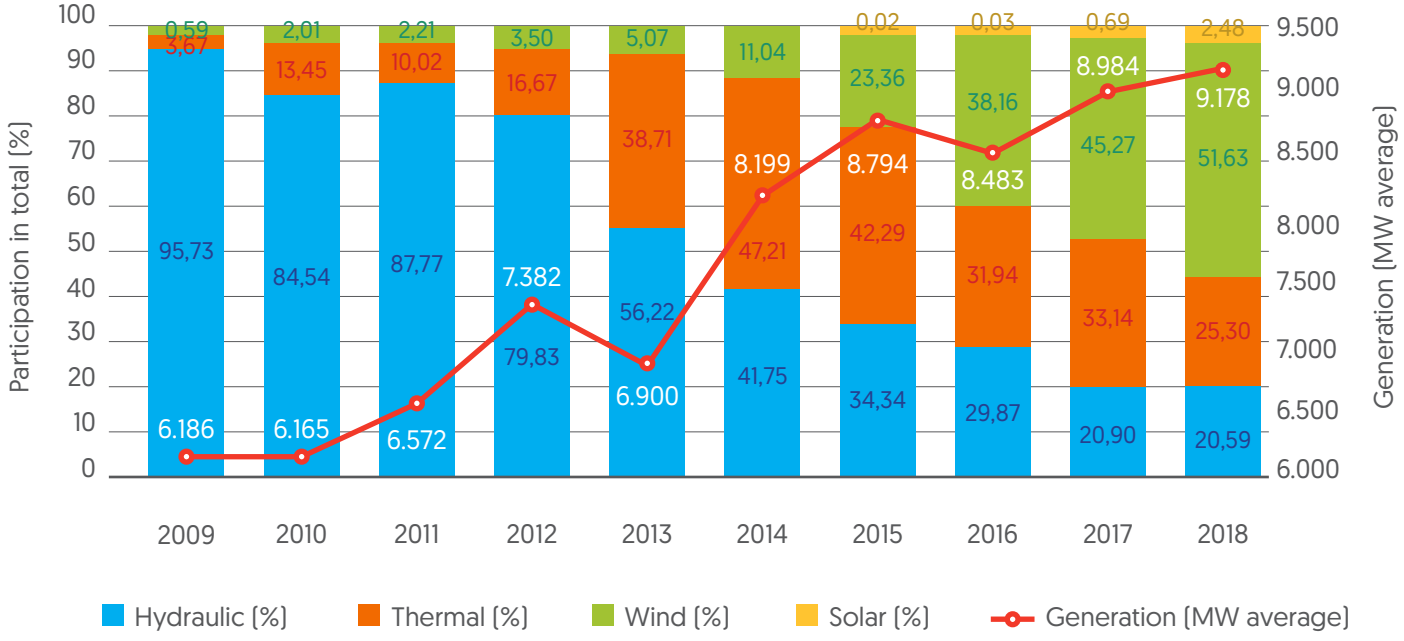
Despite the accelerated expansion, costs are still an obstacle, especially in poor regions such as the Semiarid. "Over the last ten years, the price of the technology has fallen by more than 85%", says the executive president of Absolar, Rodrigo Sauaia, in another article by the newspaper O Estado de S. Paulo. Even so, the example cited by the newspaper of an urban residence is expressive: "The cost of system installation varies from R$25,000 to R$30,000 for medium to large-sized houses. An average Brazilian household, with four people, with consumption around 190 KW/h per month, will need a system that costs between R$ 10,000 and R$ 15,000".[43]

[42] Osava, M. Energía solar sigue en expansión en Brasil, pese a la pandemia. Inter Press Service (IPS), July 23, 2020. Available at http://www.ipsnoticias.net/2020/07/energia-solar-sigue-expansion-brasil-pese-la-pandemia/?utm_source=Spanish+-+Mejor+de+la+Semana&utm_campaign=4e4384a993- EMAIL_CAMPAIGN_2020_07_24_05_24&utm_medium=email&utm_term=0_b685ec7ed3-4e4384a993-5193541. Accessed on July 27, 2020.

[43] Siqueira, F. Energia solar no Brasil cresce mais de cinco vezes em dois anos; veja como funciona. O Estado de S. Paulo, August 18, 2020. Available at https://economia.estadao.com.br/noticias/geral,energia-solar-no-brasil-cresce-mais-de-cinco-vezes-em-dois-anos-veja-como-funciona,70003403589

In the Northeast Region, where almost all perennial rivers have little or no hydroelectric potential, electricity from regional water sources comes almost exclusively from plants built on the São Francisco River. Its basin is mainly in the Semiarid region but has its springs and most of its main tributaries in areas that are not part of it. As a result, the regional matrix has evolved as shown in the graph below, reproduced from the study "Panorama da Infraestrutura no Nordeste do Brasil: Energia Elétrica," published by Banco do Nordeste do Brasil[44]:

Graph 3. **Evolution of electricity in the Northeast Subsystem (average MW) and participation of sources in the total generated (%) – 2009 -2018**



Source: Reproduced from Bezerra, 2019

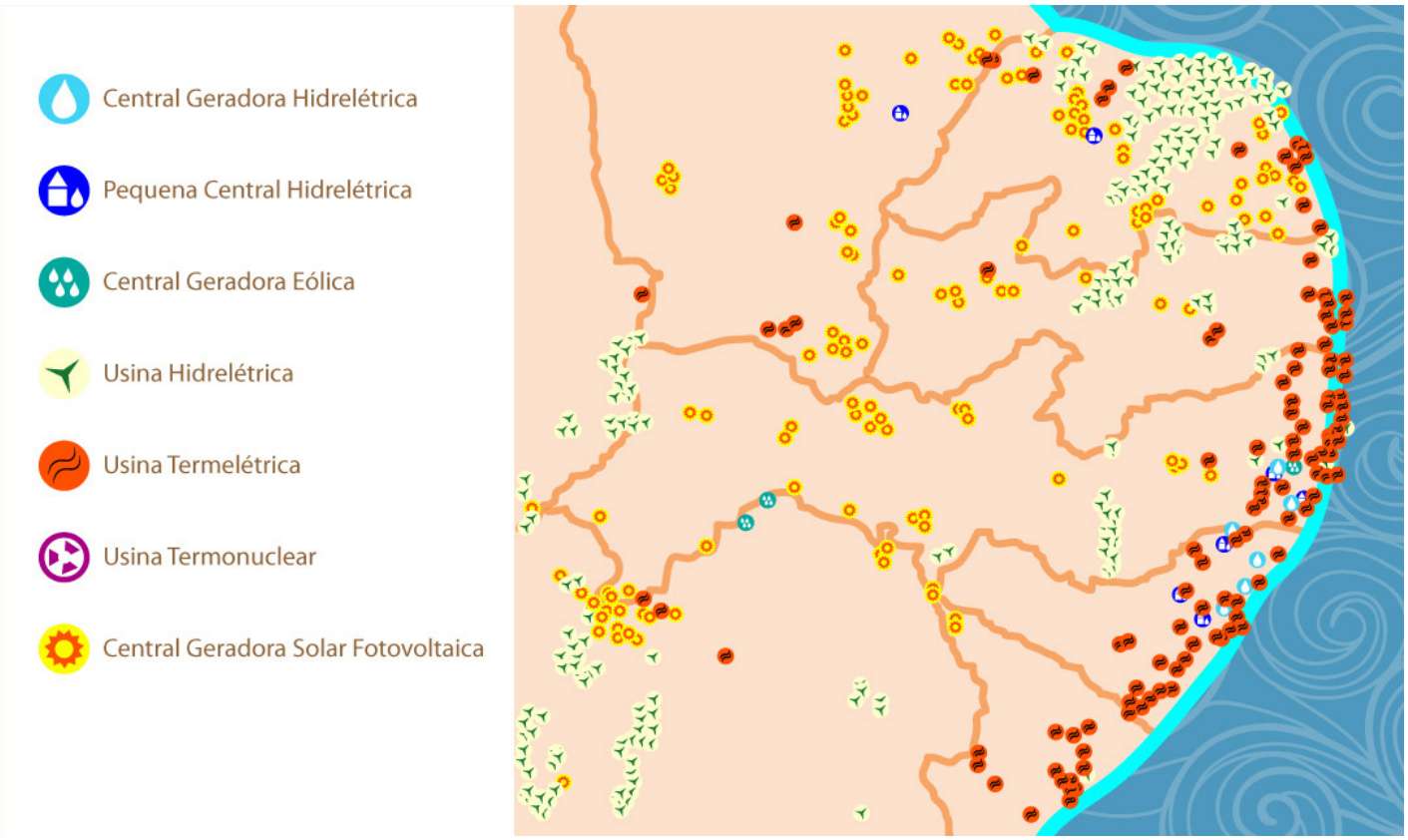
The variations in sources in less than a decade are remarkable. The drop in the percentage of hydraulic energy is due to the growth of the others. The transient increase in the thermal source corresponds to the emergency activation of thermoelectric plants, from 2012 (when the drought reduced the flow of the São Francisco River), but decreasing from 2014, when an accelerated growth of the wind source began and, after 2017, of solar.

[44]Bezerra, F. Panorama da infraestrutura no Nordeste do Brasil: Energia Elétrica. Caderno Setorial ETENE. Ano 4, n 65, January 2019. Available at https://www.bnb.gov.br/documents/80223/4570889/65_Energia+Eletrica.pdf/bf31c1f8-23d9-6b1e-a6c0-2a6f3eba0c98

While the growth in wind and solar energy has occurred throughout Brazil, it was more accentuated in the Northeast region. It is not by chance that the largest photovoltaic solar energy generator park in the country is located in the Semiarid region of Paraíba. It is the complex of Coremas, in the municipality of the same name, whose third phase was inaugurated on 17/09/20. When completed, in June 2021, it will have 686,000 photovoltaic modules installed and a power of 312 MW.[45]

The map below shows the primary current sources of energy in the Northeast region and their approximate locations.[46]

Figure 5. **Map of electric power generation enterprises**



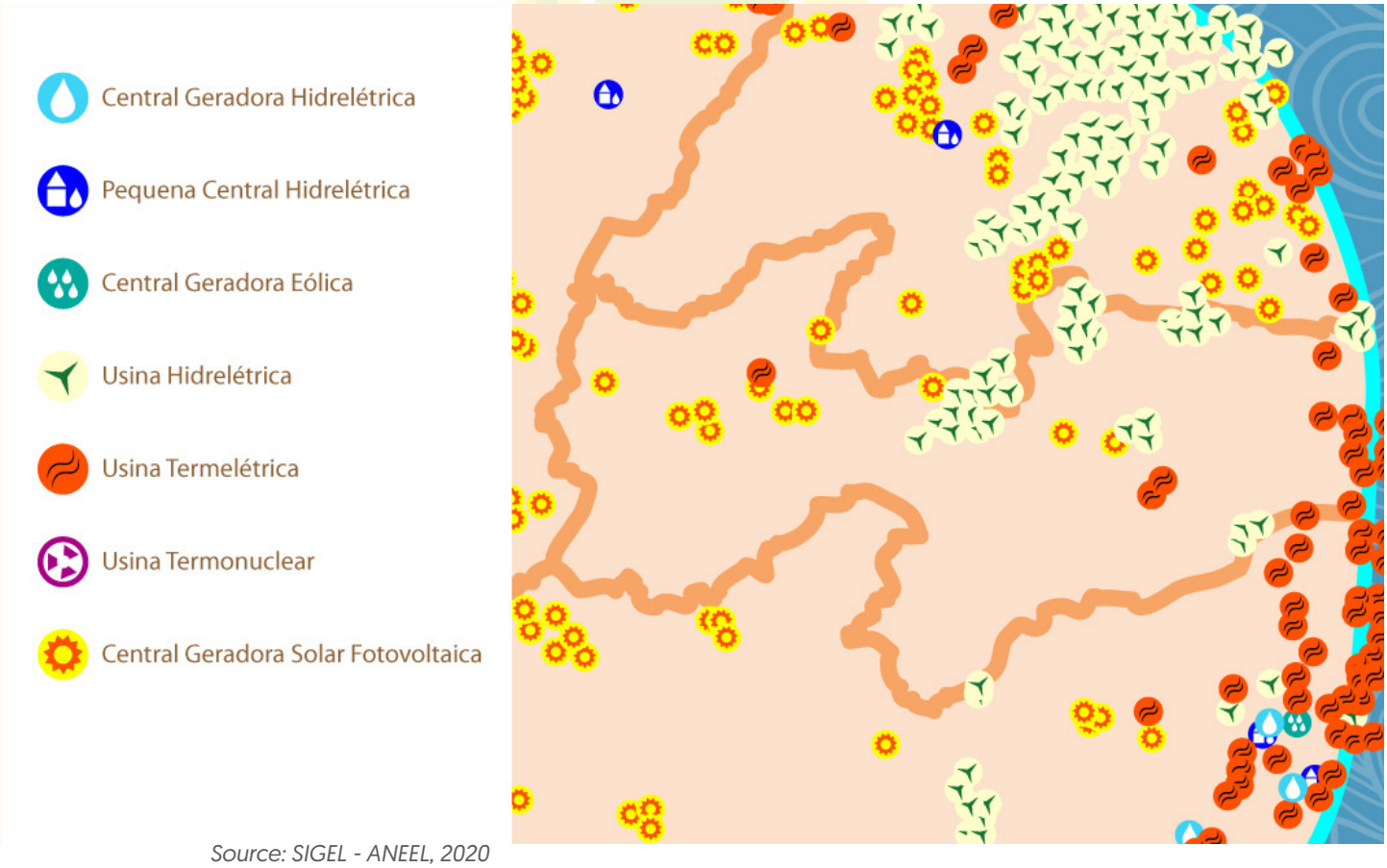
Source: SIGEL - ANEEL, 2020

[45] Agência Canal Energia. UFV Coremas é inaugurada na PB já com projeto de expansão AGÊNCIA CANALENERGIA 09/17/20 https://www.canalenergia.com.br/noticias/53147702/ufv-coremas-e-inaugurada-na-pb-ja-com-projeto-de-expansao

[46] Sistema de Informações Geográficas do Setor Elétrico (SIGEL). Available at https://sigel.aneel.gov.br/portal/home/. Accessed on October 14, 2020.

The same map, enlarged to cover only Paraíba, has the following configuration:

Figure 6. **Map of electric power generation enterprises highlighting the State of Paraíba**



Source: SIGEL - ANEEL, 2020

The reason for the location of the hydraulic sources has already been mentioned. The primary thermal sources, which use natural gas as fuel, are concentrated in the coastal strip, which is explained not only by a logistical issue (fuel supply) but also because this type of generating plant requires a large volume of water for cooling the equipment.

The Termonordeste and Termoparaíba plants are installed on the outskirts of João Pessoa, with a power of 171 MW each. To give an idea of what a thermoelectric plant, even efficient, consumes water, suffice it to say that the thermoelectric plant in "Pecém I, in Ceará, for example, consumes as much as cities with up to 200,000 inhabitants".[47]

[47] EcoD. Termoelétricas chegam a consumir volume de água que abasteceria cidades de até 200 mil habitantes. November 26, 2016. Available at http://www.ecodesenvolvimento.org/posts/2016/posts/novembro/termoeletricas-chegam-a-consumir-volume-de-agua?utm_source=dlvr.it&utm_medium=facebook. Accessed on October 20, 2020.

In other words: "According to the United Nations (UN), a person should have access to 20 liters of water a day, while the Marlim Azul thermoelectric plant, one of the most modern ones, under construction in Macaé (RJ), will consume around 78 liters per second of water. This occurs in a municipality that already hosts two other thermoelectric plants that together consume around 150 L/s.[48] One of the significant problems of water consumption by thermoelectric plants is that 62.9% of them are located in regions in a critical or worrying situation regarding the levels of the scarcity of water resources.[49]

Chart 1. **Thermoelectric plants in operation in Paraíba**

Plant Name	ID_ANEEL	Municipality
Campina Grande	UTE.PE.PB.000612-2.01	Campina Grande
Termonordeste	UTE.PE.PB.029641-4.01	João Pessoa
Termoparaíba	UTE.PE.PB.029638-4.01	João Pessoa

Source: ANEEL, 2020

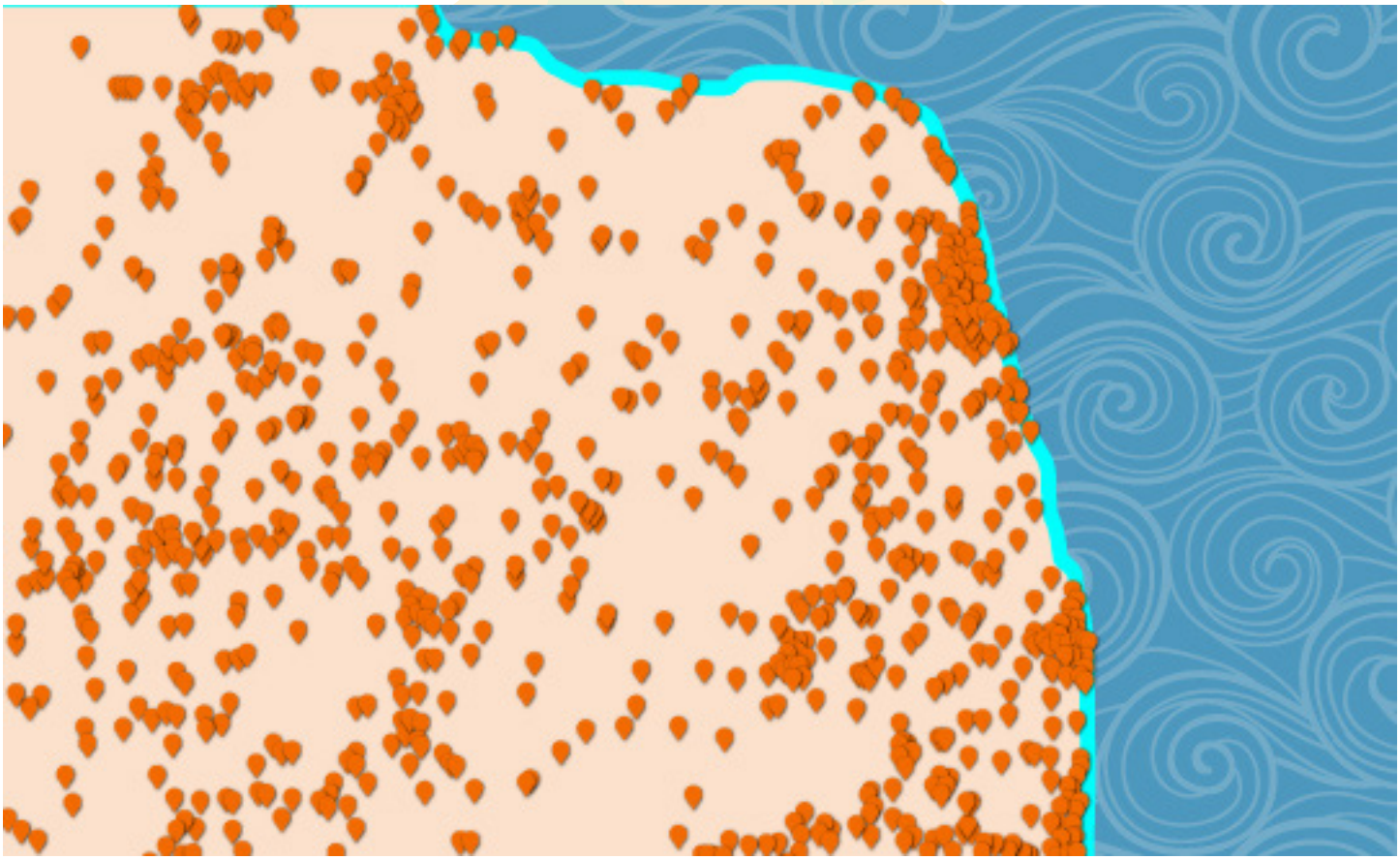
The "farms" of wind energy in the Northeast region, as in the whole country, are mostly located in coastal areas. However, as shown on the map, the Northeast region has several units located north of Paraíba and south of Rio Grande do Norte. Further west in the Semiarid region, the presence of solar generation parks is growing.

Distributed Generation

Previous maps do not include low power sources, which may lead to the assumption that solar units are few. However, if the map is programmed only with "distributed energy" sources, mostly renewable energies, and an increasing proportion of "distributed solar photovoltaic generation," the situation is surprising.

[48] Clima Tempo. Plataforma de usinas termelétricas é atualizada. March 11, 2020. Available at https://www.climatempo.com.br/noticia/2020/03/11/plataforma-de-usinas-termeletricas-e-atualizada-2308. Accessed on October 3, 2020.
[49] EcoD. Termoelétricas chegam a consumir volume de água que abasteceria cidades de até 200 mil habitantes. November 26, 2016. Available at http://www.ecodesenvolvimento.org/posts/2016/posts/novembro/termoeletricas-chegam-a-consumir-volume-de-agua?utm_source=dlvr.it&utm_medium=facebook. Accessed on October 20, 2020.

Figure 7. **Brazil map with distributed energy sources**



Source: SIGEL - ANEEL, 2020

For the reasons mentioned, the Semiarid territory in general – particularly in the State of Paraíba – has great potential for generating renewable solar energy.

"Distributed generation," mentioned earlier, is not a new concept, nor is it restricted to solar energy. The Energy Efficiency National Institute (INEE), a non-profit, non-governmental organization whose objective is to "promote increased efficiency in the transformation and use of all types of energy for the benefit of the economy, the environment, and greater safety concerning the access to energy and well-being of society," explains that "Distributed Generation (DG) is an expression used to designate the electric generation carried out at or close to the consumer(s) regardless of power, technology, and energy source. DG technologies have evolved to include increasingly smaller potencies. DG includes cogenerators

(in which the heat produced in the electrical generation is used in the production process as steam), generators that use combustible process waste as an energy source, emergency generators, generators for peak-hour operation, photovoltaic panels, and Small Hydroelectric Power Plants (PCHs)".[50]

The same INEE summarizes the evolution of this form of generation in a way that makes it easy to understand the reason for its current notoriety:

> *Electric generation close to the consumer became the rule in the first half of the century when industrial energy was practically all generated locally. From the 1940s, however, generation in large power plants became cheaper, reducing consumer interest in DG and, as a consequence, technological development to encourage this type of generation also stopped.*
>
> *The oil crises introduced disturbing factors that irreversibly changed this scenario, revealing the importance, for example, of the scope economy obtained in cogeneration. Starting in the 1990s, the reform of the Brazilian electricity sector allowed competition in energy services, creating competition and stimulating all electricity potentials at competitive costs.*
>
> *With the end of the electricity generation monopoly, in the mid-1980s, the development of technologies was once again encouraged, with visible results in cost reduction.*[51]

"Distributed generation" gained importance at the beginning of the 20th century as one of the expansion axes of the Brazilian electric system because, as explained in the publication *"Geração Distribuída: conceitos e caminhos para o desenvolvimento sustentável"* (Distributed Generation: concepts and paths for sustainable development), by the Brazilian Association of Distributed Generation (ABGD), "is a counterpoint to the idea that electricity should only be produced in large plants, which are far from urban centers, and taken to homes and commercial and industrial establishments, through long transmission and distribution lines – the model known as a centralized generation. The logic is simple: when several people install thousands of small plants across the territory, the network becomes more stable, more reliable, more resilient". 52

Regulations applicable to small distributed generation projects

The implementation of photovoltaic electricity generation units in a decentralized generation regime, as was done by the four cooperatives supported by the International Fund for Agricultural Development (IFAD) through PROCASE, resulted from all the knowledge summarized up to now and still observing the regulations for this type of generation established by the

[50] Instituto Nacional de Eficiência Energética (INEE). O que é geração distribuída. Available at http://www.inee.org.br/forum_ger_distrib.asp. Accessed on October 22, 2020

[51] Idem

[52] Associação Brasileira de Geração Distribuída (ABGD). Geração Distribuída: conceitos e caminhos para o desenvolvimento sustentável. 2020. Available at https://mailchi.mp/abgd.com.br/rzhz7eknxi.

National Electric Energy Agency (ANEEL), based on Decree 5,163, of July 30, 2004. The cooperatives' experience is described below. This decree "regulates the commercialization of electric energy, the process of granting concessions and authorizations for the generation of electricity..."[53]

Based on Decree 5,163, ANEEL issued specific regulations through Normative Resolution No. 482, of 04/17/2012, which established the general conditions for the access of micro-generation and mini-generation distributed to electric energy distribution systems, the system of electricity compensation, and other provisions. This administrative act was revised and amended by Resolutions 687 of 11/24/2015 and 786 of 10/17/2017.

As per these regulations, as informed by ANEEL, "using any renewable source is allowed, in addition to qualified cogeneration. Distributed micro-generation is the generating plant with installed power up to 75 kilowatts (KW), and distributed mini-generation is the one with power above 75 kW and less than or equal to 5 MW, connected to the distribution network through installations of consumer units."[54]

Also, per the regulations above, the energy amount generated in a month, if larger than that consumed in the same period, gives the generator/consumer credits that can be used to reduce the bill for the following months. Credits cannot be reversed in cash, with a validity period of 60 months. They can be used to reduce the consumption of consumer units of the same holder located in another location, provided that it is in the service area of the same distributor. This type of use of credits was called "remote self-consumption."

Currently, ANEEL also permits the installation of distributed generation in condominiums (multiple consumer units). The energy generated can be shared among the unit owners in percentages defined by them. Also, there is "shared generation," when several interested parties join together in a consortium or cooperative to install micro or mini distributed generation and use the energy generated to reduce their costs.

Likely, the micro-generation by solar photovoltaic sources in the cooperatives mentioned above causes a "leftover" of the energy generated during the day. This leftover is injected into the network, which, at night, "returns" the energy to the consumer unit and supplies additional needs. This eliminates the need to install batteries to store the surplus for use at night or another day.

ANEEL does not establish the cost of generators or the financing conditions. It is up to the person interested in becoming a generator/consumer to carry out the appropriate studies taking into account, as recommended by the Agency, variables such as: "type of energy source (solar panels, wind turbines, biomass generators, etc.), equipment technology, size of the consumer unit and the generating plant, location (rural or urban), the value of the tariff to which the consumer unit is subject, conditions of payment/financing of the project and existence of other consumer units that can benefit from the credits of the electricity compensation system."[55]

[53] Brazil. Decree No. 5,163, of July 30, 2004. Available at http://www.planalto.gov.br/ccivil_03/_ato2004-2006/2004/decreto/D5163.htm
[54] ANEEL. Geração Distribuída – SRD. September 28, 2015, last modification: August 15, 2018. Available at https://www.aneel.gov.br/geracao-distribuida. Accessed on October 21, 2020.
[55] Idem

Even if the amount of energy injected into the network is larger than consumption, the person responsible for the distributed generation at low voltage must pay a fee to the distribution company to which it is integrated corresponding to the "availability cost." The value in reais is equivalent to 30 kWh (single-phase), 50 kWh (two-phase), or 100 kWh (three-phase).

The presentation of the regulations by ANEEL and the distributors seems to indicate the concern with constructing a public service that benefits all partners equally. Bursztyn is, once again, a dissenting voice:

"The Brazilian regulation referring to the distributed generation of electricity reflects the strong lobby of the distribution companies, whose business strategy values the sale much more than the purchase of energy. According to current regulations, a company or legal entity can generate and sell energy distributed on the grid. However, an individual can only get credits, to deduct from their consumption in the smart grid system."[56]

[56] As the author explains, the term designates "Literally, smart grid, which is based on the possibility that energy production and consumption can take place in a bidirectional way, allowing consumers to also sell part of the energy they generate." Bursztyn, M. Energia solar e desenvolvimento sustentável no Semiárido: o desafio da integração de políticas públicas. Estudos Avançados (online), vol. 34, n. 38, 2020. pp.167-186.
https://doi.org/10.1590/s0103-4014.2020.3498.011

International cooperation to bring solar energy to the Semiarid region of Paraíba

From what has been said so far, it should be clear that solar energy is the most suitable modality for the Semiarid region since it uses an abundant element as fuel, inexhaustible in a predictable horizon, without cost, except for the equipment necessary for its use. Such use does not require other scarce inputs, such as water, does not generate waste, and can have their use expanded without supply problems. Furthermore, the technology required for its distribution and use is widely known, and the necessary resources are available.

The sun, as a source of energy, is what economists call a "public good." In other words, something accessible to everyone, whose consumption by someone does not imply limiting use by others – is not exclusive access or whose increased consumption

Coasc on-site solar panels

implies a reduction in use by each one of the users. The increase in consumption does not imply an increase in the costs of supplying or extracting the raw material. It can be used simultaneously in any amount, without any user being affected. No one can be excluded from accessing the sun and using it as a source of energy. However, as already explained. They may be prevented from obtaining an economic advantage from their investment in the related equipment for debatable reasons. It is hard to find a better example of a public good.

In addition to the advantages mentioned in the previous paragraph, using the sun as a source of solar energy has incomparable benefits concerning others regarding environmental impact and direct or indirect contribution to reducing the factors that generate climate change.

Due to all these factors, solar energy generation has an unparalleled potential, especially in areas like the Semiarid region, where other energy sources have insurmountable or significant disadvantages. Examples of these disadvantages are the water availability, generation or transmission costs, environmental impact, and final cost to a consumer in a region characterized by poverty, especially in rural areas. There is, however, a significant obstacle to the broader use of solar energy in the Semiarid region as a factor for sustainable development and poverty reduction: the cost of implementing the systems, even on a small scale.

In this context, the International Fund for Agricultural Development (IFAD), which began collaborating with the federal and state governments of Brazil in the 1980s, investing in rural development activities in the semiarid region of the Northeast, expanded its activities to include projects for the implementation of solar energy generating unit.

As its documents emphasize, IFAD is an international financial institution and a specialized United Nations (UN) specialized agency headquartered in Rome. All IFAD-funded projects in the country focus on supporting and promoting family agriculture. The objective is to increase the production and income of family farmers by facilitating their access to essential services (training, rural credit, and technical assistance, with particular attention to climate-adapted technologies), strengthening their organizations, and connecting them to markets.

One of the main aspects of IFAD-supported operations in Brazil has been the search for technical innovations and good agricultural practices that provide family farmers with appropriate tools to develop in the challenging environment of the Semiarid region of the Northeast. Examples include organic and agroecological production methods, water collection and conservation technologies, and participatory planning methodologies to harness innovations and traditional knowledge.

Renewable energies, particularly solar, feature prominently among the lines of action addressed by IFAD in the document "How to do - Access to finance for renewable energy" of May 2018 (available in English only). According to this study, "With major advances in the development of renewable energy technologies (RETs), the promise of universal access to clean, safe, and easy energy, particularly for remote rural populations, has never seemed more tangible." The document recognizes, however, that "Despite these opportunities, access to RET funding remains limited, and there are significant challenges that constrain its expansion." Among the difficulties present in Brazil, mentioned in the study, is that the equipment sector is not mature enough. It means that it has a limited presence in rural areas [specifically in remote and poor areas

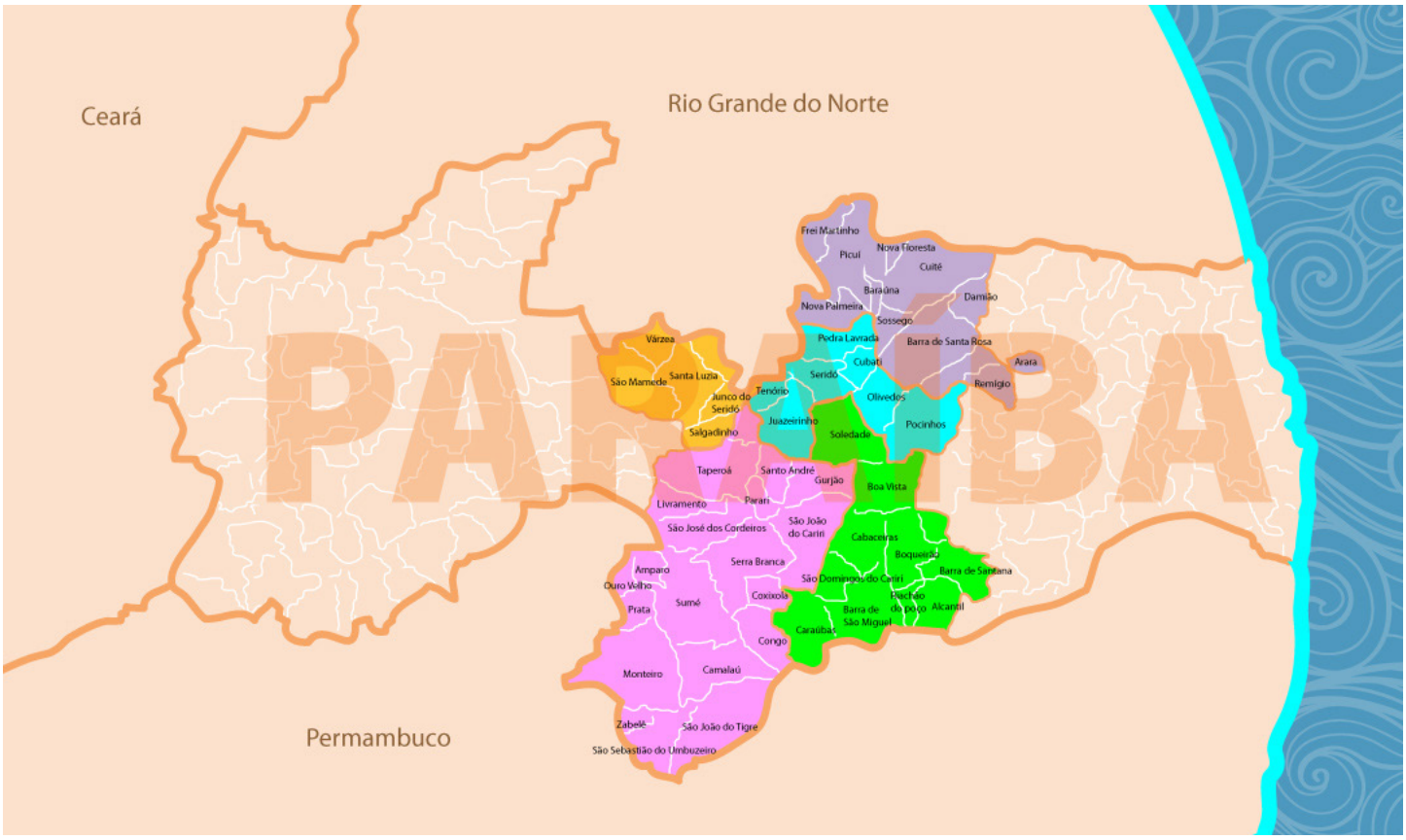
such as the Semiarid region, despite being precisely the region with more significant potential]. The companies have limited resources, tending to concentrate their activities in regions with more excellent business prospects and greater capacity to incorporate technology. This scenario, still according to the document, tends to discourage possible project funders, which makes it challenging to identify partners by interested rural organizations.

In analyzing the possibilities of renewable energy projects, the IFAD document points out the need to consider that "public policies and regulations can play a key role in supporting or hindering the development of the renewable energy supply chain, as well as the provision of financing for projects of the kind." Therefore, it maintains that "ensuring an enabling environment is essential before starting a project to finance [renewable] energy." That said, the text lists issues that should be analyzed.

Most of the items mentioned are positively present in the case of the semiarid region of Paraíba. More importantly, at the time of writing the document, IFAD already had a partner: the government of the state of Paraíba, via the Cariri, Seridó and Curimataú Sustainable Development Project (PROCASE), through which it developed work to promote actions

aimed at developing human and social capital, improving the production of small farmers, combating desertification, and promoting the sustainable resource management. More than that, in 2016, according to the documentation of the State Action Program to Combat Desertification and Mitigate the Effects of Drought in the State of Paraíba – PAE-PB, executed by PROCASE, solar energy energy was incorporated as one of the components of the "Emergency Plan" of coping with effects of the prolonged drought. The plan started to support initiatives to capture water by constructing underground dams, obtaining pest-resistant forage, drilling deep tubular wells, and installing irrigation kits.

Figure 8. **PROCASE coverage area map**



Source: Procase, 2019[57]

[57] (Procase). Technical Progress Report - Period: 1st semester of 2019 (Loan - IFAD I-798-BR), João Pessoa, July 2019.

The primary source of PROCASE's actions is a loan agreement entered into with IFAD (Loan – IFAD I-798-BR), responsible for 50.31%, with the remainder coming from the State Government's counterpart (24.35%), from PRONAF funds (6.84%), and compensation funds from beneficiaries and other partnerships (18.5%).

Projects financed by the IFAD contract continued in the following years. In a memorandum of 2019, mentioning its main strengths, IFAD, when referring to the Environmental Component of PROCASE, specifically mentioned the "implementation of panels for the generation of solar energy in processing units"

Four cooperatives gain new life in the sun

The implementation of photovoltaic solar electricity generation units within the scope of PROCASE benefited four cooperative agro-industries (CAPRIBOM, COOPEAVES, ARTEZA, and COOASC) defined by "spontaneous demand" – i.e., by initiatives taken by the interested parties. In an interview for this document, PROCASE environmental consultant Thiago César Farias da Silva, acting as an expert in the IFAD Supervision Mission, reported that "Rural cooperatives got in touch with the project coordinator at the time, Aristeu Chaves. Sensitized with the situation, he asked the PROCASE technicians to establish agreements for the implementation of photovoltaic energy systems."

The intervention in the process of implementing Solar Energy Systems (photovoltaic) in the four supported agro-industries consisted of the technical follow-up of the Project's support team (consultants and scholarship holders) and the Technical Advisors (ATs) contracted.

In 2017, a standard agreement was signed with each of the cooperatives. Subject to each project's qualifications and specificities, the general conditions of the project financed by IFAD and the government of the State of Paraíba and executed by PROCASE were established. *The clauses of the agreements are reproduced in an annex at the end of this document.* Its objectivity will prove decisive for the quick and efficient implementation of the project.

As stipulated in the agreements, one of the counterparts of the cooperatives was to provide the engineering project for the photovoltaic energy system. According to Thiago César Farias da Silva's testimony, the contracting of the engineering project followed the standard procedure in PROCASE. Thus, a Permanent Bidding Committee (CPL) of the Cooperative was created (composed of members of the board in force at the time of the agreement, chosen at a meeting, and formalized in the minutes) to monitor the entire procurement process.

For the supply and installation of the generation systems, a specialized company was contracted according to the Shopping modality – one of the types of acquisition of PROCASE/IFAD manuals. The members of the CPL supervised the process of contracting and executing the provision of services, while PROCASE supported the process and supervised the execution of the agreement.

The full use of the energy generated by the photovoltaic solar system in a distributed generation regime (integrated with the electricity distribution company's network in the respective areas of operation of the cooperatives) under the current regulations in Brazil required signing a contract with the distribution concessionaire. ENERGISA is the concessionaire in the entire state of Paraíba.

Under the contract, the photovoltaic energy system is connected to the in-grid system (the energy produced is not accumulated in batteries but is injected into the compensated distribution network, as described above).

Once the technical projects were completed and the agreements' conditions were met, considering the energy needs of each cooperative, the systems' budgets systems were defined as summarized in the table below:

Chart 2. **Main characteristics of solar energy projects benefited by PROCASE**

Organization	**Implementation time**	**Location** (Territory and Municipality)	**Energy Type**	**Application Type***	**Installed Capacity** (kWp)	**Investment** (R$)	**Power generation** (KWh/day)**
CAPROBOM	15 months	Monteiro/ Cariri Ocidental	Concessionaire electric energy + photovoltaic energy *(in the grid)*	Agro-industry and milk receiving points	71,28	R$ 358.955,00	400
ARTEZA* **	7 months	Cabaceiras/ Cariri Ocidental	Concessionaire electric energy + photovoltaic energy (in the grid)	Agro-industry	56,1	R$ 334.750,00	226
COOASC	8 months	Picuí/ Curimataú	Concessionaire electric energy + photovoltaic energy (in the grid)	Agro-industry	56,1	R$ 298.700,00	226
COOPEAVES	3 months	Monteiro/ Western Cariri	Concessionaire electric energy + photovoltaic energy (in the grid)	Agro-industry	56,1	R$ 298.700,00	271,7

*Type of application refers to the use that will be made of solar energy, i.e., whether it will provide electricity for a house, for a weather station, for public lighting, for agro-industry (dairy, pulp), tanning, or other production processes.

**Energy generation refers to measurements of how much the plant is currently generating or to the estimation made of energy generation in the design stage

***The value of the ARTEZA agreement was higher than those of COOPEAVES and COOASC - even with the exact technical specifications - due to the services necessary for the regularization of the electricity consumption system associated with the Concessionaire.

Source: PROCASE, 2020

The development of the projects in the four cooperatives was fast and already in the "Technical Progress Report - Period: 1st semester of 2019" those responsible for PROCASE were able to present the first results of social and economic impact on the agro-industries. These companies received the solar energy enterprise when the environmental commitments were being implemented to environmentally regularize the projects.

"**1. CAPRIBOM:** "1. CAPRIBOM: has been operating its photovoltaic system since 2018. Currently, there is a monthly reduction of approximately 10,000 kW, generating savings of R$ 9,500.00. According to the Fronius monitoring software, there are already 30 tons of avoided carbon, corresponding to a carbon fixation of 772 trees and inhibition of 200,597 km of CO2 by cars. In April, SUDEMA issued the Operating License No. 1018/2019, making CAPRIBOM's environmental regularization a reality.

In this context of licensing, it is essential to note that PROCASE provoked COPAM/PB to create a regulation that will reduce the licensing fee for family agriculture enterprises to 01 (one) UFRPB.

CABRIBOM increased its membership by more than 70 cooperative members in the social field, 20 of which are goat milk producers and 50 bovine milk producers for obtaining derivatives (cheese, yogurt, etc.). This is due to new sales contracts in government purchases with the Army, PAA, and the Paraíba Milk Program. With the increase in the number of partners, today, CABRIBOM is acquiring more than 10,000 liters of milk a day, benefiting more than 400 producers, most of which are family farmers.

2. ARTEZA: completed the implementation of its photovoltaic energy system at the end of May/2019, connecting the specific meter by the energy distribution concessionaire (ENERGISA).

3. COOPEAVES: there was a considerable advance in the system installation process, delayed by technical and operational issues.

4. COOASC: after solving the technical problems associated with the energy distribution system of the three-phase grid at the end of April/2019, authorization was given to install its photovoltaic energy system."[58]

The implementation of the projects was facilitated by some factors such as:

a) Carrying out an environmental analysis for the installation of these systems was not required. Due to their size, they are considered micro-generation (domestic use). Even though there is no need for environmental licensing, the Department of Environmental Management and Coexistence with the Semi-Arid Region (GGACS) did not identify a significant impact, as there was no conversion of natural areas for the implementation of the systems. CAPRIBOM and COOPEAVES implemented their systems on the roof of agro-industries; ARTEZA and COOASC used already consolidated areas, as established by Federal Law 12,651/2012 concerning the installation of solar panels.

b) An assessment of the sectors of the cooperatives in which the energy from the photovoltaic unit would be used was not necessary. This is because the analysis was based on the entire agro-industry. The energy consumption based on the energy bill referred to the entire building installation (administrative and industrial parts). Also, after installation, due to the high solar incidence, the system was found to operate close to 100% efficiency (higher than standard), which allowed other cooperative structures (milk collection points, points of sale, etc.) to benefit from the reduction of their energy bills.

[58] Rural Cariri, Seridó, and Curimataú sustainable development project (Procase). Technical Progress Report - Period: 1st semester of 2019 (Loan - IFAD I-798-BR), João Pessoa, July 2019.

c) Following a lengthy bidding process to define the suppliers was not required. The selection was carried out by the Shopping process, through which free competition was opened, with companies invited to participate. The one that offered the best global value based on the Terms of Reference for the project and the technical project was chosen;

d) Carrying out a pre-operation period for the system was not required. As the systems are for micro-generation, they are already standardized, eliminating the need for tests to calibrate their dimensioning. Only the tests associated with the installation protocol were needed;

e) As explained above, an assessment of this pre-operation was not necessary before the definitive replacement of the energy source used;

f) There were no technology and equipment suppliers problems because they all had qualified professionals in their technical team and used quality equipment. Also, remote monitoring systems were made available;

g) The environmental impact of the new technology is positive, as there was a reduction in the use of the energy matrix provided by the concessionaire (although essentially hydroelectric in origin, it has a thermoelectric component). Furthermore, the cooperatives' administrators have become aware of the importance of renewable energies concerning the sustainability of the biome where they are installed. An example of this is the fact that one of them, CAPRIBOM, immediately started planning the replacement of its biomass energy boiler for a solar heating system (with its resources);

h) Although the cooperatives did not have personnel specifically trained for the operation and maintenance of the systems, PROCASE had this concern and dialogued with the directions of the cooperatives so that the final product of the system installation contract was training in the use of technology. In some cases, the board itself, some members with mastery of electrical technique, and all members willing to learn about the technology received training;

i) There was no need to adjust the conditions contracted with suppliers and operating conditions dependent on own resources (including personnel training). All systems were implemented following the Terms of Reference and established contracts;

j) There were no unforeseen events in the initial phase of the operation due to the facilities and human resources involved because all cooperatives had the photovoltaic system installed in structures built or previously evaluated as adequate for their installation. Also, training in the use of the system ensured its good use.

k) There was no need to resize the systems implemented due to the actual energy demand. As reported in this document, solar radiation in the region is extraordinary, and the systems operate at the limit of their capacity, possibly slightly higher. Thus, even if cooperatives operate with predictable growth, the capacity of the installed systems will be sufficient to meet the demand for the next five years.

CAPRIBOM milk collection unit in the municipality of Monteiro.

- CAPRIBOM -
The cooperative saved by the sun

"Solar energy made the difference. If it had not been for the savings obtained with the replacement of electricity from the distributor with solar energy from our panels, perhaps the cooperative would have closed in the pandemic." The relieved comment is from Rubens Remígio, veterinarian, farmer, and founding director of the *Cooperativa dos Produtores Rurais de Monteiro Ltda* (CAPRIBOM, Cooperative of Rural Producers of Monteiro Ltda).

Before installing the photovoltaic panels on the roof of the cooperative, in the Sítio Morro Fechado district, rural area of Monteiro, Paraíba, CAPRIBOM spent around R$15,000.00 on electricity. With the new system, spending was reduced by almost 80%, says its president, Fabrício Ferreira.

Known by the diminutive Rubinho, Remígio says he does not understand why Brazil does not invest more in solar energy. Energy expenditure threatened the cooperative's survival. According to him, solar energy was perceived as a solution. However, as CAPRIBOM has always maintained a non-debt policy, its resources were insufficient to implement a system with the necessary dimensions.

PROCASE was the solution, and now, with the savings obtained, the cooperative will expand the system with an investment of R$ 50,000 in photovoltaic panels acquired with its resources. The additional production of energy will allow the deactivation of the wood-fired boiler, reducing the environmental impact. Also, in this regard, the solar energy project was indirectly crucial because, to benefit from IFAD's resources via PROCASE, CAPRIBOM had to adapt to various sustainability requirements, which implied the construction of a waste treatment unit a renovation of the production area.

CAPRIBOM has 400 associates and used to process 10,000 liters of cow's and goat's milk a day before the pandemic. It currently receives 7,000 liters, 3,000 of which are from goats. The region was severely affected by the last major drought, and the cooperative was recovering when the pandemic began. Immediately, the impact was huge. Public purchase programs for food from family agriculture were suspended – in the case of the cooperative, the suspension lasted four months. What sustained production was the supply of milk to the Army and the private market – incipient but growing –, including in the capital, João Pessoa, located 300 km from Monteiro.

With the energy savings, the financial situation of the cooperative on the brink of bankruptcy has wholly changed. It enabled the cooperative to pay the financing for purchasing a refrigerated truck to distribute the product to the points of sale, reducing expenses with third-party freight. Furthermore, the board is already thinking about expanding the generation system with its resources.

Erika Cazuza, CAPRIBOM's Administrative and Financial Director since 2019, is one of the cooperative's seven employees (among the others are the veterinarians, responsible for the technical part of the production). She recalls that the value of the first energy bill after installing the solar panels dropped to R$300.00. "Hey! If it were not for solar energy, we would have closed; you can be sure. We had to stop because of the pandemic on March 15, but energy expenses were overhead costs".

The “bottleneck” for CAPRIBOM is no longer the cost of energy. Today, it is sales, evaluates Rubens Remígio. “I know PROCASE will work on it. It is necessary to prioritize the development of sales channels. You cannot sell only to the government,” he says with emphasis. The cooperative currently works with an outsourced company. However, his dream is to set up a marketing company that works for other agro-industries, an organization that is itself a cooperative.

Upon concluding his testimony for this work, Remígio made a point of expressing the gratitude of CAPRIBOM members to PROCASE.

Video

- COOPEAVES -

The cooperative is reborn with the sun

Veterinarian Luis Ricardo Borges Morato, is the president of the *Cooperativa de Avicultores de Galinha Caipira e Agricultura Familiar Do Estado Da Paraíba* (COOPEAVES, Cooperative of Rustic Chicken Farmers and Family Agriculture of the State of Paraíba), suggestively located in the Mutirão neighborhood, like CAPRIBOM, in Monteiro. Upon learning of a solar energy program with resources from IFAD and the State Government, he contacted PROCASE to find out about the possibility of enabling the reactivation of COOPEAVES.

The cooperative was founded seven years ago and initially had 23 members, all small breeders of what is commonly referred to as "rustic chicken," i.e., not raised in a conventional aviary. In the beginning, all production was destined to government buyers, of which, in a second moment, the federal state-owned National Supply Company (CONAB) became a part. This assured demand attracted other breeders and allowed COOPEAVES to obtain financing to construct its slaughterhouse. When the federal government drastically restricted the public procurement policy, the cooperative could not keep operating with sales to the private market, mainly because of the energy costs for the slaughterhouse, of R$ 7,500 at the total activity. Under these conditions, the cooperative was forced to suspend its operations.

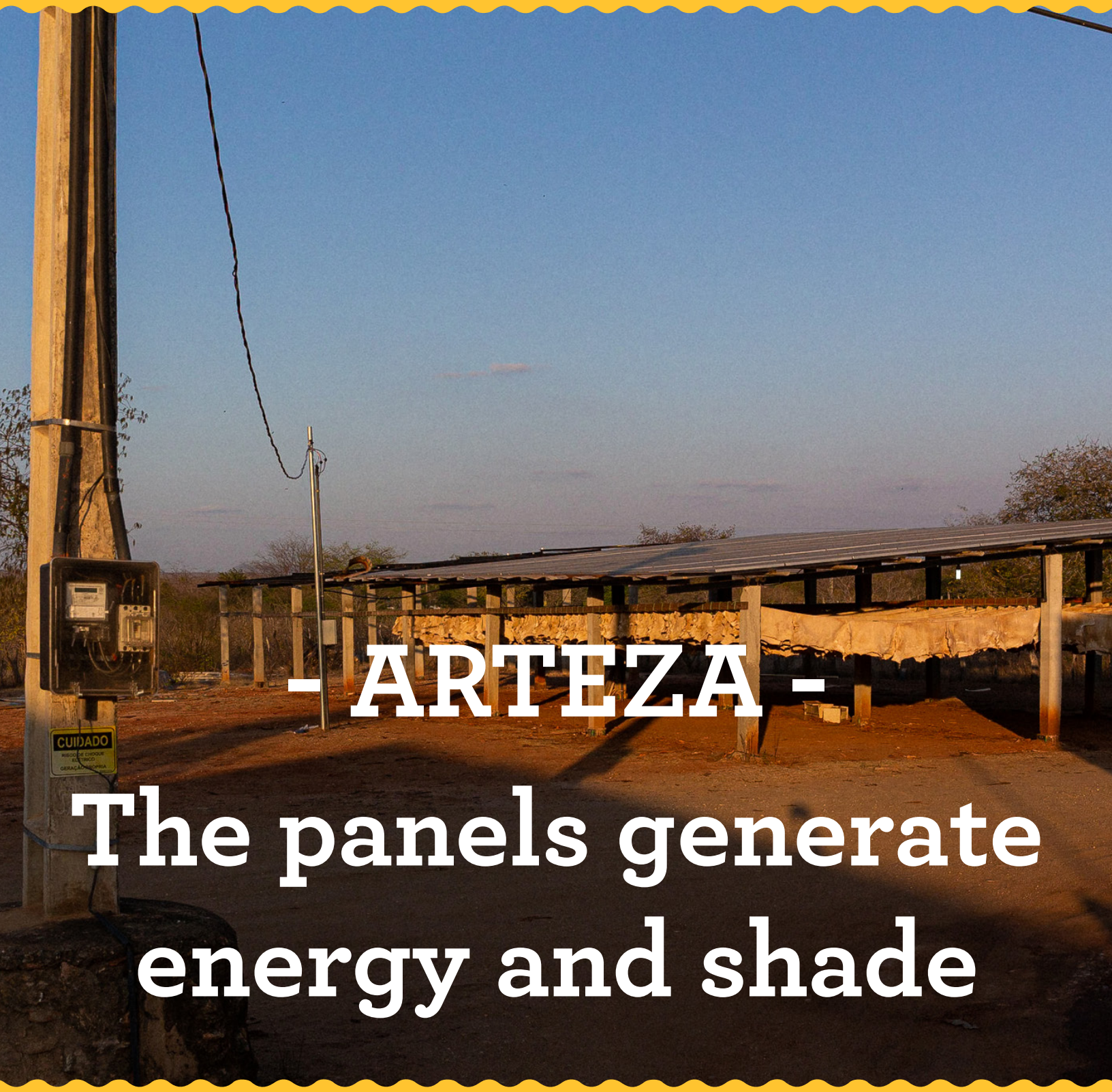
The approval of the solar energy project under PROCASE will allow the reactivation of COOPERAVES. However, Morato knows that the savings obtained with photovoltaic panels alone do not ensure the sustainability of the cooperative. Its members cannot be restricted to rustic chickens to enable the resumption of activities as a private market's supplier, in addition to being obliged to find a solution to the lack of scale that prevents the slaughterhouse from functioning correctly. Therefore, Morato is negotiating the outsourcing of this area. In the search for partners, the installed solar energy system is an important asset. If the cooperative were in regular operation, the savings obtained would be more than 80% compared to the distributor's conventional energy. "There are interested parties, and the low energy cost from solar panels has been an attraction for them."

Another Morato project to support COOPEAVES is installing a rendering plant, an establishment that processes feathers, bones, fats, blood, and other by-products from slaughterhouses and transforms them into raw material to produce animal feed and fertilizers, and cleaning material. The cooperative's solar system will also make a difference here.

In the new business model, made possible from the savings obtained through solar energy, says Morato, the cooperative will walk on its legs, not depending exclusively on government purchases and making the producer more independent.

The implementation of the solar generation system, according to Morato, did not only have an economic impact. It also had an educational effect, both for the cooperatives and for the city. "After the two cooperatives here in Monteiro implemented this form of energy production, many people became interested and are installing photovoltaic panels." In the specific case of COOPEAVES, he adds, PROCASE came at a fundamental moment, in which the cooperative was in difficulties. Moreover, in addition to the economic benefits enabling the cooperative reactivation, PROCASE also positively impacts the environmental issue.

Video



- ARTEZA -

The panels generate energy and shade

The municipality of Cabaceiras in Paraíba, 180 km from João Pessoa, has a 300-year tradition of leather processing. It is there that, in 1998, 28 artisans decided to form the *Cooperativa dos Curtidores e Artesãos de Ribeira de Cabaceiras* (ARTEZA, Cooperative of Tanners and Artisans of Ribeira de Cabaceiras), and thus escape dependence on middlemen.

Ângelo Mácio, current president and member of the third generation of a family of tanners, says that the cooperative already knew about PROCASE when it applied for support for installing its solar generation system. Before that, with the help of the program, it had already carried out environmental treatment actions.

The initial project foresaw the installation of the panels on the ground. When forwarding the documentation, the cooperative board proposed an alteration that had not occurred to the technicians: The panels could be raised and converted into a roof for a new drying area, measuring 340 m². Thus, a problem faced by the cooperative would be solved, i.e., a minimal area, of only 36 m², for drying the hides, done naturally and in the shade.

Also, the space between the panels could be filled with PVC gutters through which rainwater would be collected, reducing the consumption of water obtained from an artesian well. The modification was approved, and the additional cost was covered with resources from the cooperative itself. At the same time, expenditure on electricity, which used to be R$ 4,000 per month, fell by around 60%.

With the new configuration, ARTEZA could increase the processing of hides from 500 to 800 units per month to around 15,000 per month, placed on the Northeastern market. In the future, the cooperatives expect abroad. The increase was so significant that it required diversifying leather sources (mainly sheep and goats) as there is not enough availability in Paraíba.

Leather processing is water-intensive. In the case of ARTEZA, it is obtained from wells. With solar energy, the cooperative will be able to invest in liquid waste treatment to the point that it can be used to raise tilapia while the solid parts can be used as fertilizer. The plan for this is underway and budgeted for between R$ 60,000 and R$ 80,000.

Lucas Castro, 33 years old, artisan and ARTEZA's Financial Administrative Director, is another descendant of a generation of tanners and artisans. He is very concerned about the environmental impact. In general, tanneries use industrial chemicals for tanning the hides. ARTEZA uses organic products. Thus, the cost is higher, and the cooperative's products would have competitiveness problems. From the use of the solar generation system, energy savings enables the cooperative to offset the higher cost of organic tanning.

Milene Farias is an administrator in charge of inventory management and product marketing. She started in the cooperative 14 years ago when she was 20 years old. She went to ARTEZA to make a photocopy because the office had one of the few machines in the city. Upon arrival, she was invited to work as an assistant. She is convinced that the cooperative will grow and attributes this perspective to the impulse generated by solar energy and the support of PROCASE.

Video

Mari Preto Community, municipality of Picuí. Fruits processed at COOASC

- COOASC -

Sun to generate cold in the Semiarid region

Fruits are the main permanent crop in the municipality of Picuí, in northern Paraíba, close to the border with Rio Grande do Norte. In 2011, a group of family farmers got together to form the *Cooperativa Agroindustrial do Seridó* (COOASC, Seridó Agroindustrial Cooperative).

With resources from credit lines for such enterprises, the cooperative is classified as a fruit processor. In 2015, according to former president Júlio Pereira da Costa, sales of pulp to city halls began, benefiting from public procurement policies. The pulps are made with equipment acquired via PROCASE in what was the beginning of an institutional relationship that would lead the cooperative to plead for a solar energy generation system that would reduce expenses of R$ 5,000 per month with the operation of cold rooms. This amount corresponds to 50% of the cooperative's costs, which, in 2018, had a gross monthly income of R$35,000.

With the retraction of public purchases by the federal government in recent years, the cooperative would not continue receiving the production of its 30 members, whose families, in addition to delivering the raw material, participate in the processing.

The solar system allows COOASC to remain in business, as it can keep its cold rooms (which currently store 48 tons of products) and the processing unit in operation. Meanwhile, the cooperative's board of directors is attentive to the need to diversify its clientele, supported by the Brazilian Micro and Small Business Support Service (Sebrae).

Among the actions in progress is the installation of own points of sale in cities such as Campina Grande, João Pessoa, and Recife. Also, in partnership with other cooperatives, the plan is to enter the hotel market and invest in tasting actions, offering different packaging options, such as sachets, in addition to 1-liter bottles. COOASC hopes to triple sales, which is possible because its fruit suppliers can increase raw material supply. On average, the suppliers are owners of 15-hectare properties.

Avani Dias da Costa, COOASC's Financial Director and former President recorded his testimony for this work in front of a wall on which the IFAD logo is painted. He, who participates in COOASC since 1991, when an association that would give rise to the cooperative was formed, is proud of the fact that the institution has a healthy financial situation, without debts. He emphasizes that the union of the members has been decisive in achieving this situation.

The cooperative producer Edelita da Silva Costa participates in the cooperative since 2011 and claims to be proud to be part of COOASC. Her testimony, on several occasions, stated that the cooperative has been growing "thanks to God," adding "and to PROCASE." She does not forget to mention that COOASC "is a family" in which women actively participate, including the Board.

Video

Lessons learned

The implementation of photovoltaic solar generation systems in a distributed system integrated with the regional distribution company and the start of operations in the cooperatives in which this occurred showed that this way of obtaining electricity is the most suitable for agro-industrial enterprises located in the Semiarid region.

In addition to presenting advantages over all other options concerning sustainability, its operation allows a reduction in company costs. It can mean the economic viability of the enterprises, either allowing them to remain active (in the case of CAPRIBOM) or making it possible to resume once suspended (in the case of COOPEAVES).

Notwithstanding the apparent advantages of the solar option, the experience of the four cooperatives is equally unmistakable as to the difficulty of reproducibility. Equipment costs are incompatible with the scale of the business and with the revenues of similar enterprises.

Despite the reduction in costs registered in recent years, as mentioned above, there is no evidence that, within a predictable period, this reduction will reach levels that make it possible to adopt solar systems by similar projects only with the use of their resources.

However, less bold fiscal initiatives than the supply of non-repayable systems (with minor consideration from interested parties, as in the case of the cooperatives analyzed in this document) or through the granting of direct subsidies for the implementation of solar systems would already be enough to encourage its adoption in regions where solar radiation makes this energy source competitive once the panels are installed.

The experience of the state of Minas Gerais proves such a statement. There, the installed power of solar systems is already more significant than that existing in the nine states of the Northeast, according to a recent report by the IPS news agency, based on information provided by Daniel Lima, president of Northeastern Association of Solar Energy (Anesolar), founded in August 2020. The difference is attributed to the tax exemption granted by the government of Minas Gerais five years ago.[59] This is evidence of how public policies can induce the introduction of solar systems.

If the federal and state governments do not adopt aggressive public policies to encourage the adoption of small-scale solar generation systems, the model will not be reproducible. An exception is under the conditions of the cooperatives analyzed in this document, which involved the transfer of high non-repayable resources percentage of the final cost of the projects.

For analytical purposes, the "neutralization" of the cost impact of electric energy on the enterprises' economy (disregarding the cost factor of the systems) is a powerful argument favoring the adoption of this energy source. However, the experience of the four cooperatives analyzed in this work allows for evidence of other critical factors for the development of enterprises.

[59] Osava, M. Generación distribuida, esperanza energética para los pobres en Brasil. 22 de outubro de 2020. Disponível em: - http://www.ipsnoticias.net/2020/10/generacion-distribuida-esperanza-energetica-los-pobres-brasil/?utm_source=Spanish+-+Mejor+de+la+Semana&utm_campaign=aba116f4f6-EMAIL_CAMPAIGN_2020_10_23_08_47&utm_medium=email&utm_term=0_b685ec-7ed3-aba116f4f6-5193541. Acessado 22 de outubro de 2020.

Overcoming the critical factors not addressed by the energy solution requires interventions of another type. However, the more intensive use of solar energy or the release of resources previously used to pay conventional energy tariffs may be decisive for its solution.

The issue exposed in the previous paragraph is better understood with the following cases observed in the four cooperatives:

The three food-producing cooperatives were heavily dependent on public purchases for the placement of their products. These purchases were part of public policies to support family farming for over a decade. However, they were enormously changed as of 2016, resulting in a drastic loss of market and income by family farmers across the country. The situation became even more serious with the Covid-19 pandemic. To a large extent, part of the remaining public purchases – purchases by states and city halls for school meals, for example, were suspended due to the interruption of in-person activities.

Faced with the loss of the "captive market" of public purchases, agro-industries linked to family agriculture run a serious risk of being forced to suspend their activities despite the cost reduction obtained with solar generation. In these circumstances, it would be essential for projects such as those analyzed in this document to include some component of market strengthening of the benefited entities.

CAPRIBOM store in downtown Monteiro

The implementation of solar generation units in the four cooperatives created conditions to increase activities in the short term. For COOPEAVES, their resumption, as it had lost the public procurement market and, even if it achieved access to the private market, it would not be viable economically without reducing energy costs.

The possibility of increasing activities by the cooperatives above allows us to assume that a similar increase will occur in replicating this type of project. In these circumstances, it is essential to bear in mind that the adoption of renewable energy sources is not only for economic purposes, primarily when financed through mechanisms such as IFAD and PROCASE. Sustainability is a crucial aspect and must be considered when expanding agro-industrial activities through initiatives of this kind.

In the case of the four cooperatives, the increase in activities implies an increase in the use of scarce resources, especially water and raw materials. In a fragile biome threatened with degradation like the Caatinga, the impact of an expansion of agro-industrial production cannot be ignored. As mentioned above, the knowledge about the Semiarid region accumulated over the last few years allows the economic life of the region to subsist and develop without reducing the population or keeping activities at a minimum level. There is enough groundwater, for example, although it must be desalinated.

There are technologies to conserve water resources, minimize losses due to evaporation, and recycle liquid and solid waste. Electric energy is a fundamental factor in the mentioned technological solutions, which indicates that it would be important that projects such as those analyzed here and similar include in their dimensioning the generation of additional energy for the corresponding additional demand.

The financial result of the systems' implementation in the cooperatives awakened the perception of the importance of solar energy as a factor of sustainability and economy. From this arises the perception that the same impact can be produced at the level of family properties (which can be done

CAPRIBOM effluent treatment plant

on a tiny scale), generating an increase in income and the quality of life of families. It would be vital for programs such as the one analyzed in this document to provide some form of extension of systems to family units, projects, or financing mechanisms.

Current Brazilian legislation on distributed generation does not allow the remuneration of integrated system operators for the excess energy delivered to distributors *(see Bursztyn's criticism)*. However, changing this regulation could be an essential factor in generating additional revenue for enterprises such as the cooperatives mentioned in this document and contributing to the amortization of similar projects.

The experience of the four cooperatives analyzed shows that the impact of implementing solar generation units goes beyond the strictly economic. The reports recorded in the collection of information for this document evidenced the dynamization of agro-industrial activity, production, and income at the level of family producers and a significant increase in social capital at the local level. There is evidence that these factors reduce gender inequality and create an alternative to the rural exodus, especially young people.

Solar energy opens new perspectives for cooperative agro-industry and young people in the Semi-arid region of Paraíba

Annex – Procase-cooperative agreement template

AGREEMENT nº XXX/2017 - PROCASE

CGE Registration No.

Agreement between the state office for family agriculture and the development of the semi-arid region – seafds / procase-ifad and cooperative xxx, for the purposes it specifies.

Object (Clause one)

Reduce the electricity consumption at XXXX, in the municipality of XXXX, through the implementation of a photovoltaic energy system.

Work plan (Clause two)

It is part of this Agreement... the technical project and the work plan contained in the respective physical and financial execution schedule approved by the agreeing parties.

Paragraph One - The Work Plan may be revised and amended upon agreement through an apostille.

Obligations (Clause three)

SEAFDS/PROCASE:

a) Monitor and supervise the execution of the object of this Agreement, taking all necessary measures and permitted by law to avoid the de-constitution of its activities;

b) Monitor the execution of the activities provided for in the Work Plan and Project that gave rise to this Agreement;

c) Extend its term when there is a justifiable delay in the execution of the work.

d) Release the amount contained in the Commitment to cover the execution of the Agreement. This is to be done in the bank account to be opened in the name of the agreement to be signed between the parties.

e) Analyze the documents referring to the bidding processes, contracts for the acquisition of goods, works, and services carried out for their faithful fulfillment, for accountability purposes by the Grantee.

Cooperative:

a) Carry out its activities related to the execution of this agreement with diligence and efficiency, and following technical, economic, financial, administrative, environmental, and social standards and practices solidly and that meet the requirements of **PROCASE/IFAD;**

b) Comply with State Decree No. 33.884/2013, legislation governing agreements, and Federal Law No. 8.666/93 and its amendments, as applicable;

c) Designate a person from the Cooperative to monitor the execution of scheduled activities;

d) Open a bank account in the name of the Agreement in an official banking institution, with free movement and keep the funds invested in a Savings Account, when the use of funds occurs for a period exceeding 30 (thirty) days;

e) Promote the bank account movement through the Financial Manager (GFN) or through the ISSUE OF A NOMINAL CHECK to make payments for any purchases of goods and/or services after the payment of the expense and PROCASE attestation.

f) Ensure the execution of resources within the current legislation;

g) Perform the services following the technical project and execution schedule;

h) Present the economic consideration, which can be proven through financial resources or economically measurable goods and services, whose monetary expression is verified in the Work Plan.

i) Carry out a bidding process for the acquisition of goods and services to perform the activities provided for in the Work Plan, meeting the requirements stipulated by IFAD for acquisitions financed in whole or in part with its resources, and Law 8.666/93, as applicable;

j) Ensure access at any time, by representatives of the Grantor through PROCASE, who are responsible for monitoring and inspecting this Agreement, including internal control bodies - CGE, external control - TCE, and IFAD, to all documentation that demonstrates the execution of the Project;

k) Submit a report proving the economic consideration in the object of the Agreement, carried out following the foreseen physical-financial execution, which must be presented in the act of accountability;

l) Prepare and deliver, or cause to be prepared and delivered, to **UGP**-PROCASE and IFAD any information that **UGP**-PROCASE or IFAD reasonably requires, relating to the implementation of the Agreement;

m) Implement management and inspection measures that guarantee the good performance of the actions carried out and the use of resources;

n) Investigate allegations of irregularities in any of the actions carried out;

o) Disclose, in any promotional activity related to the object of the Agreement, the SEAFDS/PROCASE/IFAD, and the participating entities, except during an election period or that favors the individual personally;

p) Communicate any abnormalities to PROCASE and provide any clarifications deemed necessary;

q) Commit to ensuring the correct use/operation of the assets resulting from this Agreement and promote their maintenance correctly.

r) Comply with the economic consideration established in this agreement.

s) Comply with the provisions of the attached work plan

Financial resources (Clause four)

According to the table below, the resources to cover this agreement will be consigned at address XXXXX through financial resources from Sources 148, according to the table below, per Budget Reserves **Nos**.

Grantor	Grantee	Concedente
Fad (source 148) (100% Of the amount to be financed)	Cooperative at least 3% of the Financed Budget	Project total amount
xxxx	xxxx	xxxx

Capital expenditure	Source 148 - xxxxx
Current expenditures	Source 148 - xxxxx

Distribution by initial and source

Release of resources (Clause five)

According to Art. 50, of Decree 33,884/2013, this agreement resources will be released under the terms of approval after the extract publication in the DOE.

Term and validity (Sixth clause)

The term of validity of this Agreement will be 12 (twelve) months, counted from the date of its signature.

Extension (Seventh clause)

This Agreement may have its validity extended ex-officio if there is a delay in releasing resources, as provided for in Art. 40, VI, of Decree 33,884 of 05.03.2013, and may also be extended by the parties' interest, expressly expressed 30 (thirty) days before its termination.

Optional termination (Clause eight)

The participants may terminate this agreement at any time, preserving the obligations assumed during the period in force of the adjustment and the destination of any benefits acquired in the same period, per Art. 40, XX, of State Decree 33,884/2013.

Publication (Clause nine)

The Agreement will become effective after its publication in the Official Gazette of the State - DOE. It will be provided by the grantor up to 20 (twenty) days after its signature, which must always occur by the fifth business day of the month following the signature, following the principle of publicity of administrative acts provided for in Art. 37 of the Federal Constitution, with Art. 44 of Decree No. 33,884/2013.

Changes (Clause ten)

This Agreement may only be modified through an addendum duly justified, formulated within 30 days before the end of its term, subject to the relevant legal and regulatory formalities. Any modification in its object is prohibited.

Termination (Clause eleven)

The expiration of the term of this Agreement will occur during the term expressed in Clause Six, which may be advanced:

a) by the initiative of either party, upon prior notice of at least 30 (thirty) days, without prejudice to the activities agreed before the term, or at any time, in the face of a legal impediment making it formally and materially unenforceable;

b) partially or entirely for non-compliance with any of the rules contained in this Agreement.

c) By early completion of its object evidenced by a term of closure signed by the signatory parties.

Accountability (Clause twelve)

The GRANTEE will forward the accountability documentation of the agreement to the GRANTOR, consisting primarily of the documents listed below, 60 (sixty) days after the end of its term, keeping in its files all the original receipts for subsequent inspection.

1. The accountability will be sent through an official letter addressed to the PROCASE Coordinator of the Management Unit, mentioning the title of the Project, the number of the Agreement, the period to which it refers, and the value of the resources received.

2. **Authenticated** documents, evidencing expenses, containing:

a) Indication of the name and CNPJ (National Registry of Legal Entities), or CPF (Individual Taxpayer Identification Number), for an individual, and the address of the supplier or beneficiary;

b) A declaration that the materials were received and used, or the services provided for the benefit of the Project. The name SEAFDS/PROCASE/IFAD - Agreement No. 0013/2017 must be included in the fiscal document, in addition to the complete signature of the person who received the good or service, with the full name; the use of initials is not valid;

c) Present proof of **transfer**, date, and signatures of the President of the Cooperative and the Treasurer, provided that each check contains two signatures;

d) Sales slips or invoices, copies of the funds citation and the respective payment orders issued, receipts, and others;

e) proof of expense, which may not contain erasures or amendments.

3. Proof of accountability corresponding to the installments received.

4. Work Plan.

5. Copy of the Agreement and its amendments.

6. Financial, physical execution report, as per Annex III of Decree No. 33,884 of 05.03.2013.

7. Financial balance of resources.

8. Statement of reconciliation of bank balances, as per Annex IX of the aforementioned Decree.

9. Income statement, as per Annex X of the aforementioned Decree.

10. Specific bank account statement of the Agreement.

11. Proof of credit notices.

12. List of goods acquired, built, or produced with resources from the Agreement, as per Annex VI of Decree No. 33,884 of 05.03.2013.

13. List of all payments, as per Annex V of the Decree above.

14. Proof of payment of funds not invested in account Nº. 41,020-9, agency No. 0063-9 Banco do Brasil, of the GRANTOR.

15. Copy of the bidding procedures, including the Adjudication and Homologation acts and the contract signed between the Grantee and the winning bidder.

16. Declaration as to the suitability of the documentation, as per Annex XI of Decree No. 33,884 of 05.03.2013.

17. Proof of application of the resources of the Economic Compensation in the object of the Agreement.

18. Expenditure documents numbered consecutively and initialed.

19. Statement of revenue and expense execution, as per Annex IV of Decree 33,884 of 05.03.2013.

20. List of services provided, as per Annex VIII of the Decree above.

Prohibitions (Clause thirteen)

Resources from this Agreement cannot be used for the following expenses:

1. incur expenses as an administration fee, management fee, or similar;

2. pay, in any capacity, public servant or employee, member of the staff of a public agency or entity of direct or indirect administration, for consulting services or technical assistance, except in the cases provided for in specific laws and the Budget Guidelines Law;

3. use, even on emergencies, the resources for a purpose other than that established in the instrument, except for the cost of implementing the environmental preservation measures inherent to the works included in the Work Plan;

4. incur expenses on a date before the term of the instrument;

5. make payment after the instrument term, unless expressly authorized by the competent authority of the Grantor and provided that the event giving rise to the expense occurred during the term of the agreed instrument;

6. incur expenses with bank fees, fines, interest, or monetary correction, including those relating to payments or collections outside the deadlines, except, concerning fines, if arising from delay in the transfer of funds by the Grantor, and provided that the deadlines for payment and the percentages are the same applied in the market;

7. incur advertising expenses, except for educational, informational, or social guidance expenses, which do not contain names, symbols, or images that characterize personal promotion and provided that they are foreseen in the Work Plan, observing what is defined in the agreement or a normative instrument of the Grantor;

8. make payment of expenses with active, inactive, and pensioner personnel of the State or Municipalities, as per Item X of Article 167 of the Federal Constitution, and;

9. Any others that are not provided for in the work plan of said agreement.

Normative authority (Clause fourteen)

The GRANTEE recognizes the normative authority of the GRANTOR to exercise, within the term of execution and accountability of the Agreement, the managerial function, control, and inspection of the execution of the Agreement being able to reorient actions, accepting or not justifications concerning any malfunctions occurred in the execution of the object of the Agreement, and to assume or transfer its responsibility, in the case of stoppage or the material fact that may occur, to avoid its discontinuity.

Assets remaining at the end of the contractual term (Clause fifteen)

The remaining assets acquired or produced as a result of this Agreement, provided for in the Work Plan, upon the termination of this Agreement, will remain under the custody and responsibility of the Grantee to ensure the continuity of the governmental program, as per Art. 38, Paragraphs1 and 2 of Decree 33,884/2013. At the end of the Agreement, the Grantor may choose to donate the remaining assets if it deems it essential for the continuity of the supported project.

Fraud and corruption (Clause sixteen)

The Grantee must observe and ensure that its suppliers and subcontractors observe, if subcontracting is admitted, the highest standard of ethics throughout the entire bidding process, contracting, and execution of the contractual object.

SUB-CLAUSE ONE - For this clause, the following practices are defined:

a) "corrupt practice": offer, give, receive, or request, directly or indirectly, any advantage to influence the action of a public servant in the bidding process or the execution of a contract;

b) "fraudulent practice": the falsification or omission of facts to influence the bidding process or contract execution;

c) "collusive practice": design or establish an agreement between two or more bidders, with or without the knowledge of representatives or agents of the bidding agency, aiming to establish prices at artificial and non-competitive levels;

d) "coercive practice": cause harm or threaten to harm, directly or indirectly, people or their property, to influence their participation in a bidding process or affect the execution of the contract.

e) "obstructive practice": (i) destroy, falsify, alter, or hide evidence in inspections or make false statements to IFAD representatives, to materially prevent the investigation of allegations of practice set forth above; (ii) acts intended to materially prevent the exercise of IFAD's right to carry out inspection.

SUB-CLAUSE TWO - In the event of partial or complete financing by IFAD, through advance or reimbursement, this body will impose a sanction on a company or individual, including declaring it ineligible, indefinitely or for a specified period, for the award of contracts financed by the body if, at any time, verify the company's involvement, directly or through an agent, in corrupt, fraudulent, collusive, coercive, or obstructive practices when participating in the bidding process or the execution of a contract financed by the organization.

SUB-CLAUSE THREE - Considering the purposes of the above clauses, the Grantee agrees and authorizes that, if the agreement is financed, in part or in full, by a multilateral financial organization, through an advance or reimbursement, the financial organization and/or persons by he formally appointed may inspect the place of execution of the contract and all documents, accounts, and records related to the bidding and performance of the contract.

Final provisions (Clause seventeen)

The omitted cases will be resolved by mutual agreement between the parties. The jurisdiction of the Judicial District of João Pessoa will be elected to solve any litigation arising from this Agreement.

Moreover, being fair and agreed, the parties sign the present Agreement, in 03 (three) copies of equal content and form, which after being read and found to comply, is signed by the agreeing parties together with the witnesses named below.

The **sun** is no longer the *villain*
in the **Semiarid region of Paraíba**