# CLIMATE CHANGE RESILIENT DEVELOPMENT OF FAMILY FARMERS IN THE BRAZILIAN SEMIARID: AN ANALYSIS OF PUBLIC POLICIES AND OF THE COEXISTING WITH THE SEMIARID PARADIGM

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Tese de Doutorado apresentada ao Programa de Pós-graduação em Planejamento Energético, COPPE, da Universidade Federal do Rio de Janeiro, como parte dos requisitos necessários à obtenção do título de Doutor em Planejamento Energético.

Orientador: Emílio Lèbre La Rovere

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A todos que considero minha família. Em especial à minha avó Zilmar Cintra Wittlin (in memoriam) e ao meu grande amigo, Pedro Sangirardi Duarte (in memoriam).

“Wins the battle who can stand five more minutes” (vence a batalha quem aguenta mais cinco minutos)

Maria Luiza Pernambuco Machado, minha avó

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# DESENVOLVIMENTO RESILIENTE ÀS MUDANÇAS CLIMÁTICAS PARA AGRICULTORES FAMILIARES NO SEMIÁRIDO BRASILEIRO: UMA ANÁLISE DAS POLÍTICAS PÚBLICAS E DO PARADIGMA DE CONVIVÊNCIA COM O SEMIÁRIDO

Letícia Wittlin Machado

Março/2018

Orientador: Emílio Lèbre la Rovere
Programa: Planejamento Energético

A região semiárida brasileira abriga a população mais desfavorecida economicamente do país e um dos dois biomas mais vulneráveis às mudanças climáticas no Brasil. Políticas públicas para a região estiveram concentradas nas secas, porém, a sociedade civil começou a buscar alternativas para enfrentar os desafios complexos da região, focada em soluções mais holísticas para a convivência humana com as condições semiáridas a partir da década de 1980. Esta tese analisa as políticas públicas para o semiárido durante três períodos históricos e o paradigma liderado pela sociedade civil, Convivência com o Semiárido (CSA), para verificar se eles promoveram resiliência às mudanças climáticas para os agricultores familiares. A pesquisa segue um quadro teórico de sistemas sócio-ecológicos e resiliência, e tem como metodologia análise de documentos, trabalho de campo e entrevistas. Os resultados da pesquisa indicam que as políticas públicas recentes contribuíram para a melhoria das condições de vida dos agricultores familiares e enfrentamento dos impactos das secas, mas não promoveram substancialmente resiliência às mudanças climáticas. Portanto, as conquistas obtidas através de políticas públicas estão em risco, uma vez que as mudanças no clima criam novas condições ambientais e econômicas. A CSA aumenta a resiliência climática dos agricultores familiares aplicando tecnologias sociais através de uma abordagem participativa, construindo conhecimento local e promovendo o uso sustentável dos recursos. No entanto, esses resultados apenas aparecem quando várias atividades são combinadas. A CSA foca na sociedade civil e não na esfera governamental como agente fundamental de transformação.

Abstract of the Thesis presented to COPPE/UFRJ as a partial fulfillment of the requirements for the degree of Doctor of Science (D.Sc.)

CLIMATE CHANGE RESILIENT DEVELOPMENT OF FAMILY FARMERS IN THE BRAZILIAN SEMIARID: AN ANALYSIS OF PUBLIC POLICIES AND OF THE COEXISTING WITH THE SEMIARID PARADIGM

Letícia Wittlin Machado

March/2018

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The Brazilian Semiarid region comprises the poorest people in the country, and one of the two biomes most vulnerable to climate change in Brazil. Public policies have been focused on droughts, but a more organized and articulated civil society in the 1980´s started to seek alternatives to addressing the complex challenges in the region, focusing on more holistic solutions for human coexistence with the Semiarid conditions. This thesis analyses public policies during three historical periods and the civil society-led paradigm *Convivência com o Semiárido* (CSA, Coexisting with the Semiarid) to verify if they promoted resilience to climate change for family farmers. The research follows a theoretical framework of Social-Ecological Systems and Resilience Thinking, and uses document analysis, fieldwork and interviews. It was found that recent public policies have assisted family farmers to improve living conditions and face droughts impacts, but they have not substantially promoted climate change resilience. Therefore, achievements gained through public policies are at risk, as the changes in climate create new environmental and economic conditions. Concurrently, CSA increases family farmers` climate resilience by applying social technologies through a participatory approach, building local knowledge and promoting the sustainable use of resources. In accordance to resilience theory, CSA is a social process with the potential to drive transformational change, which can be sustained into the future. It only succeeds, however, when several activities are combined. It focuses on civil society rather than the government sphere as pivotal agent of transformation.

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**List of Acronyms**

| | | |
|---|---|---|
| ADENE | Agência de Desenvolvimento do Nordeste | Northeast Development Agency |
| ANA | Agência Nacional de Águas | National Water Agency |
| APA | Área de Proteção Ambiental | Environmental Protection Areas |
| AR4 | Quarto relatório de avaliação | Fourth Assessment Report |
| ASA | Articulação Nacional do Semiárido | National Articulation of the Semiarid |
| ATER | Assistência Técnica e Extensão Rural | Technical Assistance and Rural Extension |
| BNB | Banco do Nordeste | Northeast Bank |
| BSA | Semiárido Brasileiro | Brazilian Semiarid region |
| CBD | Convenção Sobre Diversidade Biológica/ Convenção da Biodiversidade | Convention on Biological Diversity |
| CODEVASF | Companhia de Desenvolvimento dos Vales do São Francisco e do Parnaíba | San Francisco Valley Development Company |
| CGEE | Centro de Gestão e Estudos Estratégicos | Center for Strategic Studies and Management in Science, Technology and Innovation |
| CONVIVER | Programa de. Desenvolvimento. Integrado e Sustentável do Semi-Árido | Integrated Actions for Co-existence with the Semiarid |
| COP 3 | Conferência das Partes | Third Session of the UN Conference of Parties Against Desertification |
| CSA | Convivência com o Semiárido | Coexisting with the Semiarid |
| DNOCS | Departamento Nacional de Obras Contra as Secas | National Department of Work Against Drought |
| ECLA | Comissão Econômica para a América Latina (CEPAL) | (United Nations) Economic Commission for Latin America |
| EMBRAPA | Empresa Brasileira de Pesquisa Agropecuária | Brazilian Agricultural Research Corporation |
| FHC | Fernando Henrique Cardoso | |
| FNE | Fundo Constitucional de Financiamento do Nordeste | Northeast Constitutional Financing Fund |
| FUNCEME | Fundação Cearense de Meteorologia e Recursos Hídricos | Ceará Foundation of Meteorology and Water Resources |
| FUNDAJ | Fundação Joaquim Nabuco | Joaquim Nabuco Foundation |
| GDP | Produto Interno Bruto | Gross domestic product |
| GTDN | Grupo de Trabalho para o Desenvolvimento do Nordeste | Working Group for the Northeast Development |
| IABS | Instituto Brasileiro de Desenvolvimento e Sustentabilidade | Brazilian Institute of Development and Sustainability |

| | | |
|---|---|---|
| IBGE | Instituto Brasileiro de Geografia e Estatística | Brazilian Institute of Geography and Statistics |
| ICID | Conferência Internacional: Clima, Sustentabilidade e Desenvolvimento em Regiões Semiáridas | International Conference on Impacts of Climate Variations and Sustainable Development in Semiarid Regions |
| IFOCS | Inspetoria Federal de Obras contra as Secas | Federal Work Inspection Sector Against the Drought |
| IHGB | Instituto Histórico e Geográfico Brasileiro | Brazilian Geographic and Historic Institute |
| INCRA | Instituto Nacional de Colonização e Reforma Agrária | National Institute of Colonization and Agrarian Reform |
| INSA | Instituto Nacional do Semiárido | National Institute of the (Brazilian) Semiarid (region) |
| IOCS | Inspetoria de Obras Contra as Secas | Work Inspection Sector Against the Drought |
| IPCC | Painel Intergovernamental sobre Mudanças Climáticas | Intergovernmental Panel on Climate Change |
| IRPAA | Instituto Regional da Pequena Agropecuária Apropriada | Appropriate Regional Small Farmers' Institute |
| MCT | Ministério da Ciência e Tecnologia | Ministry of Science and Technology |
| MI | Ministério da Integração | Ministry of Integration |
| MST | Movimento dos Trabalhadores Rurais sem Terra | Landless Workers' Movement |
| NGO | Organização não Governamental | Non Governmental Organization |
| P1+2 | Programa Uma Terra e Duas Águas | One Land, Two Waters Program |
| P1MC | Programa Um Milhão de Cisternas | One Million Cisterns Program |
| PAA | Programa de Aquisição de Alimentos | Food Acquisition Program |
| PAPP | Programa de Apoio ao Pequeno Produtor Rural no Nordeste | Small Rural Producers Support Program |
| PDRSS | Plano de Desenvolvimento Rural Sustentável e Solidário | Sustainable and Solidarity Rural Development Plan |
| PDSA | Plano Estratégico de Desenvolvimento Sustentável do Semi-Árido | Semiarid Sustainable Development Strategic Plan |
| PNDR | Política Nacional de Desenvolvimento Regional | National Policy for Regional Development |
| POLONORDESTE | Programa de Desenvolvimento de Áreas integradas do Nordeste | Northeast Integrated Areas Development Program |
| Projeto Sertanejo | Programa Especial de Apoio ao Desenvolvimento da Região Semi-Árida do Nordeste | Special Program to Support the Development of the Northeastern Semiarid Region |

| | | |
|---|---|---|
| PRONAF | Programa Nacional de Fortalecimento da Agricultura Familiar | National Program to Strengthen Family Agriculture |
| PRONI | Programa Nacional de Irrigação | National Irrigation Program |
| PROTERRA | Programa de Redistribuicão de Terras e de Estímulo à Agro-indústria do Norte e do Nordeste | Land Redistribution Program to Encourage North-Northeast Agriculture |
| RIO-92 | Conferência das Nações Unidas sobre o Meio Ambiente e o Desenvolvimento | United Nations Conference on Environment and Development |
| SUDENE | Superintendência de Desenvolvimento do Nordeste | Superintendence for the Development of the Northeast |
| UNCCD | Convenção das Nações Unidas para o Combate à Desertificação e Mitigação dos Efeitos das Secas | United Nations Convention to Combat Desertification and Mitigating the Effects of Drought |
| UNCED | Conferência das Nações Unidas sobre o Meio Ambiente e Desenvolvimento (Cnumad) | United Nations Conference on Environment and Development |
| UNEP | Programa das Nações Unidas para o Meio Ambiente (PNUMA) | United Nations Environment Programme |
| UNFCCC | Convenção-Quadro das Nações Unidas sobre a Mudança do Clima | United Nations Framework Convention on Climate Change |
| WCA | Países da África Ocidental | West African Countries |

# 1 Introduction

## 1.1 Presentation of the subject and introduction to the problem

The Brazilian Semiarid (BSA) region known as the *Sertão* is located in the Northeast part of the country (Figure 1) and is one of the two areas[1] most affected by climate change in Brazil (NOBRE, LAPOLA, *et al.*, 2007; SEDDON, MACIAS-FAURIA, *et al.*, 2016). The *Sertão* is characterized by the unique Caatinga biome - mostly consisting in deciduous forests, with uneven rainfall patterns and land distribution, climatic variation and social disparities. Several public policies have been adopted since 1877 to address the issues of the region, predominantly related to water scarcity; yet, the *Sertão* remains marginalized. Family farmers are the area's most vulnerable social group, in particular diffuse farmers.

[1] The other large hotspot in Brazil for climate change is the Amazon region.


Legend: ---- BSA ---- Sudene operation area

**Figure 1- The Brazilian Semiarid delimitation according to Sudene, 2017**

Source: Modified by Sudene (2017)

The BSA comprises various political, cultural, social, environmental and economic aspects characterized by the modern-traditional duality (MACHADO e SILVINO, 2017). Its landscape includes fertile oases such as the floodplains (várzeas) of the *São Francisco* river, as well as areas in the process of desertification in the backlands of the *Inhamuns*, Ceará (OLIVEIRA, 2008). An active agroindustry is progressively setting up in the

plateaus; concomitantly, small plots of cattle and goats are found in the country depressions where crystalline soils allow little availability of water resources (SOUZA, 2006). The ecosystems present in the BSA are responsible for supplying a range of services that underpin productive human activities (PAGANO e ARAÚJO, 2011), nevertheless, dry tropical vegetations are usually underestimated. They are usually considered unproductive, a smaller source of natural resources when compared to other biomes and ecosystems (ALBUQUERQUE e ANDRADE, 2002).

The *Sertão* and other Semiarid regions around the world are part of the priority conservation areas for climate change adaptation, called hotspots, due to its natural arid climate and soil and for hosting social and economically vulnerable smallholder farmers (IPCC, 2007). Those sites are under extreme climatic and edaphic environmental conditions. Desertification and other climate change impacts in the *Sertão* are grounded on these conditions and on the development model prevalent in Brazil, characterized by unsustainable natural resource consumption, income and resource concentration (ARTICULAÇÃO SEMIÁRIDO BRASILEIRO (ASA); INSTITUTO NACIONAL DO SEMIÁRIDO (INSA/MCTI), 2015). Power and wealth accumulation in the hands of the local oligarchies had a pivotal role in forging poverty and life conditions of the region (FURTADO, 1959). Notwithstanding, policies are based on the premise that low economic and social development in the *Sertão* is the result of water shortage and therefore they have focused on measures to counter droughts (SILVA, 2007; CAMPOS, 2014).

Even though the BSA is a region of natural and social contrasts, the predominant feature displayed is that of droughts. They appear as a social tragedy due to a natural phenomenon, from which derived the socio-political construction of the BSA and forged an ideological resource that consolidated the national image of the *Sertão* (CASTRO I, 1997). In it, droughts in the Northeast become a reference that symbolically represents a region of adverse nature responsible for the socio-economic problems of the BSA and creating a socially homogenizing political imaginary, employed by the local elite (MACHADO e SILVINO, 2017).

Despite natural challenges found in its soil and limited water availability, most adversities that determine low levels of socio-economic development are related to inadequate access

to resources, framing the vulnerable structure in which family farmers are found. Increased frequency and magnitude of extreme climatic events - as a result of climate change - are expected to exacerbate these adversities and worsen the conditions for family farmers.

Civil society disagreement with public policies targeted to the Semiarid region has resulted in society`s engagement in presenting alternatives to achieve better conditions of life. They conceived guidelines for living in the BSA that resulted in the Coexisting with the Semiarid (CSA) paradigm.

## 1.2 Objective

This study revises public policies from 1877 to 2010 in the Brazilian Semiarid region to understand whether they have promoted social-ecological resilience to climate change for family farmers. It also reviews the alternative civil society-led paradigm Coexisting with the Semiarid, its guidelines and activities, to analyse whether they promote climate change resilience. Moreover, it seeks to (1) demonstrate family farmer´s vulnerability to climate change; (2) expose natural and political constraints in the Semiarid region; and (3)- bring to light the different realms of resilience - social, economic and environmental – which constitute climate change resilience.

Therefore, our research questions were: (1) Have public policies from the three analyzed periods (1877-1958/ 1959-1991/ 1992-2010) promoted social-ecological resilience to climate change of family farmers?; (2) What aspects are incorporated in climate change resilience?- considering that climate change does not act on farmers in isolation (ELUM, MODISE e MARR, 2016); (3) How is the CSA model inserted in this context?

## 1.3 General assumption

Our underlying thesis assumption is that the Brazilian governmental policies adopted in the Semiarid region have not been sufficient to ensure climate change resilience for family farmers.

## 1.4 Methodology

To carry out this research, the first step was to review primary data and literature on public policies for the BSA. From there, three distinct public policy periods named: Hydraulic construction phase (1877-1958), Regional development ( 1959-1991) and Towards a more sustainable development (1992-2010) have emerged according to their strategies for the Semiarid region (ANDRADE, 1970; CARVALHO, 1988; MAGALHAES e GLANTZ, 1992; MI, 2005; CAMPOS, 2014) MI (2005). Next step was an analysis of the assumptions and strategies, observing breaches, continuity, positive results and possible flaws of public policies.

In this process, two expressions were frequently found: "combating the droughts" and "coexisting with the Semiarid". "Combating the droughts" was associated to public policies and advertised as the solution ("combating") to the issues present in the BSA ("the droughts"); coexistence solutions with the Semiarid conditions regards a parcel of civil society that disagrees with the mentality and solutions for the BSA promoted by the government. These differences allowed to identify the different interpretations of "Semiarid" for stakeholders. Such analysis also allowed to correlate "positive" and "insufficient" outcomes found in public policies to distinct groups of society, leading to a more general discussion of Development in the BSA, in light of climate change.

This research is grounded on the concepts of development, climate change, social-ecological systems and resilience, and it is based on published material, primary documents and fieldwork. Resilience of the Semiarid's whole social-ecological system was considered, with a focus on the specified resilience (FOLKE, CARPENTER, *et al.*, 2010) "of what, to what" (CARPENTER, WALKER, *et al.*, 2001). In this context, meaning 'of' family farmers (a particular part of the system) related 'to' climate change (a particular control variable in the system), 'to' one or more identified kinds of shocks, in this case, - desertification, prolonged periods of droughts, increases in temperature, biodiversity loss, power structure, etc.

Indicators in this multi-dimensional field are highly debatable (VEIGA, 2010; LAWN, 2006) and the choice here was to use the perception of the interviewees and literature review based on available secondary sources supported by primary sources (mostly

government and social society reports). The reflexive behavior of people in respect to the impact of policies on them and their use of ecosystems is drawn out in discussions with stakeholders, as proposed in the analysis of resilience from Walker et al. (2002). Ex-post evaluations were a large limitation found during the research and confirmed during the interviews, as most governmental programs did not conduct or publicize them.

Methods adopted were participatory observation, individual unsystematic observation, and open and semi-structured interviews (Appendix 1, 2 and 3), commonly used in most qualitative exploratory researches (MARCONI e LAKATOS, 2003). Interviews were considered fundamental to complement the insights gained from the analysis of available scientific literature on the subject and to gain knowledge on stakeholders' perception of change. There were two semi-structured questions grounded on the overall research used in the interviews: (1) What have been the most beneficial public policies for family farmers in the BSA? (2) What are the major challenges for family farmers in the BSA? These questions allowed us to evaluate whether public policies addressed major challenges for family farmers, increasing their resilience to climate change and other stressors. Most cited answers are gathered in Appendix 4. Interviews' answers were framed according to the main questions instead of being allocated by institutions. This is due to the various spontaneous citations mentioned by interviewees, hard to gathered under the same institution.

The semi-structured method was chosen to allow interviewees to define on their own what policies and challenges they considered relevant to mention, without being induced by specific questions. Using this method it was possible to cross answers to check if there was a common ground between different stakeholders, as well as to comprehend their different biases. Techniques used to register the interviews were voice and written record. The frequently resulting answers are summed up and available in the Results Section and in Appendix 4.

There were 24 interviews conducted with: one government authority of each Ministry - of Environment, of Integration and of Tourism; with the Research Supervisor of the Tourism Superintendence of Alagoas state; six public employees from the *Superintendência de Desenvolvimento do Nordeste* (SUDENE, Superintendence for the Development of the Northeast); two researchers from *Fundação Joaquim Nabuco*

(FUNDAJ, Joaquim Nabuco Foundation), two researchers from the *Instituto Nacional do Semiárido* (INSA, National Institute of the Semiarid), one employee of the *Departamento Nacional de Obras Contra as Secas* (DNOCS, National Department of Work Against Drought) and three public employees from *Empresa Brasileira de Pesquisa Agropecuária* (Embrapa, Brazilian Agricultural Research Corporation); and with NGOs employees, (three) from the *Articulação Nacional do Semiárido* (ASA, National Articulation of the Semiarid), (one from) the CAATINGA, (one) from the Associação Caatinga and the director of the *Instituto Regional da Pequena Agropecuária Apropriada* (IRPAA, Appropriate Regional Small Farmers' Institute). They were performed by phone, email and in person, for about one or two hours each. Detailed information can be found in Appendix 1, while the % of interviews per sector are seen in Figure 2 below.

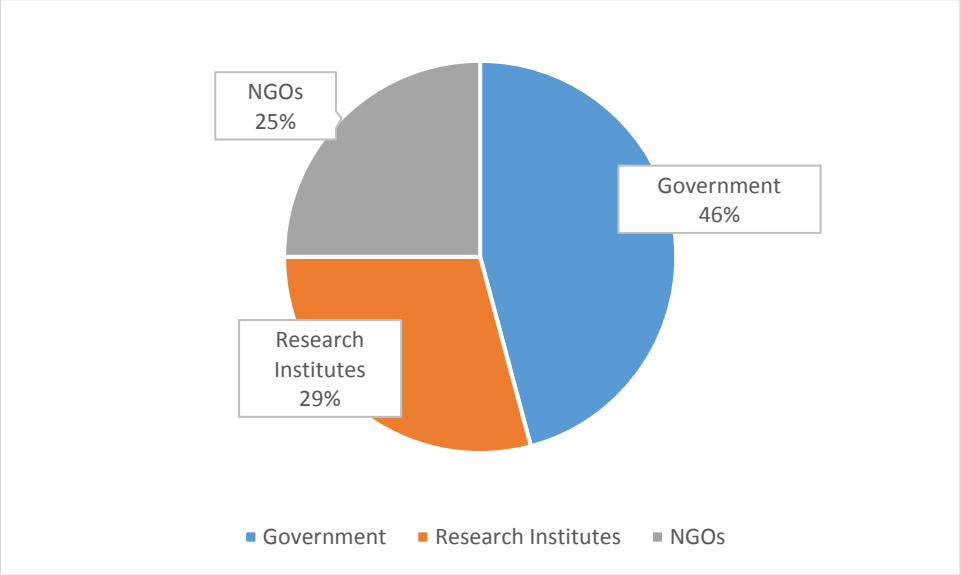


**Figure 2- Interviews divided by sectors**

The sample size was based on the discussions on the topic in the qualitative analyzes. ADLER, ADLER, et al (2012) suggest up to 30 interviews for a thesis. This number is related to the idea of saturation of answers, in which it seems to the interviewer that opinions begin to repeat themselves. This actually occurred during the research, consolidating the answers found. It was also considered how long it takes to get good interviews and the ease of access to the possible interviewees (FLICK e BERLIN, 2012). The fact that interviews were semi-structured and there was not one single question to be answered called for less interviewees.

Institutions were selected based on their relevance, which was previously investigated.

These key institutions have been playing an important role in the development of the Semiarid Northeast and are commonly acknowledged by literature and people. Some are described in the Public Policies chapter.

Our goal was to engage with the main stakeholders in the field to learn their perceptions and experiences. The interviewees were selected based on their job positions, referrals from other interviewees and availability. They hold political and technical positions, ranging from directors of well-known institutions to recently hired fieldwork agents. We had the chance to speak with professionals responsible for complex engineering constructions, as well as with young, middle-term and long-term career employees.

Data collection included individual unsystematic observation (MARCONI e LAKATOS, 2003) during the attendance of three seminars- *3rd International Seminar of Coexistence with the Semiarid* (Piranhas, Alagoas. Nov, 2016), *2010-2016 Drought in the Brazilian Semiarid* (Fortaleza, Ceará. Dec. 2016), and *Productive Coexistence with Droughts: technological solutions and action strategies* (Petrolina, Pernambuco. Mar. 2017), and individual participatory observation in the three-week workshop promoted by the *Instituto Brasileiro de Desenvolvimento e Sustentabilidade* (IABS, Brazilian Institute of Development and Sustainability) in the Alagoas *Sertão*, Brazil (2016), as part of a Coexisting with the Semiarid Program.

The workshop was an immersion program where participants, including the author of this thesis, had to live in the 70 hectares of the Xingó center (city of Piranhas) during three weeks in November, 2016, with approximately 40 other participants who were family farmers, employees of public institutions for the Semiarid region, agricultural technical assistants, academics, networkers, policy makers and activists. During the workshop, participants discussed adversities and opportunities found in the BSA; productive activities; the diffusion of social practices and technologies; and technical assistance provided by public programs. The program included visits to sites where social technologies were being implemented, such as units of cisterns for rainwater harvesting and bio-constructions; and where family farmers were involved in promoting sustainable local technologies referred by them as social technologies. In addition to these activities, there were also opportunities to visit traditional technologies implemented by the government, specifically hydropower sites.

This experience in the field has allowed to engage in local discussions and field visits to a *Instituto Nacional de Colonização e Reforma Agrária* (INCRA, National Institute of Colonization and Agrarian Reform) settlement, meeting members of the *Movimento dos Trabalhadores Rurais sem Terra* (MST, Landless Workers' Movement), and to the Jacaré-Curituba community settlement.

## 1.5 Thesis Framework

This thesis is structured as follows:
An Introduction to the subject contains the research problem, the thesis objective and general assumption. It also includes the presentation of the Methodology and of the thesis framework.

In chapter two is presented the conceptual framework, discussing what *Sertão* and Semiarid mean and how the latter is a social-ecological system. Resilience to climate change is defined here and showed in the perspective of family farmers.

The literature review consists of the following four chapters. Chapter three exposes the social and climatic characterization of the Brazilian Semiarid region, and its natural and political constraints that forged the region vulnerability. Its strengths are also highlighted to avoid the mistake of taking the *Sertão* for granted as an unfeasible place to live.

Chapter four is dedicated to present public policies from 1877 to 2010, and chapter five illustrates civil society´s response to them, through the emergence of the paradigm and guidelines of Coexisting with the Semiarid.

Chatper six is dedicated to bring to light development theories and climate change in the context of the *Sertão*. The development debate is presented from an international political economy perspective to bring out the the evolution of the concept of development over time, starting with political economy theorists, particularly Adam Smith, David Ricardo and Karl Marx, to reach development theories of the twentieth century. It is then shown how the discourse on climate change became part of the development debate and the development proposals for the Brazilian Semiarid region.

The seventh chapter presents Results and Discussion, including limitations of public policies, CSA potential to promote climate change and non-climatic resilience and the implications of the findings for other Semiarid regions, particularly for Africa. The last chapter summarizes the conclusions and recommendations of this work.

## 1.6 Contributions to Knowledge

A major common concern regards the impact of climate change on Semiarid lands (FRASER, DOUGILL, *et al.*, 2011). This research aims to contribute to improve efforts promoting climate resilience in the Semiarid regions by generating a critical analysis of public policies and the CSA model in Brazil, with a view to influence decision makers as they develop future strategies. Most cited concerns in Semiarid regions around the world are similar to those we see in the *Sertão* (HUDSON, 1987), although their conditions vary greatly: the soil, the climate, the social factors, availability of mechanization and of labor and type of livestock, to mention a few. They result from a complex interaction of population growth rates, climate, and environmental responses linked to human activities ((IPCC), 2001). Lessons learnt from the Brazilian Semiarid experience can help other Semiarid regions to adapt to the multiple adversities faced by them, including climate change. Its contribution can be especially relevant to Semiarid regions of African countries more alike the BSA.

It also contributes to the incipient scientific literature on the Coexisting with the Semiarid topic. Resilience thinking applied to social-ecological systems from the family farmers' perspective in the Brazilian Semiarid responds to the urge for addressing these concerns, as declared by Harvey (2010) and Pelling and Manuel-Navarette (2011). It can identify pathways for transformation in social systems and by extension social-ecological systems.

The understanding of the Brazilian Semiarid area as a social-ecological system is a major contribution. By doing so, this work moves beyong the climatic classification into a systems analysis and links public policies to the Semiarid as a climatic classification and Coexisting with the Semiarid to the system of the Semiarid. Further more, this thesis also

aims to contribute with information and insights to the Brazilian debate on how to change the design and implementation of public policies targeted at the Brazilian Semiarid region.

# 2 CONCEPTUAL FRAMEWORK

Three main concepts are particularly relevant to this study: Semiarid, Social-ecological systems and Resilience. Nonetheless, because there is considerable confusion in the terms Semiarid, Northeast and *Sertão*, it is first clarified their differences and showed how they erroneously turned into equivalents. During this chapter, we also present the terms "traditional technologies" and "social technologies", and briefly describe the concept of a paradigm, in view of the work presented as the Coexisting with the Semiarid paradigm.

## 2.1 Northeast, the *Sertão* and the Semiarid area

There has been significant misuse of the terminology Northeast, Semiarid and *Sertão* as interchangeable in literature and speech in Brazil [ie. Plano Estratégico de Desenvolvimento Sustentável do Semi-Árido (PDSA, Semiarid Sustainable Development Strategic Plan) (MI, 2005)] The Northeast is one of the five geographical-political macro-regions in Brazil which encompasses nine states: Alagoas, Bahia, Ceará, Maranhão, Paraíba, Piauí, Pernambuco, Rio Grande do Norte and Sergipe. It is subdivided in four areas, named: *Meio-Norte*, *Agreste*, *Zona da Mata* and *Sertão*. Because the media focus almost exclusively on droughts and the socio-economic difficulties found in part of the Northeast, predominantly in the *Sertão*, these two areas are frequently confused and used to express one another.

Besides representing a geographical- political sub-division, *Sertão* also carries a cultural significance. The word was used, during the colonial period, to indicate unexplored and little inhabited portions of land in the country side in the Northeast and other regions, as a synonym of hinterland or backland. But, within time, it became closely associated with the Northeast Semiarid region, considerably due to several distinguished literature authors who spread through their novels the image of a romanticized Northeast Semiarid *Sertão*. In doing so, it led people to refer to cultural aspects of that specific *Sertão* simply as *Sertão*. Artistic work, cultural manifestations and *sertanejo´*s (people from the *Sertão*) way of life compose the new meaning of the word "*Sertão*" and became part of the Northeast cultural heritage.

"Semiarid" is an international climatic reference mostly used according to the Köppen[2] (and revised as Köppen- Geiger in 1961[3]) or Thornthwaite[4] climate classification systems, accounting for precipitation levels below potential evapotranspiration. In Brazil, the Semiarid region is located in the Northeast part of the country is present in all Northeast states. It also includes the north of Minas Gerais, located in the macro-region of the Southeast. There have been three major political- geographical delimitations of the Semiarid region in Brazil and some changes in its criteria, the latter in 2017 (Appendix 5).

There has also been some attempt to sub-divide the Semiarid itself. This is an acknowledgement of the territorial hetereogenicity. The sub-regions were differentiated according to its production potentialities, "*Sertões de Dentro*" (Inner *Sertão*) and "*Sertões de Fora*" (Outer *Sertão*)[5], later defined by their economic ocupation, such as livestock, mining and agriculture (MI, 2005). The subsequent classifications were based on agrarian activities and areas considered to be geostrategic by the government. Since 2003, the Northeast Semiarid area has been subdivided in three geostrategic units- *Sertão do Norte, Ribeira do São Francisco e Sertão do Sul* (Figure 3). The latter is the largest in area and population (table 2).

[2] (KÖPPEN, 1936; KÖPPEN, 1918)
[3] (PROVINCIAL GOVERNMENT OF CARINTHIA; CLIMATE CHANGE AND INFECTIOUS DISEASES GROUP)
[4] (THORNTHWAITE, 1943)
[5] Delimitations of the Inner and Outer *Sertão* in literature also refer to the sides of the Bahia and Pernambuco states divided by the river (RÊGO, 2016). Capistrano de Abreu (ABREU, 1998) attribute Sertões de Fora to pernambucanos (those who were born in Pernambuco state), which in his conception comprised from Paraíba to Acaracu, in Ceará. Sertões de Dentro were the baianos (those who were born in Bahia state), englobing the region from the São Francisco river until the southwest of Maranhão.

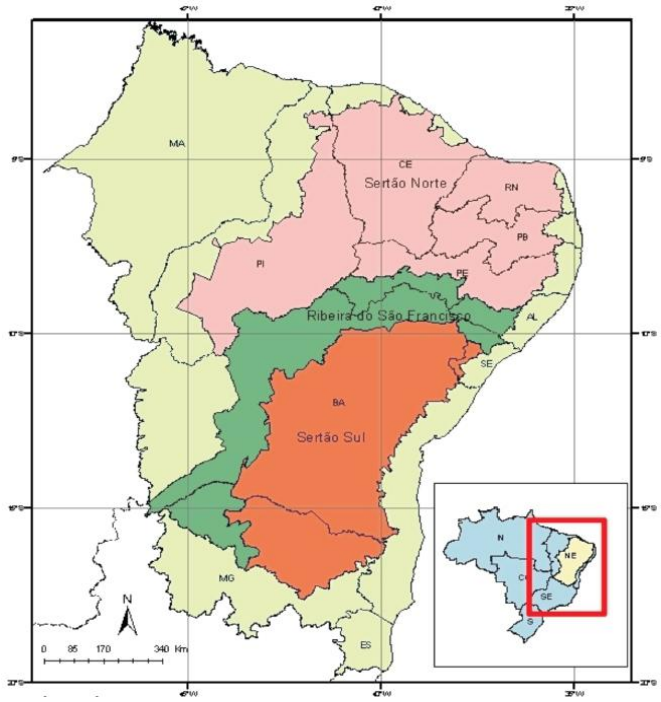


**Figure 3- PDSA Geostrategic units: Sertão do Norte, Ribeira do São Francisco and Sertão do Sul.**

Source: PDSA, cartogram 2.2 (MI, 2005)

**Table 1- Geostrategic Areas of the Northeast Semiarid: Basic Data**

| Geoestrategic areas | Municipalities | % of total BSA | Area (Km2) | % of total BSA | Total population in 2000 | % of total BSA |
|---|---|---|---|---|---|---|
| Sertão do Norte | 307 | 27 | 328,822.80 | 33,6 | 6,534,121 | 31,3 |
| Ribeira do São Francisco | 126 | 11 | 214,157.41 | 21,9 | 2,810,317 | 13,4 |
| Sertão do Sul | 702 | 62 | 435,474.12 | 44,5 | 11,533,487 | 55,3 |
| New Semiarid delimitation (2005) | 1135 | 100 | 978,134.33 | 100 | 20,877,925 | 100 |

Source: PDSA, table 2.1 (MI, 2005)

These three units are separated in nine development sub-regions- *Sertão do Piauí, Sertão do Apodi, Sertão do Araripe, Sertão de Borborema, Ribeira do Médio São Francisco, Ribeira do Submédio São Francisco, Ribeira do Baixo São Francisco, Sertão de Canudos,* and *Sertão de Contas* (Figure 4). The nine development sub-regions are the focus of the priority development actions of the Semiarid Sustainable Development Strategic Plan (PDSA) (MI, 2005).


**Figure 4- PDSA Development sub-regions: Sertão do Piauí, Sertão do Apodi, Sertão do Araripe, Sertão de Borborema, Ribeira do Médio São Francisco, Ribeira do Submédio São Francisco, Ribeira do Baixo São Francisco, Sertão de Canudos, and Sertão de Contas**

Source: PDSA, cartogram 2.4 (MI, 2005)

Areas inserted in the Brazilian Semiarid delimitation receive a 25% compliance bonus from the *Fundo Constitucional de Financiamento do Nordeste* (FNE, Northeast Constitutional Financing Fund (in comparison to the 15% in the rest of the Northeast) and at least 50% of all resources from this fund invested in productive activities. In 2005, there were R$ 2.5 billions or around $800 millions dollars (conversion rate from 2017) available to that end (BRASIL, 2005). In addition, several governmental programs are oriented to benefit these areas (programs are described in Chapter 4). These financial benefits turn regions classified as Semiarid politically attractive.

The common use in the Portuguese language refers to the Brazilian Northeast territory of a Semiarid climate simply as "Semiarid". It might be related to the fact that there is a clear political- territorial delimitation, similar to states, and a tendency to homogenize all inserted territories by its climate, which by the way, varies quite a bit in between them. As it happened to the term "*Sertão*", the concept of "Semiarid" was extended beyond its original meaning as a climatic definition to embrace cultural, environmental, social and

political aspects. It regards the dynamics and life found in the region. As set by Malvezzi (2007), the Brazilian Semiarid is climate, vegetation, soil, sun, water, people, music, art, religion, politics, history and culture. When new territories are added to the Semiarid delimitation, they bring along their regional particularities.

This topic intended to argued that our research identified some misuse in the terminology Northeast, *Sertão* and Semiarid. Northeast and *Sertão* are not interchangeably, once the first refers to a much wider area (see Figure 7, delimitation of the *Caaatinga* biome, BSA and Northeast). The Semiarid is sometimes confused with the "Northeast" because it geographically overlaps the latter (SILVINO, VIGLIO e FERREIRA, 2016), but they do not represent the same territory. Their use as a synonym is a reductionism and endorses a misguided popular imagination. The exception is to compare "*Sertão*" to "Semiarid", in view of the fluid characteristic of the language which allowed them to evolve into new similar meanings, beyond hinterland and a climatic reference. Therefore, they are referred to as synonyms during this thesis.

## 2.2 Semiarid and social ecological systems

Literature has focused on social, economic, and political systems in isolation from their biophysical surroundings, or has considered the environment as merely a backdrop for the functioning of social systems (COLLINS, CARPENTER, *et al.*, 2011) approximately until the 2000s. Community ecology studies are built on natural ecosystems, neglecting human beings as agents of change. To consider how people use resources and affect plant populations and landscapes can be useful in building models that aggregate a greater number of variables (ALBUQUERQUE e ANDRADE, 2002).

Natural systems and social systems are both complex systems, but adding the complexity of interactions between them leads us to complex social-ecological systems. Their linkage has become more evident for researchers working in interdisciplinary fields as drivers (climate change, unsustainable consumption patterns, destruction of natural forestry coverage, etc) increasingly affect ecosystem services and put at risk future generations.

Elements of the Semiarid combined- its people, the soil, the dry forest, etc - constitute an integrated system, in which the social and the environment are part of an interconnected

body. We classify this interaction as a social-ecological system (SES), described as linked systems of people and nature, in which humans are understood as part of nature as opposed to a separated system (figure 5) (BERKES e FOLKE, 1998). Family farmers are part of this system, affecting and affected by its climate, fauna, flora, biome and by each other.

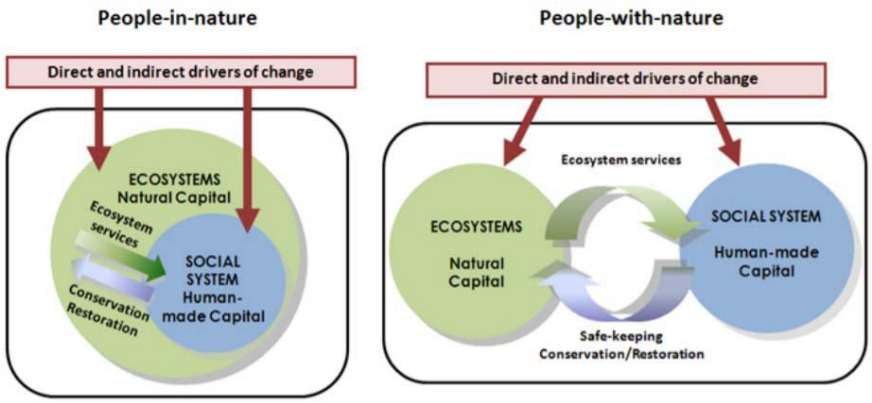


**Figure 5- People in Social-Ecological Systems**

Source: (BERKES e FOLKE, 1998)

A SES can be defined as an ecological system essentially related to and affected by one or more social systems. As for an ecological system, Anderies, Janssen and Ostrom (2004) describe it as an interdependent system of organisms or biological units, while social systems are interdependent systems of organisms. They refer to SES as "the subset of social systems in which some of the interdependent relationships among humans are mediated through interactions with biophysical and non-human biological units" (ANDERIES, JANSSEN e OSTROM, 2004, p. 3). Social-ecological systems address biophysical and social drivers, constraints and factors that frequently interact as complex, nested systems at multiple scales (organizational, special and temporal), using critical resources in continuous adaptation (REDMAN, 2004).

To understand biophysical processes is critical to better manage ecological resources and the dynamics of coupled social and ecological systems, although a degree of uncertainty always exists, (i.e. biophysical disturbances and their effects linked to climate change) (ANGELSTAM, ANDERSSON, *et al.*, 2013). Walker et al. (2002, p. 1) point out that uncertainties are difficult to characterize because of three factors: 1) key drivers are unpredictable, i.e. climate and technological change. Many key drivers change in a non-linear way; 2) human action in response to forecasts is reflexive and people can change

predictions through their reactions; 3) the system may change faster than the forecasting models can be revised. This may occur specially during unstable periods of transition, so forecasts are most unreliable in precisely the situations where they are most wanted. The high complexity of SES is one of the obstacles, likely the biggest, to forecasting future scenarios and outcomes in a meaningful way.

As SES reach out multiple scientific disciplines, frameworks are effective tools as they provide diagnostic, descriptive, and prescriptive research and a set of common language and elements (MCGINNIS e OSTROM, 2014). The SES framework was initially proposed by Ostrom (2007) with the goal of forging a common vocabulary and a logical linguistic structure among scholars (MCGINNIS e OSTROM, 2014). Anderies, Janssen and Ostrom (2004, p. 2) highlight three issues to be taken into account in a SES framework: *1) cooperation and potential for collective action must be maintained within the social system, 2) ecological systems are dynamic, as are the rules of the games that agents play amongst themselves, and 3) ecological systems can occupy multiple stable states*[6] *and move rapidly between them*. Among its contribution, social-ecological systems framework provides assistance in the analysis and assessment of ecosystem services and their value to society.

The following structure is grounded on the cooperative aspect of social systems as fundamental (Figure 6). Here, resources (A in Fig. 6) supply communities or individuals (B in Fig. 6), that is, multiple resource users. Public infrastructure providers (C in Fig. 6) can also be resource users, but not necessarily. Those are decision-makers and their multiple forms of governance influence resource users directly. Public infrastructure refers to physical (engineer works) and social (governance, rules) capital. Arrow 7 (Fig. 6) represents external disturbances related to biophysical distresses that impact the resource (A in Fig. 6) and public infrastructure (D in Fig. 6). Arrow 8 (Fig. 6) also refers to external disturbances, but related to socioeconomic changes that impact resource users and the public infrastructure providers (ANDERIES, JANSSEN e OSTROM, 2004).

[6] The state of a system refers to a particular instant in time and the collection of values of the state variables at that time (WALKER, CARPENTER, *et al.*, 2002).

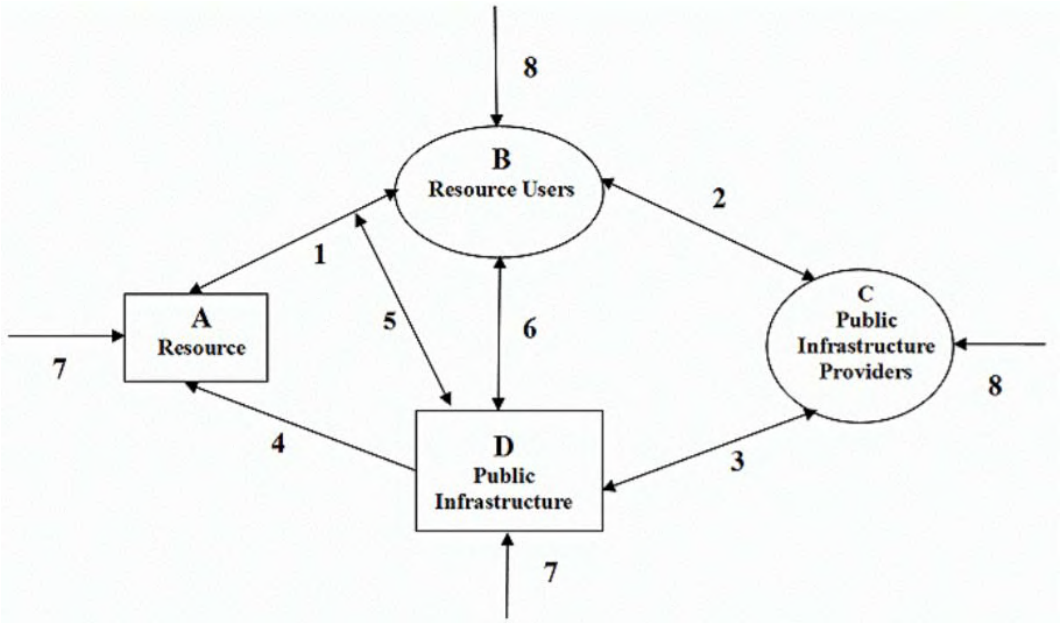


**Figure 6- A Conceptual Model of a SES**

Source: (ANDERIES, JANSSEN e OSTROM, 2004)

A is mostly affected by B through the impact caused by humans and the local fauna in the environment. The relation from B to A is based on direct extraction and availability of resources. From B to C, interaction is mostly based on voting for and monitoring performance of providers; access to resources and infrastructure. Life conditions of resource users (B) vary according to appropriate policies from C. Responsibilities from C to B are to elaborate and execute policies and contribute with resources. The link between C and D is building initial structure; keep regular maintenance; monitoring and enforcing rules. A is impacted by the infrastructure brought on by D, just as the dynamics of resource-resource users (arrow 1 in Fig. 6). B and D are also interrelated, through workforce, (community) monitoring and creation of parallel infrastructure.

The above SES conceptual model applied to the rural BSA in a simple approach would present the elements found in table 1(adding a fauna resource users' category). Although there are several elements not included bellow as the BSA is a complex system, table 3 presents the major components related to resources, resource users, public infrastructure providers and public infrastructure:

**Table 2- The BSA According to the SES Model Found in Figure 5**

| Categories | BSA |
|---|---|
| A. Resource | Land<br>Water<br>Timber<br>Fruits/Vegetables/ Tubers<br>Wildlife |
| B. Resource users (people) | Family farmers<br>Land owners of large properties<br>Tourists<br>Local communities |
| B. Resouce users (fauna) | Cattle<br>Goats<br>Birds<br>Fishes<br>Bees<br>Aligators<br>*Tatu-bola* (armadillo)<br>White-wing pigeon |
| C. Public infrastructure providers | Local government<br>Federal government<br>CSA Civil society<br>Council of local users' association |
| D. Public Infrastructure | Dams<br>Irrigation canals<br>Roads<br>Network of farmers<br>Personalized farming plans |

Source: elaborated by the author

Most resources (A) found in the BSA can be described as land, water, timber, fruits/vegetables/ tubers and wildlife. These are used as a survival strategy, especially through demand for agriculture commodities, or leisure by family farmers, land owners of large properties, local communities and tourists (B- people), driving Resource-Resource Users relations (arrow 1, Fig.5). Local fauna (B- fauna), both domestic and wildlife, generates environmental impacts through greenhouse gases, land erosion and deforestation. Positively, they assist the ecosystem in supplying services that are fundamental to resource users (examples of animals were selected based on their relevance and do not represent the totality of fauna in the BSA).

Management of the negative impacts caused by B can be provided by public infrastructure providers (C), which can be government bodies or civil society. Public infrastructure (D) to address these issues consist in dams, irrigation canals, roads, personalized farming plans and less engineering solutions, such as network of farmers and seed stock, among others.

External forces on resource and infrastructure are represented by Arrow 7 (Fig. 5), which in the BSA case would be first and foremost the droughts and soil erosion. The region is also affected by heavy rains in specific regions and by climate change. External forces on social actors (arrow 8, Fig. 5) are represented by major changes in political system, migration, commodity prices, and regulation (partially based on (ANDERIES, JANSSEN e OSTROM, 2004).

The SES of the BSA it is a human-dominated system. Commonly, the natural disturbance regime in most ecosystems, including loss of biodiversity, deforestation (land-use change), control of floods and diversion of rivers (management decisions) has been altered by human activities (COLLINS, CARPENTER, *et al.*, 2011), causing, among several consequences, climatic change. This is occurring at a faster pace than previously experienced, putting at risk the current social-ecological system of the BSA. Considering these events, it is crucial to explore pathways by which it is possible to generate resilience for the social-ecological system of the Brazilian Semiarid region.

## 2.3 Resilience

### *2.3.1 Concept debate*

Resilience concepts have been applied in many fields [i.e. Ecology-Holling (1973), Berkes & Folke (1998); physics- Young, (1807), Nash, (1982); psychology - Rutter (1985), Yunes, (2001); social-ecological systems- Carpenter et al (2001), Berkes, Colding & Folke (2003), Adger et al (2005), Folke, (2006), Nelson, (2007), Béné, (2014); community development- Berkes & Ross, (2013)] carrying several meanings, but recent definitions tend to highlight similar elements and understand resilience as an ability as opposed to an outcome (BÉNÉ, NEWSHAM, *et al.*, 2014).

According to the Intergovernmental Panel for Climate Change (2007), resilience is "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and operating modes, self-organizational skills and the ability to adapt to stress and change " or as the "ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner" (IPCC, 2012). Similarly, the Resilience Alliance definition points to "the capacity of a social-ecological system to absorb or withstand perturbations and other stressors such that the system remains within the same regime, essentially maintaining its structure and functions" [Holling (1973),Gunderson & Holling (2002), Walker, et al., (2004)].

In general terms, resilience is described as the ability to recover from a shock, whereas the impact of the shock, which can be of economic, physical, ecological or political nature, is proportional to the receptor's vulnerability, (vulnerability) defined as the degree of exposure (ANGEON e BATES, 2015). As Berkes and Ross (2013) suggest, resilience is the capacity of the system to continually change and adapt and yet remain within critical thresholds. Moreover, it refers to the capacity of an individual or community to cope with stress, overcome adversity or adapt positively to change (KAPLAN, 1999), permeating the field of governance when related to social, economic, political and cultural boundaries of human adaptation to change. Walker et al. (WALKER, CARPENTER, *et al.*, 2002) further argue that resilience (policies) management aims at preventing an SES from moving into undesirable configurations, understanding where and how resilience can be lost or gained in a SES.

Adger et al (2011) claim that there are multiple sources of resilience in most systems, therefore policies should identify such sources and strengthen capacities to adapt and learn. Nevertheless, it is not simple to define drivers that generate resilience and therefore reduce vulnerability in complex interactions like social-ecological systems. Resilience here is considered an important property in which people play a pivotal role extracting from and impacting the environment (RESILIENCE ALLIANCE), linking ecosystems and people as integrated social-ecological systems in which social systems and ecosystems are recognized as coupled, interdependent, and coevolving (BERKES e ROSS, 2013). Such complexity makes it hard to measure and define resilience, an issue that continues to challenge many scholars (ADGER, 2000). Thus, what are the stresses

and disturbances in the Brazilian Semiarid? What promotes resilience and what are the opportunities presented by disturbances?

As stressed by several authors (FOLKE, 2006; BARBIER, 2008), resilience goes beyond "the degree to which the system is capable of self-organization, learning and adaptation" (RESILIENCE ALLIANCE) into opportunities that disturbance opens up in terms of recombination of evolved structures and processes, renewal of the system and emergence of new trajectories. (FOLKE, 2006). Social–ecological resilience, for instance, is characterized by the interplay between disturbance and reorganization, sustaining and developing. It is focused on adaptive capacity, transformability, learning and innovation in the context of integrated system feedback and cross-scale dynamic interactions (FOLKE, 2006).

Accordingly, resilience requires to work with several fronts, which are closely related to sustainability. To compreheend the loss, creation, and maintenance of resilience through the process of co-discovery (by scientists, policy makers, practitioners, stakeholders, and citizens) is the core of sustainability (WALKER, CARPENTER, *et al.*, 2002; GUNDERSON e HOLLING, 2002). As Holling and Walker (2003) suggest, "a resilient social-ecological system is synonymous with a region that is ecologically, economically, and socially sustainable".

Rather than a unanimous concept employed to social-ecological systems, resilience is sometimes criticized in literature for its troublesome application to systems in which some components are consciously designed, as opposed to self-organized. As resilience and adaptive capacity are interconnected, some authors ask the question of what is the cost and how to design for adaptive capacity. Anderies, Janssen and Ostrom (2004) do not abandon the concept of resilience, but propose to apply a similar, but what they consider more suitable, concept, "robustness" to SES. They argue it emphasizes the cost–benefit trade-offs suited to deal with disruptions, as it is associated with systems designed to cope with uncertainty.

Designed and self-organizing components interact in SES. Notwithstanding, in SES "the majority of components are self organizing (ecological systems, social networks), very few are designed (rules of interaction), and uncertainty is high (experimentation is

difficult or impossible)" (ANDERIES, JANSSEN e OSTROM, 2004, p. 2), therefore the concept of resilience seems appropriate.

### *2.3.2 Climate change resilience and adaptation in social-ecological systems*

Current literature analyses climate change resilience through social-ecological systems thinking, given that the ability of a human society to cope with change may cost greatly to an ecosystem (FOLKE, 2006). Changes in climate affect agriculture, economy, political decisions and how culture is shaped. Thus, resilience framework must be focused on understanding processes of change (ADGER, BROWN, *et al.*, 2011) in its multiple perspectives.

Umar, Musa and Tologbonde (2014, p. 245), citing Folke (2006) and Nelson et al. (2007), describe climate resilience "as the capacity for a social-ecological system to absorb stresses and maintain function in the face of external stresses imposed upon it by climate change, and adapt, reorganize, and evolve into more desirable configurations that improve the sustainability of the system, leaving it better prepared for future climate change impacts". The resilience approach seems appropriate in the context of climate change for it underlines nonlinear dynamics, thresholds, uncertainty and surprise (FOLKE, 2006), characteristics found in climatic scenarios. It also emphasizes how periods of gradual change interplay with periods of rapid change and how such dynamics interact across temporal and spatial scales (FOLKE, 2006).

Climate resilience of family farmers addresses the vulnerability that communities currently have in regards to the impacts of climate change comprising social, economic, political, environmental, technological and cultural strategies. It involves issues of governance, participatory approaches, social organization, adaptation and transformation. When resilience involves societal and biophysical factors, the concept is similar to adaptive capacity, being frequently used interchangeably (WALKER, CARPENTER, *et al.*, 2002) as the ability to develop and implement effective adaptation strategies, or to react to dangers and stress in order to reduce the likelihood or size of constraints. From that derived the concept of adaptive governance, an institutional response to challenges characterized by iterative learning, allowing that individuals to cope with uncertainty and change (FOLKE, T., *et al.*, 2005; ANGELSTAM, ANDERSSON, *et al.*, 2013).

While in natural systems adaptation is reactive, in human systems it also can be anticipatory. Adaptation to climate change is an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects. Among the types of adaptation there are: anticipatory or proactive adaptation- adaptation that occurs before the impacts of climate change are observed; autonomous or spontaneous adaptation - adaptation that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by the market or welfare changes in human systems; planned adaptation - adaptation that is the result of a deliberate policy decision, based on an awareness that conditions have changed or are about to change and that action is needed to return, maintain or achieve a desired state (IPCC, 2007).

Nature can adapt to the new conditions, but reactive adaptation may bring unexpected consequences and a great cost to the system, which can be avoided through planned and anticipatory adaptation. Adapting to climate change involves developing strategies, policies and measures (GEF, 2004). It requires the ability to mobilize physical and social elements able to respond and implement strategies to cope with current or future events using resources like physical capital, technology, infrastructure, information, scientific and technical knowledge, institutions, the capacity to learn, and social capital (ADGER, BROWN, *et al.*, 2011). Regions with limited infrastructure, resources, low levels of technology, information and skills, and inequitable empowerment and access to resources are highly vulnerable to climate change damages, just as they are more vulnerable to other stresses ((IPCC), 2001). Therefore, the capacity to adapt varies considerably among regions, classes and over time.

It also depends on the stability and efficiency of cultural, economic, social and governance institutions, which have the power to facilitate or restrict the response of human systems (GEF, 2004). Those can be carried out by various group of actors such as knowledge carriers, stewards, innovators and leaders, or bridging organizations of multilevel institutions, considered central by Folke et al (2005).

Nevertheless, there is a lack of conceptual clarity on the relationships between adaptation, adaptive capacity and resilience in literature (BAHADUR, IBRAHIM and TANNER, 2010 as cited in BÉNÉ, NEWSHAM, *et al.*, 2014) Adaptive capacity is an aspect of

resilience that reflects learning, flexibility to experiment and adopt new solutions (WALKER, CARPENTER, *et al.*, 2002). Adaptive capacity to cope with climate change is influenced by economic development, technology and social factors, such as human capital and governance structures at different scales (ADGER, BROWN, *et al.*, 2011).

If the concept of adaptation implies reducing vulnerability of communities and regions to climate change, then resilience can be interpreted as a result of a successful adaptive process. And therefore, a way of promoting sustainable development (HUQ, REID e MURRAY, 2003). But in a reverse analysis, Angeon & Bates (2015) point out that despite the fact that there is a general consensus that vulnerability prevents development, there is no scientific evidence supporting that sustainable development can lead to mitigation, adaptation and recovery from a shock, reducing the vulnerability of regions and communities and increasing their resilience.

Vulnerable (social-ecological) systems need to build resilience to adapt to stresses and to allow transformation to happen, creating a new system when the existing is untenable (WALKER, HOLLING, *et al.*, 2004). This process occurs according to the system's adaptive and transformative capacity. What is, then, the ability of family farmers engendered by public policies to adapt and/or to transform? And is the system in need of shifting its nature? As in resilience theory, "transformability is the capacity to create untried beginnings from which to evolve a new way of living" (WALKER, 2004 as cited in BERKES e ROSS, 2013).

Considering that adaptation measures are likely to be implemented if they are consistent or integrated with decisions or programs that address nonclimatic stresses (IPCC, 2007), climate change resilience implies observing several factors beyond climate, as vulnerabilities associated with climate change are rarely experienced independently of nonclimatic conditions ((IPCC), 2001). It must be embedded in local and national policy and development approaches, as the impact of climate change, felt by individuals and communities, is a combination of climatic conditions and changes to the wider social and economic conditions, inserted in a social-ecological system.

## 2.4 Traditional technologies X Social technologies

The type of technologies applied in the Brazilian Semiarid region is one of the variables that defines the degree of exposure to shocks and the vulnerability of the Semiarid social-ecological system. Throughout this thesis, solutions based on large construction projects extensively applied during the 20th century in the Brazilian Semiarid region are referred as "traditional technologies" (see table 5). It is used here as a synonym of the traditional technological approach or traditional techniques, referring to mainstream technological governmental policies most related to "engineering solutions". This conceptual reference is found in both national (MI, 2005) and international literature when referred as "government policies … characterized by … a technical vision in the BSA" (PÉREZ-MARIN, ROGÉ, *et al.*, 2017, p. 2). Moreover, those terms are frequently used interchangeably in the Brazilian Semiarid field by different stakeholders, such as farmers, researches, organizations and decision makers, as verified during our fieldwork.

The traditional technological approach can be identified in several periods of public policies. These periods are divided according to their strategies for the BSA in the literature and in primary documents (MI, 2005; ANDRADE, 1970; CARVALHO, 1988; MAGALHAES e GLANTZ, 1992; CAMPOS, 2014). These policies are mainly based on the rationale that addressing the social-ecological vulnerability of the Semiarid system can be attained by programs designed to combat drought by focusing on water security improvement through almost exclusively hydraulic solutions.

The other technological approach of this research is called Social Technologies. They were identified as part of the activities of the paradigm and social movement called "Coexisting with the Semiarid" (CSA) and can be found in the CSA guidelines (ARTICULAÇÃO DO SEMIÁRIDO BRASILEIRO (ASA); CARITAS BRASILEIRA; CONTAG; CPTFETAG-BA; CUT-PE; FETAG-ALFETASE; FETAG-AL; FETAPE; FETAG-BA; SABIÁ; ET AL., 2013), in several websites of CSA organizations (ASA; IRPAA) or in surveys on this topic, including government institutions like the Embrapa (EMBRAPA SEMIÁRIDO). This term is found in the literature (DIAS, 2011; MALVEZZI, 2007; CONTI e SCHROEDER, 2013; ASA, 2011; NORD, (JIUN-SHEN)LEE, *et al.*, 2016) and sometimes alternatively described as "appropriate technologies" or "technologies for social inclusion". It was also verified to be a common term used by different stakeholders during our fieldwork. In general, social technologies as found during this research are adapted technologies with a participatory approach that

take place mostly through local and decentral projects referring to problems of a social character.

Social technologies for the BSA are presented by researchers, farmers and government as technologies that rely on the coexistence with local characteristics. They are based on forestry integration, the adoption of new productive systems, agro-ecological production, the potential for the productive use of plants native to the Caatinga and the use of water reservoirs (ASA, 2011; ASA; CARITAS BRASILEIRA; CONTAG; CPTFETAG-BA; CUT-PE; FETAG-ALFETASE; FETAG- AL; ET AL., 2013; SILVA, 2007). These are achieved through capacity building of the communities in water management for food production (called *Gerenciamento da Água para Produção de Alimentos*- Gapa), simplified water management systems (called *Sistema Simplificado em Manejo da Água para Produção*- Sisma) and mason training before the technology is implemented, among other initiatives.

Technologies, policies and activities are examined during this thesis through conceptual references seen in this chapter. In the next chapter, we present the social and climatic characterization of our region of study, the *Sertão*.

## 2.5 A Brief description of a paradigm

Paradigm can be interpreted as a reference, a guideline or ideals. Physicist Thomas Kuhn used it as a scientific term in his book "The Structure of Scientific Revolutions", published in 1962, in which he associated the concept with conceptual models, exposing problems and providing solutions for a community (KUHN, 1997).

A paradigm is a disciplinary matrix that supports a conception of the world at a given time, endowed with a model of rationality embracing scientific and philosophical spheres. It serves as an initial reference for the analysis or evaluation of studies and research, as criterion of validation and recognition. In that sense, the Coexisting with the Semiarid paradigm is an example of a new development model based on agroecology, social participation, contextualized education and decentralized processes. It is a philosophical re-interpretarion of the social-ecological system of the Brazilian Semiarid, pointing at multiple. Moreover, literature defines the CSA as a paradigm.

# 3 THE BRAZILIAN SEMIARID REGION: SOCIAL AND CLIMATIC CHARACTERIZATION

## 3.1 General aspects of all Semiarid lands

Arid and Semiarid regions represent an area of approximately 40% of the surface of the planet (BIZIKOVA, n.d.) (Figure 7). These regions are home to rare species and about two billion people, of which 90% are in developing countries (BARBIER, 2008). Semiarid climates can be of a hot or cold climate, and tend to provide scrubby vegetations in regions where they exist (PAGANO e ARAÚJO, 2011).

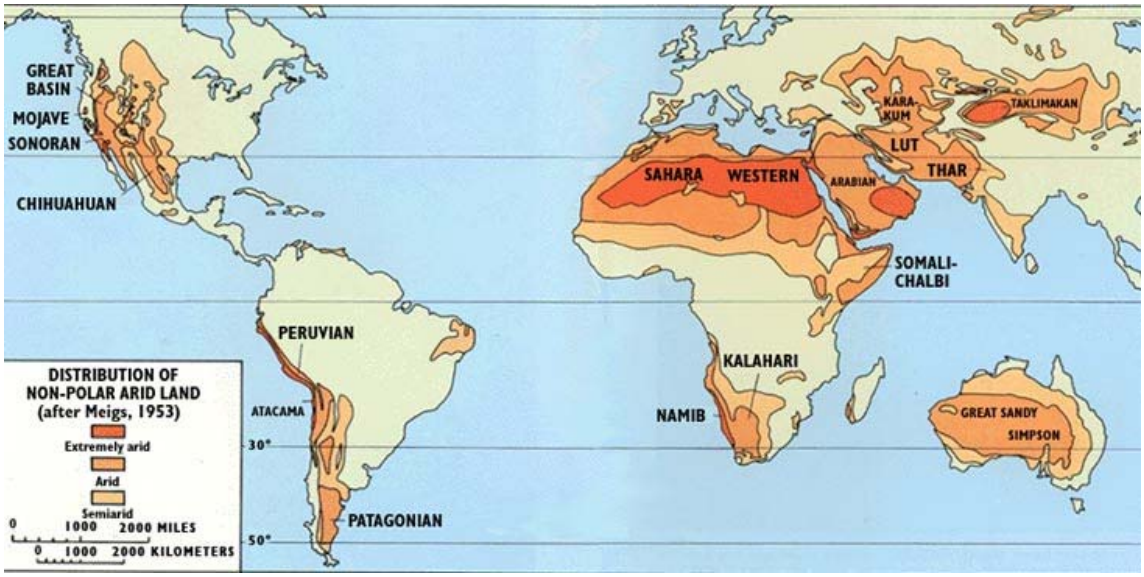


**Figure 7. Arid lands in the world**

**Source- International Arid Lands Consortium** *(2013)*

Also referred to as drylands (NEW, 2015), they serve as habitats for wild fauna and flora species, account for 50% of the world's cattle animals and nearly half of all cultivated systems providing one in three grown cultivated products in the world (UNIC). The economic importance of the Semiarid regions is also increasing as demand for food, fuel, shelter and clothing escalate and higher productive land is no longer available.

Notwithstanding, the increase in world water consumption at twice the rate of population growth contributes to escalate water scarcity in countries in Africa and the Middle East

classified as hydric stressed. And scarcity of water leads to food shortages. It takes 1,000 tons of water to produce 1 ton of grain ((BROWN, FLAVIN e FRENCH, 2000 as cited in BRITO, BRAGA e NASCIMENTO, 2010).

Human impact in Semiarid lands has exceeded the capacity of soils to withstand exploitation and the limits to which economic development can be pressed without causing ecological degradation. Soil degradation in drylands often leads to conditions similar to those of the deserts (UNIC) and these regions tend to irreversible loss of soil productivity because of erosion, a process called desertification (IPCC, 2007). Plants of the BSA loose their leaves in the dry season, so the soil is completely uncovered, without a vegetation cover to protect and minimize water and wind erosion. As people in Semiarid areas are affected by multi-stressor factors, these, combined, have diminish traditional responses to the ecosystem dynamics of the Semiarid regions and enhanced vulnerability to climatic variability (NEW, 2015).

General adversities found in Semiarid regions are erosion, caused by both heavy rain and wind, salinity, shortage of information, lack of access to technology, land ownership issues, farming background and increased pressure on natural resources, largely because of population growth and competition with other land-uses (UNDDD). Poor adoption of new techniques is also among them, related to the inability of the subsistence farmer to take risks, as family farmers have no risk capital to gamble with (HUDSON, 1987). Low rainfall and its unreliability are the biggest stressors, linked to food security and ecosystem and human health. Therefore, an increase in the temperature of Semiarid locations may cause significant losses for resource-poor farmers, increasing the risk of food insecurity. Furthermore, several of the social and political disturbances and inequalities found in Semiarid regions are rooted in colonization policies.

Among the above adversities, deforestation and pollution play a distinct role, frequently leading to the acidification of the soils and the oceans. This process results in the loss of plants and animal species. Reduction of coral reefs has been a major concern and is caused by excess of CO2 in the atmosphere related to human pressure. Australia´s Great Barrier reef lost half its coral cover between 1985 and 2012 (DE'ATH, FABRICIUS, *et al.*, 2012) and evidence of the country's vulnerability for the effects of climate change in the next hundred years is consider significant (IPCC, 2007), putting the reef at a higher risk.

Furthermore, most of the states in Australia have severe rainfall erosion problems in areas of low rainfall (HUDSON, 1987).

The historical and current land use, specially farming, is directly related to the problems experienced in the Semiarid regions. Several African countries, as Brazil, have focused on agricultural use "towards maximizing the production on the highly mechanized large farms on the better soils in the regions with most reliable rainfall" (HUDSON, 1987, section 1.4). Nevertheless, sereval African countries have turned investments, after independence, to small-scale subsistence farm on drylands, as Zimbabwe, an attempt to change the exclusive attention of colonial policies towards the international market. Hudson (1987) points out the political-will factor as the transformational driver that allowed the socio-economic adjustment to occur.

In general, African countries of a Semiarid climate have been impacted by extensive "droughts in the early nineteen-seventies and mid-eighties… and by centuries of abuse and mismanagement of the land and the people" (HUDSON, 1987). Overgrazing and economic demand have pushed to an increased aridity, while water usages competition have reduced access to water for family farmers and adversely impacted communities ((IPCC), 2001). Some particular characteristics of macro-African regions consisting of a Semiarid climate are the following:

West Africa Semiarid areas are affected by strong inter-annual and inter-decadal climate variability. They are characterized by high levels of poverty, absence of social safety nets and by population pressures that cause changes in land use and rangelands degradation. These characteristics associated with top-down policy on resource management have exacerbated vulnerability to drought (ASSAR).

East Africa major problem is food insecurity, worsen by communal conflict and the lack of appropriate institutional and economic capacity to deal with climate change impacts (ASSAR). Semiarid areas in Southern Africa are characterized by high rainfall variability, frequent droughts, low soil moisture and extreme events. Economical activities are susceptible to climate change impact, dependent on primary production and natural resources (ASSAR).

In 2016, several stakeholders in West and Central Africa (WCA) discussed drivers of resilience with the overall aim of increasing production and productivity of the farming systems through effective technology packaging and delivery, where the following research gaps and trends were listed, among others (CENTRE FOR DRYLAND AGRICULTURE, 2016):

- growing demand for crop-livestock products in WCA,
- Price volatility of major agricultural produce and natural resources associated with marketing of agricultural produce,
- Challenges of managing pastoralism and conflicts with farmers,
- Climate change,
- Inadequate synergy between research and policy and low participation of women and youth in agricultural extension,

In response, they presented the following demands: (CENTRE FOR DRYLAND AGRICULTURE, 2016),

- Higher synergy through multi-disciplinary research for crop-livestock integration, adoption of better management practices including climate-smart farming systems,
- Increased investment for smallholder mixed-crop-livestock systems through effective land use planning and efficient management of soils, water, pasture, and other essential resources,
- Dissemination of improved technologies,
- Need for appropriate legislations to provide legal framework for sustainable implementation.

The overexploitation of typical vegetation of Semiarid drylands added to climate change will result in biodiversity, ecosystem services and potential for adaptation loss. Agriculture can be severely affected if measures are not provided. The Fourth Assessment Report (AR4) from the IPCC (2007) states that it is possible to avoid potential damage to food production through adaptation practices, such as investing in biotechnology and in techniques that allow quality farming in degraded areas overcoming the need of expansion in preserved areas. It demonstrates the importance of planning for adapting vulnerable communities and their crops.

Myers et al (2000) define hotspot as a biogeographic unit that contains at least 0.5% of 300,000 vascular plant species of the world and that has lost 70% or more of its native vegetation. They state that two-thirds of the hotspots are in the tropics, some of which have the highest percentage of overall plants and up to 28% of habitat area with primary vegetation. Moreover, hotspots are areas that have exceptional concentrations of species, including many endemic species, and are, therefore, priority areas for conservation (IPCC, 2007). These areas have strong local values (cultural, social and economic) as well as global values, for their environmental services. Therefore, they are considered unique and priority entities when they are threatened.

Scenario projections indicate an increase in temperature in the BSA. For the pessimistic scenario, temperature increase between 2º to 4º C will result in 15-20% less rain. The optimistic scenario foresees that temperature raising from 1º to 3º C, rain reduction will achieve 10-15%. That is, the raining period concentration will be shorter, reducing its precipitation. Even the optimistic projection can substantially harm agriculture in Semiarid regions (IPCC, 2007).

Temperature increase will result in the rise of water body evaporation and, therefore, in the reduction of the drained water volume drained, contributing to aquifer recharging cutback in up to 70% until 2050, and to rivers outflow regeneration reduction. As a repercussion from evapotranspiration, it is likely that salinization levels will increase in shallow and groundwater. Evapotranspiration elevation causes soil hydric deficit and puts at risk agricultural production, contributing to food insecurity. In hydrographic basins of those regions, changes in the draining patterns can harm hydropower generation, irrigation maintenance and population supply (ASSAD. e PINTO, 2008). Another foreseen consequence from climate change in the BSA is the substitution of the Caatinga for more typical arid land vegetation.

### 3.2 *Sertão* before colonization

The territorial occupation, nature appropriation and use of available resources before and after colonization shaped the social-historical process in the Northeastern Semiarid region. The purpose of this sub-section is to bring to light some of the components found before colonization to underline the development of the human-nature relations that took

place and changed the landscape, forging the current social-ecological system of the Brazilian Semiarid.

Inhabitants of the *Sertão* before colonization were nomad indigenous groups. The occupation of the *Sertão* by human groups occurred approximately 50,000 years before present. This discovery happened through material found at the *Toca do Boqueirão* archaeological site of *Pedra Furada*, in the Piauí state (ETCHEVARNE, 1999-2000). Arqueological research in the Brazilian Semiarid region shows a diversity of clay styles, stone tools and rupestrian paintings, leading to the conclusion of several existing pre-colonial indigenous people living in the region (MEDEIROS, 2002). Stratigraphy done at the *Toca do Boqueirão*, for instance, denotes a sequence of occupations of groups of hunter-gatherers ranging from almost 50,000 years to approximately 6,000 years AP (GUIDON, 1991 as cited in ETCHEVARNE, 1999-2000).

Populations of hunter-gatherers moved unrestricted around the three biomes established in the Northeast profiting from inputs offered by the tropical forest, rivers and ocean. Settlements in the *Caatinga* biome were more frequent at the margins of rivers of permanent course, like *São Francisco* and *Paraíba*. It is likely that temporary streams and creeks were used by pre- colonial indigenous groups to move to the hinterlands of the Caatinga (ETCHEVARNE, 1999-2000).

The European settlement ocurred through the perpetual "*sesmarias*" system, in which land portions were given to Portuguese citizens willing to cultivate them in exchange for one sixth of the output. Furthermore, *Sertão* was gradually occupied through exploratory expeditions and merchandisers present on the São Francisco river (FERRAZ, 2006), converting population mainly into mamelukes[7].

During the occupation, most natives were killed or displaced from fertile lands, and their traditional knowledge about the environment was not assimilated (TEIXEIRA, 2006). The Portuguese occupation of the territory had a severe impact in the socio-historical processes of indigenous societies since the culture, perception and relation to the environment of the Europeans prevailed. They introduced new technological equipment,

[7] In Brazil, mamelukes refer to descendants of indigenous mixed with white people.

animals and plants, and more important, a different way of appropriation of the territory and natural resources (ETCHEVARNE, 1999-2000). Changes in the regional landscape were drastic as indigenous groups were replaced along with their mode of production and ways of life (ETCHEVARNE, 1999-2000). Production relations in the Semiarid economy had been stablished on family relations until that moment, not based on slavery (TEIXEIRA, 2006).

Difficulties found in a precise description of these groups are due to the extermination of several of them during the Portuguese colonial conquer and the lack of writing register of their existence. Consequently, and also due to political interests, the dominant Brazilian historical vision does not recognize the diversity of indigenous groups in the region, although they have been shown in archaeological and ethnological fields, gradually forgotten since the colonial period (MEDEIROS, 2002).

### 3.3 Social and economic characterization

Currently, there are about 23,5 million inhabitants in the Brazilian Semiarid region, from which 62% live in urban zones and 38% in rural areas (INSA, 2014). The BSA comprises eight Northeastern states and the north of Minas Gerais, occupying 982,563.3 km² (12% of the country, 53% of the Northeast). 89.5% of the Semiarid area is concentrated in the Northeast region, containing 1,134 municipalities, while the remaining 10,5% of Semiarid area is in Minas Gerais (IBGE).

Despite the economic potential found in tourism, native plants (for medical and cosmetic use) and other sectors, the *Sertão* remains home to a large portion of the country's poorest people, predominantly constituted by family farmers, although poverty rate has generally been reduced in the 2000s (NERI, 2011). According to the *Instituto Brasileiro de Geografia e Estatística* (IGBE, Brazilian Institute of Geography and Statistics ) (IBGE, 2010; JÚNIOR, 2003) 59% of the population living in extreme poverty in Brazil lies in the Northeast. The macro-region encompasses 9,609,803 people living in extreme poverty (the highest amount in the country), from which 5,049,317 are in rural areas. This is also the highest number of extreme poverty in rural areas in the country (BRASIL, 2014, p. 81).

**Table 3. Geographical Distribution of the Brazilian Population and the Brazilian Population living in extreme poverty, 2010**

| Total population | Population living in extreme poverty | |
|---|---|---|
| | Total | Total |
| Brazil | 190,755,799 | 16,267,197 |
| North | 15,864,454 | 2,658,452 |
| Northeast | 53,081,950 | 9,609,803 |
| Southeast | 80,364,410 | 2,725,532 |
| South | 27,386,891 | 715,961 |
| Midwest | 14,058,094 | 557,449 |

**Source:** (BRASIL, 2011)

As seen in table 4, there is a considerable disparity between the Northeast and other sub-regions of Brazil in terms of population concentration living in extreme poverty. Not only the total figure is higher in the Northeast, but the ratio between the total population and population living in extreme poverty is also the highest, about 18%, followed by the North region (around 16%). Agriculture and livestock play an important role in the regional economy of the Northeastern Brazil. Honey, cashew, cotton, beans, corn and cassava represent the most traditional cultivated products (SILVA e FILHO, 2006).

The BSA economy consists of so-called traditional activities - such as those that structure the livestock-cotton-food crops (*gado-algodão-lavoura*) consortium, non-conventional activities (local base) and dynamic activities linked to agribusiness and industry. The industrial product of this region comprises branches of industries in mining and quarrying, manufacturing and construction, besides industrial utility services (MI, 2005).

The predominant economic activities are related to the subsistence agriculture, small and medium-sized animal farms, handicrafts and extractivism for family consumption. In the most favorable areas, a diversified agriculture is associated with livestock farming, mainly for local and regional consumption. Different types of soils allow a significant diversification of crops, despite the risk associated with random precipitation characteristics. In the most unfavorable areas, extensive goat-breeding and sheep-farming predominate. In some localities, traditional farming practices still follow the highly predatory itinerant model, which includes the total deforestation, burning of wood, cultivation (corn and beans, basically) for up to 2 years, followed by fallow, in search of

the recomposition of native vegetation and fertility from soil. The exception rests on the areas closest to the perennial rivers, mainly the *São Francisco* and the *Parnaíba*, and around some large reservoirs of water, where a specialized agricultural zone prevails, based on the intensive irrigated cultivation of fruits and vegetables, where the livestock farming has little expression (SILVA e FILHO, 2006).

Due to the region's main economic activities historically linked to livestock-cotton-food crops, part of the population of the Brazilian Semiarid region lives in what some authors define as an "economy without production". Silva and Filho (2006) interpreted it as the income of retired workers and civil servants, and Union transfers for municipalities and state governments. Gomes (2001) highlights the income transferring programs. An alternative view is to understand how income transfers allow the ecomony to circulate. The injection of part of those resources can be seen as investments, generating jobs and income, while the other share is used for services and goods, such as those represented by the production of different forms of handicrafts (MI, 2005).

Families constituted of peasants in the BSA have not yet developed a production culture towards the market, as there re several obstacles such as the presence of intermediaries, difficulties in access to irrigation systems and to the market itself. According to IRPAA, the main reason for the economic obstacles is the fact that they do not own the land they live in, and therefore they maintain a temporary connection with the farmland (IRPAA). The index of concentration of land ownership, measured by the Gini coefficient (0.811), is the second largest in the country and loses only to the North Region (SILVA e FILHO, 2006). The serious problems arising from concentration and inequality in the distribution of land is a direct consequence of the inheritance of the archaic regional agrarian structure, further explained during the “Political Constrains” sub-section.

The spatial organization of the BSA region reflects its diversity. The maintenance of the rural population in more peripheral spaces of the region`s economy depends on technical, economic and social innovations adapted to the local conditions, able to value the productive resources in their various combinations. Environmental management has been organized around distinct occupations, mainly based on the extensive pasture area occupied by the Caatinga, where farmers freely raise their herds during the rainy season and part of the dry season. The herds are mainly small ruminants, usually goats. They

represent the main form of savings available to producers important for the survival of the local population. Another occupation corresponds to the small cultivation of crops linked to the supply of the families' food needs (beans, cassava, corn, rice, among others) and as a source of income (castor bean, cotton, sisal, among others) (SILVA e FILHO, 2006).

Family farmers are a representative population, around one sixth of the total population of the Semiarid region. The definition of a family farmer has been presented by the law 11,326, from July, 2006, as the farmer who simultaneously I- does not possess an area bigger than four fiscal modules [ 5 to 100 hectares, defined by INCRA according to the municipality (EMBRAPA)], II- Essentially uses family work force in the economic activities of its establishment; III – income is mostly obtained from economic activities associated with their own establishment. Groups who are also considered in this description are silviculturalist, fish farmers, extractivist communities, fishmen, indigenous people, *quilombolas* and settled communities derived from the agrarian reform (IBGE, 2006). In addition, Wanderley (2009) highlights that the family owns the modes of production of this micro-system with different strategies that shape the social heterogeneity of family farming.

According to the last rural demographic census of 2006 (a 2017/18 census is being conducted by the IBGE), there are 1,527,861 family farmers' establishments and 185,684 non family farmers`s in the BSA. That means 89,16 % of all establishments in the region are occupied by family farmers, against 10,84% non family farmers, a difference of more than eight times. Nevertheless, from the 49,517,046 hectares occupied by agricultural and livestock establishments, 28,067,999 belong to non family farmers businesses while 21,449,047 were used by family farmers (IBGE, 2006, p. table 1109). Only a small parcel of that area relies on irrigation systems, 218,826 ha representing 94,382 family farmers establishments and 250,902 ha occupied by 19,558 non family farmers establishments (IBGE, 2006, p. table 2007).

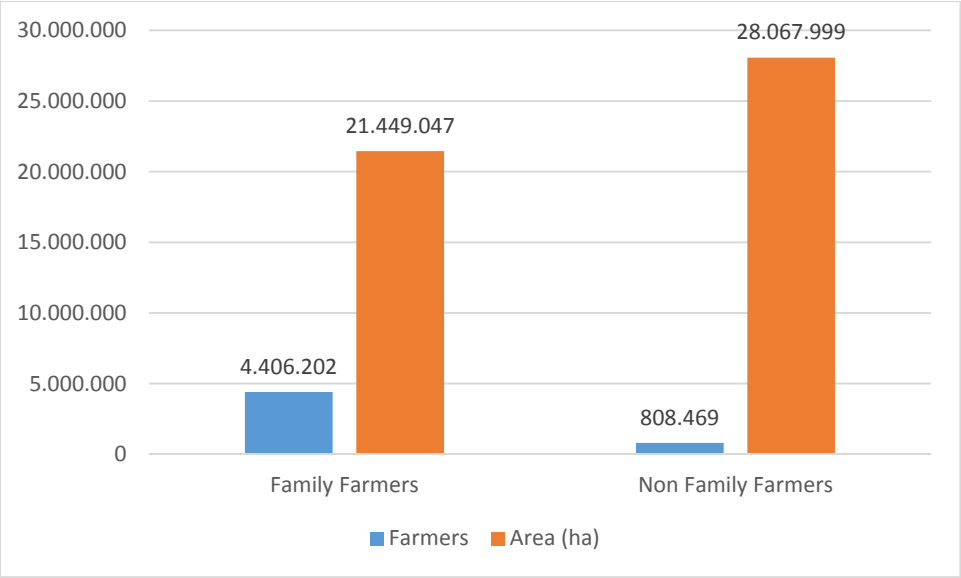


**Figure 8- Family and non-family farmers land distribution**

The exact number of family farmers in the BSA is not available. The IBGE methodology for the above cited census considers only one farmer per establishment as a producer (in charge), which can mislead to 1,527,861 establishments = 1,527,861 family farmers. Observed reality and vast literature show that at least two members of the family (but so often many more) assist in the farming activity, especially until the 2000s, as a great number of the younger have found opportunity to study and/or work away from home after that period.

In light of the total amount of people working in agricultural and livestock establishments and the parcel which is family-related to the producers, we can estimate the number of family farmers in the Brazilian Semiarid region, considering that the majority of the work force comes from the farmers´s family (as per the previous cited law). There are 4,406,202 workers (IBGE, 2006, p. table 1113) in family farms, from which 3,914,453 are related to the producers (IBGE, 2006, p. table 1114). Men force- 2,934,278- represent almost the double of the female workers- 1,471,924 (IBGE, 2006, p. table 1113). The difference is even greater for non family farmers, 613,359 are men and 195,110 are women (IBGE, 2006, p. table 1113). In a regional perspective, family farmers in the *Sertão* represent around 70 % of all family farmers living in the Northeast and about 35% of total family farmers in Brazil (IBGE, 2006, p. table 1113).

From the 1,527,861 family farmers' establishments, 1,380,641 were able to produce in 2006. Together, their production value was the equivalent to 8,420,596,000 reais (IBGE, 2006, p. table 1118).

Several factors are often referred to as potential barriers to the development of agriculture in this region. Those include, but are not limited to environmental adversities, disability in logistics, technological underdevelopment, little knowledge on optimizing funding or lack and/or inconsistent technical assistance. From the 1,527,861 family farmers' establishments, 1,299,758 did not rely on any source of funding in 2006. Reasons vary: 504,270 claimed it was unnecessary; 360,235 were afraid to incur debt; 222,147 alleged different reasons; 103,495 due to bureaucracy; 64,443 could not obtain funding for lack of payment of previous loans; 26,963 lacked personal guarantee; and 18,205 did not know how to obtain funding (IBGE, 2006, table 1119).

The majority of family farmers who obtained funding (227,903 establishments) had the purpose to invest in the establishment. They accounted for 151,931 establishments, followed by those interested in operational expenses 47,883; maintenance of the establishment 32,566; and commercialization 4,116 (IBGE, 2006, p. table 1120).

As seen in Appendix 5, there are 4,406,202 family farmers working in 21,449,047 hectares and only 808,469 non family farm workers (including owners and employees) in 28,067,999 hectares in the BSA. Family farmers represent 84,5% of the totality of farmers allocated in the region, but occupy 43,32% of the land, while the remaining 15,5% of farmers keep 56,68% of the area.

### 3.4 Ecological characterization

The BSA is represented by a wide variety of landscapes and environments (CORREIA, KILL, *et al.*, 2011). The Semiarid vegetation cover is predominantly constituted by the Caatinga, which occupies approximately 80% of the area, almost 850 thousand $km^2$. The Caatinga vegetation is distributed in 17 large landscape units, which in turn are subdivided into 105 geoenvironmental units (RODAL e SAMPAIO, 2002), of a total of 172 in the Northeast as a whole (SILVA, RICHE, *et al.*, 1993).The remaining territory is covered by other vegetation types, such as the Cerrado and highland marshes (*brejos*) (SILVA, TABARELLI, *et al.*, 2003). Vegetation cover is the natural defense of a terrain

against erosion and other pressures. The type of vegetation is xerophytic (*xerófila*), with varied physiognomy and floristic composition, mainly small and medium-sized, deciduous, shrub and tree species. Most of them endowed with thorns. Some important adaptive mechanisms of these species to abiotic factors (climate, soil and relief) are thin and small leaves, stomata (*estômatos*) closure, leaf loss during the dry season, short phenological cycle, reserve storage systems and dormancy seeds (SILVA e FILHO, 2006). The Semiarid soils have very different characteristics due to the great lithological variety, reflecting both in the floristic composition of the vegetation and in the context of the occupation and use of space by man (SILVA e FILHO, 2006).

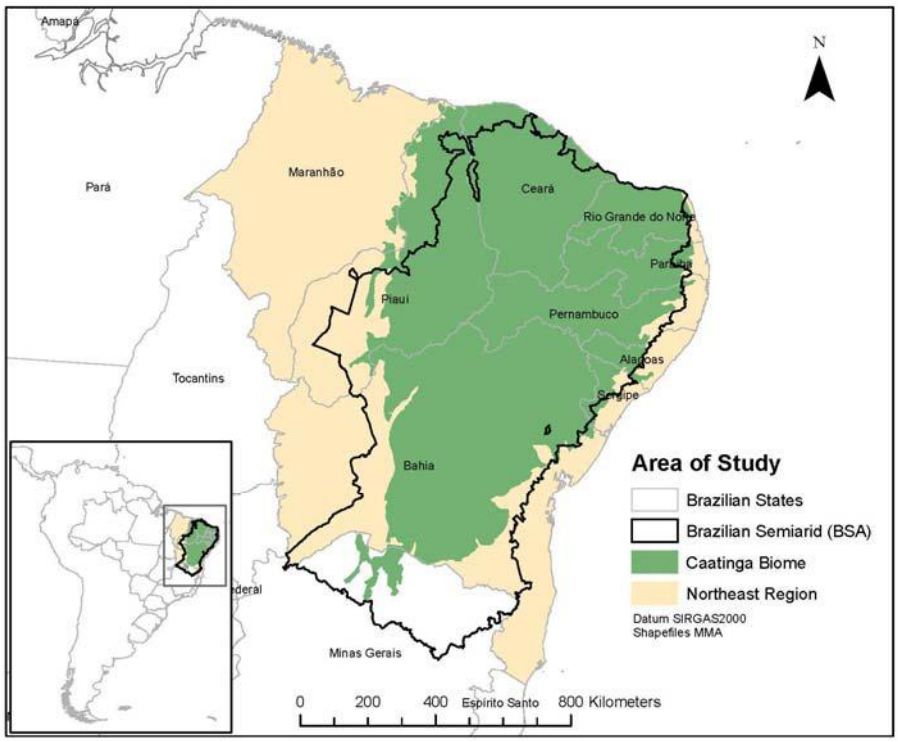


**Figure 9- Delimitation of the Caatinga biome, BSA and the Northeast region of Brazil**

The *Caatinga* biome consists mainly in the deciduous forest, seasonal forests, rupestrian fields and Cerrado. The *Caatinga*, sometimes referred as Savanna Step[8], is considered by most researchers as an exclusively Brazilian biome (HAUFF, 2010), however, this unique position among the Brazilian biomes was not enough to guarantee the *Caatinga* the priority it deserves (SILVA e FILHO, 2006). Only 7.5% of the biome is legally considered as a protected area, constituted by conservation units. It is one of the least

[8] In Portuguese: savana estépica

protected biomes in the country and most of the biome conservation units, especially the Environmental Protection Areas (APAs), have a low level of implementation (MMA, 2012). Deforestation is one of the main activities contributing to desertification, droughts and loss of biodiversity. Degradation is attributed to inadequate practices for the exploitation of its physical and biological resources, among which are the spoliative cropping systems, the Caatinga overgrazing and predatory extractivism (SILVA e FILHO, 2006).

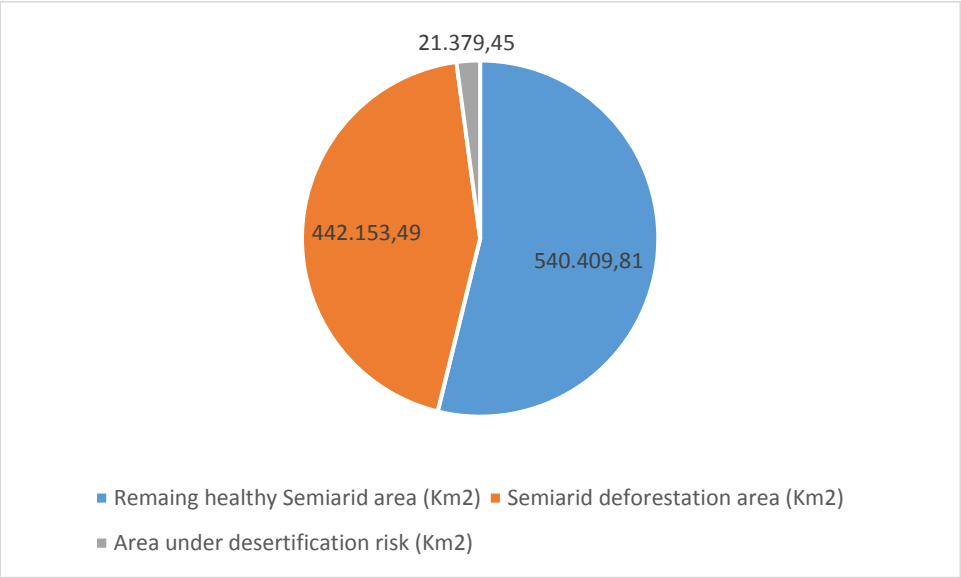


**Figure 10- Semiarid land state-of-art**

About 28 million people inhabit the *Caatinga* in all its extension, including outside the Semiarid territory. Poverty found in the region is responsible for a significant natural resource-dependence economic base. In light of the increasing pressure on the *Caatinga* biome, conservation and sustainable use of the natural resources are essential (DECLARAÇÃO DA CAATINGA, 2012).

When extraction is based on a healthy human-nature relation from a social-ecological perspective, the original vegetal cover can provide the necessary resources for human settlement. The *Caatinga* deciduous forest is adapted to the Semiarid climatic variability and soil, supporting long periods of drought and able to rejuvenate to the contact of the first rains (NIMMER, 1977).

Nevertheless, the common view of the *Caatinga* refers to a dry vegetation, with scattered and twisted trees, where water bodies give way to cracked and parched soils containing

animal skeletons, unable to survive dry seasons. This is a well-known consolidated image, used by politicians to dispute financial resources on an emergency basis with the support of the media. But this image portrays a region that is socially and environmentally degraded and not what the *Caatinga* actually is (SIQUEIRA FILHO, 2013). It represents a landscape modified by human activities, specially in areas under desertification. Although there is more to the *Caatinga* and Sertão´s scenic sites than droughts and death, these have been presented as a "unique truth" of the region.

The degraded image of the *Caatinga* is so well consolidated that disseminates an idea of a biodiversity-poor biome (HENRIQUES, 2008; MAIA, 2012). This mislead representation becomes an obstacle when it comes to justifying the importance of the scientific research in the region. And the high level of disinformation about the *Caatinga* diminishes the attention gained in and out of Brazil in comparison to the Amazon and the Atlantic forests.

The perception that the preservation of the environment is directly linked to poverty reduction is vastly found in the literature (BARBIER, 2008). The consequences of failing to provide adequate supplies and sanitation, and the transformations that our planet has gone through, driven by human action, are reflected in the low quality of life and health among the inhabitants of lower income, the most affected, which can lead to social unrest and conflict. Some vulnerabilities found in the lower classes in relation to environmental degradation are: (1) greater dependence on natural resources; (2) increased exposure to environmental disasters, as they are concentrated in geographic locations most at risk of extreme events of weather or in areas with greater environmental unsustainability; (3) greater vulnerability for interactions with social, political and economic aspects related to restrictions on access to public drinking water, sanitation, health care, access to education, poor housing and infrastructure (CORREA, 2012). These are some of the aspects found among the BSA inhabitants.

Prevailing myths about the Caatinga's biodiversity are being challenged. For instance, the conception of a homogeneous landscape. Contrary to what is proposed, the *Caatinga*, in fact, is extremely heterogeneous and its physiognomy has been classified in different ways. Luetzelburg divides it into the *Caatinga Arbustiva* and *Caatinga Arbórea*, the first composed of nine subtypes and the second by three. These 12 types of Caatinga present

great variation in the floristic composition, resulting from the influence of the abiotic factors that compose this biome, which interfere with anthropic activities (SILVA e FILHO, 2006).

### 3.5 Vulnerabilities of the *Sertão*

Literature suggests that the Brazilian Semiarid region remains social-ecologically vulnerable in spite of unprecedented levels of investment, myriad policy programs, and innumerable technological fixes (ADGER, BROWN, *et al.*, 2011).

A group considered vulnerable to climate change is also vulnerable to non-climatic stressors and not rarely they are put in this position by political and economic factors. Burney et al. (2014), when describing family farmers' vulnerability to climate, cite low yielding production practices and reliance on scarce and seasonally variable water resources; other authors relate the issue to social injustice and environmental unsustainable practices (EAKIN e LUERS, 2006; JR, PRINS, *et al.*, 2007; OBERMAIER, 2011).

### 3.5 Constraints

#### *3.5.1 Climatic and environmental vulnerability*

The BSA is part of the area known as the Drought Polygon, characterized by rainfall volumes between 300-800 mm year$^{-1}$. This is lower than the evaporation index, which in the Brazilian Semiarid region is 3,000 mm per year. Rainwater losses are estimated in more than 90% due to its evaporation and to its surface runoff. As a consequence, the region has to endure water deficits.

In general, the *Sertão* is characterized by irregular rainfall, short periods of heavy rain- in certain areas- and long periods of drought, evidenced by records dating from the time of the Portuguese Empire in Brazil in the XVI century. The local climate, dry and hot, with high temperatures and low precipitation rate, is an obstacle to the development of agriculture and livestock, with the exception of the region on the banks of the São Francisco river, in Bahia and Pernambuco states, where there are currently irrigation systems created by the SUDENE. Agricultural activities, apart from native or adapted varieties, are limited by insufficient and unstable rainfall patterns, concentrated between

three and four months of the year, and by high levels of evapotranspiration (NIMMER, 1977). The *Caatinga* species, when not degraded, are part of a dense forest that remains dry during dry season as a survival strategy (LIMA, 2012; MAIA, 2012).

The soil found in most of the territory is shallow and unable to retain water. About 70% of the territory is composed by a rocky and thickening soil, called crystalline, where rocks are found a few meters below ground (EMBRAPA, n.d.). This means low rainwater infiltration capacity, high superficial water running and low natural drainage capacity. Stored water is easily exposed to evaporation and its quality is usually low.

Erratic rainfall distribution results in a dry climate pattern most of the year, but distinctive from extreme drought events longer than regular dry seasons. The preserved biodiversity is able to adjust to the regular dry seasons, but not necessarily to unpredicted longer drought periods.

Drought in the region is the result of three conditions: the water temperature of the Atlantic Ocean, low atmospheric humidity and the El Niño phenomenon in the Pacific. For these reasons, the *Sertão* is one of the most vulnerable regions to climate change in Brazil (IPCC, 2007; MESQUITA, BURSZTYN e WITTMAN, 2014; MARGULIS e DUBEUX, 2010), which combined with growing population and increasing demand for water has the potential to affect water systems in the region (BRAGA, DE NYS, *et al.*, 2013). Additionally, local water resources have been degraded due to the destruction of forest cover through deforestation and burning (including riparian forests), the accumulation and uncontrolled use of water and the release of polluting agents in the water sources (SILVA e FILHO, 2006).

As a result of climate change, the region has also been affected by periodic heavy rainfall, causing adverse effects as perverse as the ones caused by drought, such as erosion processes. Climate change will affect agricultural production in the South hemisphere increasing the vulnerability of smallholder farmers (EASTERLING, AGGARWAL, *et al.*, 2007; NELSON e FINAN, 2009; ZIERVOGEL, CARTWRIGHT, *et al.*, 2008). Climate models agree that future changes in the Brazilian Semiarid area, including increased rainfall variability, drought and temperature, and intensification of the hydrological deficit, are likely to happen (BURNEY, CESANO, *et al.*, 2014).

Scenario projections indicate that temperature increase will result in increased evaporation, reducing the water volume retained in the area and contributing to reduce the aquifers recharge by up to 70% by 2050, and to reduced rivers flows. Evapotranspiration is likely to increase shallow and groundwater salinization, putting agricultural production at risk and contributing to food insecurity. Changes in the drainage patterns in the hydrographic basins of the region have the potential to interfere in hydropower generation, irrigation maintenance and population supply (PINTO, ASSAD, *et al.*, 2008).

The overexploitation of native vegetation (as seen in the ecological characterization sub-section) associated with climate change will result in losses in biodiversity, ecosystem services and potential for adaptation (IPCC, 2007), and contribute to desertification processes. Because of the restricted available water, it takes longer for the vegetation to be restored, increasing the vulnerability of the ecosystem, which can rapidly move from Semiarid to Arid. Susceptible areas to desertification have been estimated in 1,335,439.70 km² in 2004 in the Northeast, with the potential to affect 3,389,104 people (MI, 2005). In the BSA, areas in the process of degradation from low to severe intensity already total more than 20 million hectares, corresponding to about 22% of the Semiarid Region (SILVA e FILHO, 2006).

The costs of investments in preventing soil degradation in the *Caatinga* are lower than recovering degraded areas. But besides natural challenges, there are political constraints found on the roots of family farmers' vulnerability, described below.

### *3.5.2 Political constraints*

There are three main historical determinants that shape the context for public policies in the Brazilian Semiarid: land structure (agrarian reform), power structure (*coronelismo* and patronage) and the drought industry.

Uneven land distribution in Brazil can be traced back to 1530, with the colonization policy of the captaincies of Brazil and the perpetual "*sesmarias*" system, explained in our sub-topic "*Sertão* before colonization" on page 33. On the coast, most of the productive land

was used for sugar mills once sugarcane monoculture was stimulated by the high profitability of exports to the European market. Brazil became what Furtado (1982) defined as an Agro-trade-company. The new activity demanded pack animals and animal protein, displacing local population from *Zona da Mata*, where the sugar mills were installed, to nearby regions like the Semiarid, creating their own economic periphery dependent on the sugar mill industries and reconfiguring the Northeast (FURTADO, 1959).

The Semiarid production of cattle and farming responded to the demands of the sugar milling population and the new landowners, who were not adapted to the Semiarid, with their European habits. Therefore, it introduced new farming items in the *Sertão*. The central and the periphery economy were severely affected by the sugar market crisis, leaving family farmers to survive in the subsistence mode of production (FURTADO, 1959), especially because the land was structured in landlordism (*latifúndios*). The land structure is considered one of the main factors responsible for the low efficiency of the BSA family farming production systems (SILVA e FILHO, 2006).

Landowners of large properties (*latifúndio*) were called "colonels" because their private power, including the use of violence and political influence, often overcame the public power. From that derived the term "*coronelismo*" ("colonel" = "*coronel*"). The *latifúndio* operated as a power system, where the dominant elite was forged - and still is - by agricultural oligarchies inserted in a "*coronelismo*" and patronage power structure, although the colonel figure has changed into a more institutionalized personification nowadays, such as city councilors or political positions in general.

The landlords which withheld access to political and natural resources, especially land and water, started profiting from the drought periods, selling water when needed and using the basic needs of people to obtain political advantages, such as voting promises. They held the job offers for those who need to migrate or find work as a result of having lost their livelihoods due to drought events. This context reinforced the concentration of power and the dependent relation for most of the local population (CASTRO, 1946). In addition, local politicians use drought events to request the government more funding for the region, but much of it is used in mega constructions which benefits landlords, or in private properties. This phenomenon was named "Drought Industry" for the first time by

Antonio Callado in the 1940s (CALLADO, 1960).

## 3.6 **Strengths of the *Sertão***

### *3.6.1 The Caatinga dry forest: eco-systemic services, medicinal use and products of the socio-biodiversity*

The economic potential for the valorization of the biodiversity of the Semiarid and its Caatinga Biome is enormous (SILVA e FILHO, 2006). Among the potentialities presented by the *Caatinga* forests, we can highlight eco-systemic services, medicinal use of native plants and products of the *Caatinga* socio-biodiversity. There is also enormous potential for income generation in activities such as ecotourism and sustainable use of biodiversity, but in general their economic potential is still little valued. Silva and Filho (2006) attests that the *Caatinga* presents great forage, fruitful, timber, energy, honey, medicinal and faunal potential, among others.

Environmental services or eco-systemic services are the direct or indirect benefits obtained from nature. Forests provide wood, food, medicinal substances and fiber, and produce genetic resources. Animals have multiple functions: bees pollinate plants that will sequester carbon from the atmosphere, animal feces fertilize the soil, and so on. Those elements are interconnected and are part of a social-ecological system. They contribute to mitigate extreme climatic phenomena, protect against natural disasters, control erosion, decompose waste, maintain fertile soils, among several other assistances.

There are about 1,500 plant species, of which 318 are endemic to this ecosystem. Regarding animal groups. the literature shows that there is a lack of information for most of them. To date, 148 species of mammals (10 endemic), 348 birds (15 species and 45 endemic subspecies), 154 amphibians and reptiles (15% endemic), 191 aquatic fauna (57% endemic) have been registered (SILVA e FILHO, 2006). 187 species of bees were recognized, with 32% of endemism (ZANELLA e MARTINS, 2003).

Ecosystem services function as a bridge between biophysical and social templates and are divided into four categories: 1- provisioning services: products obtained from ecosystems, like food, fresh water and wood; 2- regulation services: benefits obtained

from natural processes that regulate environmental conditions, i.e. $CO_2$ uptake by photosynthesis of forests, climate control, plant pollination, water purification, disease and pest control; 3- cultural services: these are the intangible benefits obtained from recreational, educational, religious or aesthetic-landscape nature; 4- support services: contribute to the production of other ecosystem services, such as nutrient cycling, soil formation and primary production (FAO). Figure 11 shows their connection to the human well-being:

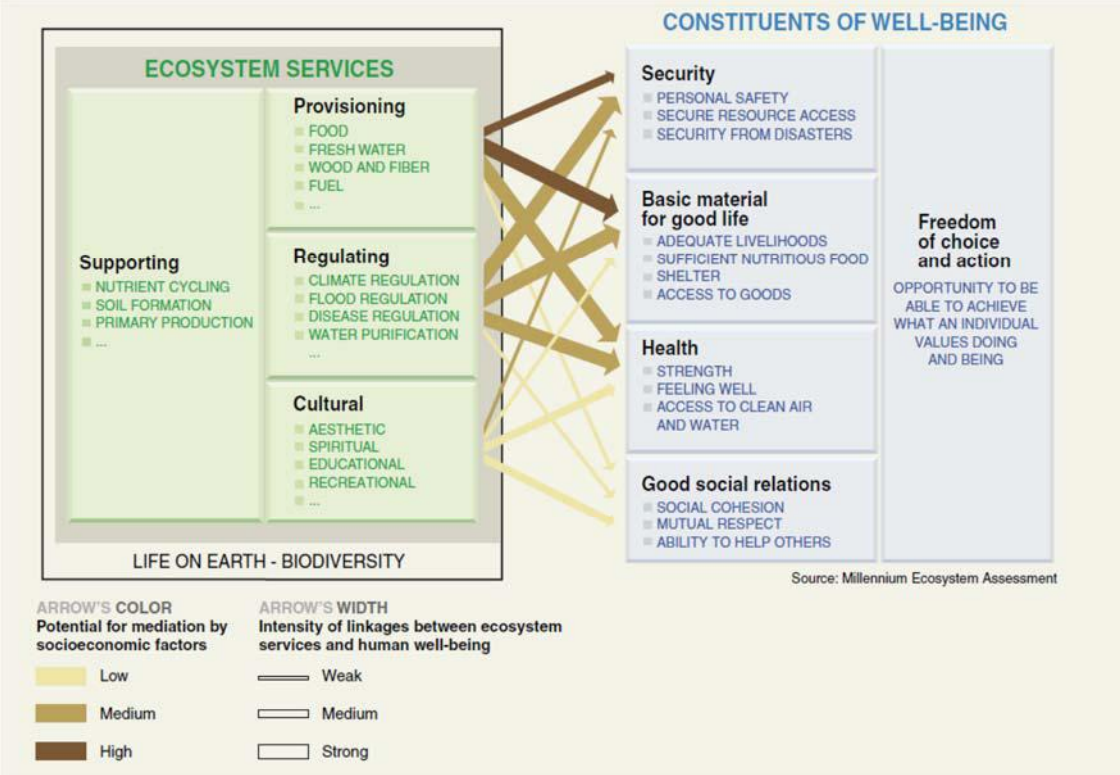


**Figure 11- Ecosystem services and human well-being**

Source: (MILLENNIUM ECOSYSTEM ASSESSMENT, 2005)

Concomitantly, ecosystems are subjected to a variety of environmental stressors, such as increasing atmospheric carbon dioxide concentrations, nitrogen deposition and global warming (COLLINS, CARPENTER, *et al.*, 2011). These presses modify the quantity and quality of essential services that humans gain from the *Caatinga* forests, which are fundamental to sustain life quality and economic development of local communities. Ecossystems provide conservation of water, soil and genetic resources, and the flora found in different ecosystems are sources for therapeutic use and commercialization. Alburqueque and Andrade (2002) refer to the knowledge accumulated by the local

populations as a powerful tool of which developmentalists can use when planning and managing these areas and show ethnobotanical studies confirming positive impacts of humans in vegetal communitites and resources.

Salick (1995) states that the relationship between plants and people can contribute to progress when considering the evolutionary ecology, for instance. In genetic ecology, people act as selective agents for plants; they alter the life cycle, patterns of mortality, reproduction and survival of plant populations; and modify and take advantage of plant chemical defenses for their benefit.

The *Caatinga* is commonly associated with the provision of timber and medicinal resources. The *Caatinga* provides non-timber forest products that generate employment and income for the population, and presents an economic potential for the chemical, pharmaceutical and food industries. There are several products of the *Caatinga* socio-biodiversity. Some fruitful potentialities are the *umbu, araticum, jatobá, murici* and *licuri*. Plants used for fodder mentioned by EMBRAPA are *Camaratuba, Carqueija, Catingueira-verdadeira, Espinheiro/ Jacurutu/ Jiquiri, Facheiro, Favela/ Faveleira, Feijão- brabo, Imbuzeiro/ Umbuzeiro, Juazeiro, Jurema-preta, Jurema-vermelha, Macambira, Mandacaru/ Mandacaru-de-boi, Maniçoba, Marmeleiro/ Marmeleiro-preto, Moleque-duro, Mororó/ Unha-de-vaca, Quebra- faca, Sabiá, Sete-cascas/ Cascudo/ Pau-de-cascas* (LIMA, 1996). Interest in the *Palma* cactacea has recently been growing for fodder finality as well, due to its less water consumption.


**Figure 12- COOPERCUC– Cooperativa Agropecuária Familiar de Canudos, Uauá e Curaçá**


**Figure 13- Embrapa instructions for processing passion fruit**

The implementation of sustainable production and consumption patterns in the *Caatinga* include to understand and recognize privation, demands and knowledge of local

populations. Based on traditional knowledge, researchers have found local and adapted species with medicinal potential and their popularity in the Brazilian *Caatinga*. These researches show the *Caatinga* cultural service and reinforce the importance of biodiversity conservation for rural communities.

Traditional botanical knowledge is an ancient traditional study of plants and their potential usage. In the Northeast, the use of plants in the treatment of diseases is a common practice. In a rural community located in the municipality of Alagoinha, in the state of Pernambuco, surveys in agroforestry systems (homegardens) and in natural vegetation identified more than 108 species of plants used, distributed in 10 categories: food, medicinal, wood (for fuel, construction etc), domestic use (technology), forage (fodder), poison, insect repellent, ornamentation, for shade purposes and mystic functions (ALBUQUERQUE e ANDRADE, 2002).

An ethnobotanical survey of medicinal plants commercialized and consumed in the municipality of Itapetinga, Bahia, showed that all interviewees make use of medicinal plants. Their predominant use relies on the leaves (87%) and most of it is done by infusion (70%). The efficacy of the treatment with medicinal plants was rated as moderate by most of the users sampled (59%) (SANTOS, FREITAS, *et al.*, 2014). Similar results were found at different regions (CUNHA LIMA, RIDRIGUES, *et al.*, 2008).

Another survey developed at a rural community in the municipality of Caicó, Rio Grande do Norte state, pointed out 62 species used in the region. *Aroeira* and *Cumaru* were found to be the most common species for therapeutic use (ROQUE, ROCHA e LOIOLA, 2010). Another study in the municipal district of Jequié, located in a transition area between the *Caatinga* and the Atlantic forest, in the state of Bahia, described the diversity of medicinal plants commercialized in free markets. They were 22 species from 10 botanical families, being the most representative in number of species the Caesalpiniaceae, Asteraceae e Lamiaceae (SILVA, SOUZA, *et al.*, 2006).

EMBRAPA (EMBRAPA) highlights the following medicinal plants used in the *Sertão*: *amburana de cheiro* or *cumarú* (Amburana cearensis), *pata de vaca* or *mororo* (Bauhinia cheilantha), *catingueira* (Poincianella pyramidalis), *imburana de cambão* (Commiphora leptophloeos), *alecrim pimenta* (Lippia sidoides), *jurema preta* (Mimosa tenuiflora),

*aroeira* (Myracrodruon urundeuva), *barauna* (Schinopsis brasiliensis), *umbu* (Spondias tuberosa), *quixabeira* (Syderoxylum obtusifolium) and *juazeiro* (Ziziphus joazeiro). The most common therapeutic indications for these species are diabetes, headaches, hemorrhages, gastritides, ulcers, maldigestion, dysentery, urinary tract problems, flu, coughs, colds, asthma, bronchitis, colic, rheumatism and constipation. They are also used as anti-inflammatory, healing, astringent, febrifuge, vermifuge, laxative, analgesic, soothing, sedative, hypotensive, antiallergic, antitumor and diuretic.

**Figure 14- Caatinga resource for medicinal use**

Nevertheless, formal or informal trade poses a serious risk to plant populations, since often people involved in collecting this resource are uncommitted or unaware of the proper techniques for obtaining the desired product without harming populations. Among these plants are worth stressing the *aroeira, mulungu, baraúna, angico* and *imburana-de-odor*. Some elements are considered capable of compromising the future existence of these plants: 1. intense consumption; 2. absence of crops or at least some form of propagation of such plants; 3. local markets and herbal products companies, which require a large amount of raw material; 4. unawareness of distribution and amplitude of the natural populations in which there is a strong economic interest; 5. absence of studies evaluating the impact of extractive techniques on the structure and biology of populations (ALBUQUERQUE e ANDRADE, 2002).

### *3.6.2 Tourism*

Tourism is a multi-sector productive activity based on human-environment relations, both in urban and rural areas. It is one of the main economic activities for several countries and it is perceived as a tool for sustainable development by many authors. Studies that show tourism as an activity that promotes local development have been developed

especially since the 1990s (SEABRA e PORTUGUEZ, 2014). Although the media focuses on green landscapes and beach paradises, there is a great potential yet to be explored in Semiarid lands. They are becoming more attractive for tourists, especially ecotourism and adventure tourism, with a growing interest in community-based-tourism and rural tourism, which is common in Semiarid regions, such as Argentina and Chilean Patagonia, the Atacama Desert, the United States Midwest National Parks, South Africa and the deserts of Morocco, Namibia, Tunisia, Egypt and Australia. In comparison, the BSA is less explored and not yet inserted in the touristic agenda. The lack of data available about tourism in the BSA from federal and local bodies as verified by the Ministry of Tourism and City tourist bodies witnesses the little attention given to this particular region, in spite of its recent modest tourism growth.

One of the major causes for the disparity above is the collective imagination in regards to what each of those places represent and how they are perceived. While the Namibia desert is viewed as a great exotic natural wonder, the *Sertão* is associated with poverty and death. But as communication means keep expanding, so are people´s interests in breaking taboos by visiting unexplored or less touristic explored areas, many located in less developed regions.

#### *3.6.2.1 Characterization of tourism in the BSA*

In the Brazilian Semiarid environment, the dominant morphological feature is the Sertaneja Depression (*Depressão Sertaneja*), drained by intermittent rivers. There are residual masses (*maciços residuais*) and sedimentary plateaus shattered by erosion, outlining scenic landscapes with rivers, streams, waterfalls, grottos, cut mountains, vegetation of different features, etc., that the modern interests have transformed into object of consumption. High plateaus and highland massifs (*planaltos e maciços com superficies elevadas*) with more than 600m are called "*brejos*", areas in which one finds average monthly temperatures below 20ºC in the winter season, due to the altitude and/ or exposure to humid winds. Its vegetation cover is constituted of sub humid forest and has been attracting tourists and people interested in living in the region (SELVA e COUTINHO, 2004). On this peculiar scenario, social practices are transforming the natural spaces through crops production, wineries, industries, handicrafts, cuisine, parties, etc, in which the human-environment relations add value to the already existing

significance of the scenic landscape of the Brazilian Semiarid, encouraging more tourists to visit the region.

So tourism in the BSA has incorporated the characteristics of the regional *Sertaneja* culture, with a focus on the local community (SEABRA, 2003; COUTINHO, NETO, *et al.*, 2005). The diversity of environments and landscapes has been shaped throughout the process of occupation and is reconfigured by the dualism of traditional economic activities and modern processes, the latter seen in the modern irrigated agriculture and faster and more accessible means of communication.

Tourism in the BSA combines an interactive leisure activity with the interior landscape, where the natural frame, the local culture and the integrated participation of the resident community are present. It is framed by an agrotourism and cultural profile, with a social base.

The rural space has been going through great changes, especially in the social relations of production and labor, as a result of the advance of capitalism in the countryside, promoting a conservative modernization of the rural area. The "new rural" incorporates the provision of services to the traditional agricultural practices, giving rise to rural tourism and agrotourism, which, according to Zimmermann, (1996) attracts its visitors not with the traditional comfort and activities found in major tourism agencies or in the already consolidated touristic routes. It does so by selling the opportunity of interacting with a different, marginalized reality or living a great adventure. This is achieved using local resources as attractions, such as the rural productive activity, access to the remote region, differentiated lodging, valuing the countryside landscape, its gastronomy and culture, and encouraging local-focused shopping, promoting a different image from the one related to climate impacts.

Some of the main touristic spots in the BSA are conservation units and heritage sites. There are hundreds of archaeological sites, caves and impressive geological formations. One can find prehistoric art still preserved in some of these sites.


**Figure 15- Vale dos Mestre archaeological site, Canindé de São Francisco, Alto Sertão de Sergipe, Brazil**

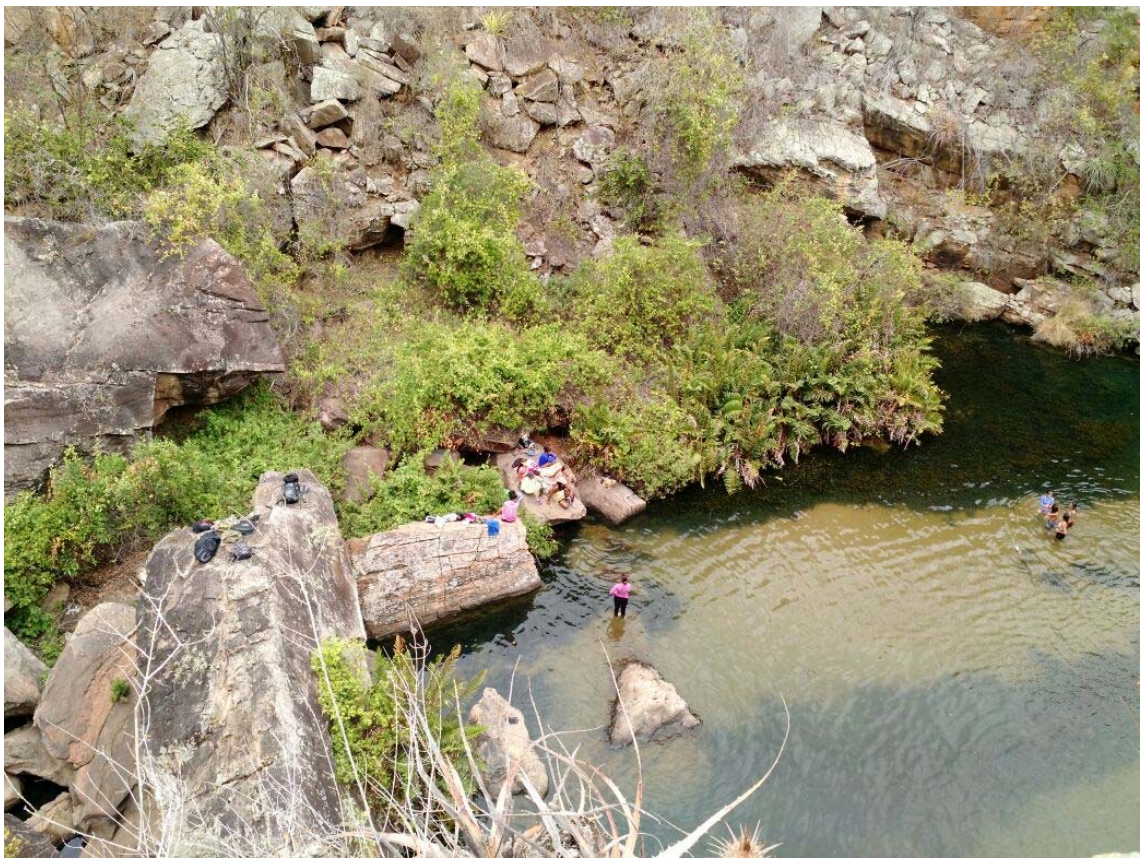

**Figure 16- Vale dos Mestre archaeological site, Canindé de São Francisco, Alto Sertão de Sergipe, Brazil**

Among the major touristic areas are the surroundings of the São Francisco river. The region of Xingó (Alagoas, Sergipe), especially the city of Piranhas, has been developing a touristic infrastructure to accommodate the growing visitors in the region. This historical site attracks people for it is where the notorious armed group led by the

"*cangaceiro Lampião*" lived. They were known for their violent robberies and "justice done by their hands" against the corrupted police and elite. For the interested public in history and archeology, in the "*Boqueirão*" site rests the first reliable manifestations of rock art discovered so far (Guidon, 1991 as cited in Etchevarne, 1999-2000). Other natural attractions discovered by tourists are the *Cariri paraibano*, in particular the "*Lajedo do Pai Mateus*", situated in the *Cabaceiras* municipality, in the Paraíba state. At the same region, in the Borborema plateau, it takes place one of the ten biggest events in Brazil known as "*Maior São João do Mundo*", a traditional folk party.

When a site becomes a touristic attraction, its commercial exploitation and predatory use is triggered and in the absence of a strategic planning, chances are that it will lead to its depletion. One site at risk is *Casa da Pedra*, one of the largest Brazilian caves, carved out over millions of years in marble, located in the mountain town of Martins, Rio Grande do Norte.

# 4 PUBLIC POLICIES

Official public policies focused on the challenges of the Semiarid region only began with the creation of an imperial commission assembled by Dom Pedro II[9] to deal with the "Great Drought" of 1877 (CAMPOS, 2014; BARRETO, 2009), despite the fact that severe droughts and its consequences had been reported since 1580. In the years leading up to the Great Drought, the risk posed by droughts to the economic viability of the recently established white population and cattle farmers became more prominent. As a result, politicians and intellectuals began to pay closer attention to these issues and placed the subject in the government`s agenda (CAMPOS, 2014; SILVA, 2007).

Since then, many public policies have been established with the purpose to address droughts in the Semiarid Northeast, at first, but incorporating other aspects within time. They are gathered bellow in three historical periods, introduced by two previous phases, mostly according to Andrade (1970), Carvalho (1988), Magalhães & Glantz (1992), and Campos (2014). The previous phases are contextualized bellow in the items 4.1 and 4.2.

[9] Dom Pedro II was the Brazilian Emperor from 1840 to 1889.

## 4.1 Contextualization: the first information about the Semiarid (1583- 1848)

The difficult access to the hinterlands caused them to remain unknown by the Portuguese colonizers for the first centuries. Therefore, the *Sertão* was inhabited by indigenous groups until mid-17$^{th}$ (BARRETO, 2009). Information about the Semiarid region was mostly accounted or registered by jesuits. Priest Cardim registered the consequences of the 1580 drought in several sugar mills and cassava farms and the migration of between 4,000 and 5,000 indigenous from the *Sertão* in search for food (CARDIM, 1939). Similar drought consequences had also been reported by land owners (*capitão-mor*), whose slaves and crops were unable to survive.

The gradually occupation by the colonizers after the 17th century resulted in a chronological increasingly enduring character of registered droughts and its social and environmental impact. Population increase was not accompanied by the required infrastructure which contributed to distress the social-ecological system of the BSA.

The colonial government did not engage in formulating public policies for the Semiarid Northeast at the time, as documented in official letters. Rather different, the situation was perceived as a result of native unwillingness to properly work and determined a fine for whose fields weren't producing cassava flour (CAMPOS, 2014). The gradually white demographic occupation and cattle farming threaten by the droughts placed the subject in the government agenda in the following period.

## 4.2 Contextualization: Construction of knowledge (1849-77)

In 1849, Emperor Dom Pedro II initiated round sessions about national problems conducted by the *Instituto Histórico e Geográfico Brasileiro* (IHGB, Brazilian Geographic and Historic Institute). From those debates, a first Imperial Commission was designed (1859) to acquire knowledge about the hinterland and other inhospitable territories of Brazil. Their results presented several of the socio-economic consequences of droughts seen in the Semiarid region. These were discussed between the 1860s and 1880s and exposed in multiple channels like media, public institutions and literature. During the sessions, they were interpreted in different ways by the commission.

Part considered the BSA unworthy of assistance, once the problem lied on a wasteful and lazy population who were living on a fertile land. This share of the scientific commission pointed out the human responsibility in degrading the environment and therefore causing or worsening the droughts.

Another group perceived droughts as a serious social problem which deserved an effective government action, consisting of constructions and assistance. Some proposed to relocate population and cattle when drought season came, and to distribute provisions for farmers without work (CAMPOS, 2014). They interpreted the difficulties faced in the *Sertão* as a national problem and suggested proposals for coexisting with the drought. As droughts were considered by them as a human problem, the Semiarid was a possible and perhaps desirable place to live, in contrast with the image associated to the region in the XX century.

### 4.3 Hydraulic construction phase (1877-1958)

Three years of severe drought between 1877 and 1879 displaced hundreds of thousands of people from the *Sertão* towards less affected places. In the capital of the Ceará province (Fortaleza), hungry families went door to door asking for water, food, clothes or invading plantations. Groups of starving people looted deposits of government supplies in and out of the city. It is estimated that about five hundred thousand people died as a result of the drought of 1877 (BARRETO, 2009; CAMPOS, 2014). The tragedy remains in the popular imagination until the present.

This event is known as the “Great Drought" and it urged the government to acknowledge droughts as a national problem (CAMPOS, 2014). Dom Pedro II designed a second imperial commission to present water supply means to the population and cattle beyond irrigation systems (GUERRA, 1981 as cited in CAMPOS, 2014). The outcome was the establishment of governmental institutions and several proposals of infrastructure construction.

The first governmental institution to deal with the adversities in the BSA was created in 1909 as the *Inspetoria de Obras Contra as Secas* (IOCS, Work Inspection Sector Against the Drought) and later renamed *Inspetoria Federal de Obras contra as Secas* (IFOCS,

Federal Work Inspection Sector Against the Drought). It was based on a technical hydraulic engineering management. Until 1945, they had built 7,136 km of highway, 2,303 wells (ALVAGONZALEZ, 1981) and, between 1909 and 1950, 133 public dams and 317 dams in cooperation with private landowners (MI, 2005). In 1945, the National Department of Work Against Drought (DNOCS) replaced the IFOCS.

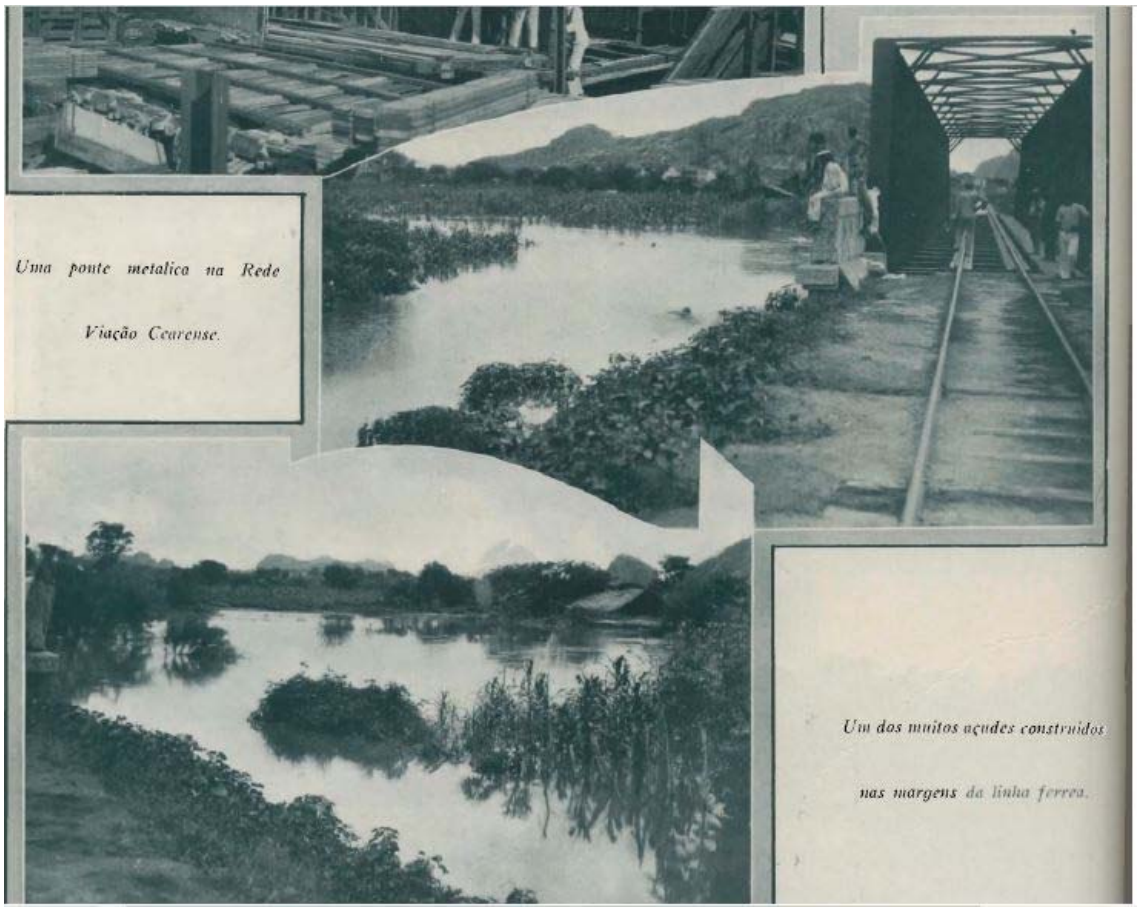


**Figure 17- Railroad of the Ceará State, built by IFOCS**

**Source: Revista Ilustração Brasileira, 1942, em Crônicas Taipuenses (2017)**

The three institutions referred above were focused on engineering solutions to store water, although not a consensus among politicians (MI, 2005). The hydraulic solution present in political discourses was used to justify the financial flow that accompany these constructions, which not rarely favored local elites and clientelistic relations.

The transition to the next phase was triggered by the establishment of the *Grupo de Trabalho para o Desenvolvimento do Nordeste* (GTDN, Working Group for the Northeast Development) in 1958 and its questioning regarding the roots of the Northeast "underdevelopment", moving it from a climate-related to a socio-economic perspective.

## 4.4 Regional development (1959-1991)

Regional development was promoted all around Brazil during this period. In the Semiarid region, it was emphasized by institutions, programs and projects over two stages: economic development, from 1950 to 1970, and social economic development, from 1970 to 1991. Policies for the BSA were related to the GTDN strategies and irrigation processes, the latter promoted mostly in the 1960s and 1970s (SUASSUNA, 2002).

The 1950's brought last longing institutions to promote the economical development, based on regional development. In 1952, the Banco do Nordeste (BNB, Northeast Bank) was created to promote development in the Northeast through financial support for regional producers and "to plan and implement a genuine development program, according to local peculiarities" (SISTEMA FIEC, 2014).

Embedded in the industrialization economic development theories of the time, specially the Economic Commission for Latin America (ECLA), the GTDN brought forth the Superintendence for the Development of the Northeast (SUDENE) in 1959, with the purpose of matching the Northeast conditions to the South-Central region by developing an advanced industrial sector. SUDENE was responsible for creating and executing several "special programs" in the 1970s to promote irrigation in the Northeast, reinforced by the *Programa Nacional de Irrigação* (PRONI, National Irrigation Program) and the *Companhia de Desenvolvimento dos Vales do São Francisco e do Parnaíba* (CODEVASF, San Francisco Valley Development Company), both created in 1974.

CODEVASF is a public company under the Ministry of National Integration conceived to: I) promote the development and revitalization of the San Francisco, Parnaíba, Itapecuru and Mearim river basins through sustainable use of natural resources and II) to structure productive activities for economic and social inclusion. It has been closely working with DNOCS and BNB and a list of their activities and achievements can be found at the Results and Discussion section.

The irrigation system particularly benefitted the region of the San Francisco river due to irrigation facilities when compared to the rest of the Semiarid hinterlands. The

government invested in cattle and crop farming irrigated modern poles intended to export its production, specially fruits, successful in building a fruit-agro-industrial export pole.

Relevant programs created in the 1970's by SUDENE include the *Programa de Redistribuicão de Terras e de Estímulo à Agro-indústria do Norte e do Nordeste* (PROTERRA, Land Redistribution Program to Encourage North-Northeast Agriculture), to promote irrigation in the Northeast; the *Programa de Desenvolvimento de Áreas integradas do Nordeste* (POLONORDESTE, Northeast Integrated Areas Development Program), directed to the development of selected wetlands; and the *Programa Especial de Apoio ao Desenvolvimento da Região Semi-Árida do Nordeste* (Sertanejo Project, Special Support Program for Development of the Northeast Semiarid region).

Despite those programs, the 1979-83 drought exposed how levels of poverty remained as serious as before, if not worst, so that the "special programs" were reevaluated into a rural development strategy that culminated in the Northeast Project in the 1980s. It resulted from the efforts done by the federal and state governments oriented to strengthen the Semiarid economy and was supported by the World Bank (MI, 2005).

The first direct policy towards family farmers[10] occurred under the Northeast Project. The project was intended to assist small farmers to have access to irrigation, education, health and sanitation in rural areas through several specific sub-projects, including the *Programa de Apoio ao Pequeno Produtor Rural no Nordeste* (PAPP, Small Rural Producers Support Program). Nevertheless, rural credit only reached large- scale producers.

The 1988 Federal Constitution increased resources and offered greater autonomy to states and municipalities, decentralizing decisions and once again emphasizing regional development as such that inequality reduction was established as a fundamental objective of the Republic (art. 3). Notwithstanding, fiscal budgets and State investments in regionalization which were supposed to allocate resources according to popular criteria did not work because this process was not regulated by the Congress.

[10] The term Family farmers substituted "Small rural farmers" in the 1980s.

## 4.5 Towards a more sustainable development: relative power decentralization and social safety mechanisms (1992- 2010)

Sustainable development in Brazil was boosted by the United Nations Conference on Environment and Development (Rio- 92), held in June, 1992, in Rio de Janeiro, and the International Conference on Impacts of Climate Variations and Sustainable Development in Semiarid Regions (ICID), held in Fortaleza, also in 1992. They contributed to introduce the concept in the Northeast region (IICA; MI, 1993- 1997) which set the tone for the following actions (and reactions) from civil society and government.

The relative power decentralization occurred mainly through two channels. First, changes in the Federal Constitution increased social participation and offered more autonomy to states in decision making processes. The constitution contributed to boost water co-management, defining the criteria for granting water use rights involving various stakeholders such as councils, committees and basin agencies at the same time that the national system of water co- management was reinforced by the National Policy for Hydric Resources (1997).

Secondly, civil society and political efforts combined gave rise to a new (sustainable) development strategy for the Northeast, with elements related to the essence of the coexistence with the Semiarid (MI, 2005).

The Áridas Project (1993) was a governmental response to the several previous unsuccessful programs (IICA; MI, 1993- 1997) spurred by organized rural workers, associations, cooperatives and NGOs who had occupied SUDENE's building as a reaction to the 1992 drought effects and policies, demanding the central government to development a permanent plan of action for the Semiarid (SILVA, 2007). It was a similar proposal to the GTDN in terms of land restructuring and, in addition, suggested a set of measures for demographic and productive occupation compatible with the carrying capacity of land and water resources (FUNDAÇÃO GRUPO ESQUEL BRASIL, 2014). It resulted in 54 thematic reports, various plans and programs (MI, 2005).

In 1996, the government launched a rural credit line program for farmers, the *Programa Nacional de Fortalecimento da Agricultura Familiar* (PRONAF, National Program to

Strengthen Family Agriculture), and its subprogram named *Assistência Técnica e Extensão Rural* (ATER, Technical Assistance and Rural Extension). Rural Extension is a cooperative educational process towards rural communities focused on teaching agriculture methods, livestock and domestic economy. It is target to changing habits of the rural family to increase production, improve productivity and increase its income. It is supported by two instruments: technical assistance and rural credit lines. Both technical assistance and rural extension exist in Brazil since 1940s; among its changes we highlight the role of the technician and rural agent, before assigned as knowledge holder decision makers in comparison to a later social participatory approach.

The increased participation of civil society influenced governmental projects and new development concepts based on the coexistence with the Semiarid, as will be described in the next chapter. The 21 Brazilian agenda, prepared between 1997 and 2001, tried to internalize the coexistence with the Semiarid by proposing "to enable the farmer to deal with drought by encouraging the use of proven technologies which have been disseminated by research centers and non-governmental organizations with experience in the management of natural resources in Semiarid regions" (BRAZIL, 2002b, p. 78).

The Brazilian document proposed the combination of environmental activities with socio-economic initiatives and adopted the strategy of encouraging educational activities and bringing awareness in local population for the preservation and recovery of the *Caatinga*, while offering livelihood options and commercial species farming opportunities to improve the population income. In short, agenda 21 incorporated the traditional challenges of the Semiarid as: fighting poverty; ecosystem management and fight against desertification and drought; and water quality and management.

Several programs were nested according to those challenges, but focused on major topics as income redistribution (social packages) and water access (infrastructure constructions). Therefore, several of the ensuing projects embodied social safety net mechanisms.

The first relevant social safety development was the rural retirement granted by the Federal Constitution (but only implemented after 1992) guaranteeing the right to women and men rural workers to retire with the same conditions. This event was particularly important considering the low socio-economic conditions of family farmers, providing a

steady income that frequently supports the entire family, including the new generations. Furthermore, it was a recognition of female workers as farmers, that for decades had been farming along with their husbands and family, but were considered housewives, without a legal retirement pension.

Social safety programs include income transfer, housing, food, education, health and infrastructure such as: *Brasil sem Miséria (Fome Zero*, *Bolsa Família)*, *Bolsa Estiagem*, *Garantia Safra* (**Income transfer**); *Minha casa, minha vida* (**Housing**); *Programa de Aquisição de Alimentos* (PAA), *Programa Nacional de Fortalecimento da Agricultura Familiar* (Pronaf*)* (**Food**); *Ciência sem Fronteiras*, *Educa Mais Brasil*, *FIES*, *Fundeb*, *Jovem Aprendiz*, *Pronatec, ProUni* (**Education**); *Sistema Único de Saúde*, *Mais Médicos*, *Rede Cegonha, Saúde da Família*, *Farmácia Popular*, *Saúde não tem Preço* (**Health**); *Água para Todos*, and *Luz para Todos* (**Infrastructure**).

*Bolsa Estiagem* provides insurance against "drought by calamity" in the Northeast since 2004 and it is among several social income transferring programs first developed in the Fernando Henrique Cardoso (FHC) government, but extended during Lula´s presidency (Luis Ignácio Lula da Silva), after 2003. *Garantia Safra* started in 2002 providing temporary financial assistance to those farmers whose farming of selected products have been lost at least in 50% by drought or excessive rain (MDA) *Bolsa Família*, 2003, is the largest of those programs and consists in directly income transfer to families in extreme poverty or poverty contexts. All those programs are interconnected since Lula´s government, meaning citizens must be part of a federal unique registration –*Cadastro Único*– to receive benefits, sometimes demanding to be in or out of some of the other programs. As a counterpart, beneficiaries of the programs must have their children in school, keep their registration in the *Cadastro Único* updated as well as their medical agenda, especially in regards to vaccination.

The Coexisting with the Semiarid ideals became part of the policies in both FHC and Lula's presidencies, although unclear to what extend, if even was beyond political discourses. FHC created the "*Sertão Cidadão, Convivência com o Semiárido e Inclusão Social*" (Citizen *Sertão*, Coexisting with the Semiarid and Social Inclusion) program, proposing to develop permanent actions to increase education, income and health indicators. In order to do that, he proposed to develop a system for planning and managing

the BSA, which would monitor the spatial and temporal dynamics of ecological and socioeconomic systems of the area. It was also proposed a Dissemination Program for Appropriate Technologies for the Semiarid, focused on technological patterns changes and market insertion alternatives (SILVA, 2003).

The 2003 Brazilian new president, Lula, launched another program called *Programa de Desenvolvimento Integrado e Sustentável do Semi-Árido* (CONVIVER, Integrated Actions for Coexistence with the Semiarid), aimed at improving the lives of small farmers through sustainable development. The federal government priority was based on people's coexistence with droughts, once more, and its main actions were: crop insurance (minimum income to producers); the purchase of food by the federal government, guaranteeing income for farmers in the region; access to credit, investing in forage crops and the *Caatinga* management; a Food Card to purchase food; technical assistance and education for developing methodologies and technologies for coexisting with the Semiarid (BRASIL, 2009). With the creation of the National Integration Policy and Regional Development Board in 2004, the various actions of the government for the region began to be coordinated by it.

The National Institute for the Semiarid (INSA) was also created in 2004 as a Research Unit, part of the basic structure of the then *Ministério da Ciência e Tecnologia* Ministry of Science and Technology (MCT, Ministry of Science and Technology). It focuses on multiple issues concerning the Semiarid, including: the formation of a Development and Social Technology Center; Water Resource Management; Information and Knowledge Management; and Desertification and Climate Change in the Brazilian Semiarid. In partnership with the NGO Articulation of the Semiarid (ASA), they launched the project "Resilient Family Farming Systems to Extreme Environmental Events in the Context of the Brazilian Semiarid: alternatives to face the processes of desertification and climate change."

In 2005, the Ministry of Regional Development conceived the Strategic Plan for the Semiarid Sustainable Development (PDSA), through the *Política Nacional de Desenvolvimento Regional* (PNDR, National Policy for Regional Development) and assisted by former *Agência de Desenvolvimento do Nordeste* (ADENE, Northeast Development Agency). The plan is characterized as a support instrument to the National

Policy for Regional Development and it is described as "... a Strategy Plan, articulating actions that derived from different projects and programs for the Semiarid" (PDSA, p. 71, 2005).

**Table 4- Main achievements by DNOCS and partners between 1909–2013**

| Initiatives | Activities | Benefits |
|---|---|---|
| Hydraulic constructions | Construction of 328 public water reservoirs. | Total capacity of 25.8 billion $m^3$ of water. |
| | Construction of 622 reservoirs in cooperation with states, municipalities and private individuals. | Total accumulation capacity of 1.5 billion $m^3$ of water. |
| | Drilling and installation of 28,682 deep tubular public wells. | Utilization rate of 90%. |
| | Installation of 405 desalination plants. | |
| | Implementation of 177 public water supply systems in inland cities. | It benefited a population of 2 million inhabitants and provided water supply through state concessionaires to more than 5 million users. |
| | Installation of eight small hydropower plants in public dams. | Total nominal capacity of 10.3 MW. |
| | 4000 km of intermittent rivers into perennial rivers in the Northeastern semi-arid region, with an average of 100 $m^3/s$. | It allowed the irrigation of 65,000 ha (65%) for 18 million inhabitants (35%). |
| | Installation of 71,739 irrigable hectares through 38 irrigation projects. | 41,271 ha delivered for 7197 producers using small irrigation systems; 1090 ha for 66 agronomists; 864 ha for 67 agricultural technicians; and 20,097 ha for 335 agricultural companies. |
| | Use of upstream areas of 91 dams. | It enabled the exploitation of 75,462 ha by 15,552 families of small farmers. |
| | Construction of 1724 km in four regional pipelines in operation. | Designed to serve 1.6 million people. |
| | Construction of 4,878 cisterns. | |
| | Construction of the *Castanhão* dam. | |
| Fish-related initiatives | Construction and operation of 14 Fisheries Stations, a Research and Aquaculture Center. | They produced 45 million fingerlings and 700 thousand shrimp larvae in 2008. |
| | Construction of four fish farming stations (underway and/or in start-up). | With the potential to increase annual production capacity to 100 million fingerlings per year. |
| | Monitoring of fishing in 181 public dams. | Production of 17,583 tons of fish in 2008. |
| Transport infrastructure | Construction of 22,600 km of highways and 10 km of bridges. | |

| | |
|---|---|
| | Construction of 89 landing fields. |
| Basic services | Implementation of 795 km of electric power transmission lines. |

**Elaborated by the author, data from Araújo** (2013)

### 4.6 An update of the water reservoirs in the BSA- 2013- 2017

From 2015 to 2017, the *Agência Nacional de Águas* (ANA, National Water Agency) analysed 204 reservoirs in the BSA (which represent more than 80% of the storage capacity in the region) with a total storage capacity of more than 31 billion cubic meters of water. The analyzes indicate that only 85 of them are able to meet new demands and that 119 reservoirs are at the limit of their storage capacity. From the 204 reservoirs, 154 are water sources for urban water supply and 198 are for the rural population. 51 of these dams supply 43 irrigated perimeters of the region, corresponding to about 50,000 ha of irrigable area (AGÊNCIA NACIONAL DE ÁGUAS (ANA), 2017).

The reservoir systems - the main dams and their water systems - were gathered into five hydrographic basins: i) Apodi, Curimataú and Paraíba rivers (PB and RN); ii) Piancó-Piranhas-Açu (PB and RN); (iii) Jaguaribe (EC); iv) Acaraú, Curu, Pacoti and Parnaíba (EC and PI); and v) Capibaribe, Contas, Ipojuca, Jacuípe, Vaza-Barris and Affluent Basins of the São Francisco River located in Bahia, Minas Gerais and Pernambuco. The water balance was calculated according to the amount of water demanded by the users and the characteristics of the Semiarid, in addition to parameters related to the socioeconomic reality of the population. The types of uses identified in the study were: human supply, animal watering, irrigation, industrial supply and dilution of domestic and industrial effluents (AGÊNCIA NACIONAL DE ÁGUAS (ANA), 2017).

In the state of Paraíba, 123 water resorvoirs were monitored by the Executive Agency for Water Management of the State of Paraíba (Agência Executiva de Gestão das Águas do Estado da Paraíba- AESA) in 2013. 13 were in a critical situation (with less than 5% of their total volume), 35 are under observation (with less than 20% of their total volume), 74 have a capacity of more than 20% of the total capacity, but present a low level, and only 1 small reservoir (313,680 m³) is with the total capacity (ALVES e AZEVEDO, 2014).

# 5 SOCIAL MOBILIZATION: COEXISTING WITH THE SEMIARID

## 5.1 Coexisting with the Semiarid trajectory, obstacles and successes

Disagreement with implemented public policies related to climate variation, power abuse and (remote) family farmers of the BSA led to several social demonstrations in the 1980s and 1990s conducted by charity institutions, NGOs, unions, family farmers, activists and academics that worked in the region, resulting in the Coexisting with the Semiarid (CSA) paradigm and guidelines.

Coexisting with the Semiarid is defined by the *Instituto Regional da Pequena Agropecuária Apropriada* (IRPAA) as the lifestyle and production choices that respect the local knowledge and culture by using technologies and procedures appropriate to the environmental and climatic context. “It promotes diversity and harmony between communities and the environment, enabling a great quality of life and the possibility of family farmers to remain on their land, despite climatic variations” (IRPAA).

The CSA is a mosaic of claimings, from cherishing and respecting traditional knowledge to practical activities. Carvalho (2011) refers to a reinterpretation and re-appropriation of the Semiarid nature and culture, an attempt to rescue shared local values forgotten by the dominant elites and their policies. In this sense, it searches to deconstruct the hostility and negativity presented by communication channels based on negative impacts caused by droughts and the association of them as a meteorological anomaly, letting aside all other cultural aspects of the region.

Its guidelines are based on ideals of recapturing a territorial identity to express the peoples of the Semiarid through positive images of themselves, their culture and landscape, reframing territoriality by strengthening its roots and feeling of belonging (CARVALHO, 2011). At the same time, it emphasizes the cultural and geographical differences found in the BSA to stress that policies should be according to each region. Buainain & Garcia (2013) use geo-processing models of socioeconomic indicators by municipality to show the heterogeneity of the Brazilian Semiarid region, reassuring that rural poverty must be faced accordingly.

## 5.2 Guidelines, Projects and Coexisting solutions

As a result of discussions promoted by several stakeholders, 38 guidelines for coexisting with the Semiarid and oriented to public policies were established in 2013 (ARTICULAÇÃO DO SEMIÁRIDO BRASILEIRO (ASA); CARITAS BRASILEIRA; CONTAG; CPTFETAG-BA; CUT-PE; FETAG-ALFETASE; FETAG-AL; FETAPE; FETAG-BA; SABIÁ; ET AL., 2013). Their goal is to subsidize public policies (FETASE, 2013), therefore they are addressed as a political project by the Semiarid Articulation network (ASA).

They are divided in 10 topics: organization, management and funding; mapping, systematization and multiplication of social technologies; access to infrastructure; access to the land; protagonism of youth and women, their organization, job offers and income; technical assistance and rural extension; access to education; nutrition and food security; environment; and to value peoples and cultures. These guidelines subsidize and propose to support the creation of a Coexisting with the Semiarid National Policy (ARTICULAÇÃO DO SEMIÁRIDO BRASILEIRO (ASA); CARITAS BRASILEIRA; CONTAG; CPTFETAG-BA; CUT-PE; FETAG-ALFETASE; FETAG-AL; FETAPE; FETAG-BA; SABIÁ; ET AL., 2013).

The topics above aim to achieve several goals. The first is an appropriate land size to produce a variety of food and enough crops to survive the long dry season, and therefore to cope with climate change impacts. This is proposed through the establishment of collective areas. Another issue is to differentiate uses and priority for water. These are divided in the so called first water- to drink; second water- for agriculture and animals; third water- emergencies; and fourth water- community use. CSA guidelines also point out to the urgency in using a different periodization to calculate water reserve, animal food and bank credit other than year time, since it has to be according to the dry season period.

Another topic broadly debated across sectors refers to a contextualized education to highlight local aspects that are not mentioned in the conventional education system. Contextualized education brings the discussions in school closer to the issues experienced

by the students and their communities in their social practices. CSA also pursuits to guarantee women's autonomy and rights, modifying the secular patronal system in which women were considered subservient or had less legal rights then men.

Several networks and organizations were forged though the identity of coexistence, but there were previous ongoing projects which already carried shared principles of traditional knowledge and adapted elements for the Semiarid climate. Relevant institutions that have been working in the BSA are the *Instituto Regional da Pequena Agropecuária Apropriada*- IRPAA, Brazilian Cáritas, *Centro Sabiá, Caatinga* and *Associação Caatinga*. Among those institutions, the *Articulação Nacional do Semiárido*-ASA (Semiarid Articulation network) plays a pivotal role because it englobes several of the above mentioned organizations and many more.

ASA was born under the influence of the United Nations and as a result of discussions of approximately 50 NGOs in the late 1990s. It consists of more than three thousand civil society organizations and emphasizes the sustainable use and environmental recovery of the *Sertão* natural resources, and the end of access to land, water and other means of production monopoly (ASA). Their participation in the Third Session of the UN Conference of Parties Against Desertification (COP 3) in 1999 resulted in a "disruption of combating the drought policy" document, (ASA) entitled "Declaration of the Semiarid", and the establishment of the "Coexisting with the Semiarid Training and Social Mobilization Programme" (SILVA, 2003). The latter focused on promoting capacity building and coexistence with the environment, addressing aspects of water management, construction of tanks, citizenship and gender relations. They are put in action through the systematization of experiences and exchange between family farmers to promote a collective construction of knowledge.

There are four main projects developed by ASA, being the federal government engaged as a partner in the first two: *Programa Um Milhão de Cisternas* (P1MC, One Million Cisterns Program), *Programa Uma Terra e Duas Águas* (P1+2, One Land, Two Waters Program), "Cisterns at Schools" and "Seeds from the Semiarid" (2015). "One Million Cisterns" was formulated in 2003 to benefit about five million people in the Semiarid region with potable water for drinking and cooking, by building concrete cisterns and training local people to use them. It is intended for families earning up to half the

minimum wage per family member. Recently, government actions were conducted to substitute concrete cisterns for plastic ones, but several organizations protested against it on the streets and the changes were suspended. The “One land, two waters Program" is based on one water for human consumption and another water for food production, defining, that way, priorities in water usage.

These programs were set up to promote participatory processes in rural development in the Brazilian Semiarid region, to improve self-sufficiency and food and nutrition security. In addition, they seek to promote employment and income opportunities for family farmers (ASA).

CSA guidelines are put in practice through different activities in projects or simply by use in agriculture in various territories of the Semiarid region. They are referred to as “coexisting solutions” and are listed in table 6 below:

**Table 5- Solutions, systems, activities and achievements of the coexistence with the Semiarid**

| | |
|---|---|
| **Solutions** | Correct management/ use of soil |
| | Reduction of ruminant methane emissions |
| | Forestry management of the *Caatinga* |
| | Tillage (*lavoura*)- stockbreeding/animal husbandry (*pecuária*)- forestry integration |
| | Genetic improvement |
| | Rainwater collection and storage |
| | New productive systems adoption |
| | *Caatinga´*s plants productive potential usage |
| | Agro-ecological production |
| **Systems** | 16K L Cisterns made of pre modeled concrete for human and domestic consumption (*Cisterna de placa*)[11] |
| | 52K L Concrete cisterns for agriculture (*Cisterna Calçadão*) |
| | Canvas and cardboard cisterns |
| | Ecological ovens—using firewood, solar or sawdust |
| | Sustainable practices for production diversification (*quintal produtivo*) |
| | Native seeds storage for exchange (*sementes crioulas*) |
| | Inland wall up to 50 cm above surface in the contrary water course, leaving the land humid for up to 5 months (*barragem subterrânea*) |
| | Rock barriers (*barramento de pedra*) |
| | Non-irrigated cultivation (*cultivo de sequeiro*) |
| | Hotbed for good quality seeding |
| | Stone tank |
| | Popular water pump |
| | Exchanges between farmers |
| | Systematization of experiences |

[11] For details on how cisterns are built, please see (GOVERNO DO ESTADO DO CEARÁ, 2010; NUNES, 2011)

| | |
|---|---|
| **Activities** | Registration of families belonging to banks and community seed houses. |
| | Technical training, training of municipal commissions. |
| | Training in community management of seed diversity. |
| | Training in stock management of community seed banks. |
| | Territorial training on seed selection, production and multiplication. |
| | Regional training of teams. |
| | Exchange visits. |
| | Implementation of banks and seed houses. |
| | Training and mobilization of people for protecting the Semiarid, demystifying and combating the ideas and practices of the drought industry. |
| | Family farming as a proposal of good practice for sustainable and inclusive development, including the recycling and reuse of inputs from the property, previously ignored. |
| | Implementation of about 350 agroecological stoves; 30 biowater (*Bioáguas*) and at least 100 Agroforestry Systems initiated. These technologies are disseminated through the councils and other public policy fora. |
| **Achievements** | 143 municipalities of the Semiarid were benefited with rural cisterns between 2009 and 2011. In total, 603,348 rural cisterns in family farmers' houses were implemented until 10 July 2017, from the "One Million Cisterns" program in partnership with the Brazilian government. |
| | 4,725 cisterns in rural schools were installed until 10 July 2017, from the "Cisterns at Schools" program. |
| | 94,468 technologies of family use, 1,318 technologies of community use until 10 July 2017, from the "One Land, Two Waters" program in partnership with the Brazilian government. |
| | 663 seeds houses (*casas de sementes*) until 10 July 2017, from the "Seeds from the Semiarid" program. |
| | Regarding territorial governance, Participation in the Management of Common Pool Resources (PMCPR)—including Family Seed Reserves (FSR), Community Seed Banks (CSB), Rotating Solidarity Funds (RSF), and collective Fruit Processing-experienced, indicators have shown an average positive change of 49%. Involvement in Spaces of Political Organization (ISPO) showed an average positive change of 28% (PÉREZ-MARIN, ROGÉ, *et al.*, 2017) |

Source: (MACHADO e ROVERE, 2018, data retrieved from Carvalho, 2017, and ASA)

The "coexisting solutions" are a set of sustainable actions and principles that mixes traditional and scientific knowledge. They were contemplated for the Semiarid environmental system with the potential to reduce the *Sertão*'s social-ecological vulnerability. Lately, many researchers started to refer to these activities and principles as "Living in the Semiarid" instead of "Coexisting with the Semiarid".

General principles behind the coexisting solutions are the correct management and use of soil, the reduction of ruminant methane emissions, forestry management of the *Caatinga*, genetic improvement, rainwater collection and storage, new productive systems´ adoption, agro-ecological production and *Caatinga*`s plants productive potential usage.

The following chapter is dedicated to discuss "development", considering that policies promoted by the government and the activities of the CSA are based on different

development ideas and are, at the same time, part of the development of the Brazilian Semiarid region.

# 6 DEVELOPMENT AND CLIMATE CHANGE IN THE *SERTÃO*

"Development" is an ongoing concept that carries a different meaning in each place and in each historical period of society. It is multidimensional and therefore understood from different approaches taking into account cultural, economic, social, environmental and political transformations.

As a conceptual framework, one can find multiple definitions of development in which the same variables are present but in distinct levels of priorities. Divergence is related to the multiple stakeholders interested in discussing development with different views on its meaning and how to achieve it.

The concept of development is influenced by a set of variables combined in different periods: economy, technology, availability of natural resources, employment, infrastructure, media, cultural behavior, institutions and so on. According to the priorities given to each variable, the concept is mainly State oriented, Market oriented or with the development of alternative approaches, Human or Environmental focused. There are different ideologies behind each one of them, and the following questions help us to identify those: (1) who determines what development means; (2) who benefits from the concept of development/ - who holds the knowledge, what knowledge is interested to be disclosed and to whom; (3) what are the variables that influence the concept of development; 4) what is the role of the State, the market and the society; 5) What are the development indicators; (6) what is the relation between the discourse of development and the dominant powers (hegemonic power).

Those questions are not intended to be answered during this work, but to serve as a provocation to reflection. They lead us to shifts in perceptions of what represents development. New stages of development bring along new obstacles to society, other routines, and leeds people to reevaluate their priorities. Simultaneously, it establishes new technological standards bringing facilities that make it possible for people to redirect their concerns to other issues.

Development proposals to fight poverty respecting the limits of the environment emerged with greater impetus in the 1970s, when the term "eco-development" was coined by the Secretary General of the 1972 Stockholm Conference of the Human Environment, Maurice Strong, as an alternative form of economic development instead of economic growth (MELLOS, 1988). This term was later reformulated to "sustainable development" in the Brundtland Report entitled "Our Common Future", and expressed as: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT, 1987).

Such definition aimed to analyze the conjunction of economic efficiency, social justice and ecological prudence from a holistic perspective, recognizing the distinct historical responsibilities of countries, to propose an alternative model of development from what had been implemented. Alternative development models were grounded on the evidence that economic growth and increased competition have frequently resulted in negative impact on the environment, as seen along history (ANGELSTAM, ANDERSSON, *et al.*, 2013). In that sense, homogeneous development proposals focused on economic growth presented as the solution to the so called undeveloped or developing countries were being challenged by new perspectives, adding several other aspects to the equation.

These ideas have not always been concerned with climate change, in fact, the topic was introduced in parallel with the international climatic discussions after the 1980s. Therefore, it is not desirable to discuss development in the Northeast Semiarid region without further examining how the development debate unfolded in the rest of the world.

## 6.1 The Debate on Development

Until 1945, the development debate revolved around international relations between countries. The main theories and debates before 1945 that have contributed to the formation of the concept of development are inserted in the following arenas and respective thinkers: Competitive capitalism (1700-1860)- Adam Smith, Malthus, David Ricardo, Marx, Engels; Imperialism (1860-1945)- Marshall, Walras, Jevons; and Classical Imperialism- Hilferding, Bukharin, Luxemburg and Lenin (LARRAIN, 1989).

The assumptions that supported the different concepts of development during the twentieth century came mostly from the idea of progress in the XVII and XVIII centuries and by the hypotheses developed by theorists of political economy, particularly Adam Smith and Karl Marx. By mid-nineteenth, progress was related to the notion of social evolution, which classified societies according to their "levels" and "degrees of advances" (NISBET, 1969). Development was, then, associated to the diseases of progress, such as population (Malthus), loss of employment (for Luddites) or social issues (Marx), specially in England (PIETERSE, 2001). Progress and social evolution were related to modernization and its diffusion in theoretical thought of the twentieth century, and very connected to technical progress (PREBISCH, 2012).

Development theorist Smith was concerned with the role of the market. The self-regulating market optimizes the production of all parts and leads to the maximum accumulation of wealth. He argued that the free market, through the perfect competition generated by the invisible hand, would balance the supply and demand curves, optimizing, through this self-regulation system, the market itself. Inequality is seen as an incentive to work and to enrichment, where social justice and equity would be achieved through economic progress. Progress is seen in 4 stages as an account of economic and social development: The Age of Hunters; the Age of Shepherds; the Age of Agriculture; and the Age of Commerce (SMITH, 1976; SMITH, 1978; BREWER, 2008). Pre-capitalist societies were identified as those living of subsistence agriculture.

In Marxist terms, the stages represent a transition from feudalism to capitalism (BREWER, 2008). Marx´s view differs from Smith as he understood this process to lead to the alienation of the proletarians and the loss of their freedom, as they would have no choice but to sell their workforce to the market. Work becomes more specialized and divided, resulting in a distance between the worker and what he produces, as such that he is unable to recognize himself in the final product of his effort. The worker eventually becomes a repetitive machine, in a system where this person, usually, does not have access to the product of his own work. Thus, what begins with a division of labor, ends up also being configured as a social division. His theories were developed at the time of the rise of capitalism.

Until 1850s, within the logic of progress and capitalism, the countries were part of a colonial economy, based on resource management and export of raw material (PIETERSE, 2001). The industrial revolution changed the paradigm of development. The industrial development undermined the work made by craftsmen, as the products were delivered faster through the factories. The working day was intense with low wage levels; profits were destined for the bourgeois in an accumulation of wealth at a much greater speed than hitherto seen. So production processes became much faster and increased the flow of products on the market to the detriment of the social conditions of workers (PIETERSE, 2001).

Development, then, was associated with the increase of productivity, with quantity, to the idea of efficiency, speed and improvement of productive capacity through energy discoveries, grounded on the Industrial and Green Revolutions. This lastedfor the first half of the XXth century. Gradually, it became connected with the local context and valorization of the workforce and quantity was redirected to quality.

The development debate as known today is a product of the end of World War II. It is considered that prior to this moment, denominated the modern development thinking era, development practices occurred without the term being effectively applied (PIETERSE, 2001).

The post-war developmental debate occurred through the following theories and concepts: modernization theory (and take-off theory); the structuralism of the ECLAC school, highlighting unequal trade theory; dependency theory; eco-development; alternative development (1970); human development (1980); neoliberalism (1980); post development (1990); sustainable development (1990-2010); green economy (2000-2010); shared economy; welfare economics (alternative indicators). We won´t discuss all of these theories, but will highlight the main arguments that influenced the development debate.

Discussions about development started in the context of the post-war due to the necessity of reconstruct the European periphery, a region that was facing problems similar to other peripheries (SACHS, 2008). It regarded the relative economic delay of some countries and their various levels and diversification of international consumption. The dominant

neoclassical thought at the time insisted that economic growth, which was used as a synonym to development, would occur through adoption of economic practices based on national comparative advantages. One of the main theories embedded in this assumption was Modernization theory, proposing economic growth through five stages, known as the take- off theory, where the take-off would be led by punctual sectors at first, according to Rostow's Stages of Economic Growth model (ROSTOW, 1960). The concept of modernization addresses a supposed process of evolution that societies go through, leaving a traditional condition and evolving into a modern society with a higher degree of industrialization, urbanization and technology. Therefore, it emphasizes the traditional-modern dichotomy. It is an analysis of society based on stages of evolution found on Darwin. This is the foundation of what is considered the mainstream development, based on economic growth and liberalization, the latter being the case since the 1980s. But even that has its variations, although commonly simplified as a homogeneous thrust, which we won´t be able to discuss here. In any case, the following theories are very much a response to this.

In the 1950s, Latin American economists of the Economic Commission for Latin America and the Caribbean (ECLAC) questioned such precepts which imposed Latin America the role of commodity exporters. By analysing the power structures behind trading, one of its leading exponents, Raul Prebisch, suggested that the international economy was divided into center and periphery, based on the international division of labour reinforced by the Industrial Revolution. He argued that the liberal assumptions led to the deterioration of terms of trade, a falling tendency in relative prices of commodities in the international trade and an unequal distribution of the benefits of technical progress, which in turn resulted in a structural imbalance. This was called “perverse development” by ECLAC. According to the neo-developmental theory proposed by ECLAC, development was achieved through an economic policy with strong State intervention based on the growth of industrial production and infrastructure, which would lead to increased consumption.

Similarly, the dependency theory in the 1960s proposed that underdevelopment was a result of the domination carried out through structural patterns which asymmetrically connected the peripheral to the central economies. Dependency theory suggested that domination happened between countries and between classes and pointed out that a Reformer-State was not the solution to overcome underdevelopment, as suggested by

ECLAC. Both ECLAC and the Dependentists did not question the idea of development itself, only the uneven distribution (ROVERE, 1992).

Pollution and the consequences of using pesticides indiscriminately became an environmental concern from the 1960s on, seen as health-destroying agents. The unsustainable and inadequate use of resources associated with social disparities and economic distress contributed to the development crisis that emerged in the 1970s. The environment has always been a development issue, since society has always had to deal with the constraints of natural resources and with the adversities and opportunities provided in each region. Nevertheless, it was incorporated into the development discourse as a limitation to future development in the 1960s and 1970s.

Social and economic conditions that conduced to the development crisis also led to the emergence of an alternative development theory moving away from market forces and GDP growth indicators. Overall, alternative development has been concerned with alternative practices, with local development, participation of the community and people-centered. It emphasizes people´s capacity to effect social change, although much of the debate takes place around its role and what the real differences to main stream development would be. Along with the several alternative theories that emerged under the alternative development perspective, Pieterse identifies some tendencies worth highlighting: to represent alternative development as a counterpoint that unites dissident forces; and to equate development with modernization and alternative development with de-modernization or anti-development (PIETERSE, 1998).

Two other concepts emerged in the developmental debates during the crisis of the 1970s. The first, “perverse development”, was mostly employed by the developmentists to define the negative aspects of development. The structural distortions were considered to be caused by technological-industrial civilization patterns. The second was launched at the Stockholm conference by Strong and Sachs, named eco-development, having a strong parallel to alternative development.

Eco-development was based on the following assumptions: (1) oriented to meet the needs of the population and not subjected to the logic of production; (2) real autonomy of population decisions (endogenous); and (3) highlighting the ecological dimension. This

paradigm criticizes evolutionary ideas, particularly the waste of resources in the industrialized regions, and states that there are no universal models of development. It condemns evolutionists and their unsustainable industrial processes, in addition to undesirable technological-industrial standard. The concept also includes economic, social and environmental objectives at three levels: social demand, which should be a consumption policy; social provision, to allow production choices (social offer: choice of technology, low-profile energy demand and natural resources, and industrial decentralization); and environmental management.

The very use of the word development was re-thought by Sachs. He proposed that countries should no longer be classified as developed or developing on the grounds that these are associated with pre-defined stages to be achieved (SACHS, 2008).

There were several critiques towards these theories. Glaeser and Vyasulu, two of the critics of the eco-development, pointed out the difficulties of overcoming the social impasses. Cardoso questioned who the subjects of transformation would be, the same line of question used towards ECLAC. Sunkel concerns were related to the means in which popular control of policy formulation would be held in Latin America while Amin questioned the viability of alternative development within a capitalist system based on the international division of labor (ROVERE, 1992).

The term "eco-development" was extended and replaced by "Sustainable Development"[12] with the launch of the Brundtland Report, in 1987. It incorporated three new aspects to development- technological, cultural and political- to the already existing economic, social and environmental. For the so called Third World countries, this new conceptualization brought a development contradiction: to raise funds, these governments would facilitate the establishment of industries from other nations that for environmental concerns had restrictions in implementing them in their own countries. In the developing countries, environmental laws were more flexible and labor requirements lower. So pollution became a new market itself, in which governments sought to attract investment through the slogan "Come to pollute here".

[12] Nevertheless, Sachs applies both terms as synonymous; see footnote 2 from “Estratégias de Transição para o Século XXI”, 1993, p.12.

Still in the 1980s, the theory of Endogenous Development arises in opposition to the classic models of growth, and affirms that development is related to the use, execution and valorization of local resources and to the capacity to control the process of accumulation through the use of available resources and the introduction of innovations. It consists of endogenizing a series of previously exogenous variables (such as human capital, the environment, etc) (GAROFOLI, 1992). Barquero (2007) argues that endogenous development theory unites several views of development, such as self-centred development, human development, sustainable development or bottom-up development.

The general effects of what had hitherto been understood as progress and development resulted in the deterioration of the quality of life, air and water pollution, traffic in the urban areas and stress, which led to a transformation in people's perception of housing in the city. When society bought the idea of sustainable development, several wellbeing parameters changed. To be close to the big urban centers started to carry a negative meaning related to stress, violence, noise and pollution.

Development was related to the productive capacity (through industrialization), energy sources, and chemical products in agriculture which pushed the green revolution. Those same advances previously considered as progress have slowly become causes of maladies in the eyes of society, as people became better informed of their effects in the various domains. In the environmental sphere, the society started noticing the destruction of natural resources, the effects on the soil, such as infertility, the impacts on the ozone layer and the greater scarcity of water. In the economic field, industrialized products fabricated by large multinationals invaded national-local markets, same as with mass social production in less developed countries. Culture became pasteurized, processed, homogenized, a cult of hegemonic mass culture to the detriment of local culture.

## 6.2 Climate Change and Development

Growing human influence on biophysical processes have led to many perceived environmental problems, specially as a result of the Industrial Revolution’s new production system. They were significantly introduced in the develop debate from the second half of the twentieth century, notwithstanding, it was not until the late 1980s that

climate change emerged as a central issue in the global discourse on environment and development, relating emissions of CO2 eq.[13] to the current economic growth patterns.

Several national and international agencies, organizations and programs were created to address the growing concerns about global warming, based on the evidence that the carrying capacity of our planet was overloaded by the current production and consumption paradigm. These organizations and tools are meant to guide national and global public policy regarding the use of natural resources and mitigation and adaptation measures related to greenhouse gases. They represent an acknowledgement of the scientific community to the unsustainable growth and natural resource depletion model carried out since the Industrial Revolution.

The United Nations Environment Programme (UNEP), established in 1972, and the World Meteorological Organization, created in 1950, launched the Intergovernmental Panel on Climate Change (IPCC) in 1988 to provide relevant scientific information on climate change and its potential environmental and socioeconomic impacts. IPCC had a decisively participation in the development of another instrument, the United Nations Framework Convention on Climate Change (UNFCCC), which resulted from the United Nations Conference on Environment and Development (UNCED) in 1992 and started operating on March, 21st, 1994.

Another important result of UNCED, also known as Rio 92, was the document entitled Agenda 21, which consists of a plan of action in the global, national and local levels to achieve sustainable development (UNITED NATIONS CONFERENCE ON ENVIRONMENT & DEVELOPMENT, 1992). Agenda 21 was conceived as an instrument to support an action plan and a participatory planning, whose priorities can be characterized as social inclusion programs; access to education and health; and income distribution. The document was created in the context of new development theories and

[13] $CO_2$ eq is a measure used to compare the emissions of various greenhouse gases based on the global warming potential of each (IPCC) (ORGANISATION FOR ECONOMIC COOPERATION AND DEVELOPMENT (OECD), 2001).

social and political demonstration movements from the 90's, right after the "lost decade"[14], generating guidelines aligned with the sustainable development precepts.

During Rio 92, two other major challenges to achieve sustainable development were also diagnosed: the desertification process and biodiversity loss, resulting in the Convention on Biological Diversity (CBD) in 1992, and the United Nations Convention to Combat Desertification and Mitigating the Effects of Drought (UNCCD) in 1994. The latter was developed to address the arid, Semiarid and sub-humid areas, known as drylands, where some of the most vulnerable ecosystems and populations are located (UNCCD).

All these organizations and conferences have increased climate change global relevance at the same time that they were the product of the growing concerns around the topic. Climate change emerged in the academic debate and was gradually incorporated into the discourse on fighting poverty and development strategies. The general perception was that developing countries are hurt the most by climate change as climate change hits the poor hardest. Therefore, future climatic scenarios should be considered to achieve successful development proposals. But are they in the development models applied in the Brazilian Semiarid?

## 6.3 Models of Development in the Sertão: The Agro-industrial model X Climate-compatible development strategies (Coexisting with the Semiarid)

Development processes in Brazil are generally characterized by a lack of planning and depletion of natural resources, resulting in several negative social impacts. Between the nineteenth century and 1930, Brazil was developed as a primary exporting country, based on an outward-looking model of development, a product of the development of international trade and the international division of labor (BRESSER-PEREIRA, 1973). It is possible to identify two models of development that succeeded in the Brazilian Semiarid: the first, within this perspective, the agro-export model, based on developmental and industrialization theories. It occurred in two stages: the first stage is the Semiarid periphery and the second stage is the Semiarid protagonist, through the poles

[14] The 1980's is referred to as the lost decade in South America in regards to its economy by many authors (ANGELICO e LUCCHESI, 2017; NU. CEPAL, 1996, p. 21, 24; OCAMPO, STALLINGS, *et al.*, p. 9, 19).

and irrigated perimeters of the São Francisco river. The second model of development is represented by the Coexistence with the Semiarid, which contains climate-compatible development strategies, carried out by civil society.

The development model based on the agro-export company started with the discovery of the fertile soils and adaptability of the sugar cane in the Northeast coast in the sixteenth century, conditions that favoured the colonial settlement and the occupation on the coast. Using the plantation system and oriented to exportation, especially to the European market, it gave rise to the economic model that has been perpetuated, based on large production in "*latifúndios*" in the monoculture system. The native forest cover was substituted by agricultural crops and pastures.

This type of system is based on large concentrations of land and causes a series of ecological imbalances and social impacts, such as loss of productivity due to the disequilibrium of the physical, chemical and biological soil conditions caused by the lack of crop rotation. There is disruption of the natural process of recycling nutrients, impovereshing the soil and decreasing productivity. Monoculture is incompatible with maintaining soil quality and makes the producer dependent on favorable climatic conditions. These conditions are also responsible for diseases, pests and weeds (GALERANI, 2005).

Inadequate soil management results in low levels of organic matter, unstructured and compacted soils due to the incorrect use of agricultural machinery, and laminar erosion (the one the farmer does not perceive, but which eliminates the surface layers of his soil) (GALERANI, 2005).

This model was applied in the Northeast in general, and imposed the Semiarid a peripheral role until approximately the 1960s. The "*Sertaneja*" region was responsible for supplying raw material and workmanship for sugar mills and for the cotton industry, for providing labor for large landowners and low-cost migrant labor for other Brazilian regions.

There were specific public policy proposals - strongly related to the consequences of the droughts - prior to the 1960s, which largely guided the following policies and the development model adopted. Nevertheless, the planned development of the Semiarid only

began with the proposals for regional development seen in chapter four, especially since the work of the GTDN. That was the first approach to development oriented according to regional characteristics.

In view of the neo-developmental ECLAC version of development related to the growth of industrial production and infrastructure, the Northeast was considered a highly backward and underdeveloped region, lacking an industrial park and infrastructure at the same level of the south-southeast region. The report presented by the GTDN in 1959 pointed out that the most fragile part of the Semiarid economy was the subsistence agriculture (BRASIL, 1959), encouraging new studies conducted to evaluate the development possibilities based on the industrialization of the Northeast, to be carried out by SUDENE.

The role of the BSA in the division of labor changed from the 1970s on. The implementation of the irrigation perimeters created by SUDENE transformed the region in a tropical agro-fructiferous pole based on fruits, flowers and grains. The most relevant irrigate pole in the BSA is located in Petrolina / PE- Juazeiro / BA. The Semiarid irrigated agriculture exports more than US $ 500 million per year (ALVES e SOUZA, 2015). It presents itself through a model of automatic and industrialized irrigation, following the logic of mass production, resignifying the Semiarid as a central region, a producer, green, protagonist of the agro-exporting company in the Northeast. However, this process takes place in only part of the BSA, where water is abundant, which does not imply in positive social and ecological impacts.

Irrigation practice can cause positive or negative impacts according to its management (FAO, 1997). The irrigated pole of Petrolina / PE- Juazeiro / BA plays a key role in increasing the supply of jobs and income generation. However, irrigation systems in regions with characteristics such as those found in part of the Semiarid tends to generate processes of degradation by salinization, alkalinization, saturation and acidification of soils; degradation of socio-economic conditions by the increase of inequality, since the irrigated areas are usually in large "*latifúndios*", and lack of access - the poorest cannot afford the technology to search for water; and due to ecological degradation - reduction of biological diversity, damage to the downstream ecosystem due to the reduction of water quantity and quality, and groundwater decrease (BRITO, BRAGA e NASCIMENTO, 2010).

Existing vulnerabilities of the *Sertão*, the above-mentioned consequences and inefficient public policies for the BSA and the contributed to the emergence of the (regional) development model and project of Coexistence with the Semiarid, in resonance with the premise that policy framework is a major concern in the development field (PIETERSE, 1998). Ignacy Sachs (2000) draws attention to the urgency of living with fragile ecosystems through participative processes of rescue and cultural construction of appropriate alternatives. These processes require a contractual approach to identifying needs, local capacities and harnessing potential resources to improve the living conditions of local populations (SILVA, 2007).

Changes began to occur out of a society demand through protests, which in Brazil contributed to culminate in the end of the dictatorship and in the constitution of 1988. The constitution brought components that promote the right of minorities and decentralization of power, turning itself into an ally for the movement. Several actors were able to question the power hold by the oligarchy and to demand a different way to relate to the Semiarid, seeking to live with the drought, not fight it.

It could be discussed whether the CSA corresponds to a model, a project or a theory of development. According to Ostrom (2005), a theory assumes specific causal relationships among core variables, while a model comprises a more detailed manifestation of a general theoretical explanation in terms of the functional relationships among independent and dependent variables important in a particular setting (MCGINNIS e OSTROM, 2014). In another analysis, Walker et al. (2002) describe a model according to Root-Bernstein and Root-Bernstein (ROOT-BERNSTEIN e ROOT-BERNSTEIN, 1999) concept, being any representation that allows people to manipulate or understand abstractions. Furthermore, Wacker (1998) defines a theory as consisting of four basic criteria: conceptual definitions, domain limitations, relationship-building, and predictions.

Although there is a set of assumptions and propositions found in the CSA, it can be refuted as a theory because it is not seeking to predict future results based on an exposed model. Neither is a well-confirmed type of explanation of nature, made in a consistent way with scientific method, fulfilling the criteria required by modern science. It is not, therefore, a theory of development, academic, but a gathering of organized and planned solutions to

face adversities known in the region for centuries, pointing to how desirable change in society is best achieved. They are development strategies, but they overlap with various theories of local development.

CSA is people-centred, one of the key features of alternative development. Such a characteristic is arguably also evolving in mainstream development (PIETERSE, 1998). But as a premise, the CSA seeks local solutions based on the involvement of the community where they act as drivers and in control of its development process, that is, in a participatory and active way. In addition to the valorization of local resources, it is characterized as an endogenous development model. So it confronts the theory of modernization or neoliberalism.

The CSA is a development model because it i) proposes to re-evaluate what was historically placed as causes and solutions for socio-ecological problems of the Brazilian Semiarid region; ii) is based on new assumptions, it defines the type of development most suitable for the region according to its available resources and local cultural identity; and what "non-development" represents; iii) rescues local knowledge as a way to achieve sustainable development; iv) and presents a series of practical activities on how to reach social welfare levels, farmers' autonomy, valorization of natural resources and local knowledge, and a sustainable relationship between man and nature in face of climate change.

It, therefore, opposes to the paradigm of combating drought found in the roots of the agro-export model seen in the second stage, in which the Semiarid, repaginated as a green landscape, becomes pivot. Notwithstanding, the new function or position occupied by the BSA perpetuates the former, oligarchic, export-driven power structure. It does not seek solutions where droughts are not a threaten to development, and in fact, the implemented agro-industrial development model is threatened by drought (MACHADO e SILVINO, 2017). However, in a development model that considers local characteristics, these social-ecological characteristics are not seen as threats, but as opportunities.

# 7 RESULTS AND DISCUSSION

## 7.1 Interviews and Fieldwork through a Participatory Approach

The most frequent feedback obtained from the interviews and during direct interactions with farmers (i.e., local discussions and field visits) is summarized here. Regarding what the most beneficial public policies for family farmers in the BSA have been, social safety net mechanisms were cited by all stakeholders, including family farmers. The period following 2002 was unanimously considered positive. Two governmental programs in partnership with NGOs from this period were cited by all participants, P1+2 and P1MC.

Civil society initiatives known as social technologies (such as the ones above) were highlighted by family farmers, NGOs and some SUDENE and Embrapa employees as better fitted to attend dispersed family farmers. However, they were also mentioned as very important by the rest of the interviewees.

In the opinion of members of the MST, INSA, ASA, IRPAA and family farmers, recent droughts did not result in death by hunger or in farmers' migration like in the past due to the "Bolsa Família" program (public income transference program) and the P1MC. The three first organizations also cited rural retirement as one of the major achievements for farmers.

In respect to the major challenges for family farmers in the BSA, lack of access to land and uneven land distribution were mentioned by all stakeholders, but highlighted as more relevant than access to water by ASA and IRPAA. Lack of access to infrastructure and resources in general was pointed out by all civil society organizations and family farmers, as well as by some governmental organizations.

In the opinion of the representatives of civil and governmental organizations and family farmers present in the Xingó workshop, employees from Embrapa and SUDENE (the younger employees), and ASA and IRPAA, traditional technologies used by public policies to deal with the adversities of the BSA based on engineering/hydraulic solutions were considered inappropriate. They argue that these policies have enhanced the social gap by privileging big landowners with technologies family farmers do not have access

to.

NGOs, family farmers and some members of SUDENE mentioned difficulties in funding social technologies promoted by civil society. For instance, the institutional nature of SUDENE poses a constraint as it can only operate at the state level.

Government-wise, there is an absence of strategy, ex-post evaluation or proper monitoring of programs, according to members of government institutions, especially the ones that have been there longer. Young employees focused more on the absence of planning. Inappropriate technical assistance and credit were unanimously cited, although, for some representatives of governmental institutions, this was linked to what they considered low levels of education among farmers. Education was mentioned by all stakeholders, but with different meanings and it will not be detailed here.

Stakeholders unanimously highlighted how programs and projects were limited by government bureaucracy and lack of coordination between different government departments. However, some stakeholders spontaneously cited them, while others mentioned them after being asked specific questions during the interviews, such as what prevents public policies from improving live conditions or why programs and projects did not achieve their goals.

## 7.2 Limitations of Public Policies

There is a recognition that the policies and proposals that have been implemented so far have been inadequate or insufficient to significantly improve the living conditions of the Northeastern population, especially in the *Sertão*. This has generated a critical evaluation of the proposals that are presented and the demand for a deep discussion of the programs, projects and works that are presented as solutions to the sub regional problems (MI, 2006).

Three periods of public policies are discussed below followed by six main limitations in public policies for the Brazilian Semiarid region: land distribution, misuse of natural resources, the effects of the drought industry, distributive water policies, system obstacles and combating the droughts mentality. In addition, some insights on how to better develop the tourism potential in the BSA are introduced.

**Hydraulic construction phase (1877-1958)**

From 1877 to 1958, policies of infrastructure and technical fixes to water management helped to certain extension to alleviate drought impacts (GUTIÉRREZ, ENGLE, *et al.*, 2014), mainly by developing a technical base for agriculture through IFOCS and DNOCS (MI, 2005). Notwithstanding, those policies did not enhance family farmers` resilience. As pointed out by Gutiérrez et al. (2014), the water management framework has benefited people who are connected to the perennial water systems while diffused rain-fed farmers still had no reliable access to water. Instead, desertification and water basin pollution were aggravated (SILVA, 2007), which contributed to increase farmer´s vulnerability in all aspects, including to climate change. As a result, despite institutions and constructions previously made, the 1958 drought brought severe consequences and strengthen the necessity to change how policies were made (CAMPOS, 2014).

**Regional development (1959-1991)**

Since droughts measures were not able to change the roots of the social-ecological problems (FURTADO, 1998), the "technical approach" and the drought discourse were substituted by the "development" discourse in the 50s-80s. GTDN questioning over the causes of misery and inequalities was crucial, associating how economy shaped in the Northeast was related to political benefits to landlords.

The establishment of the federal institution SUDENE by the GTDN had the potential to boost regional development because it provided a political space for ministers and state governors to discuss local and regional problems, find collective solutions and act. But the military regime from the late 1960s until the 1980s altered SUDENE´s original functions based on fear of socialism and re-centralized decision- making back in the capital. Therefore, its contributions were undermined.

Main achievements during this phase were the irrigation poles in the São Francisco valley, creating thousands of jobs. It did not generate autonomy for family farmers, though, who continually kept working for large landowners.

Policies in general did not include a participatory approach. Credit and technical assistance were only provided under the adoption of a technological package previously chosen by technical advisers and agreed by the bank. During this period, we found the

first policy developed with the clear goal to strengthen family farmers to be the Northeast Project and its programs, although they were the product of a center decision, created by the federal government and not conceived locally.

"Sertanejos's" well-being did not improve considerably during this time, in spite of high economic growth rates since the 1960s (CARVALHO, 1985). Most changes in terms of programs emerged in the social sphere after the 1980s pointing at policies beyond droughts and constructions solutions, expanding the understanding of the BSA.

**Towards a more sustainable development- relative power decentralization and social safety mechanisms (1992- 2010)**

The most beneficial policy period for family farmers happened after the 1990s. Social safety net mechanisms were the most efficient policies. *Bolsa Estiagem* and *Garantia Safra* were fundamental (SILVA, 2007; GUTIÉRREZ, ENGLE, *et al.*, 2014), but more important were the income transfer programs, like *Bolsa Família*, which have helped improving social conditions of family farmers. According to the interview collected at the INSA Knowledge and Information Management Area, most recent droughts did not result in death by hunger or in farmers` migration like in the past due to Bolsa Família and the P1MC. This statement was confirmed by members of the MST movement in Alagoas, among others, during our fieldwork. Social programs also provided stability resulting in fewer social disturbances in the 2012/2013 drought (CAMPOS, 2014). It is a partial victory, considering that cattle and crops are still susceptible to climate effects and were severely affected by recent droughts.

Despite of improvements in water storage and social transferring projects, they were insufficient to withstand multi-year periods of below-average rainfall (BRAGA, DE NYS, *et al.*, 2013) and to increase family farmers´s resilience to climate change. In regards to water distribution through traditional technologies, family farmers were not positively impacted by most policies, these usually being beneficial to people who are in privileged areas with access to water infrastructure. These water supply projects did not and "do not meet current needs of family farmers, let alone anticipated needs from future stresses provoked by climate changes" (GUTIÉRREZ, ENGLE, *et al.*, 2014). The main finding is that decentralized water planning has the potential to increase long-term

resilience (ADGER, BROWN, *et al.*, 2011), considering the geographical dispersion of family farmers, the impact on the environment and the conditions of the region. Among the most beneficial programs are small and medium hydraulic constructions.

We have found several official documents and institutions from the Brazilian government that refer to the CSA approach as a necessary component of the strategies to be adopted. Among these documents is the Semiarid Sustainable Development Strategic Plan (PDSA) (MI, 2005). In governmental research institutions, we have found reference to the CSA in *Fundação Joaquim Nabuco* (FUNDAJ, Joaquim Nabuco Foundation) and in the (Brazilian) National Institute for the Semiarid. Among local governmental Plans, it is worth mentioning: *Convivência com o Semi-Árido: Um Plano de Vida para o Ceará* (MATOS), *Plano de Desenvolvimento Rural Sustentável e Solidário* (PDRSS, Sustainable and Solidarity Rural Development Plan); and *Projeto São José*, a project carried out by the Ceará state government (SECRETARIA DOS RECURSOS HÍDRICOS DO GOVERNO DO CEARÁ). References are also found in the Ministry of the Environment (MMA) and Ministry of Agrarian Development (MDA, 2015) websites.

Two programs developed within the scope of civil society became public policies: the "One Million Cisterns" and the "One Land, Two Waters" programs. As pointed out by Pérez-Marin et al. (2017), access to water infrastructure with the use of diverse technologies from 2002 to 2016 has improved, mainly related to Domestic Cisterns (DC, +58%Δ) and Production Cisterns (PC, +95%Δ).

Water storage has shown significant increase through Micro-Reservoirs (MR, +43%Δ), Stone-lined Reservoirs (SR, +25%Δ), Cement-lined Wells (CW, +45%Δ), and Watering Holes (WH, +53%Δ). Most disseminated water infrastructure works between 2002 and 2016 were DC, PC, and WH. There were similar outcomes for the indicators of agroecosystem diversification in comparison to the indicators of water infrastructure (Pérez-Marin, et al., 2017). Regarding social and political aspects, access to social (public) programs by farmers was expanded during this period.

We identified in all studied public policies periods a traditional technological approach for the BSA. These policies are mainly based on the rationale that addressing the social-ecological vulnerability of the Semiarid system can be attained by programs designed to

combat drought by focusing on water security improvement through almost exclusively hydraulic solutions. The policies adopted to mitigate hydric deficit impacts varied over time, from purely welfare actions to interventions of a more permanent nature, such as the construction of reservoirs (AGÊNCIA NACIONAL DE ÁGUAS (ANA), 2017). Our findings (summarized in Table 4) show that the technological approach has focused on developing large hydraulic infrastructure projects despite including other activities. The main achievements by DNOCS and partners using Traditional Technologies found in the period 1909–2013 were related to four predominant initiatives: hydraulic constructions, fish-related initiatives, transport infrastructure and basic services.

Hydraulic development has consisted mostly in building water infrastructure such as reservoirs, wells, water supply systems, hydropower plants, dams, irrigation projects and cisterns. Among fishing-related initiatives, we found fisheries stations, a research and aquaculture Center, and fishing monitoring activities in public dams. Transport and basic services projects delivered highways, bridges, landing fields and electric power transmission lines (ARAÚJO, 2013). Table 4 provides quantitative findings relating these initiatives to the activities and benefits achieved by 2013.

As a centralized process, it does not involve the stakeholders in the process of decision-making, therefore technology is chosen by the politicians and the local elite. Activities found in Table 5 and in data presented in the social characterization section show that government actions benefited large economic activities. It is so because the poor do not have access to water dams, irrigation and hydraulic infrastructure in general. It is usually far from their homes and it requires expensive tools to allow its use. In addition, many are in private properties. Therefore, it increases the social-economical gap.

An important example lies in Petrolina/Juazeiro irrigation centers, which mainly benefit the agribusiness (SILVA, 2007). Chacon and Bursztyn (2005) point out that, despite all efforts promoted to achieve sustainable development, extensive areas do not share its benefits.

From an ecological perspective, it fails to understand droughts as a feature of the region, inserted in the ecosystem balance in which the resilient nature finds its own way to adapt. Deciduous forests remain dry as a survival strategy during droughts, other plants only

flourish during the droughts season, and several can resist long periods of restricted water. Such ecological resilience can be used in favor of people, when the balance is respected and management done sustainably.

Many of the interventions presented had severe environmental impacts. Among them is the reduction of fish stock and flooding of extensive parts of land, destroying its fauna and flora, harming the ecosystem balance and forcing the displacement of traditional communities. Further more, constructions were carried out in areas with water sources dependent on the perpetuation of water courses resulting from medium- and large-scale accumulation works, and with known risks regarding the irregular cycle of droughts (ARAÚJO, 2013). These consequences contributed to increase the desertification process of the Semiarid region.

Nevertheless, there were positive outcomes. The work fronts and emergency relief actions have assisted a great amount of people. They had an emergency and not a long-term planning character, but contributed to save lives. Other positive results were the construction of roads to remote areas, employment generation and attention to the problems in the region that allowed the BSA to enter the national budget. Highways built between 1909 and 2013 formed the network of what is now the Northeastern road network. There were investments in energy networks, transport and telecommunications, but it is necessary to add another decisive network, still in the initial phase of implementation, which is the network of pipeworks and channels, to guarantee the supply of water resources throughout the year (MI, 2005).

Thus, achievements of this approach have improved the development of the region from a classical development perspective, that is, increased growth and improved macro-infrastructure, and forged some ground for the development of the regional economy. However, it did not reduce the social-ecological vulnerability of the BSA system or increase resilience of family farmers. Employment generation, for instance, did not promote autonomy of family farmers; instead, it kept the same pattern of dependence. It did not promote sustainability or sustainable development, in spite of penetrating policies discourses.

**1- Land distribution**

Uneven distribution of land by colonial policies created "*latifúndios*" owned by a small agricultural dominant class, while a great share of the population remained with little or no access to land and its wide range of natural resources (INCRA). Some notable groups neglected by such policies include indigenous populations and workers who had recently transitioned from slavery conditions. The "*latifúndios*" were used for extensive monocultures, displacing local population from their territory once the sugar mill complexes took over the coastal land. The high demand for animal created by the sugar economy was fulfilled by those people displaced to the hinterlands, changing the economic and social dynamic of that geographical space into new modes of production. Livestock, mainly cattle, and agricultural processes which are not suitable for this region resulted in the destruction of native species, severely affecting the natural system of the Semiarid. Moreover, seeing that family farmers were producing to serve the sugarmill demand, they were indirectly impacted by the international sugar market crisis in the XVII century, which increased their economic vulnerability.

Land distribution has been an issue at the root of social inequalities. In this case, many farmers ended up in a subordinate relationship with landowners, leaving them powerless and vulnerable to potential social, political, economic and environmental shocks and changing conditions. Landowners centralised and concentrated power allowed them to influence and shape public policies to suit their own interests and resist alternative policies with transformation potential, since too often they did not align with the promotion of regional development and drought alleviation measures. This power imbalance and struggle contributed to shape a socially excluded society (FURTADO, 1959).

Lack of access to land is pointed out by farmers, organizations and several researchers (CASTRO, 1946; CARVALHO, 1988; SILVA, 2003) as the biggest driver of the social-ecological problems in the *Sertão*, not droughts, as misery seen during drought times is related to the historical occupation of the land by colonizers (SILVA, 2003) and the continuation of land concentration after the colonial and imperial periods. According to Furtado (1982), land ownership forged a community born to serve the Agro- trade-company. The agrarian reform has been a major topic in politics and policy debates since 1920s and especially since the 1960s. Nevertheless, land access must be accompanied by other policy measures and access to other natural and human capital, specially water and

knowledge and infrastructure.

**2- Misuse of natural resources**

Several studies have verified the antropogenic impact in degrading the Semiarid area when substituting the *Caatinga* for agriculture, cattle and wood extrativism (MMA, 2007). The depletion of the *Caatinga* by extensive cattle and monoculture plus large infrastructure projects have had a considerable impact on the social-ecological system of the BSA resulting in deforestation, biodiversity loss and soil impoverishment. Unsustainable techniques of vegetal extractivism, overgrazed areas and slash-and-burn agriculture have also contributed to frame this scenario (CASTELLETTI, SANTOS, *et al.*, 2003; SOUZA, 2006; ARAÚJO FILHO, 2013; SIQUEIRA FILHO, 2013) now aggravated by climate change, especially in areas under desertification (MMA, 2005; OLIVEIRA, 2008).

The climatic specificities, characterized by the scarcity and irregular distribution of rainfall, associated to the predatory forms of territorial occupation, contributed to trigger desertification processes in some areas of the the BSA (SILVA e FILHO, 2006). As a result of natural constraints associated to the historical impact of the land and power structure supported by the drought industry, 45% of the Semiarid natural vegetation coverage has been degraded (MI, 2005) and there are 21,379.45 km² of desertification nucleus (areas characterized as high risk to desertification) that affect 390,207 people (MMA, 2007). Therefore, the environmental vulnerability limits the development opportunities of the BSA region.

**3- Drought industry**

Landowners, large entrepreneurs and civil construction companies have their power reinforced by the drought discourse and industry, profiting from exclusive access to human, political and natural capital due to their financial privileged conditions. This dynamic reinforces the social-economic disparities and power unbalance, as these actors hold the job offers for those who need to migrate or find work because of the consequences of water shortage in their local farming. Work and water access are additionally used as “favoring exchange” for earning votes during election, which ensures the maintenance of the status quo and supports the politics-drought-industry relation.

Therefore, Semiarid inhabitants (*Sertanejos*) are part of a complex dependence relationship. As indicated on the report of Disaster Resilience (COMBAZ, 2014, p. 20), citing Nelson & Finan (2009), "unequal patron-client relations are a key survival strategy for farming communities" as they "rely on patrons to give them land and protection during times of drought, in return for labour". Notwithstanding, we could also question what other parcel of society gains from this type of relation. It is not unusual in power relations for the dominant class to select some people in the subaltern level to share partial benefits in order to maintain the system functioning.

**4- Distributive water policies**

Brazil has developed hydraulic infrastructure over the years to deal with the challenges of the BSA, but family farmers still struggle to have access to water because hydric and other resources are not equally allocated among society. Distributive water policies are part of the political challenge in the Semiarid Northeast inserted in a deep structural problem found in the local power relations of patronage and landlordism, where policies favour large landowners and the local elites creating barriers that are harder to overcome than the irregular distribution of rain, although droughts have historically been presented as being the determinant of the social-economical- ecological problems of the *Sertão*.

**5- System obstacles**

During our fieldwork and interviews, we verified that programs and projects were limited by government bureaucracy and lack of coordination between different government departments. Several programs and projects eventually disappeared, mostly as a result of policy changes by subsequent governments. As addressed in the Drought Conference 2016, public policies for the BSA require institutions with a strong long-term team, career employees to prevent past experiences to be forgotten when the government changes, and with skills to take over positions in major institutions now offered as political bargain. Discontinuous planning is one of the most cited problems faced in our public policies. Existing public policies to support family farming, although strengthened in recent years, need to be better articulated (SILVA e FILHO, 2006).

**6- Combating the droughts mentality**

When we analyzed the historical evolution of policies, we found that they have improved general life conditions of family farmers when compared to the first periods, but were

unable to promote climate change resilience and provide a paradigmatic transition to allow transformation to happen, especially because the ideological foundation of policy strategies is still led by combating droughts.

From 2010, the Brazilian government and entities such as the Ministry of National Integration (MI) began to lead a paradigm shift towards a more proactive drought management. A welcome improvement, but still drought focused. Although activities like monitoring droughts are necessary, and in course now (DE NYS, ENGLE e QUITANA, 2016), they could be at risk of becoming a continuation of the historical series register that, for political reasons, including the institutional difficulty to make things happen, are not used to favor vulnerable diffused family farmers, unless political changes take place.

The problem about the "combating droughts" ideology is that it tries to address droughts' challenges without social participation; its benefits are generally focused on big land owners, not on the most vulnerable population. It is focused on only one element- water or water scarcity- in a complex reality. As a mentality to promote development, it fails for nor not recognizing the real reasons of the social-ecological vulnerability- and therefore not taking adequate measures- and for promoting the idea of fighting a natural event which cannot be fought and which is, in reality, an element part of the region, inserted in the ecosystem balance with adapted nature and possible ways of life. The imminent obstacle now, at least until the ecosystem can adjust once again, is climatic change, since the already adapted nature will no longer be adapted to the future scenarios. So policies need to adapt to include all those variables in order to positively transform to withstand climatic change.

**7- Tourism potentiality**

Tourism in the BSA region can represent an element of contribution to the local development of rural communities and municipalities provided that planning and management are carried out by public policies along with the empowerment of communities. These must be capable of managing an activity that complements or allows an alternative income in an environment with few alternatives, contributing to the

maintenance of family farmers in the field and coexisting with the edaphoclimatic conditions of the Semiarid environment (SELVA, 2014).

The development of the BSA tourism sector should be aligned with other sectors of the economy, to harmonise and facilitate the planning practices, as this is a multi-sector productive activity. Local communities and other members of civil society would act as the leaders in the process of preparation and implementation of tourism strategies, pointing out the greatest challenges experienced by them. As suggested by Bem (1997), the tourism sector planning must contain a systemic structure with a social content, without compromising the local landscape and acknowledging cultural reality. This would be a joint work with mayors of municipalities and cities, councilors and so on, in which external experts can assist in formulating local development plans to guarantee a model of self-sustaining development.

A joint effort between federal and state official bodies, city halls, local communities, universities, businessmen and the media is crucial to develop rural tourism in the BSA. Exchange of experiences will enable the recovery of the sertanejos's self-esteem and increase local economic output.

Besides more investment and an overall change in people´s perception of the Brazilian Semiarid image, to develop and plan the touristic sector in the BSA requires to establish the support capacity of the various potential touristic sites, guaranteeing that the maximum quantity of visitors will not negatively impact the environment or risk their preservation. The balance is achieved through a harmonious combination of the two common approaches to local planning, the expert and the participatory one, using the advantages of them both and neutralising their weaknesses.

When well-succeded, the tourism sector has the potential to ensure that natural resources of vital importance are preserved and used so as meet the current needs without jeopardising the possibility for future generations. It is so because the alternative income prevents the people from overexploiting natural resources for survival, contributing to the sustainability of the region. Preserved areas boost social- ecological resilience of the BSA system and strenghs the system against adversities as climate change. The principle of social inclusion contributes to create awareness of the limitation of natural resources.

## 7.3 Overcoming limitations

To meet the challenges posed by climate change and respond to the multi-level needs of family farmers, it is necessary to build resilience by formulating response strategies, integrating technical solutions to social-political dimensions to avoid moving back to technical and apolitical interpretations (BÉNÉ, NEWSHAM, *et al.*, 2014). To be climate change resilient, family farmers need a minimum land size for farming and cattle that is sufficient to accumulate reserve; appropriate credit from financial institutions; and to strengthen the community to have political voice to demand what is necessary. They need adapted seeds, access to water and technical assistance that dialogues with local knowledge as farmers rely on their traditional knowledge of the land, farming methods and climate awareness. Their traditional ecological knowledge (the memory of human-environment dynamics in landscapes) is popularly expressed in the Brazilian Semiarid through different cultural channels (artists include Luiz Gonzaga, Patativa, Graciliano Ramos, etc.). This should be taken into account, as cultural aspects are an important part of a community and their connection to their history, and a long-term learning empirical experience.

Agroecology is an example of a system comprising the understanding of local needs with technical solutions with the potential to reduce climate change impacts, once it prioritizes maximum recycling of nutrients, integration of animal and vegetable production, self-sufficiency in nitrogen through rotation and crop diversification, maintaining the nutritional balance of plants and avoiding situations of stress (EMBRAPA, n.d.).These systems can alleviate external impacts of climatic nature, minimize input dependence and provide a variety of food products, reducing vulnerability to markets' price oscillation. In agriculture, there is a substancial capacity for adaptation such as crop changes and resource substitutions ((IPCC), 2001).

As policies supposedly focused on building resilience at the farm level were actually focused on coexisting with droughts, government emergency responses to drought have been used as an "adaptive capacity" mechanism by rural communities vulnerable to environmental stress, the only possible strategy according to Nelson (2009), which reinforces the paternalistic relationship between family farmers and the State. In terms of

climate change, public policies have not been climate change resilient policies, for they have not been substantially modified to address the existing scenario framed by increasing population and aggravation of climatic events (GUTIÉRREZ, ENGLE, *et al.*, 2014).

Overcoming the social-ecological vulnerability of the *Sertão* requires more than adaptation in order to alter its primary functions and structures. Human responses to climate change must engage with social relations of power (PELLING e MANUEL-NAVARRETE, 2011), considering the political constraints found at the ground of family farmers vulnerability.

Here, transformation is needed to overhaul the basis of the relationships between different actors and the mentality that has been grounded for decades. A transformational process needs to provide a combination of institutional reforms, behavioral shifts and cultural changes powerful enough to challenge the status quo. It must embrace a combination of resilience thinking with power analyses, which is starting to emerge in literature (PELLING e MANUEL-NAVARRETE, 2011; BÉNÉ, WOOD, *et al.*, 2012; BÉNÉ, NEWSHAM, *et al.*, 2014).

One difficulty found in such analyses refers to the fact that policies that change production modes into more sustainable alternatives also challenge power structures which benefit from the current system (BÉNÉ, NEWSHAM, *et al.*, 2014). If so, obstacles that arise are the same that create the original problem, meaning transformation can be held back by power structures in its political-ideological fight to preserve power, for these changes will likely challenge its status quo (BÉNÉ, NEWSHAM, *et al.*, 2014).

So transformative changes to adapt and to become resilient to climate change conducted by public policies would encounter obstacles within state-level. This could be verified in the three historical political constraints seen during this thesis, shaped in a cyclical dynamic in which the agrarian elite status quo maintenance perpetuates those same constraints, that is- the drought industry, land concentration and uneven power relations based on *coronelismo*, at the same time that feeds from them. Therefore, it is interesting and necessary to sustain the image of droughts as responsible for social-economic difficulties of the *Sertão* to keep the achieved benefits and to deviate from the political reasons for misery seeing in a large part of the territory. Here, the media and the

educational system play an important role as instruments of the Gramscian superstructure- the ideology- to assure the dominant class´ power (GRAMSCI, 1999-2002).

Natural adversities can be mitigated with social technologies and the corresponding infrastructure as long as political barriers are defeated to allow policies to link the human, economical and technical capital to those who need them. Prolonged drought events, for instance, are highly likely to happen, therefore drought preparedness as part of a set of measures should be included in the political agenda for the Semiarid region, as it has been broadly criticized over the years (FURTADO, 1998). Drought preparedness must go beyond top-down approaches based on major infrastructure and emergency relief to include policies for diffused farmers.

Despite the Brazilian technological level and skilled professionals, we lack an organized space for articulating and networking between different spheres of society- which today is supposed to be done by SUDENE and INSA, to expose problems and present creative and effective solutions already in course through the Semiarid region, exchanging experiences. Mapping actions to be spread and multiplied. Although there are current efforts, they are few and do not encompass the various stakeholders to promote the desired exchange of knowledge. This was verified during our interviews with employees from SUDENE and INSA.
Other obstacles in public policies refer to the absence of political will to change, combined actions and a solid dialogue between different departments, continuity, strategy and planning. Challenges in management include no ex-post evaluation in programs or proper monitoring.

To overcome these obstacles, it is imperative to promote structural changes: 1) to enlarge access to knowledge and proper assistance, especially rural extension. FAO (RIVERA, 2003) recommends that governments develop a new and expanded policy agenda for agricultural extension and communication for rural development with a focus on food security and income generation of the rural poor. Benefits retrieved from rural extension and broader access to knowledge include, but are not limited to: a) food security- to produce a surplus that can be marketed and thereby generate income to improve life quality (improved diet and nutrition, for example) and to obtain effective food utilization

(food storage and processing techniques); b) conservation of natural resources; c) dissemination of useful information, as technology transfer, economical advice and to develop agricultural markets, informational system and small enterprises, besides seeking new alternatives for obtaining profits (ARION, 1991); d) sustainability of projects- many government projects do not sustain as soon as the government withdraws its support; and e) empowerment of farming groups- extensionists can play a role in empowering poor farmers to gain access to capital either through savings or credit and to promote local organizational development (i.e. associations, institutions, cooperatives, etc) (ZWANE, 2012). Studies show that extension has been successful in promoting farmers` organizations in other countries (RIVIERA, 1989). Those benefits are ony achieved when extensionists have received proper training and are also able to adapt to family farmers' circunstances.

Other over-quoted topic during interviews were 2) to "clean the house", as in to exclude the useless bureaucracy, excess of institutions and money diversion;3) to implement State instead of governmental planning; 4) to apply ex- post evaluation to link government benefits to results, preferably through an external experts and commission; 5) to increase efficiency in the existing governmental institutions like SUDENE; 6) to incorporate civil society representations in the financing destination of bodies like SUDENE and INCRA; 7) and to introduce the new generation of employees from policy sectors in the networking and articulation arenas, as our fieldwork showed that these spaces are represented by the oldest generation of employees only.

Nevertheless, the gap left by public policies also offers opportunities as crises can been seen as windows of opportunity. As literature suggests, there is a wide potential for endogenous social processes to drive transformation (PELLING e MANUEL-NAVARRETE, 2011). In a Gramscian analysis, permanent demands not abided (accepted and solved) in the governmental sphere have given space to conflict, stimulating political, social and cultural changes promoted by the excluded group- the possible hegemony crisis. This can be related to the social movement Coexisting with the Semiarid, based on people's dissatisfactions in regards to policies against droughts and general models of development promoted by the government in the region. The movement has been seen along the years but never as organized as in the 2000s and on. Here we find an active role of the subject in building social change, thus transformation in the BSA effectively occurs

through social channels, in a bottom-up approach showing that social processes play a key role in building resilience and coping with change [authors that relate governance issues to resilience point to the importance of social processes (BOYD, H., *et al.*, 2008; DUIT, GALAZ, *et al.*, 2010)]. As exposed, building resilience is transforming the social context and promoting changes in structures and processes, pointed by Walker et al. (2002) as crucial.

### 7.4 Increasing Resilience: social mobilization and beyond

In the past, it was the climatic disadvantages and the inhospitable local nature that drove the spacial organization of the BSA. Currently, it is the valorization of this territory and the increasingly recognized wealth of the Caatinga biome that causes its transformation and social organization (TEIXEIRA, 2016). The Coexistence with the Semiarid is a criticism of the traditional development model incurred by the Brazilian government on the part of civil society, which then organizes itself to propose and implement an alternative model. Their guidelines and paradigm are forged from the gap left by public policies, which were insufficient to promote climate change resilience to family farmers or social- ecological resilience of the BSA. Instead, CSA proposes to use knowledge production and collaborative learning as tools.

Relevant institutions working in the BSA are the *Instituto Regional da Pequena Agropecuária Apropriada*-IRPAA, *Brazilian Cáritas, Centro Sabiá, Caatinga and Associação Caatinga*. ASA plays a pivotal role, because it consists in more than three thousand civil society organizations, including some of the above (ASA).

CSA has been promoting social-ecological resilience mainly through the use of social technologies, where civil society are decision-makers. Activities seek to mobilize physical and social elements with the potential to implement strategies to cope with current or future events, which are part of the adaptation process (ADGER, BROWN, *et al.*, 2011) and lead to resilience. They contribute to the (1) environment through sustainable use and management of natural resources; to the (2) economy using natural potentialities in economic activities; to sustain (3) life quality, when coexisting with other beings and reducing poverty occur at the same time; to (4) cultural dimensions of the BSA valuing local knowledge and building awareness in a systematic and participatory way;

and to the 5) political dimension, as a political project to mobilize both the civil society and the State (SILVA, 2006).

The main systems, activities and achievements of social technologies are shown in Table 6. The majority of these systems have been put in practice for a long time, but started to expand in the 1980s and on a more regular basis after the 1990s. Social technologies involve the structuring of family production systems, mobilization and formation of households, promoting meetings, exchange of experiences and strengthening of an action network of family farmers' representative organizations, and to increase the capacity to influence public policies with the ideas of the coexistence with the Semiarid.

It was found during literature review (ROCHA, 2013) and confirmed by participatory observation and interviews that women have been playing a fundamental role in agroecological production, in the rescue of creole seeds and in the protection of the *Caatinga* biome. In addition, households with greater capacity to store rainwater, diversified their productive activities and engaged in social formation and mobilization processes have preserved the *Caatinga* and managed to go through this period with less difficulties than those who followed the conventional technological model.

Social technologies have been proposed by civil society different stakeholders who have required changes in policy practices for the BSA. Therefore, this is a bottom-up approach that emerged from the need of transformation, that is, a movement that in itself creates resilience. Even if we understand resilience as an ability and not an outcome (BÉNÉ, NEWSHAM, *et al.*, 2014), adversities that derived from political constraints presented an opportunity to the social-ecological system of the Semiarid to evolve into something new. In other words, it allowed transformation to happen because the adversities brought to light the strength of a transformational driver- the people of the Semiarid- showing an ability to overcome a shock.

In this perspective, technologies are implemented with the participation of the people who will use it, teaching them the know-how and the know why (construction and maintenance of cisterns, and how to store quality water), avoiding the alienation of workers. Through this approach, natural resources, especially water, can be stored locally, benefiting farmers who are dispersed in the BSA. Family farmers improve their autonomy, as they

do not depend on the government for water reserve and have acquired the technological knowledge, although they still depend on the irregular rain. As mention by Adger (2011), decentralized water planing has the potential to increase long-term resilience, especially if we consider the geographical dispersion of family farmers, the impact on the environment and the conditions of the region.

The benefits of this approach are to allow family farmers to plan in advance their water storage, food supply and their products' sales. Changes in soil management, appropriate use of natural resources, reuse of previously disregarded elements and the valorization of the *Caatinga* biome—through native seeds, recovery and conservation of the natural forest—allows the system of the Semiarid to profit from the benefits of the conserved *Caatinga*. That is, to increase the resilience of the social-ecological system of the Semiarid and to promote sustainability. We discuss below some social technologies carried out by the CSA activities.

"*Cisterna de Placa*"- Cistern made of concrete- is a social technology that requires community involvement in the construction phase, where people receive training to use and maintain the equipment. Resilience here is not acquired only by the water storage, still dependent of rain, wells and water pipe tanks, also by the domain of technology by the people. The main faced of resilience here is social rather than technical, which implies that the recent government action of substituting the concrete cisterns for plastic ones is a step back in what has been developed by the CSA. Another positive outcome of the concrete cisterns is the local income and work generation, inexistent when adopting plastic models built in the south of Brazil and taken to the Northeast, as suggested by the government of President Dilma.

"*Cisterna Calçadão"*- the Production Cistern- has the potential to store more water then the "*Cisterna de Placa*", assisting family farmers in guaranteeing their food security, but it is an inferior quality of water. It is, though, necessary to implement complementary actions for an efficient use of water, such as an adequate irrigation system, specially localized, "economic bed"[15], sunlight shelter, and appropriate irrigation schedule. It contributes for family farmers' autonomy providing irrigated products for sale and own

[15] Use of plastic canvas to avoid water percolation.

consume.

"*Cisterna nas escolas"*- Cistern in schools- it is probably one of the actions which contributes the most for generating resilience by preventing students from abandoning classes or the school from cancelling them (not fulfilling the 200 required days per year[16]) due to water shortage.

The use of cisterns strengthens social dimensions required to allow transformation and provides a necessary reservoir of water for dry seasons, but they might be insufficient for future climate scenarios as it has been developed for current climate events and drought periods. Meaning that they might not substantially increase climate change resilience unless combined with other CSA actions.

Non- irrigated cultivation "*Cultivo de Sequeiro"* and the medical use of the *Caatinga* plants contribute to cherish and validate the local nature and its benefits, changing the image propagated by the media of an unproductive land whose nature is dead and has nothing to offer. The magnitude of environmental services and usefulness provided by the *Caatinga* is yet to be understood, for we are, now, only starting to positively explore it and learn from it. As per our interview to INSA, 100 new species have been recently tested from which 10 showed anti-tumor potential action. There are several hidden potentials that the *Caatinga* can provide, but their discovery denpend on changing the economic thought to embrace it, instead of destroying it.

Underground dams contribute to storing water in the alluvial aquifers of the intermittent river basins. This occurs through infiltration and avoiding the loss of water volume promoted by the high rates of evaporation and salinization of the BSA.
Productive backyards, native seeds storages and exchange programs between farmers are activities that rescue traditional knowledge and use alternative production systems based on agroecology, contributing to enhance the social-ecological resilience of the BSA system. Native seeds contain a heterogeneous genetic composition that allows plants to better adapt to climate change adversities. Moreover, the seeds stocks reduce external inputs dependence. Both traditional knowledge and stewardship of genetic resources have

[16] According to the article 24, law no. 9,394, 1996 (BRASIL, 1996).

been acknowledged in the Convention for Biological Diversity (CBD, 1992).

Exchange programs provide a social network and horizontal cooperation, contributing to enhance resilience and potentially climate change resilience when new practices arise. Furthermore, the social and political insertion of CSA ideas contributes to disseminate principles grounded on regional identities with the potential to reconstruct the BSA image.

Contextualized Education contributes to reduce the distance between students and their realities, exposing the significance of the elements present in Sertanejo´s lives, and reassuring the importance of discussing them. That is, it dignifies the environment in which that citizen lives, raising his or her self-esteem. It empowers the community and allows them to carry out endogenous decisions and policies. Overall, it contributes to overcome the stigma of the Northeast Semiarid region as a place of poverty, impracticability and of low development potential, historically justified by the droughts phenomenon.

It remains questionable whether these activities are able to promote changes fast enough to prevent extreme damages from climate change as they are being conducted—time and space wise, with the available funding and partnerships. For an effective appropriation of these technologies, it is necessary an integrated action of producers' associations, non-governmental organizations and entities of technical assistance and rural extension, supported by more appropriate public policies focused on credit and considerative of the circumstances under which these family units operate. Furthermore, it remains unclear whether the current practice meets the needs to conserve what is left of the *Caatinga* before it is too late, or even to promote the benefits to the vast majority of family farmers. Although the activities themselves promote sustainability, their optimization depends on the ability to spread them on a fast pace, given the upcoming shocks, specifically climate change, that will increase the challenges already faced in the BSA. This could be achieved through further engagement of the government in CSA practices, including these activities in public policies.

Literature developed in the CSA core suggests that Coexistence principles should become public policies (CONTI e SCHROEDER, 2013; ARTICULAÇÃO DO SEMIÁRIDO

BRASILEIRO (ASA); CARITAS BRASILEIRA; CONTAG; CPTFETAG-BA; CUT-PE; FETAG-ALFETASE; FETAG-AL; FETAPE; FETAG-BA; SABIÁ; ET AL., 2013). The State would act as a partner who supports autonomous and creative initiatives developed and carried out by society, in a decentralized management of available resources based on local needs (ASA), similarly to the current programs in which the government already takes part as a partner. Would that be more efficient than the current policy model? Once it becomes a public policy, it might be susceptible to the same obstacles presented in current policies.

Perhaps the Semiarid system is going through a crisis in the sense of Wallerstein (1984), where the historical system is about to die, leaving us the choice of how to build the new one. If in the new system the CSA guidelines become public policies, they could be trapped in the corruption net and bureaucratic structure faced today. Considering that public politics did not achieve resilience of the social- ecological system of the BSA, it is questionable whether we should aim for CSA guidelines to become public policies. To be successful, activities and CSA guidelines would have to be properly inserted in public policies, otherwise there is a risk of excluding their social character, as it would have happened by substituting concrete for plastic cisterns.

The already existing partnership between government and CSA projects and programs may be the solution. It, then, leave us the challenge of promoting such ideas in the governmental arena without turning them into policies, at the same time that manages to obtain funding to execute the projects contemplated in the CSA. In any case, CSA represents a new development model for the *Sertão*.

## 7.5 Implications for other Semiarid regions

Brazilian Semiarid activities were developed from the necessity to promote access to land (in an appropriate size), water, appropriate technical assistance, credit, (social) technologies and social inclusion, to rescue traditional knowledge to dialogue with research centers and political institutions. Most cited concerns in Semiarid regions around the world are similar to what we have seen in the *Sertão*, although their conditions vary a lot: the soil, the climate, the social factors, availability of mechanization and of labour, and type of livestock, to cite some. It is a complex interaction of population growth rates,

climate, and environmental responses linked to human activities ((IPCC), 2001). The common ground is low rainfall, but due to variation in everything else pre-made solutions are not effective, despite several attempts to present a review of techniques suitable for use in other conditions.

The social safety net mechanisms promoted in Brazilian public policies have been of increased interest to several parts of the world and can serve to reduce socio-economic vulnerabilities of similar Semiarid regions, fostering their adaptive capacities to climate change. Especially when there is an analytical approach to the roots of vulnerabilities, usually linked to socio and political spheres.

Another important feature showed in our case study are the opportunities presented in vulnerable scenarios, which is part of resilience theory. This can reflect on finding something positive that wasn´t there before or turning negative effects into a decisive adaptive capacity. If the political scene is unfavorable it might be the incentive to gather different social groups; low rainfall can promote- by necessity- a new market, fair trade and on a solidarity-based economy with local dry-season products, such as *umbu*[17], *mandacarú* and *palma* (forage cactus, *Opuntia Ficus- indica Mill*). *Palma* is cultivated in drylands (Mexico, Brazil, Mediterranean Italy, etc) to feed the animals, for cosmetics, human nutrition and more yet to be researched. It has the potential to expand to other regions.

A commonly cited adaptation strategy is building local knowledge of climate vulnerability and responses. These strategies are found within CSA civil society activities as networking, where ASA and its partners promote exchange of knowledge and social technologies, and in government research centers, where INSA is mapping and categorizing social technologies from and to the BSA (MOREIRA).

South-south cooperation should be encouraged. Sucessull programs and projects from Semiarid regions might be adaptable for other areas alike. The Brazilian project *Adapta Sertão*[18] could be a starting point for an international dialogue, considering that it is gaining international recognition and it is already financed by international organizations

[17] Jam is already made of this fruit and exported to Europe.
[18] For more information, please access http://www.adaptasertao.net/copia-home

(Inter-American Development Bank, Climate and Development Knowledge Network). It promotes the integration of multi-stakeholder dialogues, social technology and strategies for climate change adaptation based on the concept of resilience.

Cooperation can come from adapting the activities and social technologies in course at the Brazilian Semiarid region, seen in table 6, according to local resources. Cisterns are in general low cost and effective, and can contribute to improving access to water reservoirs, given, for instance, that 98% of agriculture in the Sub-Saharan Africa is rainfed (FAO, 2002). For communities or families with very low income, it is possible to substitute the concrete cistern costing 500.00 dollars (ASA, personal communication) for those made of canvas and cardboard for 50.00 dollars (price reported by a local farmer of Alagoas, Brazil, in a meeting at the Xingó center in 2016. The durability of the technology has not been reported.). Native seeds exchange is another example of an adaptable activity for other Semiarid regions that can boost their independence from large entrepreneurs.

The social process around the CSA is likely the main achievement that can serve as an inspiration to other regions. As many countries experience similar political obstacles, social mobilization can help to empower the community to take action and achieve what hasn`t been efficiently done or to demand the government to do so. Bottom-up approaches to resource management are a key point in promoting resilience.

# 8 CONCLUSION

This thesis examined three public policies periods in Brazil's Semiarid region, the *Sertão*, to understand if they have promoted climate change resilience for family farmers, and the role of the paradigm and guidelines of Coexisting with the Semiarid. Climate change resilience has been understood from a multi-dimensional social-ecological system perspective.

The terms Semiarid, Social-ecological systems and Resilience were examined as part of the conceptual framework, in chapter two, discussing what *Sertão* and Semiarid mean, and how the latter is a social-ecological system. It was shown how Northeast, Semiarid and *Sertão* are terms used interchangeably in literature and speech in Brazil, although they are not synonyms. The Northeast is one of the five geographical-political macro-regions of Brazil composed of nine states, and occupies a wider territory than the area of a Semiarid climate. Semiarid is a climatic classification whose correspondent territorial delimitation has changed over time. *Sertão* is a geographical-political sub-division of the Northeast, but both terms "Sertão" and "Semiarid" were popularly extended beyond its original meaning to embrace cultural, environmental, social and political aspects, therefore can be used interchangeably. SES were understood as ecological systems related to and affected by one or more social systems, in which the Semiarid constitutes as an integrated social-ecological system. Resilience was broadly discussed through social-ecological systems thinking, but with a view to present its aspects, especially concerning climate change, in the perspective of family farmers.

Two technological approaches were identified during the research and referred as Traditional Technologies and Social Technologies. The first was related to mainstream technological state-driven policies associated with "engineering solutions", while the latter was identified as part of the activities of the "Coexisting with the Semiarid" movement, encompassing local, smaller and decentral projects relying on the coexistence with local characteristics. Both terms were commonly used by different stakeholders during the thesis fieldwork and in literature.

General aspects of all Semiarid lands were introduced in chapter three, before exposing the socio-economic and ecological characterization of the BSA. Prevailing adversities found in most Semiarid regions were erosion, salinity, shortage of information, lack of access to technology, land ownership issues, farming background and increased pressure on natural resources, predominantly due to population growth and competition with other land-uses.

The Sertão has been described as a socio-economic vulnerable landscape, despite recent improvements. The most vulnerable population is composed of scattered family farmers,

which represent about one quarter of the total population of the Semiarid. Traditional agriculture and livestock and the agribusiness are the most representative economic activities. The BSA vegetation cover is predominantly constituted by the *Caatinga* biome, which is extremely heterogeneous. The natural vegetal cover can provide the necessary resources for human settlement, when the SES is managed sustainably. Among the potentialities presented by the *Caatinga*, there were eco-systemic services, products of the *Caatinga* socio-biodiversity and medicinal treatments provided by local species. Economic potential was also found in activities such as ecotourism, despite the little acknowledgement given by the media.

Among the elements that forged the BSA vulnerability, social and political constraints were determinants. The territorial occupation of the BSA shaped the social-historical process and the current social-ecological system of the *Sertão*, already constrained by natural adversities. Socio-political pressures were key to frame the BSA vulnerability, as public policies could have the potential to alleviate natural stressors. Three main political-historical determinants were land structure, power structure and the "drought industry" developed in the region.

Public policies seen in chapter four addressed strategies to deal with these constraints and adversities. They were studied from 1877 to 2010, introduced by two previous periods as a historical context to the following events, characterized by the difficult access to the hinterlands and acquisition of knowledge regarding the social-ecological features of the BSA. Public policies that followed were based on engineering solutions, regional development, and relative power decentralization and social safety mechanisms and applied through traditional technologies. Brazil has historically addressed water scarcity during times of shortage and droughts through emergency response and large water infrastructure works projects. In response to the Brazilian management and policies considered insufficient by civil society, emerged the paradigm and guidelines of Coexisting with the Semiarid, showed in chapter five. They were related to (1) access to appropriate land size to produce enough variety of food crops resilient to the drought season and that allow to cope with climate change impacts; (2) water supply and use priorities; (3) use of a different periodization to calculate water reserve, animal food and bank credit according to the dry season period; (4) contextualized education; (5) gender issues; and (6) endogenous decision and policies.

Chapter six was dedicated to bring to light development theories in the context of the *Sertão*, exposing the Agro-industrial model and the Climate-compatible development strategies found in the CSA.

The Discussion and Results chapter revealed the main results obtained during Interviews and Fieldwork, discussing the fundamental limitations of public policies, ways of increasing resilience, and the CSA potential to promote climate change and non-climatic resilience. Implications of the findings for other Semiarid regions were illustrated.

The main Conclusions of this thesis show that major stresses for the Brazilian Semiarid region are extreme climatic conditions, especially drought events, resource distribution, misuse of natural resources, the drought industry, political system obstacles and "combating the droughts" mentality, framing the climate and social-ecological vulnerability of the region. Climate change is expected to exacerbate such vulnerability by escalating water scarcity and sectarian excessive rain with significant impacts on the environment and people. It will also contribute to fasten desertification processes and transform the current biological diversity.

Water shortage in the BSA is a real problem, but with a viable solution through social technologies and resource distribution. Therefore, our attention must be towards the underlying political causes of the social- ecological vulnerabilities that result in poverty and low agricultural development in the Brazilian Semiarid region, and which constrain adaptive capacities of the environment and people reproducing the vulnerabilities of less powerful groups over the long-term. Therefore, drougths in the Semiarid Northeast are a social rather than a natural problem.

Public policies primary focus was related to water scarcity, which defined the "combating the droughts" mentality, creating a gap that led civil society to define the Coexisting with the Semiarid guidelines. Activities guided by the mentality of coexistence are endogenous bottom-up activities that increase family farmers´ resilience through social technologies with a participatory approach and promoting local knowledge and sustainable use of resources. But they have not been extensively applied yet and have only been partially inserted in public policies.

Public policies in the three analyzed periods have not been sufficient to substantially promote social- ecological resilience to climate change to family farmers, although recent actions have considerably assisted family farmers to improve live conditions and face droughts impacts. The traditional approach mostly benefited large landowners, while family farmers profit more from the social approach. Achievements of the technological approach did not reduce the social-ecological vulnerability of the BSA system or increase resilience of family farmers. It boosted development from a classical development perspective, promoting macro-infrastructure and growth, but also contributed to keep the same pattern of dependence of farmers. Since changes promoted were not climate change focused, achievements can be vanished when climate changes create new conditions.

Achievements of social technologies have been promoting the sustainability of the social-ecological system of the BSA, including family farmers and the deciduous forest, and are likely to have a long-lasting impact, especially if there is more involvement of the government in the social technological activities. These promote the sustainable use of natural resources, respect and cherish local knowledge, and assist family farmers to store water and become more independent.

Overall, for a structural consistent change, it is necessary to deeper socioeconomic and political reform and stop the clientelistic social relations from undermining resilience. Given the characteristics of Semiarid regions and their vulnerability in regards to climate change, it is understood that development proposals for the region should include a participatory approach and solutions beyond technical fixes to establish and strengthen local resilience to climate change. The ideas brought in with the CSA have been applied on a small scale, but have proved to be effective. They were not incorporated as public policies, but some were conducted in cooperation with the government. Whether they should become part of public policies is still debatable, given the years of inefficient policies and the bureaucratical corruptive character of the Brazilian system.

Development contemplating social inclusion, environmental preservation and economic viability with local engagement is the key to overcome chronic hunger, underdevelopment and the structural inequalities so deepen in the Brazilian Northeast Semiarid. This would include the fluid, organic relation of people and the environment as

one system only, based on the premise that humans are part of nature, affecting and being affected by each other. Therefore, climate change resilience requires to strengthen several aspects of a complex system. In sum, the emergence of a new development paradigm for the Semiarid can provide family farmers with a resilient system to climate change and other stressors, as illustrated by the ongoing attempt through the CSA activities and paradigm.

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## APPENDIX 1- Detailed Semi-structured interviews

| Sector | Institution | Relevance | 24 Interviewees | Position/role | Location of interview | Date | Means |
|---|---|---|---|---|---|---|---|
| Government | Ministry of Environment | Government body responsible for strategies, recovery and protection of the environment | 1 | Substitute manager of Biodiversity Conservation, Office of the Secretariat of Biodiversity and Forests | Fortaleza, Ceará | December, 2016 | In person |
| | Ministry of Integration | It conducts national policies of regional development. | 1 | Technical advisor to the Regional Development Secretariat | Piranhas, Alagoas | November, 2016 | In person |
| | Ministry of Tourism | It presents a national overview of the perception of tourism in the BSA. | 1 | Advisor to the Executive Secretariat. | Rio de Janeiro, RJ | July, 2017 | by phone |
| | Tourism Superintendence of Alagoas state | Official source of information about tourism in the Alagoas Semiarid region. | 1 | Research Supervisor of the Tourism Superintendence of the Alagoas state | | July, 2017 | by phone and email |
| | SUDENE | Major and first organization created to develop the Northeast region. | 6 | Analysts, coordinators and directors of the Coordination of Sustainable Development, and Environment Sustainable Development Coordination | Recife, Pernambuco | November, 2016 | In person |
| | DNOCS | Historical official body to deal with droughts through constructions. | 1 | Chief engineer of dam works | | July, 2017 | by phone |
| Research Institute | INSA | Well known and recognized research center for the BSA related to the Ministry of Science, Technology, Innovation and Communications. | 2 | Soil researcher in dry areas and Semiarid regions 2- Researcher in development and social technologies | Campina Grande, Paraíba | October and December, 2016 | by phone and in person |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Embrapa Semiárido | It is a research unit of Embrapa focused on the sustainability of agricultural production systems in the BSA. | 3 | 1- Researcher in remote sensing, vegetation, geoprocessing and environmental zoning<br>2- Director in Research and Development in family farming, rural development, northeast, local development and production system.<br>3- Researcher in applied economics. | Petrolina, Pernambuco | March, 2017 | In person |
| | FUNDAJ | Educational studies and research institution with several publications with a strong focus on the Northeast. | 2 | 1- Science and technology of semiarid studies coordinator<br>2- Researcher of the Coordination of Studies in Science and Technology | Recife, Pernambuco | March, 2017 | In person |
| NGO | ASA | Largest network for the BSA. | 3 | 1- Coordination advisor<br>2- coordination advisor<br>3- researcher-coordinator of the project: Family Farming Resilient Systems to Extreme Environmental Events in the Brazilian Semi-Arid Context | Recife, Pernambuco | December, 2016 | In person |
| | CAATINGA | NGO dedicated to family farmers of the northeastern *Sertão*. | 1 | General coordinator | | July, 2017 | by email |
| | IRPAA | NGO working on several sustainable processed for the BSA. It was the first to discuss Coexistence with the Semiarid. | 1 | NGO Coordinator | Petrolina, Pernambuco | March, 2017 | In person |
| | Associação Caatinga | It is a reference center for the conservation of the Caatinga. | 1 | conservation coordinator | Piranhas, Alagoas | November, 2016 | In person |

## APPENDIX 2- Unsystematic observation

| Type | Institution | length | Topic | Location | Promoted by | Date |
|---|---|---|---|---|---|---|
| Lectures | Xingó Center | 3 weeks | Coexisting with the Semiarid and social technologies | Piranhas, Alagoas | Xingó Center | November, 2016 |
| Visit | MST, Jacaré-Curituba community settlement. | 2 visits | Land use and political demands | Canindé do São Francisco, Sergipe | Xingó Center | November, 2016 |
| Visit | Usina Hidrelétrica de Xingó | 1 day | Water distribution | Piranhas, Alagoas | Personal | November, 2016 |
| Seminar | 3rdInternational Seminar of Coexistence with the Semiarid | 2 days | Coexisting with the Semiarid | Piranhas, Alagoas | Xingó Center | November, 2016 |
| Seminar | 2010-2016 Drought in the Brazilian Semiarid | 3 days | Drought Evaluation 2010-2016 | Fortaleza, Ceará | CGEE and Funceme | December, 2016 |
| Seminar | Productive Coexistence with Droughts: technological solutions and action strategies | 2 days | Productive Coexistence with Droughts: Technological Solutions and Strategies of Action | Petrolina, Pernambuco | Embrapa Semiárido | March, 2017 |

## APPENDIX 3- Individual participatory observation

| Type | Institution | length | Topic | Location | Promoted by | Date |
|---|---|---|---|---|---|---|
| workshop | Xingó center | 3 weeks | Coexisting with the Semiarid and social technologies | Piranhas, Alagoas | IABS | November, 2016 |
| Visit | MST, Jacaré-Curituba community settlement. | 2 visits | Land use and political demands | Canindé do São Francisco, Sergipe | Xingó Center | November, 2016 |

## APPENDIX 4- Interviews summed-up

**(1) What have been the most beneficial public policies for family farmers in the Brazilian Semiarid region?**

- Social safety net mechanisms and the period of public policies following 2002.
- Governmental projects P1+2 and P1MC. Recent droughts did not result in death by hunger or in farmers' migration like in the past, due to "*Bolsa Família*" and P1MC.,
- Civil society initiatives known as social technologies to attend dispersed family farmers.

**(2) What are the major challenges for family farmers in the Brazilian Semiarid region?**

- Lack of access to land and uneven land distribution (cited as more relevant than access to water).
- The technological/technical approach (traditional technologies used by public policies) to deal with the adversities of the BSA, based on engineering- hydraulic solutions. They have enhanced the social gap by privileging big landowners with technologies family farmers do not have access to.
- Programs and projects limited by government bureaucracy and lack of coordination between different government departments.
- Government wise, there is an absence of strategy, ex post evaluation or proper monitoring of programs. Inappropriate technical assistance and credit.
- Funding for social technologies promoted by civil society.
- Lack of access to infrastructure.

## APPENDIX 5- Several Delimitations of the BSA

| Date | Name | Criteria | Delimitation/ Municipalities | Author |
|---|---|---|---|---|
| 1936 | *Polígono das Secas* (Drought Polygon) | Data not shown. According to the Law No.175, based on characteristics of droughts observed in these regions | Limited by the polygonal, whose vertices are as follows: cities of Aracaty, Acarahú and Camocim in Ceará; intersection of the meridian of 44º W. G., with the parallel of 9º; intersection of the same meridian, with the parallelo of 11º and city of Amargosa, in the State of Bahia; city of Traipú in the State of Alagoas; city of Caruarú, in the State of Pernambuco; city of Campina Grande, in the state of Paraíba; and Natal city, in the State of Rio Grande do Norte. | BRASIL |
| 1951 | Review of the Drought Polygon | Data not shown | Vertices defined at the edge of the Atlantic by the cities of João Pessoa, Natal, Fortaleza and the limit point between the States of Ceará and Piauí in the foothills of the river São João da Praia; by the mouth of the Longa, in Parnaíba, and, following along the right bank of this, the affluence of the Black Uruçui whose course will accompany to the springs; the city of Gilbués, in Piauí; by the city of Barras, in the State of Bahia; and, by the current line, cities of Pirapora, Bocaiuva, Salinas and Rio Pardo de Minas, in the State of Minas Gerais; cities of Vista Nova, Poções and Amargosa, in the State of Bahia; cities of Tobias Barreto and Canhoba, in the State of Sergipe; city of Gravatá, in the State of Pernambuco; and the city of João Pessoa, in the state of Paraíba. | BRASIL |
| 1989 | Substitution of the Drought Polygon | annual precipitation of the municipalities of the region (ANA, 2017) | The region included in the area of activity of SUDENE, with annual average rainfall of 800 mm or less (800 millimeters) | SUDENE |
| 1995 | Review | Not found | 1,031 Municipalities | SUDENE |
| 2005 | New Delimitation of the Semiarid | I - annual average rainfall less than 800 millimeters; II - Aridity index of up to 0.5, calculated by the water balance between relates precipitation and potential evapotranspiration, between 1961 and 1990; and III - drought risk greater than 60%, based on the period between 1970 and 1990 | 102 new Municipalities.<br>Total 1,135 Municipalitites | MI/MMA |
| 2017 | Redelimitation of the Semiarid | Same criteria, based on the years between 1981 and 2010 | (July) 54 added Municipalities, total: 1,189<br>(November) 22 added Municipalities, total 1,262 | SUDENE |

Elaborated by the author, based on BRASIL (1936; 1951; 2005), Fuckner (2017), Neto (2017), MI/Sudene (2017) and Sudene (2017)

**APPENDIX 6- Workers, Area, Establishments, Area with Irrigation Systems, Establishments with Irrigation Systems, Workers Family-related to the Producer**

| Year 2006 | Family Farmers | | Non-family Farmers | |
|---|---|---|---|---|
| | Absolute Number | Percentage of Total | Absolute Number | Percentage of Total |
| **Workers** | 4,406,202 (74.9% men, 25% women) | 84,50% | 808,469 (75% men, 24.1% women) | 15,50% |
| **Area (ha)** | 21,449,047 | 43,32% | 28,067,999 | 56,68% |
| **Establishments (units)** | 1,527,861 | 89,16% | 185,684 | 10,84% |
| **Area (ha) with irrigation systems** | 218,826 | 46,59% | 250,902 | 53,41% |
| **Irrigated area / total area** | 218,826 / 21,449,047 | 1,02% | 250,902/ 28,067,999 | 0,89% |
| **Establishments (units) with irrigation systems** | 94,382 | 82,83% | 19,558 | 17,17% |
| **Units with irrigation systems/ total units** | 94,382/ 1,527,861 | 6,18% | 19,558/ 185,684 | 10,53% |
| **Amount of workers family-related to the producer** | 3,914,453 | 90,18% | 808,469 | 9,82% |

Elaborated by the author, data from Censo Agropecuário (IBGE, 2006)

**APPENDIX 7- Funding in Family Farming**

| Year 2006 | Number of Establishments (units) |
|---|---|
| Total family farmers establishments | **1,527,861** |
| Total family farmers establishments without any source of funding: | **1,299,758** |
| - Not needed | 504,27 |
| - Afraid to incur debt | 360,235 |
| - Different reasons | 222,147 |
| - Lack of payment of previous loans | 64,443 |
| - Lack of personal garantee | 26,963 |
| - Did not know how to obtain funding | 18,205 |

Elaborated by the author, data from Censo Agropecuário, table 1119 (IBGE, 2006)

## APPENDIX 8- Differences between Combating the Droughts and the CSA Approach

| Concepts | Combating Droughts | CSA |
|---|---|---|
| Drought | Natural phenomenon, a problem to be fought. It reproduces the land, water and power concentration model. | Climatic caracteristic of the region, which requires intelligent and proactives ways to adapt and co-live with ecossystems. |
| Nature and Human relations | Nature is an externality to be explored, conquered, dominated and commercialized. | Nature is assimilated and treated by an ethical approach of prudence, keeping, care (taking care of water, and seeds) and usage through an eco-centered approach. |
| Idea of Caatinga, Semiarid and its people | Inhospitable place, dry land, unviable, obsolete, its people way of life is resigned, vitims of droughts, miserable, outraged and conformed with poverty. | The Brazilian Semiarid is climate, vegetation, soil, sun, water, people, music, art, religion, politics, history and culture. It is a social process understood in a holistc way (Malvezzi, 2007). It is a territory with multidimensional identities and various coexisting alternatives. |
| Strategies of combating and coexisting with the Semiarid | Large construction work: (emergency)work fronts, dams, transposing basins, irrigation, water pipe tanks, food hamper (cesta básica). | Multiples: based on land, water and knowledge descentralization; contextualized education and technical assistance (new knowledge and acting; to store water and seeds; access to water through social technologies; social protagonism and participation. |
| Agri-food system | Extensive grain and cattle production, monoculture, irrigated fruitculture. | Based on agrobiodiversity and agroecological production for self-use; nutritional and food security. |
| Racionality and World vision/concept | Fragmented, technical and focused on economic development. It resulted in environmental, energy, economic, food and ethical crisis. | Ecocentered and holistic, favouring the emergence of biodiversity and sustainable ways of life. |

Source: Conti & Schoeder (2013), free translation

**APPENDIX 9- Coexisting with the Semiarid and Social Technologies Seminar**

**Type:** Seminar

**Date:** November, 3rd and 4th, 2016

**Location:** Xingó Center, located in the Semiarid region of Piranhas, Alagoas State, Brazil.

**Promoted by:** the Managing Committee of *Centro Xingó*, comprising the Spanish Agency for International Cooperation for Development - AECID, Fund for Cooperation in Water and Sanitation - DFCAS, Inter-American Institute for Cooperation on Agriculture - IICA, Brazilian Institute of Development and Sustainability - IABS, San Francisco Hydroelectric Company- Chesf, Secretary of State for Agriculture, Livestock, Fisheries and Aquaculture of Alagoas - Seagri / AL, Ministry of Integration - MI, Ministry of Environment – MMA.

**Participants:** approximately 350, outnumbering the 150-200 expected guests.

**Objective:** to promote the debate on the CSA with multi-sector stakeholders and to present experiences of the Coexisting with the Semiarid.

**Figure 18- CSA seminar, 2016**

Source: www.oeco.org.br

## Topics discussed and speakers:

| SPEAKERS | POSITION (Portuguese) | POSITION (English) |
|---|---|---|
| **Based Innovation Movement: New Models of Construction and Knowledge** | | |
| Juan Mariano Fressoli | Pesquisador assistente do Conselho Nacional de pesquisa científica e técnica da Argentina (CONICET) e pesquisador do Centro de pesquisas para a transformação (CENIT) | Research assistant at the National Council for Scientific and Technical Research of Argentina (CONICET) and researcher at the Research Center for Transformation (CENIT) |
| Marcel Bursztyn | Professor titular do Centro de Desenvolvimento sustentável da Universidade de Brasília (CDS/UNB) e Co- coordenador da sub rede de Desenvolvimento Regional da Rede clima | Full Professor of the Center for Sustainable Development of the University of Brasília (CDS / UNB) and Co-coordinator of the sub-network of Regional Development of the Climate Network |
| Eric Jorge Sawyer | Diretor-técnico (IABS) | Technical Director (IABS) |
| **International Symposium on Palm Production and Use in Semiarid Regions** | | |
| Fidel Mejía Lara | Engenheiro agrícola, especialista em agrossistemas, produtor de Nopal (Palma) e colaborador no Conselho mexicano de Nopal | Agricultural engineer, expert in agrosystems, producer of Nopal (Palma) and collaborator in the Mexican Council of Nopal |
| Timóteo Domingo | Cooking Chef specialist in products of the Semiarid | Cooking Chef specialist in products of the Semiarid |
| Frederico Carlos Pereira | Professor titular do Instituto Federal de Educação, ciência e Tecnologia da Paraíba (IFPB) | Professor at the Federal Institute of Education, Science and Technology of Paraíba (IFPB) |
| Carlos Henrique Soares | Analista técnico do Serviço Brasileiro de Apoio às Micro e pequenas Empresas de Alagoas (SEBRAE/AL) | Technical analyst of the Brazilian Service of Support to Micro and Small Companies of Alagoas (SEBRAE / AL) |
| Maria Nilza Mendonça | Instrutora de gastronomia do Serviço Nacional de aprendizagem Comercial (SENAC/CE) | Instructor of gastronomy of the National Service of Commercial Learning (SENAC / CE) |
| **Climate Vulnerability and Coexistence with the Semiarid** | | |
| Saulo Rodrigues Pereira Filho | Professor adjunto do CDS/UnB e Co-coordenador da sub rede de desenvolvimento regional da Rede clima | Adjunct Professor of CDS / UnB and Co-coordinator of the Climate Network's regional development sub-network |
| Marcos Aurélio Vasconcelos de Freitas | Coordenador do instituto virtual Internacional de mudanças climáticas (IVIG/COPPE/UFRJ) e coordenador da sub rede de energias renováveis da Rede clima | Coordinator of the International Virtual Institute for Climate Change (IVIG / COPPE / UFRJ) and coordinator of the Climate Network's renewable energy sub-network |
| Stoécio Malta Ferreira Maia | Professor do Instituto Federal de Alagoas (IFAL) e Co-coordenador da sub rede de Agricultura da Rede clima | Professor at the Federal Institute of Alagoas (IFAL) and Co-coordinator of the sub-network of the Climate Network |
| Alfredo Ribeiro Neto | Professor da Universidade Federal de Pernambuco (UFPE) e Co-coordenador da sub-rede de recursos hídricos da Rede clima | Professor at the Federal University of Pernambuco (UFPE) and Co-coordinator of the sub-network of water resources of the Climate Network |

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| Marcel Bursztyn | Professor titular do Centro de Desenvolvimento sustentável da Universidade de Brasília (CDS/UNB) e Co- coordenador da sub rede de Desenvolvimento Regional da Rede clima | Full Professor of the Center for Sustainable Development of the University of Brasília (CDS / UNB) and Co-coordinator of the sub-network of Regional Development Network Climate |
| **The Hydrological Use of the *Canal do Sertão*: Production, Productive Partner Insertion, Food Security and Coexistence with Semiarid** | | |
| David Pereira Jerez | Professor do Departamento de Engenharia Agro-florestal e do mestrado em Estratégias e Tecnologias para o Desenvolvimento da Universidade Politécnica de Madri | Professor of the Department of Forestry Engineering and of the Masters in Strategies and Technologies for the Development of the Polytechnic University of Madrid |
| Sérgio Antonio Alencar Guimarães | Diretor de planejamento e articulação de políticas da Superintendência do Desenvolvimento do Nordeste (SUDENE) | Director of planning and policy articulation of the Northeast Development Superintendency (SUDENE) |
| Gertjan Beekman | Coordenador da área de recursos naturais, gestão ambiental e adaptação às mudanças climáticas do instituto Interamericano de Cooperação para a Agricultura (IICA) | Coordinator of the area of natural resources, environmental management and adaptation to climate change of the Inter-American Institute for Cooperation on Agriculture (IICA) |
| Morganna Mendes Pedrosa de Oliveira | Assessora técnica da Secretaria de Desenvolvimento Regional do Ministério da Integração (SDR/MI) | Technical advisor of the Regional Development Secretariat of the Integration Ministry (SDR / MI) |
| Alvaro Otávio Vieira Machado | Secretário de junto da Agricultura, pecuária, Pesca e Aquicultura de Alagoas (Seagri/AL) | Secretary of Agriculture, Livestock, Fisheries and Aquaculture of Alagoas (Seagri / AL) |
| **Female Protagonism and the Coexistence with Semiarid** | | |
| Maria Miguel de Oliveira (Rosinha) | Artesã e presidente da Associação Comunitária de mocotó/CE | Artisan and president of the Community Association of mocotó / CE |
| Monica Celeida Rabelo Nogueira | Professora titular da Universidade de Brasília (UnB) | Full Professor at the University of Brasília (UnB) |
| Maria José dos Santos | Representantes da NATUCAPRI- Grupo de sabonete de leite de cabra/ AL | Representatives of NATUCAPRI- Group of goat's milk soap / AL |
| Môngolla Keyla Freitas de Abreu | Professora do curso de licenciatura em Ciências biológicas e coordenadora do PRONATEC da Universidade Estadual do Ceará (UECE) | Professor of the licentiate course in biological sciences and coordinator of PRONATEC of the State University of Ceará (UECE) |
| **Semiarid Regions in the World: Potential for Collaboration** | | |
| Carlos Perez Ybarra | Responsável do programa de meio ambiente, mudanças climáticas, água e saneamento da Agência Espanhola de Cooperação Internacional para o Desenvolvimento (AECID) | Responsible for the environment, climate change, water and sanitation program of the Spanish Agency for International Cooperation for Development (AECID) |

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| Fabio de Almeida Pinto | Coordenador executivo do Instituto democrático e sustentabilidade (IDS) | Executive Coordinator of the Democratic Institute and Sustainability (IDS) |
| Salomão Medeiros | Pesquisador na área de recursos hídricos e diretor do Instituto Nacional do semiárido (INSA/MCTI) | Researcher in the area of water resources and director of the National Institute of the semiarid (INSA / MCTI) |
| Jorge José Horta Revez | Presidente da direção da associação de defesa do Patrimônio de Mertola, Portugal | Chairman of the Heritage of Mertola defense association, Portugal |
| Javier Mazorra Aguiar | Centro de inovação em Tecnologia para o Desenvolvimento Humano da Universidade Politécnica de Madrid | Center for Innovation in Technology for Human Development of the Polytechnic University of Madrid |

**APPENDIX 10- "Coexisting with the Semiarid" workshop**

**Type:** Workshop

**Date:** from the 7th to the 25th of November, 2016

**Location:** Xingó Center, in the Semiarid region of Piranhas, Alagoas State, Brazil.

**Promoted by:** the Managing Committee of *Centro Xingó*, comprising the Spanish Agency for International Cooperation for Development - AECID, Fund for Cooperation in Water and Sanitation - DFCAS, Inter-American Institute for Cooperation on Agriculture - IICA, Brazilian Institute of Development and Sustainability - IABS, San Francisco Hydroelectric Company- Chesf, Secretary of State for Agriculture, Livestock, Fisheries and Aquaculture of Alagoas - Seagri / AL, Ministry of Integration - MI, Ministry of Environment – MMA.

And the Scientific Committee, constituted by the Postgraduate Program in Sustainable Regional Development of the Federal University of Cariri - PRODER / UFCA, the Center for Innovation in Technologies for Human Development of the Polytechnic University of Madrid - ITUPUPM and the Sustainable Development of the University of Brasília - CDS / UnB.

**Participants:** 32, from the public and private sectors, universities, NGOs, trade unions, family farmers, representatives of social movements, as well as representatives from local communities and students from Brazil and Spain.

| **PARTICIPANTS** | **INSTITUTIONS** |
|---|---|
| Aline Bezerra de Sousa | UFCA |
| Amanda Sousa Silvino | UNICAMP |
| Carolina Gomes Nascimento | IABS |
| Claudemi dos Santos | Secretaria Municipal de Agricultura de Poço Redondo - SE |
| Cláudio Rodrigues dos Santos | MMA |
| Elis Gardênia dos Santos | FUNDAÇÃO ARARIPE |
| Fábio Weber Sousa Costa | Articulador |
| Francisco Marciano de Alencar Silva | UFCA |
| Francisco Mário de Sousa Silva | UFCA |
| Ialy Aparecida Angela de Moura | IFAL |
| Isaquiel Dias | EMATER |
| José Aildo Sabino de Oliveira Júnior | Sudene |
| José Cazusa Ferreira de Oliveira | Sec. Municipal de Agricultura - Inhapi |
| José Daniel Coelho dos Santos | UFC |
| José Fernandes da Silva | Secretaria Municipal de Agricultura de Poço Redondo - SE |
| Josevane Fernandes de jesus | IFS |

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|---|---|
| Karla Emanuella Sousa dos Santos | UFAL |
| Lais de Jesus Souza | FUNDAÇÃO ARARIPE |
| Letícia Wittlin Machado | UFRJ |
| Lidiane Taverny Sales | UnB |
| María Cebriá Derqui | IABS |
| Maria Cleusa Guimarães | Emdagro |
| Maria Suarez Bonet | IABS |
| Marisa Beltrão Malta | FASVIPA |
| Miriam Aprigio Pereira | UnB |
| Nathaly dos Santos Batista | UFAL |
| Renato Arruda Vaz de Oliveira | Sudene |
| Samuel Barbosa Tavares dos Santos | UFAL |
| Sandra de Souza da Silva | INSTITUTO TERRAVIVA |
| Thiago Roberto Soares Vieira | Associação Caatinga e Sociedade Semear |
| Timoteo Domingos Martins | Cooking Chef specialist in products of the Semiarid |
| Wilma Lima Maciel | UFAL |

The third edition of the International Course of Coexistence with the Semiarid is the result of demands and expectations in the process of discussion and collective construction on the topics addressed with the aim of disseminating integrated knowledge about semi-arid regions, their challenges and opportunities in an environmentally sustainable and socially adequate way.

**Objective:** to contribute to the formation of students as multipliers, holders of a comprehensive and integrated understanding of the coexistence with Semiarid and to develop creative and reflective agents, prepared to guide and stimulate the development of these environments.

**Outcome:** all participants wrote a book chapter published online Available at http://editora.iabs.org.br/site/wp-content/uploads/2018/02/Seminario-3-Xingo-web.pdf

**Module I- Social Business and Rural-Urban Integration**

During the first week a local cooperative visited the Xingó center to present the challenges of producing in the region and expose their products. Another guest at the workshop was João Neguinho, a land settler (*assentado*).

**Figure 19- Products of a BSA cooperative, 2016**

The group visited a local community, called *Sítio Bananeira*, to learn agroecological methods family farmers were using, especially organic matter left by trees, and to get familiar with the system.

Theoretical work was focused on policies to integrate the rural and urban areas, participants developing a public policy that contained stakeholders, resources and financing as an outcome. Solidarity-based-economy was discussed in the context of the Brazilian Semiarid region.

**Figure 20- Visit to the Bananeira farm, BSA, and the workshop group, 2016**

**Module II - Socio-Productive Insertion and the Use of Products from the *Caatinga* Sociobiodiversity**

During the second week, the group got acquainted with productive insertion projects, among them the "Oyster Project", developed by the IABS. We also became familiar with the San Francisco tourism route.

Participants frequently criticized plastic cisterns during discussions. Environmental services and the *Caatinga* potentialities were also discussed.

Participants visited the Jacaré-Curituba settlement to learn family farmers' social technologies.

**Figure 21- Local cistern, Jacaré-Curituba settlement, BSA, 2016**

One of the experiences was promoted by the local Chef, Timoteo Domingos, who was one of the participants at the workshop. He conducted the group through the selection of the local biodiversity for the purpose of human feeding at the Xingó Center. Participants learned how to use unusual resources for cooking.


**Figure 22- Lunch preparation with products of the Caatinga, Centro Xingó, BSA, 2016**

**Module III - Education, exchange and Rural Extension: Exchanges of Knowledge in Rural Areas**

Issues discussed included:

(i) how to assure farmers will return to the country after their education programs are concluded;

(ii) Alternative schools and universities, corresponding to the rural reality;

(iii) *escola de alternância* (type of rural school focused on agriculture knowledge where the student spends half month at home, putting into practice what they have learned at school); and

(iv) the role of EMATER and ATER.

During activities, projects form organizations working at the region were presented. Among them, the *Semear* project showed the functioning of the Zé Marculino settlement school.

Frequent critics brought up by participants included the unrecognized role of women as farmers and protagonists; difficulty in mobilizing young people to participate in rural-focused-schools; and lack of agriculture valorization.

**APPENDIX 11- 2010-2016 Drought in the Brazilian Semiarid Seminar**

**Type:** Seminar

**Date:** from the 30th of November to the 2nd of December, 2016

**Location:** Northeast Bank (BNB) complex in Fortaleza, Ceará State, Brazil.

**Promoted by:** *Centro de Gestão e Estudos Estratégicos* (CGEE, Center for Strategic Studies and Management in Science, Technology and Innovation), *Fundação Cearense de Meteorologia e Recursos Hídricos* (Funceme, Ceará State Foundation of Meteorology and Water Resources) and the TechnicalScientific Association Eng. Paulo de Frontin (ASTEF), of the Federal University of Ceará.

**Participants:** Representatives from the 11 states of the semi-arid region, the Federal Government, city governments, the private sector, civil society, international institutions (World Bank, FAO and World Meteorological Organization, Nebraska Drought Mitigation Center) and universities (Universities of Wageningen and Georgia, Federal University of Ceará, University of Brasília, State University of Maranhão and University of International Integration of Afro-Brazilian Lusophony).

**Objective:** to disseminate the results of research and development related to droughts in the Brazilian Semiarid region. Topics cover a wide range of knowledge and include themes in the areas of Meteorology, Climatology, Climate Change, Water Resources, Environment and Renewable Energies in their various aspects, from diagnostic and prognostic studies to development in the areas of monitoring, numerical modeling and information.

**Outcome:** LETTER OF FORTALEZA, comprising recommendations regarding drought policies.


**Figure 23- 2010-2016 Drought seminar folder**

| SPEAKERS | POSITION (Portuguese) | POSITION (English) |
|---|---|---|
| **Opening** | | |
| Camilo Santana | Governador do Ceará | Governor of Ceará |
| Arthur Costa Moura | General Comandante – Comando Militar do Nordeste - CNME | General Commander - Northeast Military Command - CNME |
| Marcos Costa Holanda | Presidente do BNB | President of the BNB |
| Martin Raiser | Diretor do Banco Mundial | Director of the World Bank |
| Wilfrido Tiradentes da Rocha Neto | Diretor de Gestão de Políticas, Ministério da Integração Nacional | Director of Policy Management, Ministry of National Integration |
| Antônio Carlos Filgueira Galvão | Diretor do Centro de Gestão e Estudos Estratégicos – CGEE | Director of the Center for Management and Strategic Studies - CGEE |
| Paulo Lopes Varella Neto | Diretor da Agencia Nacional de Águas | Director of the National Water Agency |
| Marcelo José de Almeida Neves | Superintendente da Superintendência de Desenvolvimento do Nordeste – SUDENE | Superintendent of the Superintendency of Development of the Northeast - SUDENE |
| Edson Duarte | Secretário Nacional de Articulação Institucional e Cidadania Ambiental – SAIC/MMA | National Secretary for Institutional Articulation and Environmental Citizenship - SAIC / MMA |
| | | |
| **Book launching "Droughts in Brazil: Proactive Management and Policies”** | | |
| Martin Raiser | Diretor do Banco Mundial | Director of the World Bank |
| Antônio Carlos Filgueira Galvão | Diretor do Centro de Gestão e Estudos Estratégicos – CGEE | Director of the Center for Management and Strategic Studies - CGEE |
| Nathan Engle | Banco Mundial | World Bank |
| Antonio Rocha Magalhães | Centro de Gestão e Estudos Estratégicos – CGEE | Center for Management and Strategic Studies - CGEE |
| Francisco José Teixeira | Secretário de Recursos Hídricos do Ceará - SRH | Secretary of Water Resources of Ceará - SRH |
| Antônio Divino Moura | Coordenador do Centro de Previsão de Tempo e Estudos Climáticos - CPTEC/INPE | Coordinator of the Center for Weather Forecasting and Climate Studies - CPTEC / INPE |
| | | |
| **Drought Policy: An International Perspective** | | |
| Martin Raiser | Coordenador- Diretor do Banco Mundial | Coordinator- Director of the World Bank |
| Bruno Biazeto | Relator - Banco Mundial | Rapporteur- World Bank |

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|---|---|---|
| Robert Stefanski | Integrated Drought Management Programme – IDMP (OMM/GWP) | Integrated Drought Management Program - IDMP (OMM / GWP) |
| Michael Hayes | National Drought Mitigation Center – NDMC (USA) | National Drought Mitigation Center - NDMC (USA) |
| Carmem Molejon | Banco Mundial | World Bank |
| Nathan Engle | Banco Mundial | World Bank |
| Wilfrido Tiradentes da Rocha Neto | Debatedor – Ministério da Integração Nacional – MI | Debater - Ministry of National Integration - MI |
| Valdemar Rodrigues | Debatedor - Diretor de Desenvolvimento Rural Sustentável - SEDR/MMA | Debater - Director of Sustainable Rural Development - SEDR / MMA |
| | | |
| **Drought Policy and Regional Development Policy** | | |
| Wilfrido Tiradentes da Rocha Neto | Coordenador – Diretor de Gestão de Políticas, Ministério da Integração Nacional | Coordinator - Director of Policy Management, Ministry of National Integration |
| Paulo Pitanga do Amparo | Relator – Coordenador Geral de Monitoramento e Avaliação - SDR/MI | Rapporteur - General Coordinator for Monitoring and Evaluation - SDR / MI |
| José Machado | Economista | Economist |
| Firmo Fernandes de Castro | Economista | Economist |
| Leonardo Bezerra de Melo Tinoco | Instituto Nacional do Semiárido - INSA | National Institute of the Semi-Arid - INSA |
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| **Drought Monitoring in the Northeast** | | |
| Paulo Lopes Varella Neto | Coordenador – Diretor da Agência Nacional de Águas - ANA | Coordinator - Director of the National Water Agency - ANA |
| Morgana Mendes Pedrosa | Relatora – SDR/MI | Rapporteur - SDR / MI |
| Eduardo Sávio Martins | Presidente - Fundação Cearense de Meteorologia e Recursos Hídricos - FUNCEME | President - Fundação Cearense de Meteorologia e Recursos Hídricos - FUNCEME |
| Marcelo Cauás Asfora | Presidente - Agência Pernambucana de Água e Clima - APAC | President - Pernambuco Water and Climate Agency - APAC |
| Eduardo Topázio | Instituto do Meio Ambiente e Recursos Hídricos do Estado da Bahia-INEMA | Institute of Environment and Water Resources of the State of Bahia-INEMA |
| Joaquim Gondim | Superintendente da Agência Nacional de Águas-ANA | Superintendent of the National Water Agency-ANA |

| SPEAKERS | POSITION (Portuguese) | POSITION (English) |
|---|---|---|
| **Climate and Drought: Analysis of the Factors that Modulate the Climate and the Forecast Emitted in the Period.** | | |
| Antônio Divino Moura | Coordenador – Coordenador do Centro de Previsão de Tempo e Estudos Climáticos - CPTEC/INPE | Coordinator - Coordinator of the Center for Weather Forecasting and Climate Studies - CPTEC / INPE |
| Meiry Sayuri Sakamoto | Relatora – Fundação Cearense de Meteorologia e Recursos Hídricos - Funceme | Relatora - Fundação Cearense de Meteorologia e Recursos Hídricos - Funceme |
| José Antônio Marengo Orsini | Chefe de Pesquisas Aplicadas do Centro Nacional de Monitoramento e Alerta de Desastres Naturais – CEMADEN/INPE | Head of Applied Research of the National Center for Monitoring and Alert of Natural Disasters - CEMADEN / INPE |
| Francisco de Assis Diniz | Diretor do Instituto Nacional Meteorologia - INMET | Director of the National Meteorological Institute - INMET |
| Mary Toshie Kayano | Pesquisadora do Centro de Previsão de Tempo e Estudos Climáticos - CPTEC/INPE | Researcher at the Center for Weather Forecasting and Climate Studies - CPTEC / INPE |
| Eduardo Sávio Martins | Presidente da Fundação Cearense de Meteorologia e Recursos Hídricos - FUNCEME | President of the Ceará Foundation of Meteorology and Water Resources - FUNCEME |
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| **Impact on Water Resources** | | |
| Paulo Lopes Varella Neto | Coordenador- Diretor da Agência Nacional de Águas – ANA | Coordinator - Director of the National Water Agency - ANA |
| Betina Ferraz | Relatora- Centro de Gestão e Estudos Estratégicos - CGEE | Rapporteur - Center for Management and Strategic Studies - CGEE |
| Ângelo José de Negreiros Guerra | Diretor Geral do Departamento Nacional de Obras Contra a Seca - DNOCS | Director General of the National Department of Works Against Drought - DNOCS |
| Sérgio Gonçalves | Diretor de Recursos da Secretaria de Recursos Hídricos e Ambiente Urbano – SRHU/MMA | Director of Resources of the Secretariat of Water Resources and Urban Environment - SRHU / MMA |
| Rodrigo Flecha | Superintendente de Regulação da Agência Nacional de Águas – ANA | Superintendent of Regulation of the National Water Agency - ANA |
| Procópio Lucena | Presidente do Comitê de Bacia do Rio Piranhas/Açu | Chairman of the Piranhas / Açu River Basin Committee |
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| **Impacts on the States- Section 1** | | |
| Sergio Zelaya Bonilla | Coordenador – Organização das Nações Unidas para Agricultura e Alimentação – FAO | Coordinator - Food and Agriculture Organization of the United Nations - FAO |
| Margareth Benício Carvalho | Relatora- Fundação Cearense de Meteorologia e Recursos Hídricos - Funceme | Relatora - Fundação Cearense de Meteorologia e Recursos Hídricos - Funceme |

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|---|---|---|
| Márcio José Honaiser | Maranhão- Secretário de Agricultura, Pecuária e Pesca - Sagrima | Maranhão - Secretary of Agriculture, Livestock and Fisheries - Sagrima |
| Sônia Maria Ribeiro Feitosa | Piauí – Gerente de Hidrometeorologia da Secretaria de Meio Ambiente e Recursos Hídricos-SEMARH | Piauí - Hydrometeorology Manager of the Secretariat of Environment and Water Resources-SEMARH |
| Gianni Lima | Ceará - Companhia de Gestão dos Recursos Hídricos do Ceará - COGERH | Ceará - Water Resources Management Company of Ceará - COGERH |
| Josivan Cardoso Moreno | Rio Grande do Norte- Diretor Presidente do Instituto de Gestão das Águas - IGARN | Rio Grande do Norte - Chief Executive Officer of the Water Management Institute - IGARN |
| Palestrante | Bahia | Bahia |
| João Cruz Reis Filho | Minas Gerais- Secretário de Estado de Agricultura, Pecuária e Abastecimento de Minas Gerais | Minas Gerais - Secretary of State for Agriculture, Livestock and Supply of Minas Gerais |

| **Impacts on the States- Section 2** | | |
|---|---|---|
| Hypérides Macedo | Coordenador – Consultor | Coordinator - Consultant |
| Sônia Perdigão | Relatora – Fundação Cearense de Meteorologia e Recursos Hídricos - FUNCEME | Relatora - Fundação Cearense de Meteorologia e Recursos Hídricos - FUNCEME |
| João Fernandes da Silva | Paraíba – Diretor Presidente da Agência Executiva de Gestão das Águas do Estado da Paraíba-AESA | Paraíba - Chief Executive Officer of the Paraíba-AESA State Water Management Agency |
| Flávio Guimarães Figueiredo Lima | Pernambuco – Presidente da Agencia Estadual de Planejamento e Pesquisas de Pernambuco – CONDEP/FIDM | Pernambuco - President of the State Agency of Planning and Research of Pernambuco - CONDEP / FIDM |
| Claudio Alexandre Ayres da Costa | Alagoas – Secretário de Estado do Meio Ambiente e dos Recursos Hídricos de Alagoas – SEMARH | Alagoas - Secretary of State for the Environment and Water Resources of Alagoas - SEMARH |
| Octaciano Gomes de Souza Neto | Espirito Santo – Secretário de Estado da Agricultura, Abastecimento, Aquicultura e Pesca - SEAG | Espírito Santo - Secretary of State for Agriculture, Supply, Aquaculture and Fisheries - SEAG |
| Overland de Amaral Costa | Sergipe – Centro de Meteorologia da Secretaria de Estado do Meio Ambiente e dos Recursos Hídricos - SEMARH | Sergipe - Meteorological Center of the State Secretariat of Environment and Water Resources - SEMARH |

| **Increasing the Resilience of Local Farming Systems - the Vision of EMBRAPA** | | |
|---|---|---|
| Iedo Bezerra Sá | Coordenador – Embrapa Semiárido – Petrolina/PE | Coordinator - Embrapa Semiarid - Petrolina / PE |
| José Roberto de Lima | Relator - Centro de Gestão e Estudos Estratégicos - CGEE | Rapporteur - Center for Management and Strategic Studies - CGEE |
| Eduardo Delgado Assad | Embrapa Informática Agropecuária – Campinas/SP | Embrapa Informática Agropecuária - Campinas / SP |

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| Gherman Garcia Leal de Araújo | Embrapa Semiárido – Petrolina/PE | Embrapa Semiarid - Petrolina / PE |
| Alineaurea Florentino Silva | Embrapa Semiárido – Recife/PE | Embrapa Semiarid - Recife / PE |
| Aderaldo de Souza Silva | Embrapa Semiárido– Petrolina/PE | Embrapa Semiarid - Petrolina / PE |
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| **Impacts on Biodiversity and the *Caatinga*** | | |
| Valdemar Rodrigues | Coordenador – Diretor de Desenvolvimento Rural Sustentável (SEDR/MMA) | Coordinator - Director of Sustainable Rural Development (SEDR / MMA) |
| Marcos Santana | Relator – Diretoria de Desenvolvimento Rural Sustentável (SEDR/MMA) | Rapporteur - Directorate of Sustainable Rural Development (SEDR / MMA) |
| Joberto Veloso de Freitas | Serviço Florestal Brasileiro- Diretor | Brazilian Forest Service - Director |
| Washington Franca Rocha | Universidade Estadual de Feira de Santana – UEFS/Projeto de Mapeamento Anual da Cobertura e Uso do Solo no Brasil (MAPBIOMAS) | Universidade Estadual de Feira de Santana - UEFS / Annual Mapping Project of Coverage and Land Use in Brazil (MAPBIOMAS) |
| Rodrigo Castro | Coordenador Geral da Associação Caatinga | General Coordinator of the *Caatinga* Association |
| Joao Arthur Seyffarth | Secretaria de Extrativismo e Desenvolvimento Sustentável – SEDR/MMA | Secretariat of Extractivism and Sustainable Development - SEDR / MMA |

| SPEAKERS | POSITION (Portuguese) | POSITION (English) |
|---|---|---|
| **Launch of the Constitutional Fund for the Northeast (FNE) Água - BNB** | | |
| Marcos Costa Holanda | Coordenador – Presidente do BNB | Coordinator - President of BNB |
| Francisco José de Araújo Bezerra | Superintendente de Políticas de Desenvolvimento do BNB | BNB Development Superintendent |
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| **States' Responses to the Drought: How They Organized, How They Responded- Section 1** | | |
| Artur Bruno | Coordenador – Secretário de Meio Ambiente do Ceará – SEMA | Coordinator - Secretary of Environment of Ceará - SEMA |
| Monica Amorin | Relatora – Universidade Federal do Ceará - UFC | Rapporteur - Federal University of Ceará - UFC |
| Marcelo de Araújo Costa Coelho | Maranhão – Secretário de Meio Ambiente e Recursos Naturais - Sema | Maranhão - Secretary of Environment and Natural Resources - Sema |
| Milcíades Gadelha | Piauí – Fundação Agente | Piauí - Agent Foundation |
| Helder Cortez | Ceará – Companhia de Águas e Esgoto do Ceará – CAGECE | Ceará - Water and Sewage Company of Ceará - CAGECE |
| José Mairton França | Rio Grande do Norte – Secretário de Estado do Meio Ambiente e Recursos Hídricos do Rio Grande do Norte – SEMARH/RN | Rio Grande do Norte - Secretary of State for the Environment and Water Resources of Rio Grande do Norte - SEMARH / RN |
| Eduardo Topázio | Bahia – Instituto do Meio Ambiente e Recursos Hídricos – INEMA | Bahia - Institute of Environment and Water Resources - INEMA |
| Gustavo Xavier Ferreira | Minas Gerais – Secretário de Estado de Desenvolvimento e Integração do Norte e Nordeste de Minas Gerais – SEDINOR | Minas Gerais - Secretary of State for Development and Integration of the North and Northeast of Minas Gerais - SEDINOR |
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| **States' Responses to the Drought: How They Organized, How They Responded- Section 2** | | |
| Eudoro Santana | Coordenador – Instituto de Planejamento de Fortaleza – IPLANFOR | Coordinator - Instituto de Planejamento de Fortaleza - IPLANFOR |
| Jair do Amaral | Relator – Universidade Federal do Ceará | Relator - Federal University of Ceará |
| Deusdete Queiroga Filho | Paraíba – Secretário Executivo de Infraestrutura e Recursos Hídricos da Paraíba | Paraíba - Executive Secretary of Infrastructure and Water Resources of Paraíba |
| Valmir Pedrosa | Alagoas – Especialista em Meio Ambiente e Recursos Hídricos – SEMARH/AL | Alagoas - Specialist in Environment and Water Resources - SEMARH / AL |
| Ailton Francisco da Rocha | Sergipe – Superintendente de Recursos Hídricos da Secretaria de Estado do Meio Ambiente e dos Recursos Hídricos- SEMARH | Sergipe - Superintendent of Water Resources of the Secretariat of State for the Environment and Water Resources - SEMARH |

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|---|---|---|
| Paulo Renato Paim | Espírito Santo – Diretor Presidente da Agência Estadual de Recursos Hídricos-AGERH | Espírito Santo - President of the State Agency for Water Resources-AGERH |
| Mauro Roberto de Souza Lacerda | Pernambuco - Gerente Geral de Revitalização e Sistemas Rurais/Secretaria Executiva de Recursos Hídricos/ Secretaria de Desenvolvimento Econômico-SDEC | Pernambuco - General Manager of Revitalization and Rural Systems / Executive Secretariat of Water Resources / Secretariat of Economic Development-SDEC |

**Federal Government Responses to the Drought 2010-2016**

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|---|---|---|
| Francisco José de Araújo Bezerra | Coordenador – Superintendente de Políticas de Desenvolvimento do BNB | Coordinator - Superintendent of BNB Development Policies |
| Tibério Rômulo Romão Bernardo | Relator – Gerente do Ambiente Escritório Técnico de Estudos Econômicos do Nordeste – ETENE/ BNB | Rapporteur - Environment Manager Technical Office of Economic Studies of the Northeast - ETENE / BNB |
| Luciano Jany Feijão Ximenes | Gerente Executivo do Escritório Técnico de Estudos Econômicos do Nordeste do ETENE/BNB | Executive Manager of the Technical Office of Economic Studies of the Northeast of ETENE / BNB |
| Coronel Cristiano Guimarães Barbosa | Comandante da Operação Carro-Pipa (EB-CMNE) | Officer Commander of Operation Pipe Car (EB-CMNE) |
| Newton Araújo Silva Jr. Diracir Lacerda | Superintendente de Abastecimento Social da Companhia Nacional de Abastecimento-CONAB | Superintendent of Social Supply of Companhia Nacional de Abastecimento-CONAB |

**Federal Government Responses to the Drought 2010-2016**

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|---|---|---|
| Bruno Pagnoccheschi | Coordenador – Coordenador de Gestão Estratégica da ANA | Coordinator - Coordinator of Strategic Management of ANA |
| Betina Ferraz | Relator – Centro de Gestão e Estudos Estratégicos CGEE | Rapporteur - Center for Management and Strategic Studies CGEE |
| Wesley Gabrieli de Souza | Agência Nacional de Águas – ANA | National Water Agency - ANA |
| Dione Maria de Freitas | Coordenadora Geral do Garantia Safra – Secretaria Especial de Agricultura Familiar d do Desenvolvimento Agrário-SEAD | General Coordinator of the Safra Guarantee - Special Secretariat for Family Agriculture of Agrarian Development-SEAD |
| Magno Gonçalves da Costa | Centro Nacional de Gerenciamento de riscos e Desastres - CENAD/MI | National Center for Risk and Disaster Management - CENAD / MI |

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|---|---|---|
| **The Contribution of the Academy in the Production of Knowledge for Decision Making** | | |
| Eduardo Sávio Martins | Coordenador – Presidente da Fundação Cearense de Meteorologia e Recursos Hídricos - FUNCEME | Coordinator - President of the Cearense Foundation of Meteorology and Water Resources - FUNCEME |
| Francisco das Chagas V. Jr | Relator – Pesquisador da FUNCEME | Rapporteur - Researcher at FUNCEME |
| Ênio Souza | Universidade Federal de Campina Grande - UFCG | Federal University of Campina Grande - UFCG |
| Francisco de Assis de Souza Filho | Universidade Federal do Ceará - UFC | Federal University of Ceará - UFC |
| Pieter Van Oel | Universidade Wageningen | Wageningen University |
| Don Nelson | Universidade da Georgia | University of Georgia |
| | | |
| **Perspectives for a New Policy on Coping with Drought: An Agenda for the Future** | | |
| Antonio Rocha Magalhães | Coordenador – Centro de Gestão e Estudos Estratégicos - CGEE | Coordinator - Center for Management and Strategic Studies - CGEE |
| Eduardo Sávio Martins | Relator – Presidente da Fundação Cearense de Meteorologia e Recursos Hídricos - FUNCEME | Relator - President of the Cearense Foundation of Meteorology and Water Resources - FUNCEME |
| Francisco José Teixeira | Secretário de Estado de Recursos Hídricos do Ceará | Secretary of State for Water Resources of Ceará |
| Wilfrido Tiradentes da Rocha Neto | Diretor de Gestão de Políticas – SDR/MI | Director of Policy Management - SDR / MI |
| Vicente Andreu Guillo | Presidente, Agência Nacional de Águas – ANA | President, National Water Agency - ANA |
| Sérgio Zelaya Bonilla | Organização das Nações Unidas para Agricultura e Alimentação – FAO | Food and Agriculture Organization of the United Nations - FAO |
| | | |
| **Closing (Semiarid Statement)** | | |
| Antônio Rocha Magalhães | Centro de Gestão e Estudos Estratégicos - CGEE | Center for Management and Strategic Studies - CGEE |
| Francisco Teixeira | Secretário de Recursos Hídricos do Ceará | Secretary of Water Resources of Ceará |

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|---|---|---|
| Eduardo Martins | Presidente da Fundação Cearense de Meteorologia e Recursos Hídricos - FUNCEME | President of the Cearense Foundation of Meteorology and Water Resources - FUNCEME |
| Valdemar Rodrigues | Diretor de Extrativismo e Desenvolvimento Regional Sustentável do MMA | Director of Extractivism and Sustainable Regional Development of MMA |
| Francisco José de Araújo Bezerra | Superintendente do Escritório Técnico de Estudos Econômicos do Nordeste - Etene - BNB | Superintendent of the Technical Office of Economic Studies of the Northeast - Etene - BNB |

**APPENDIX 12- Productive Coexistence with the Drought: Technological Solutions and Strategies of Action Seminar**

**Type:** Seminar

**Date:** 14th and 15th of Mach, 2017

**Location:** Embrapa Semiarid auditorium, Petrolina, Pernambuco State

**Promoted by:** Ministry of Agriculture, Livestock and Food Supply, Embrapa and the Federal Government.

**Participants:** Large and medium-sized rural producers and Cooperatives; small rural producers, students in areas related to the work of Embrapa, press, technology transfer agents (TT-ATER), scientific and academic community, agricultural research institutes, non-governmental organizations (NGOS), executive or legislative powers.

**Objective:** to address the current drought scenario in the Sertão and discuss the viable ways of living with the Semiarid Northeast.

**Outcome:** Group work, with the contribution of the participants of the seminar, discussing and pointing out the strategies of actions to guarantee production in the current scenario of prolonged drought. In addition to guiding Embrapa's future research work, the outcome of the discussions will become a document that could serve as a subsidy for governments and public institutions in their actions aimed at coexisting with the drought.

The Seminar presented and discussed appropriate productive strategies to situations of prolonged drought, based on the technological solutions developed by Embrapa and partner institutions. It was also based on the successful experiences of Technical Assistance and Rural Extension (ATER) and family farmers and rural producers, which result in higher resilience of Semiarid agricultural systems. Topics during the event are related to the climatic scenario of prolonged drought and its impacts on the *Caatinga* Biome, technological solutions and productive experiences in livestock and water management, and use in agricultural production.


**Figure 24- Productive Coexistence with the Drought folder**

| **Panel 1 - Climatic Scenario of Prolonged Drought and Mitigation Actions in the *Caatinga* Biome** | | |
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| Moderator: Salomão de Sousa Medeiros, INSA | | |
| **SUB-TOPIC** | **SPEAKER** | **POSITION** |
| Climatic scenarios of prolonged drought in the Semiarid | Mario Miranda | Federal University of the São Francisco Valley |
| Ecological restoration as a strategy for soil conservation in the Brazilian semi-arid region | Jacob Silva Souto | Federal University of Campina Grande, PA |
| Potentialities of the *Caatinga* biodiversity, *Sequeiro* Fruticulture | Saulo de Tarso Aidar | Embrapa Semiarid |
| Extractivism in communities pasture fund, Report of experience | Alcides Peixinho de Nascimento | Extrativist-COOPERCUC- Uauá-BA |
| Production of goat and cow milk in a small farm using the C*aatinga*, Experience report | Eduardo Emídio dos Santos | Rural farmer, Jacuípe Bahia |

| **Panel 2 - Technological Solutions and Productive Experiences of Livestock in Periods of Prolonged Drought** | | |
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| Moderator: Humberto Miranda Oliveira, the Bahia Agriculture and Livestock Federation (FAEB) and the National Rural Learning System (SENAR) | | |
| **SUB-TOPIC** | **SPEAKER** | **POSITION** |
| Food and herd management in the Semiarid | Tadeu Vines Voltolini | Embrapa Semiarid |
| Producing, conserving and supplying water via succulent forages | Gherman Garcia Leal de Araújo | Embrapa Semiarid |
| Maintenance of swarms in the dry period | José Fernandes | Bahia Ater / The Government of the State of Bahia |
| Forage palm production unit, Experience report | Rafael Sene | rural producer of Juazeiro, Bahia |
| Management strategies for milk production in the semi-arid region: successful actions of Lagedo Farm, Experience report | Luís Oliveira Gonçalves | Rural producer, Queimadas, BA |
| **Panel 3- Efficient Management and Use of Water in Agricultural Production** | | |
| Moderator: José Moacir dos Santos, Regional Institute of the Appropriate Agropecuária (IRPAA) | | |
| **SUB-TOPIC** | **SPEAKER** | **POSITION** |
| Rainwater harvesting and management in agricultural production | Luísa de Brito | Embrapa Semiarid |
| Collective green areas, an alternative for goat-ovine family-based sheep in the Semiarid | Clovis Guimarães Filho | Embrapa Semiarid |
| Bio-water and family farms | Felipe Jalfim | PhD in Agroecology |
| Strategies for managing sheep production, Experience report | Luiz Valdo | Rural producer, Dormentes, Pernambuco |
| Improving production in dry weathe, Experience report | Marsha Hanzi | Permaculture producer, Bahia |