

## Resilience to climate change in *Fundo de Pasto* Communities in the semiarid region of Bahia State, Brazil

Larisa Ho Bech Gaivizzo<sup>1</sup> 

Gabriela Litre<sup>1</sup> 

Julia Lopes Ferreira<sup>1</sup> 

Romero Gomes Pereira da Silva<sup>1</sup> 

Daniela Nogueira Soares<sup>1</sup> 

Rafael Moraes Reis<sup>1</sup> 

Ana Claudia Almeida<sup>1</sup> 

Nelson Eduardo Bernal Davalos<sup>1</sup> 

Priscylla Dayse Almeida Gonçalves Mendes<sup>1</sup> 

Diego Pereira Lindoso<sup>1</sup> 

Adriane Michels Brito<sup>1</sup> 

Saulo Rodrigues-Filho<sup>1</sup> 

Carlos Hiroo Saito<sup>1</sup> 

### Abstract

The objective of this study was to determine how to support actions to increase the resilience and adaptation of socio-ecological systems in the semiarid region of Bahia State, focusing on the *Fundo de Pasto* Communities (FPCs) of the Uauá municipality. Primary (semistructured interviews with decision-makers and community leaders) and secondary data sources were used. Five dimensions of analysis were selected to organize the primary data within a framework of adaptive capacity for climate change: territorial, socio-cultural, environmental, economic and politico-institutional. For approximately 200 years, FPCs have been communally occupying and using the Caatinga biome based on agrosilvopastoral systems. The results showed the communities' resilience in dealing with climate stresses in both the territorial and socio-cultural dimensions. This includes processes of self-organization in associations and in networks, which facilitate the flow of knowledge and collective decision-making processes. The results also identified the environmental, economic and politico-institutional dimensions of the climate risks to FPCs, which could potentially limit their adaptive capacity.

**Keywords:** Socio-ecological systems. Adaptive capacity. Agrosilvopastoral communities. Collective decisions.

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<sup>1</sup> UnB – University of Brasília, Brasília, Distrito Federal, Brazil. [larisabech@gmail.com](mailto:larisabech@gmail.com)

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## Introduction

The first records of drought in the semiarid region of Brazil date back to the 16th century (SILVA et al., 2017). The most recent, considered to be one of the most intense and extensive since the 1960s, occurred from 2012 to 2017 (MARENGO et al., 2016, 2018; SILVA et al., 2017). Climate change will most likely increase the frequency and intensity of droughts. The climate models of the Intergovernmental Panel on Climate Change (IPCC) (2007, 2014) project global surface warming between 1.5 °C in an optimistic scenario and 5 °C in the most pessimistic scenario by 2100. They also predict reduced annual precipitation, intensified droughts and reduced water availability for human, animal and plant consumption (PBMC, 2013). These climate change scenarios increase the vulnerability and put at risk social and environmental systems and the associated livelihoods that depend directly on the Caatinga, which is the predominant biome in the semiarid region of Brazil (MARENGO, 2006; ROCHA, 2009).

The vulnerability of a system depends on its exposure, sensitivity and adaptive capacity. Exposure and sensitivity indicate the susceptibility of systems to impacts and climate risks. Adaptive capacity reflects the conditions or ways in which these impacts and risks are dealt with, by absorbing them (resilience) or by adjusting to the changes they bring (adaptation) (ADGER; BROWN, 2009; FOLKE, 2016; LINDOSO; RODRIGUES-FILHO, 2016). This study analyzed the common elements in adaptive capacity that characterize the coevolutionary dynamics in socio-ecological systems. These dynamics are based on the extensive trajectories of interactions between the communities and ecosystems in semiarid regions.

### *Fundo de Pasto Communities*

*Fundo de Pasto* Communities (FPCs) are difficult to define due to their heterogeneity (FERRARO, 2008; SANTOS, 2011). They can be identified as communities that have adopted extensive community grazing systems for small animals (especially goats). In the semiarid region of Bahia (SRB), Brazil, FPCs began using land communally (FERRARO; BURSZTYN; DRUMMOND, 2017; GARCEZ, 1987) approximately 200 years ago (FERRARO, 2008).

The communal areas of the FPCs originate both from abandoned lands (*sesmarias*) and farms, which date to the 18th and 19th centuries, and from unclaimed lands occupied by families associated with cowboys, indigenous peoples, enslaved black people, and some impoverished free population (REIS, 2015). In these areas, the groups have developed and, over time, incorporated peasant (relationships between land, property, and family) and traditional (collective landholdings and the relation of the people to the territory) values. The adoption of these values resulted in the communal use of land (MARQUES, 2016; TORRES, 2011).

To date, the state government of Bahia has formally recognized 373 FPCs (GEOGRAFAR, 2018). However, based on studies of the documents of social organizations in Bahia, it has been estimated that there are over 500 FPCs occupying an area of approximately 1.2 million hectares. These encompass 20,000 rural families distributed in 52 municipalities of the state (FERRARO, 2008; REIS, 2015).

These communal areas of the FPCs developed goat breeding based on the communal use of native Caatinga pasture and plant extractivism, mainly *umbu* (*Spondias tuberosa*), but also of passion fruit (*Passiflora cincinnata*), *licuri* palm (*Syagrus coronata*), *angico* (*Anadenanthera macrocarpa*) and hogberry (*Byrsonima crassifolia*), among other species (CARVALHO, 2014; SABOURIN; CARON; SILVA, 1999).

## Materials and Methods

To analyze the coevolution of adaptive capacity in the FPCs, five dimensions of qualitative variables were identified: (i) trajectories of territorialization (territorial dimension); (ii) organizational capacity and knowledge flows (socio-cultural dimension); (iii) management of common resources (environmental dimension); (iv) diversification of income from production (economic dimension); and (v) access to public policies and the flexibility of state institutions (politico-institutional dimension) (BALBO et al., 2016; BENNET et al., 2016; FOLKE, 2016; LANCELOTTI et al., 2016; SACHS, 2002; WILSON, 2014).

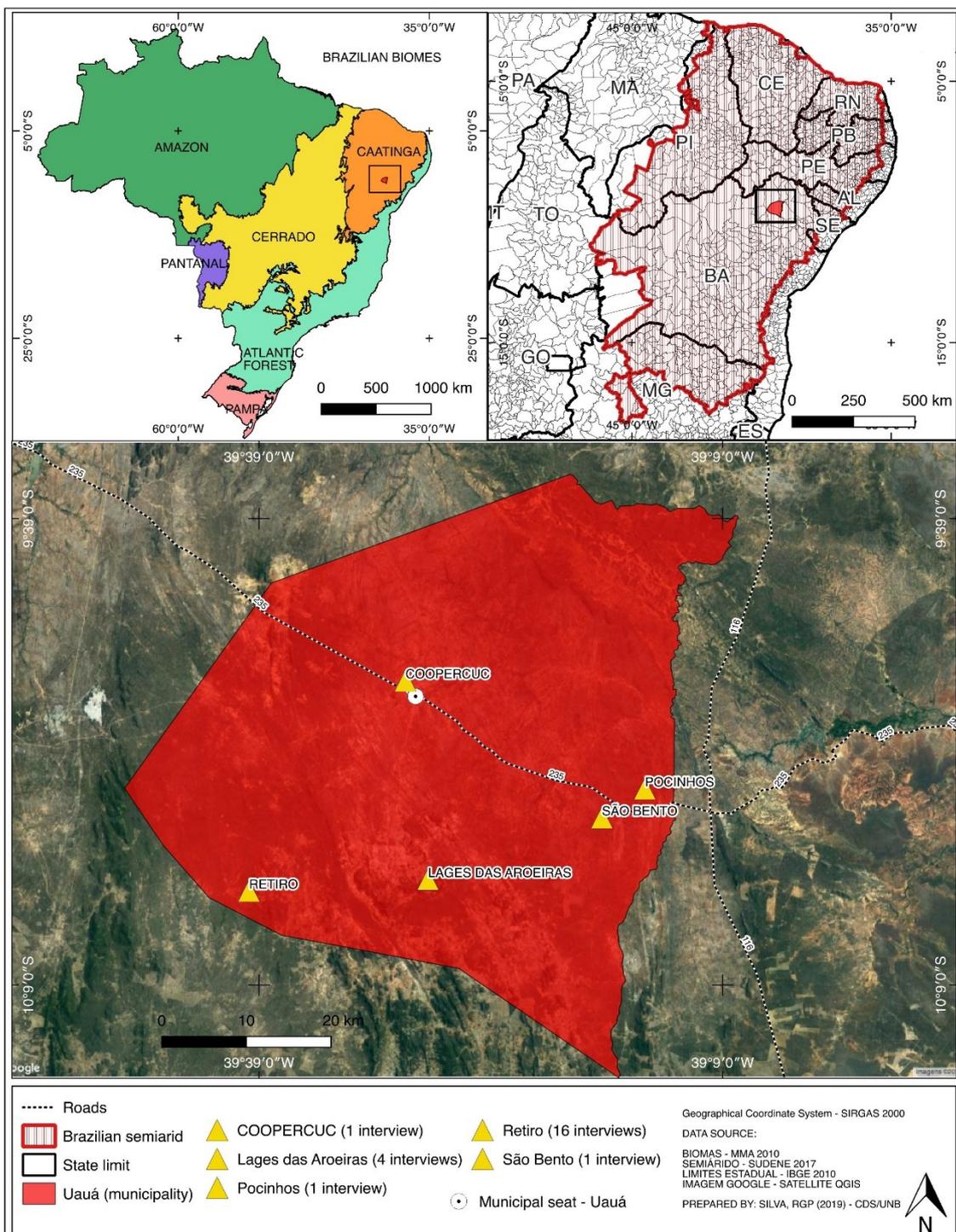
The research, based on primary and secondary data, was carried out between 2017 and 2018, using a multimethod approach that combined quantitative (such as data collection from government databases and the mapping of indicators) and qualitative (semistructured interviews) techniques (TEDDLIE; TASHAKKORI, 2009). The Ethics Committee in Human and Social Sciences Research of the University of Brasília approved the study – process number 98071318.0.0000.5540.

Technical meetings, seminars, and workshops were held with representatives of the Brazilian Semiarid Articulation (Articulação no Semiárido Brasileiro – ASA, in Portuguese), the São Francisco River Basin Committee (Comitê de Bacia Hidrográfica do Rio São Francisco, in Portuguese), the Brazilian Agricultural Research Corporation – Semiarid Division (Empresa Brasileira de Pesquisa Agropecuária – Divisão Semiárido, in Portuguese), the Federal University of São Francisco Valley (Universidade Federal do Vale do São Francisco, in Portuguese), the Ministry of Environment (Ministério do Meio Ambiente, MMA, in Portuguese) and the Ministry of Social Development (Ministério do Desenvolvimento Social; MDS, in Portuguese).

These activities also included interviews conducted with 23 local leaders from different FPCs in the municipality of Uauá, Bahia, Brazil. This municipality was chosen because it is situated in the SRB region and has many FPCs. Approximately 5% of the total area of this municipality lies in the São Francisco River Basin (IBGE, 2010) (Map 1). Among the local leaders, four are also community representatives in regional institutions: Fundo de Pasto and Feixo de Pasto (State Mobilization of the FPC); Cooperativa de Agropecuária Familiar de Canudos, Uauá e Curaçá (Cooperative of Family Agriculture and Livestock of Canudos, Uauá and Curaçá; COOPERCUC, in Portuguese); Instituto Regional da Pequena Agropecuária Apropriada (Regional Institute of Small Appropriate Agriculture and Livestock – IRPAA, in Portuguese); and the Câmara Consultiva Regional do Submédio Rio São Francisco (Regional Advisory Chamber of the Sub-mid São Francisco River) of the São Francisco River Basin Committee.

The analysis of the interviews was based on i) repeated reviews of the narratives of the actors from the field notes, in order to identify key perceptions about each theme; ii) a classification of the field information based on the dimensions and qualitative variables of the analysis; and iii) an analysis of key perceptions based on conceptual and empirical approaches from the scientific literature, as well as supplementary secondary data.

Map 1 – Mapping of the interview sites with the leaders of the *Fundo de Pasto* Communities in the Uauá municipality of the semi-arid region of Bahia.

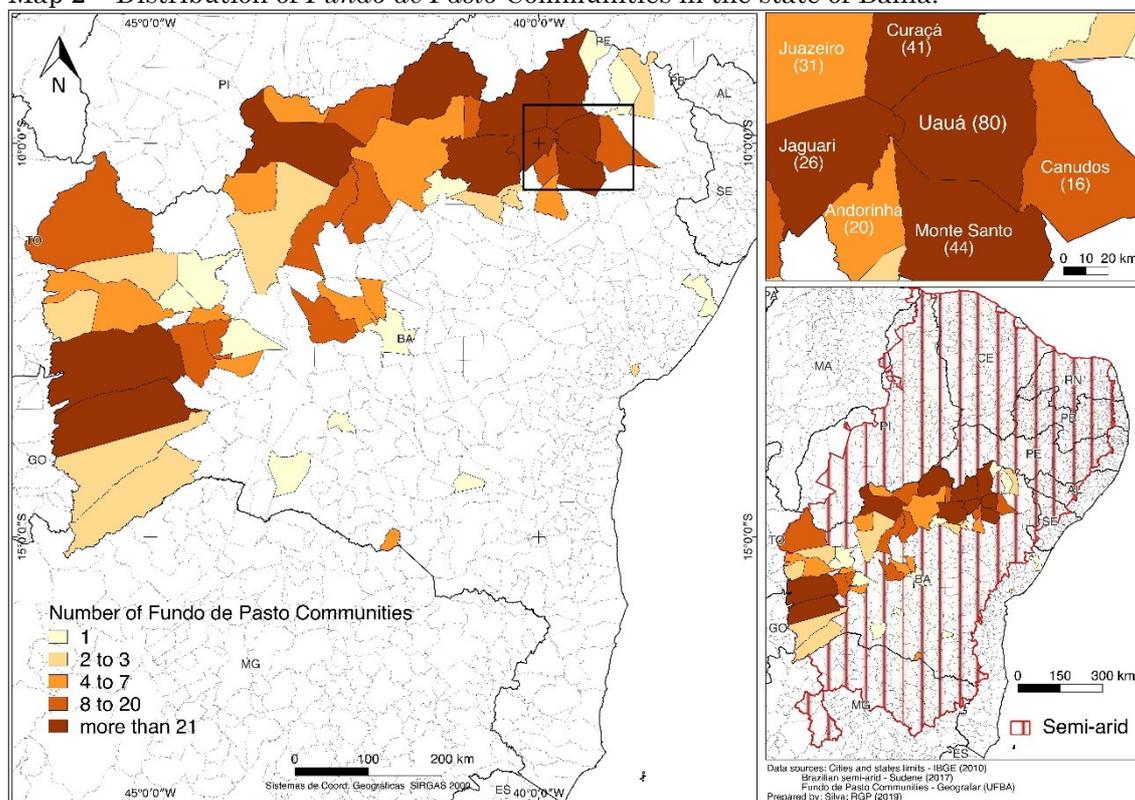


## Results and Discussion

### FPCs and Caatinga relationships: insights on challenges

Map 2 shows the spatial distribution of the 373 certified FPCs in Bahia, formally recognized by the state government (GEOGRAFAR, 2018). The municipality of Uauá is the territory with the highest concentration of certified communities (53). For the territorial dimension, the spatial and temporal analysis of the “*trajectories of territorialization*” variable corroborated Ferraro (2008), who states that the FPCs coincide geographically with the old stockyards of the *sesmarias* in Bahia – *Casa da Torre* and *Casa da Ponte*. This shows the existence of FPC resistance in the SRB and adaptive capacity coevolution related to the *organizational capacity* variable along the socio-cultural dimension.

Map 2 – Distribution of *Fundo de Pasto* Communities in the state of Bahia.



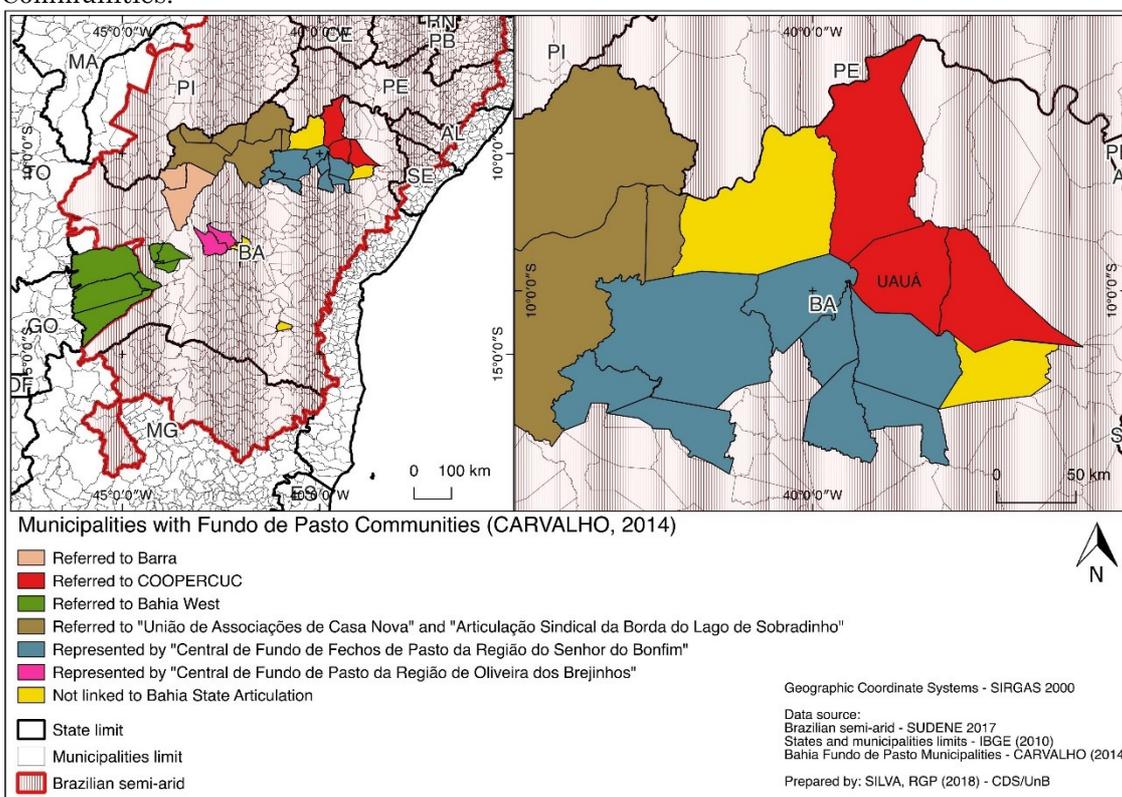
The organization of the FPCs emerged from land conflicts in the 1970s and 1980s (MARQUES, 2016). In the late 1980s, the *Concessão de Direito Real de Uso* (Granting of Real Right to Use) instrument was adopted by the state of Bahia as a strategy to build land security (CARVALHO, 2014). A Granting instrument is established between the state and legally constituted FPC associations. These processes led to the formation of 599 FPC associations and the creation of the Centers and State Mobilization of the FPC (political representation) and of COOPERCUC (representing productive inclusion) (CARVALHO, 2014; TORRES, 2011). Notably, each community often has more than one association. The associations reflect forms of organization at the local scale and link FPC families to social movements at the regional scale.

Map 3 tried to show the spatial distribution and the territorial influence of different forms of organization of the FPCs. COOPERCUC, created in 2004, has a significant role in the political representation of the communities. The IRPAA, which provides political and socio-technical support for FPCs, is the social organization responsible for introducing the cooperative system in Uauá and in the surrounding municipalities. In the same sense, during the interviews, the leaders of FPCs from 2017 to 2018 noted that the establishment of the cooperative (COOPERCUC) marked an inflection point for the FPC families, especially young people and women.

The ASA has a key role in facilitating the connectivity of the organizations that represent the FPC in the SRB. Through this role, the Articulation impacts planning and decision making in the Brazilian semiarid region and on the national level. Its creation, in the 1990s, stemmed from the emergence of the “Coexistence with the Semiarid” paradigm, as opposed to that of the “Combating Droughts” paradigm (LINDOSO et al., 2018), in response to the social needs of local and regional organizations (PORTO; FROELICH, 2018). The ASA is currently composed of more than 1,000 organizations that act in a network, developing and

disseminating technologies appropriate to the semi-arid region. Within this network, around 144 technologies have already been developed (RODRIGUES, 2016). Many of these technologies are based on water storage (such as drinking and production cisterns), seed production (such as creole seed banks) and the planting of forage such as palm (*Opuntia ficus-indica* Mill), used to supplement the feeding of goats (LINDOSO et al., 2018; PETTERSEN; SILVEIRA, 2017).

Map 3 – Symbolic representations of the social organizations of the *Fundo de Pasto* Communities.



The organizational capacity of the FPC based on associations (and, more recently, on a cooperative system) and the prioritization of networking is an adaptive resource, which in the last 200 years has coevolved in the SRB along with the territorialization of the FPCs (FERRARO, 2008; PORTO; FROELICH, 2018; SANTOS, 2011).

This broad fabric of social organizations encompasses another resource for adaptive capacity within the socio-cultural dimension, which is vital to the FPCs: the multidirectional flow of experience and knowledge (traditional, technical and scientific) between the community and regional scales. Through networks, FPCs learn, store, and share knowledge on coping with climate stress. They also make collective, polycentric decisions, through institutions able to provide flexible responses to uncertainties, and develop local solutions to problems (BALBO et al., 2016; IPCC, 2014; MARSHALL et al., 2010).

The interviewees mentioned that food and land security networks are examples of solutions that stem from this multidirectional flow of exchanges. Food security is manifested through an intensification of the exchange of food and creole seeds among communities. These interpersonal exchanges through their associations ensure the subsistence of families during periods of drought. Land security is expressed through the strengthening of collective rules that prohibit the sale of private property to people outside the community. This strengthening tends to occur in drought periods, as noted by Ferraro (2008).

Notably, the defense of territorial rights continues to be an element of cohesion between the organizations of the FPCs, and there are challenges that permeate and connect all dimensions of this research (CARVALHO, 2014; MARQUES, 2016; SANTOS, 2011).

These challenges are related both to the long period taken by public authorities to regularize the land ownership of communal areas, as well as to the nature of the regularization instrument itself. The Granting of Real Right to Use instrument ensures that the ownership of collective land remains public. In one of the communities visited, *Comunidade do Retiro* (Map 1), which has 28,000 ha of collective area under the management of 600 FPCs, only approximately 2,000 hectares have been regularized. In addition, the state government determined that the rest of the land should

be regularized by December 2018, which is a short time period in relation to the proportion of unrecognized territories.

According to the interviewees, while the state of Bahia makes efforts to regularize communal areas, it has also authorized prospecting studies of minerals in nonregularized areas. This is one of the main external threats to FPCs and represents a conflict between public policies. Reis (2015) states that several companies have already carried out mineral mapping in the municipality of Monte Santo, Bahia, which borders Uauá and has the second largest concentration of recognized communities (Map 2) and FPC associations in the state.

The interdependence of FPCs with the Caatinga is the key link to both the territorial and socio-cultural dimension variables (PEREZ-MARIN et al., 2017; ROCHA, 2009). Given the richness of the genetic and endemic resources of the Caatinga, the management of common resources in the biome – that is, the qualitative variable of the environmental dimension –, plays a crucial role in the sustainability of FPCs (FERRARO; BURSZTYN; DRUMMOND, 2017). In other words, the biodiversity allows the existence of small-scale rural economies in an environment under climate stress. The combination of traditional knowledge and management of the biome has resulted in a set of well-articulated practices, which are integrated into the culture of FPCs and have been informed by long periods of observation and coexistence in this environment (FERNANDEZ-LLAMAZARES et al., 2016; PYHALA et al., 2016).

Thus, the land use practices of the communities are based on the “health” and the (re)production of the Caatinga, which ensure its way of life. Several researchers have noted that throughout their existence, FPCs have maintained the diversity of Caatinga vegetation, aiming at the communal use of territory and management of the native potential of the vegetation to obtain income, food, water, medicines, energy, seeds and raw material for a variety of purposes, especially in periods of water shortage (PORTO;

FROELICK, 2018; SABOURIN; CARON; SILVA, 1999; SANTOS, 2011). The characteristics of the vegetation in the Caatinga reflect its evolution in semiarid conditions (ROCHA, 2009; SEYFFARTH; RODRIGUES, 2016).

In this context, reports of FPC leaders on the recent death cycle of native Caatinga plants related to the impact of the last drought are especially significant. In addition to a reduction of almost 40% of the *umbuzeiro* (the *umbu* tree) population, the leaders also mentioned a reduction in the population of the *macambiras* (*Bromelia laciniosa*), an endemic species of the biome. The reduction in vegetation cover affects the fauna pollinating flowers and dispersing seeds, which are fundamental to plant reproduction in the Caatinga (SEYFFARTH; RODRIGUES, 2016). In addition, the biome lacks appropriate conservation policies (ROCHA, 2009).

Narratives from the area indicate a consensus regarding this loss of vegetation as well as its negative effects on animal nutrition (with loss of matrices) and plant extractivism. The income from agrosilvopastoral production is based on raising goats in the natural pastures of the Caatinga as well as on the products of this biome, especially *umbu*, which is the main raw material used by COOPERCUC and is sold in the form of sweets, jams, and beer. Thus, the families of the FPCs enclosed part of the 28,000-ha communal area to restrict the access of goats and allow the vegetation to regenerate.

It is important to detail how the FPCs manage the use of natural resources, their productive strategies and the adaptive character of the agroextractivist practices in the territory. Collective rules have been developed to govern the use of common resources, and these are then reinforced during periods of drought. These collective rules provide for situations that could potentially lead to the “tragedy of the commons” portrayed by Hardin (1968). He analyzed the natural tendency of individuals to maximize their own benefits to the detriment of collective benefits. However, based on empirical studies of communities, Ostrom’s

(1990) findings oppose Hardin's view. These findings have shown that when principles for the shared management of common resources are adopted, such as the establishment of clear limits of use, the balance between benefits and costs, collective decision-making, gradual sanctions, the fair resolution of conflicts, community autonomy and bottom-up governance, individuals are selfless. The data from this study reinforce Ostrom's view, showing how communal and collective organization strengthens cooperation and governance.

The environmental dimension is especially significant when considering adaptive capacity against the backdrop of climate change. We identified elements in the literature regarding possible factors that may be affecting the stability of some native Caatinga plant species in FPCs. Among these factors are the increase in the population of goat herds as well as successive periods of drought and their intensification (LITRE et al., 2018; MARENGO et al., 2018; SEYFFARTH; RODRIGUES, 2017).

Lindoso et al. (2018) carried out a survey that pointed to an 83% increase in the number of goats in the São Francisco River Basin (the municipality of Uauá is partially in this basin, as already indicated) during the last drought. Litre et al. (2018) attributed this phenomenon to cattle ranchers' preference for goats, which have proven to be more resistant to droughts. Ferraro (2008) has described the seasonal feeding system of goats in the FPCs, in which the fruits of the *umbu* are important from January to April, while the *macambira* is important in February and from August to November. This could explain an increase in herd pressure on natural resources.

The roots of the *umbuzeiro* have tuberous organs called xylopodia, known locally as "*cucas*", which store nutrients and water. These are strategic reserves that sustain the plant even in severe drought years. However, Seyffarth and Rodrigues (2017) report that the death of *umbuzeiros* had not been observed in drought cycles prior to 2010 to 2017.

They relate this occurrence to drought intensification in the context of climate change (MARENGO et al., 2016; 2018; PBMC, 2013; SILVA et al., 2017).

The impacts of climate change, poor management practices and the susceptibility of desertification in the semiarid region are manifested in the degradation of soils and water resources, the degradation of vegetation and biodiversity and, ultimately, the reduction in the quality of life of the population dependent on the Caatinga (DOURADO, 2017; MARENGO, 2006). In addition, the projection of a significant reduction in rainfall by 2100 can lead to profound changes in ecosystem functioning (PBMC, 2013).

As for the variable of income diversification (within the economic dimension), the high dependence of the FPCs on natural resources leads to low-income elasticity. In this study, given that the extraction and processing of *umbu* are carried out mainly by women, who represent more than 60% of the members of COOPERCUC, gender can be seen as a source of differential sensitivity.

An aspect highlighted by the interviewees is that, in addition to the socio-productive inclusion of women, income from the products from the biota has strengthened the communities' political role. Thus, in the case of women members of COOPERCUC, their strategies for inclusion in the labor market and for increased income appear to be the first to suffer such climate impacts.

These impacts are not restricted to socio-productive inclusion, but they also affect the participation of these groups in decision-making. Interestingly, once again, the most socially vulnerable groups are those most affected by the intensification of multiscale phenomena, such as climate change (ADGER; BROWN, 2009; NOGUEIRA, 2017).

In terms of the politico-institutional dimension, FPC leaders mentioned the reduction in access to the policies of education, credit and rural extension. Additionally, even when the FPCs are able to access

government institutions, which have been established in a way that is incompatible with the territorial, socio-cultural and environmental complexity of the semiarid region, they encounter low institutional flexibility. This reinforces productive processes that in the medium term degrade the biome and eliminate the structure of the communal use of land by the FPCs (PEREZ-MARIN et al., 2017; REIS, 2015).

Designing public policies compatible with the social contexts of the SRB and the subsequent access of communities to them are essential for regulating the dynamics of interdependence between the FPCs and the Caatinga. The sustainability of productive activities over time depends on the maintenance of the flow of ecosystem services (provision, regulation and support) in this biome (MARENGO, 2006; MEA, 2005).

### Adaptive capacity of the FPCs

The study of the perceptions of FPC leaders provided empirical evidence for possible ways (and lessons) for the adaptation and resilience of socio-ecological systems in the SRB. These arise from the development of collective responses at the local scale. The coevolution of adaptive capacity in the socio-ecological system of FPCs can be argued on the recognition of a secular system with communal use of the territory through the establishment of collective rules for the management of common resources and land occupation. More recently, the adaptation strategies of the FPCs have evolved toward self-organization in associations and the organization in territorial networks. Through networks, there is a multidirectional flow of knowledge, with polycentric decision-making.

Santos (2011) and Marques (2016) emphasize the political character of the FPCs, which, through their struggles for communal lands, have developed a unique cultural identity known as *Fundo de Pasto*. This culture

is characterized by its own forms of social organization built on family relations and by common trajectories linked to the land. These trajectories have generated social institutions that are adapted to the climate stresses in the SRB. These institutions develop and disseminate learning, innovation and technologies, allowing for coexistence with the region.

The territorial and socio-cultural dimensions of the lessons learned from the FPCs are widely supported by the scientific literature (FOLKE, 2016; GÓMEZ-BAGGETHUM et al., 2012; IUCN, 2008, 2009; OSTROM, 1990). They are elements common to adaptive capacity, which are characterized by coevolutionary dynamics in semiarid regions (BALBO et al., 2014; MARSHALL et al., 2010; REYES-GARCIA et al., 2017).

Based on the surveys of the FPCs, it is clear the relationship between the communities and the Caatinga encompasses different facets of adaptive capacity and provides the communities with the ability to address the challenges they face. This capacity to confront such challenges is supported by the use, over successive generations, of the biodiversity of the Caatinga to face droughts (FERNANDEZ-LLAMAZARES et al., 2016; PYHALA et al., 2016).

However, the results also showed how the communities are exposed to risks on the local scale, concerning the increase in the velocity and intensity of multiscale change factors (ADGER; BROWN, 2009; BENNET et al., 2016). Notably, the drought from 2010 to 2017 was one of the most severe in the last 60 years. The Caatinga, although resistant to semiarid edaphoclimatic conditions, is already characterized by pronounced water stress. It also has low carbon sequestration and stocks, both of which could diminish even further with the intensification of droughts. This would result in profound changes in the structure and ecosystem services of the Caatinga (PBMC, 2013). These changes may also impact community-developed coexistence measures and affect their ability to respond to climate stresses (BALBO et al., 2016).

The reduction of the *umbuzeiro* population is an important indicator of the environmental dimension. Social systems dependent on biodiversity resources are more sensitive to climate impacts and risks. As this dependency increases, social systems become more vulnerable to climate change (ELLIS, 2000; MARSHAL et al., 2010). As such, the analysis of the economic and politico-institutional dimensions indicates that the low diversification of productive income limits the capacity of the FPCs to deal with multiscalar change. This is worsened by restrictions and impediments to accessing the socio-technical and financial resources of public policies that are targeted at agrosilvopastoral production and the conservation of the Caatinga. Additionally, state institutions operate based on a vision that is incompatible with the complexity of the semiarid region, which further limits the ability of the FPCs to deal with multiscalar changes.

The consensus expressed by the FPC leaders regarding the setbacks in federal policies, which are considered crucial for coping with the most recent drought, as is the case of production cisterns (Uma Terra e Duas Águas Program; P1+2, in Portuguese) and institutional markets (Program for Food Acquisition - Programa de Aquisição de Alimentos – PAA, in Portuguese), is another relevant indicator in the politico-institutional dimension. To the communities, the setbacks in federal policies are related both to lower budgetary appropriations and to changes in the methodological frameworks of these policies, which ignore important social factors that contribute to the development of adaptive strategies (NOGUEIRA, 2017; PORTO; FROELICK; 2018).

The FPC leaders also recognize that production-oriented policies differ from those designed for social protection (the Bolsa Familia program) and social security (rural retirement), which are essential to the income of FPC families. Therefore, it can be asserted, in agreement with Marques (2016), that the FPCs have developed a collective consciousness, which allows them to transform themselves as political actors to challenge the

expansion of regional mercantile capital. Their ability to do so is born out of their long history of facing land conflicts.

The analysis of resilience as the capacity of human and environmental systems to absorb impacts is associated with the notion of a positive quality of adaptive capacity and can be indicated by the extent, balance and overlap of the territorial, socio-cultural, environmental, economic and politico-institutional dimensions (LANCELOTTI et al., 2016; WILSON, 2014). As such, the resilience of the FPCs appears to be centered in its socio-cultural and territorial dimensions (as long as the communities' territorial rights are respected). The environmental, economic and politico-institutional dimensions related to the FPCs can either increase or destabilize resilience.

While territorialization and land use are central elements to the adaptation of FPCs, several factors contribute to the increase in their exposure and sensitivity and consequent reduction in adaptive capacity with respect to climate change. As such, how these communities have learned to coexist with the semiarid region can provide important lessons of resilience in complex adaptive systems (BALBO et al., 2016; FOLKE, 2016; LANCELOTTI et al., 2016). This supports the assertion that the FPCs are a key locus for the study of resilience, vulnerability and local adaptation to climate change in semiarid areas.

## Final Considerations

FPCs are an important repository of local measures to deal with climate stress. The territorial and socio-cultural dimensions of these measures have been strengthened over time. However, their environmental, economic and politico-institutional dimensions are vulnerable, often due to external forces. This vulnerability can lead to future scenarios with low resilience to climate change.

The capacity of state institutions and the sustainability of public policies are crucial. At the same time, the attunement of cultural rooting with FPC practices is essential for adaptive capacity. Last, with respect to territoriality, the adaptive capacity of FPCs guarantees that the communities continue living in rural areas. This is in contrast to the strong exodus to the cities and its consequent implications.

The environmental services provided by FPCs can and should be valued in various ways, such as payments for its conservation. However, it is important to note that FPCs are more sensitive to climate risks, which increase as dependence increases, because they are social systems dependent on biodiversity resources. As such, it can be said that the vulnerability to climate stresses is multifaceted, and this conceptualization is supported by the present study on FPCs.

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## References

- ADGER, W. N.; BROWN, K. Vulnerability and Resilience to Environmental Change: Ecological and Social Perspectives. In: **Global Environmental Change**. JANSSEN, M.A.; OSTROM, E. (Eds.). Elsevier. 2006. v.16. p.235-316.
- BALBO, A. L. et al. Resilience of small-scale societies: a view from drylands. **Ecology and Society**, v.21, n.2, p. art53, 2016. <https://doi.org/10.5751/ES-08327-210253>

- BENNETT, N. J. et al. Communities and change in the anthropocene: understanding social-ecological vulnerability and planning adaptations to multiple interacting exposures. **Regional Environmental Change**, v.16, n.4, p.907-926, 2016. <https://doi.org/10.1007/s10113-015-0839-5>
- CARVALHO, F. P. D. **Fundos de Pasto**: territorialidade, luta e reconhecimento. Dissertation (Doctoral Degree), Brasília: Universidade Federal da Bahia, 2014.
- DOURADO, C. DA S. **Áreas de risco de desertificação**: cenários atuais e futuros, frente às mudanças climáticas. Dissertation (Doctoral Degree), Campinas: Unicamp, 2017.
- ELLIS, F. The Determinants of Rural Livelihood Diversification in Developing Countries. **Journal Of Agricultural Economics**, v.51, n.2, p.289-302, May. 2000. <https://doi.org/10.1111/j.1477-9552.2000.tb01229.x>
- FERNÁNDEZ-LLAMAZARES, Á. et al. Local perceptions as a guide for the sustainable management of natural resources: Empirical evidence from a small-scale society in Bolivian Amazonia. **Ecology and Society**, v.21, n.1, 2016. <https://doi.org/10.5751/ES-08092-210102>
- FERRARO, L. A. J. **Entre a invenção da tradição e a imaginação da sociedade sustentável**: estudo de caso dos fundos de pasto na Bahia. Dissertation (Doctoral Degree), Brasília: Universidade de Brasília, 2008.
- FERRARO, L. A.; BURSZTYN, M.; DRUMMOND, J. A. Sustainability of the remaining agricultural commons in the Brazilian northeast: **Challenges beyond management**. *Erde*, v.148, n.2-3, p.150-166, 2017.
- FOLKE, C. Resilience (Republished). **Ecology and Society**, v.21, n.4, 2016.
- GARCEZ, A. **Fundo de Pasto**: um projeto de vida sertanejo. Bahia: INTERBA/SEPLANTEC/CAR, Salvador, 1987.
- GEOGRAFAR. **Formas de acesso à terra no Estado da Bahia**. Banco de Dados, 2018. Available in: <[www.geografar.ufba.br](http://www.geografar.ufba.br)>. Accessed in: May 10, 2018.
- HARDIN, G. **The Tragedy of the Commons**. *Science*, 162: 1243-1248, 1968. <https://doi.org/10.1126/science.162.3859.1243>
- IBGE – Instituto Brasileiro de Geografia e Estatística. **Censo Demográfico 2010**. Rio de Janeiro: IBGE, 2010.
- INSA – Instituto Nacional do Semiárido. **Estabelecimentos agropecuários do Semiárido Brasileiro**. Campina Grande (PB): INSA, 2017.
- IPCC – Intergovernmental Panel on Climate Change. **Climate Change 2014**: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (Eds.)]. IPCC, Geneva, Switzerland, 2014.
- \_\_\_\_\_. **Fourth Assessment Report**: Climate Change 2007. Cambridge, 2007.
- IUCN. International Union for the Conservation of Nature. **Indigenous and Traditional People and Climate Change. Issues Paper**. IUCN: Gland, 2008. 66 p.
- LANCELOTTI, C. et al. Resilience of small-scale societies' livelihoods: A framework for studying the transition from food gathering to food production. **Ecology and Society**, v.21, n.4, 2016. <https://doi.org/10.5751/ES-08757-210408>
- LINDOSO, D.; RODRIGUES FILHO, S. **Vulnerabilidade e adaptação**: bases teóricas e conceituais da pesquisa. In: Marcel Bursztyn & Saulo Rodrigues Filho (Eds.). *O clima em transe: vulnerabilidade e adaptação da agricultura familiar*. Rio de Janeiro: Garamond. p. 19-34, 2016.
- LINDOSO, D.; LITRE, G.; GAIVIZZO, L.; RODRIGUES-FILHO, S.; REIS, J. C. Vulnerabilidade climática da produção rural no semiárido: reflexões para o debate sobre desenvolvimento sustentável e agronegócio. In: **Sustentabilidade e Agronegócio**. ANDREOLI, C.; PHILIPPI JR., A. (Eds.). São Paulo: Editora Manole. Coleção ambiental (em avaliação).
- LITRE, G.; LINDOSO, D.; GAIVIZZO, L.; RODRIGUES-FILHO, S. **Vulnerabilidade e Adaptação Climática da Pecuária Familiar no Bioma Caatinga**: Limites e Potencialidades do Paradigma de Convivência com o Semiárido. Resumo expandido. Third

- International Conference “Agriculture and Food in a urbanizing society”. Porto Alegre, UFRGS, 2018.
- LITTLE, P. E. Territórios sociais e povos tradicionais no Brasil: por uma antropologia da territorialidade. **Anuário Antropológico**, p. 251-290, 2004.
- MARENGO, J. A. **Mudanças climáticas globais e seus efeitos sobre a biodiversidade**: caracterização do clima atual e definição das alterações climáticas para o território brasileiro ao longo do século XXI. Brasília, DF: Ministério do Meio Ambiente, 2006. 159 p. (Biodiversidade, 26).
- MARENGO, J. A., TORRES, R. R., ALVES L. M. Drought in Northeast Brazil – past, present, and future. **Theor Appl Climatol**, p.1-12, 2016.
- MARENGO et al. Climatic characteristics of the 2010-2016 drought in the semiarid Northeast Brazil region. **Anais da Academia Brasileira de Ciências**, v.90, n.2, p.973-1985, 2018. <https://doi.org/10.1590/0001-3765201720170206>
- MARQUES, L. de S. As comunidades de fundo de pasto: um intento de construção conceitual. Pegada. **A Revista da Geografia do Trabalho**, v.17, n.2, 2016. <https://doi.org/10.33026/peg.v17i2.4706>
- MARSHALL, N. A. et al. **A Framework for Social Adaptation to Climate Change: Sustaining Tropical Coastal Communities and Industries**. IUCN, 2010.
- MEA – Millennium Ecosystem Assessment. **Ecosystems and Human Well-Being: Synthesis**. Washington, DC: Island Press, 137 p., 2005.
- NOGUEIRA, D. Segurança Hídrica, Adaptação e Gênero: o caso das cisternas para captação de água de chuva no semiárido brasileiro. **Revista Sustentabilidade em Debate, Dossiê Água e Gênero**, v.8, n.3, 2017. <https://doi.org/10.18472/SustDeb.v8n3.2017.26544>
- OSTROM, E. **Governing the Commons: the evolution of institutions for collective action**. Indiana University, University Press, Cambridge, 1990. <https://doi.org/10.1017/CBO9780511807763>
- PBMC – Painel Brasileiro de Mudanças Climáticas. **Contribuição do Grupo de Trabalho 1 ao Primeiro Relatório de Avaliação Nacional do Painel Brasileiro de Mudanças Climáticas**. Sumário Executivo GT1. Rio de Janeiro: PBMC, 2013. 24 p.
- PÉREZ-MARIN, A. M. et al. Agroecological and social transformations for coexistence with semi-aridity in Brazil. **Sustainability (Switzerland)**, v.9, n.6, p.1-17, 2017. <https://doi.org/10.3390/su9060990>
- PETERSEN, P. F.; SILVEIRA, L. M. Agroecology, public policies and labor-driven intensification: Alternative development trajectories in the brazilian semi-arid region. **Sustainability (Switzerland)**, v.9, n.4, 2017. <https://doi.org/10.3390/su9040535>
- PORTO, S. FROELICH, G. **Articulação para o Semiárido Brasileiro**. Relatório. Rio de Janeiro: ASA, 2018 (documento interno).
- PYHÄLÄ, A. et al. Global environmental change: local perceptions, understandings, and explanations. **Ecology and Society**, v.21, n. 3, p. 25, 2016. <https://doi.org/10.5751/ES-08482-210325>
- REIS, F. S. **Associativismo em comunidades de fundo de pasto no município de Monte Santo (BA)**: mobilização social, dinâmica de poder. Thesis (Master Degree), Cachoeira: Universidade Federal do Recôncavo da Bahia. 2015.
- REYES-GARCÍA, V. et al. Small-scale societies and environmental transformations: Coevolutionary dynamics. **Ecology and Society**, v.22, n.1, p.1-6, 2017. <https://doi.org/10.5751/ES-09066-220115>
- ROCHA, W. F. Situação da cobertura vegetal do bioma Caatinga. In: ANGELOTTI, F.; SÁ, I. B.; MENEZES, E. A.; Pellegrino, G. Q. (Orgs.). **Mudanças climáticas e desertificação no Semiárido brasileiro**. Petrolina: Embrapa Semiárido; Campinas: Embrapa Informática Agropecuária, 2009. cap. 5, p.77-94.
- RODRIGUES, R. S. **O caminho das águas**: tecnologias de convivência com o semiárido e transições sociotécnicas no sertão brasileiro. Thesis (Master Degree). Universidade Federal Rural do Rio de Janeiro, Instituto de Ciências Humanas e Sociais. 180 f. 2016.

- SABOURIN, E.; CARON, P.; SILVA, P. C. G. DA. O manejo dos “fundos de pasto” no nordeste baiano: um exemplo de reforma agrária sustentável. **Raízes – Revista de Ciências Sociais e Econômicas**, v.18, n.2, p.90-102, 1999.
- SACHS, I. **Caminhos para o desenvolvimento sustentável**. Rio de Janeiro: Garamond, 2002.
- SANTOS, C. J. S. E. **Fundo de pasto – tecitura da resistência, rupturas e permanências no tempo-espaço desse modo de vida camponês**. Dissertation (Doctoral Degree), São Paulo: Universidade de São Paulo, 25 fev.2011.
- SEYFFARTH, A. S.; RODRIGUES, V. Impactos da seca sobre a biodiversidade da Caatinga. **Parc. Estrat.**, v.22, n.44, p.41-62, 2017.
- SILVA, A.R.S. et al. Variações no Índice de Anomalia de Chuva no Semiárido. **Journal of Environmental Analysis and Progress**, v.2, n.4, p.377-384, 2017. TEDDLIE, C., TASHAKKORI, A. **Foundations of Mixed Methods Research: Integrating Quantitative and Qualitative Approaches in the Social and Behavioral Sciences**. California (USA): SAGE, 2009.
- TORRES, P. R. **Terra e territorialidade das áreas de fundo de pasto no semiárido baiano**. Thesis (Master Degree), Salvador: Universidade Católica de Salvador. 2011.
- WILSON, G. A. Community resilience: path dependency, lock-in effects and transitional ruptures, **Journal of Environmental Planning and Management**, 57:1, 1-26, 2014. <https://doi.org/10.1080/09640568.2012.741519>



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