Biotemas, 32 (3): 105-116, setembro de 2019
ISSNe 2175-7925
http://dx.doi.org/10.5007/2175-7925.2019v32n3p105

Local representation of change and conservation of a Brazilian Caatinga refuge

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Submetido em 22/08/2018
Aceito para publicação em 16/05/2019

Resumo

Representação local da mudança e da conservação de um refúgio da Caatinga brasileira. A caatinga brasileira é uma das florestas tropicais secas mais ameaçadas do mundo, principalmente devido á fragmentação de habitats em função das pressões antrópicas. No entanto, as regiões montanhosas da Caatinga são consideradas refúgios de biodiversidade, com elevada riqueza de espécies vegetais, as quais são utilizadas para diversas finalidades por populações humanas locais. O presente estudo buscou identificar o conhecimento ecológico local das comunidades rurais no entorno de uma Serra na região semi-árida do Brasil, considerada um refúgio para a biodiversidade. O estudo foi realizado por meio de entrevistas semiestruturadas, com informantes-chave sendo selecionados pela técnica de amostragem de bola de neve. Segundo os informantes, a serra representa o resgate na memória de paisagens anteriores, ligadas à biodiversidade que ela contém e explicando a importância como fonte de recursos e influência nos regimes locais de chuvas. Para as populações locais, a conservação da biodiversidade da Caatinga representa mais do que apenas a preservação da fauna e flora, compreendendo também a permanência das funções dos ecossistemas para a manutenção de suas atividades.

Palavras-chave: Agricultor; Bioindicador climático; Percepção ambiental; Representação ambiental; Semiárido brasileiro

Abstract

The Brazilian Caatinga is one of the most threatened tropical dry forests in the world, mainly due to habitat fragmentation from anthropic activities. However, mountainous regions in the Caatinga are refuges of biodiversity, with high plant species richness, which are used for various purposes by local human populations. The present study sought to identify the local ecological knowledge of rural communities on a mountain in the semiarid region of Brazil, which is a refuge of biodiversity. The study was conducted through semi-structured

interviews with key informants selected using the snowball sampling technique. According to the informants, the mountain helps recall memories of previous landscapes, which are linked to the biodiversity that it contains and its importance as a source of resources and influence on local rainfall regimes. For local populations, the conservation of Caatinga biodiversity represents the preservation of fauna and flora, the permanence of ecosystem functions and the resilience of intrinsic values related to maintaining their activities.

Key words: Brazilian semiarid; Climatic bioindicator; Environmental representation; Farmer; Perception

Introduction

The local representation of native vegetation has been recognized as important ecological knowledge when evaluating changes in landscapes in different regions of the world (GÓMEZ-LIMÓN; FERNÁNDEZ, 1999; LYKKE, 2000; XU et al., 2006; SILVA et al., 2014). Through these studies it is possible to identify changes in a landscape based on the "vision" of local communities, since local people can indicate which species have declined over the years, and this information can be used to support restoration projects (SILVA et al., 2014) and the sustainable maintenance of local activities that use natural resources (LOPES et al., 2017).

Local populations have unique perceptions about the use of resources and the environment that are important to the conservation (LOPES, 2017) and traditional management (MITTERMEIER et al., 2003) of biodiversity. It is increasingly recognized that local ecological knowledge (LEK) is an important component that guides conservation actions (BERKES et al., 2000; ARAÚJO, 2010; TOLEDO; BASSOLS, 2010; HUNTINGTON, 2011; LOPES, 2017).

Biodiversity conservation must incorporate social participation since it results in changes among local communities due to their connection with the environment (HUNTINGTON, 2011; MARQUES et al., 2001; SILVA et al., 2014; CARREGOSA et al., 2015). Thus, the representation that human populations have about their environment is reflected in the way they interact with and the availability of resources in their surroundings (ALBUQUERQUE, 2006; CARREGOSA et al., 2015), and also assists in the analysis of changes occurring in ecosystems over time (BYG; SALIK, 2009).

Variations over time are inevitable, but this issue has recently become more significant in the world's dry forests, and those who most feel the consequences of climate change on natural resources are the people who use these forests directly for their daily needs (BYG; SALIK, 2009). This is especially true when plant resources do not respond as bioindicators of change. Farmers observe the flowering pattern of species to predict rainy periods in regions. Thus, farmers characterize these species as bioindicators. In this way, the involvement of local communities in the biodiversity conservation process is necessary (WELLS; MCSHANE, 2004; LOPES et al., 2017) and important to maintain local biodiversity (ESMERALDO et al., 2011).

In this context, local communities in the semiarid regions of Brazil use a variety of plants from dry forests (Caatinga), for example, as food, in religion and magic, for medicine, ludic, aesthetic and artistic purposes, in craftwork, and as house decorations (LUCENA et al., 2012; LUCENA, 2013). These activities homogenize habitats and change the structure of plant communities (ALBUQUERQUE et al., 2012; RIBEIRO et al., 2016), which in turn has influenced the forms of management and use of biodiversity by local communities (LUOGA et al., 2000; CASAS et al., 2014; LINS-NETO et al., 2014). On the other hand, such actions have improved the survival, diversity, and availability of resources used by local human populations (LINS-NETO et al., 2014; CASAS et al., 1997). It should be noted that the exploitation of Caatinga vegetation has also increased due to advances in agricultural management, logging and forest fires that are carried out by groups of people that do not belong to traditional communities (LEAL et al., 2005; RAMOS et al., 2008; ROQUE et al., 2010).

Seasonally dry tropical forest (SDTF) is an important component of tropical vegetation and one of the most threatened biomes in the world (MILES, 2006). The Caatinga represents one of the largest areas of SDTF, occupying more than 912,529 km² in northeastern

Brazil (MORO et al., 2014; SILVA et al., 2017). Intense exploitation of Caatinga vegetation has made it the third most degraded Brazilian phytogeographic domain; 80% of this vegetation has been modified and there are isolated areas of desertification (MORO et al., 2014; SILVA et al., 2014). Furthermore, for this biome, only 1.13% is within conservation units and 6.32% in sustainable management areas (FONSECA et al., 2017). However, biodiversity refuges in the Caatinga are located on mountains and the tops of plateaus above 500 meters elevation (PRADO, 2008; LOPES et al., 2017). Since they have endemic species and greater richness and diversity (SILVA et al., 2014), the montane regions are considered priority areas for the creation of new conservation units (SILVA et al., 2014; LOPES et al., 2017).

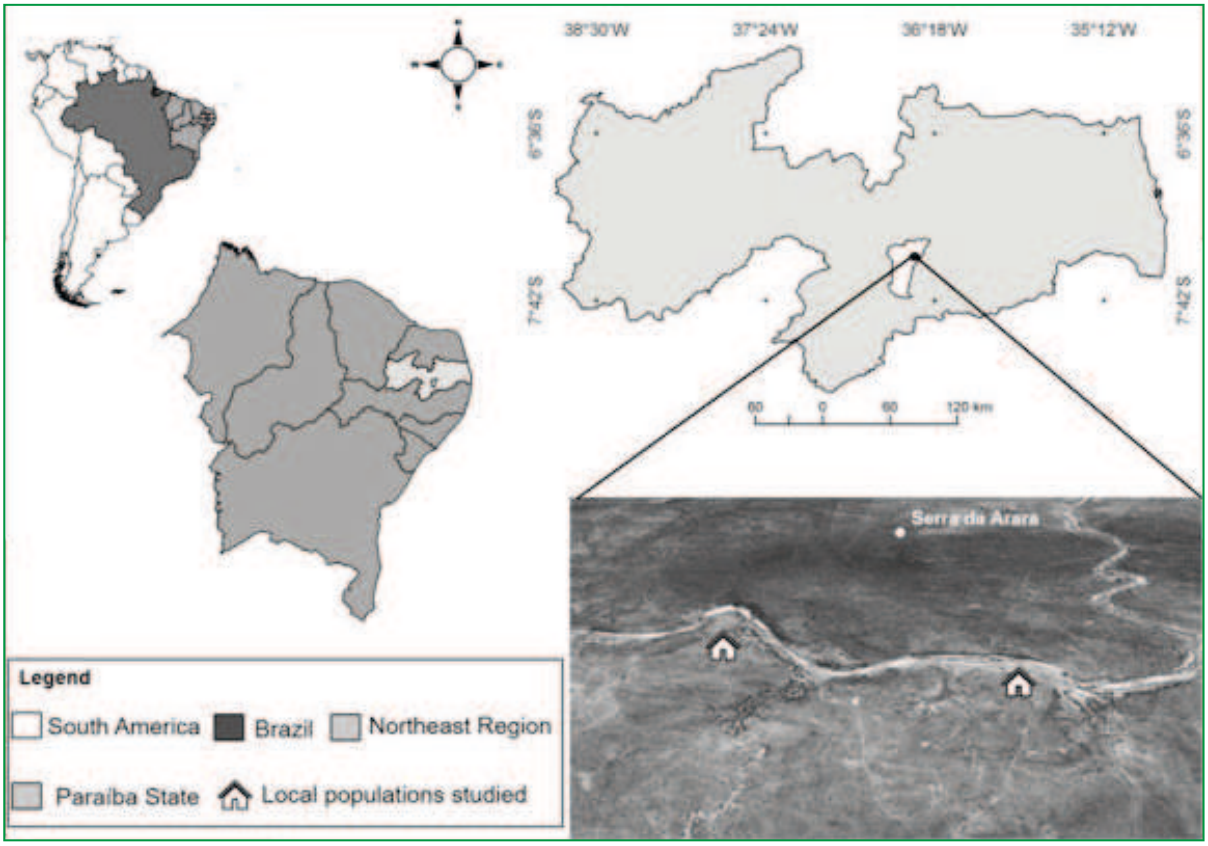
In this context, the present work aimed to analyze the changes over time and local representation of a montane area in the Brazilian semiarid region, which is a refuge for Caatinga biodiversity (LOPES et al., 2017). This study addresses the following main questions: How do local people perceive changes in this Caatinga refuge over time? What does this refuge of Caatinga biodiversity represent to the local community?

Materials and Methods

Methods and study site

The municipality of São João do Cariri is in the microregion of Cariri, Paraíba State, in the Northeast Region of Brazil, and is 13,845 km^2. The municipality has an urban population of 4,344 inhabitants (IBGE, 2010). The study was performed in two rural communities around the mountain called Serra da Arara (07º23'8.12"S, 36º23'36.74"W), approximately 15 km from the urban center of Lucas and Riacho Fundo (Figure 1).

FIGURE 1: Location of Serra da Arara and rural communities studied in the city of São João do Cariri, Paraíba State, in the Northeast Region of Brazil



The climate in the region is Bswh, hot semiarid, according to the updated Köeppen-Geiger classification (FRANCISCO et al., 2016). The average annual temperature is around 26 ºC, with minimum averages below 20 ºC. The Caatinga biome has an extended dry season, which can last 7 to 10 months. On the other hand, the rainy season is marked by scarcity and spatial irregularity of rain, and the hottest period of the year is between November and January and the coldest period is the month of July (MORO et al., 2016; SILVA et al., 2018).

The study area is one of the driest areas of the Caatinga and has a variety of different vegetation types, such as shrub-tree with xerophytic characteristics, presence of spines, microphylls, and a high density of individuals in the families Cactaceae and Bromeliaceae (ALCOFORADO-FILHO et al., 2003; LEAL et al., 2005; IBGE, 2012). The vegetation is influenced by drought-related water deficit due to rainfall irregularity and other factors characteristic of the region, such as high temperatures, associated with light intensity, which results in the desiccation of the soil (ALCOFORADO-FILHO et al., 2003; TROVÃO et al., 2007). Among the areas of Caatinga vegetation, the mountainous regions (known locally as *serranous*) are peculiar because they have species typical of Atlantic Forest and high species richness compared to flatter areas (LOPES et al., 2017; SILVA et al., 2018). The soil of the region is a Chromic Luvisol (EMBRAPA, 2006; OLIVEIRA et al., 2009) and is rocky in many places (EMBRAPA, 2006).

Socioeconomic description of the studied communities

Both communities have approximately 130 residents. The main economic activities in the studied communities are mostly related to agriculture. In the rural communities, traditional crops, such a maize and beans, are mostly produced for family consumption. In addition, some properties regularly irrigate with water from the tributaries of the Taperoá River and cultivate fruits and vegetables, for family consumption and trade, or grass forage for domestic animals. Most of the local owners possess small livestock herds, including cattle, sheep and goats, which are raised freely in the Caatinga on most rural properties (ARAÚJO, 2010).

The communities Riacho Fundo and Lucas are located near the boundary between the municipalities of São João do Cariri and Cabaceiras, Paraíba State, Brazil. Although they are neighbors, the communities possess some particularities that interfere directly with their way of life and, consequently, with their habits and customs. In the studied communities, the economy is based on raising cattle and breeding sheep and goats. The Lucas community differs because its main economic activity is processing leather, for utensils, in tanneries. It is worth mentioning that the leather is processed using angico bark (*Anadenanthera colubrina* Griselb.), a practice that has a strong impact on the populations of this species. In addition, most of the inhabitants of both communities are retired or civil servants. Most of the residents have an incomplete elementary education; although, younger individuals have a high school or higher education.

Inventories

The research has qualitative components and seeks to understand the local environmental representation about the mountain. Information was collected through semi-structured questionnaires, related to changes in the landscape over time, and the informant's environmental representation of Serra da Arara. Data were collected from May to October 2015, and informants were selected using the snowball technique (BAYLEY, 1982), which consists of acquiring information from a key informant (a culturally competent person) who is very popular in the region and has great knowledge about the use of plants. This person then recommends another informant of similar competence and the process is repeated with the new informant, and so on. There was a total of 25 informants (13 women and 12 men), 22 informants (11 men and 11 women) from the Lucas community and two women and one man from the Riacho Fundo community, with a mean age of 65 years. Prior to obtaining ethnoecological information from an informant, the purpose of the research was explained and a Free and Informed Consent Form was signed, which is required by the Conselho Nacional de Saúde (National Health Council) (45049415.5.0000.5187) through the Comitê de Ética em Pesquisa (Research Ethics Committee; Resolution 466/12).

Data from extensive open interviews and participative observations were studied to interpret and identify environmental representation on behalf of the informants. An effort was made to respect and describe the significance and perspectives of the representations expressed (VALLES, 2000), particularly with regard to issues related to native cosmology.

For the informants' statements we used the content analysis proposed by Bardin (2011), which interprets the interviewees' statements by means of exploitation of the raw data with the transformation and aggregation of speech that results in an interpretation of the content. Subsequently, a framework was created that allowed transcribed and coded statements to be organized, facilitating the categorization of all answers. The content was categorized using the semantic criterion, where statements were grouped based on the perspective of the coherence and sense of the answers. First, the text of each answer of each individual interviewed was given an identification code for the answer and the question number. For example, text of the answer from the first respondent, referring to the fifth question asked, received the following: E1:5, where E1 refers to Interviewee 1 and 5 refers to the fifth question. After all the interview content was codified, each set of content was arranged in tables, which allowed the responses to be viewed simultaneously. This was done to better understand the fundamental semantic convergences and/or divergences related to the classification and, therefore, categorization. Based on this, we defined two categories for the interview answers: statements related to changes in the landscape over time were grouped in the category "Landscape changes – reflection of history and uses" (Code 1); and statements related to the representation of the informants about Serra da Arara were grouped in the category "The mountain as a biodiversity refuge: representation of local population" (Code 2). Subsequently, each answer from each individual interviewed received a code identifying the informant and the category. For example, respondent 1 with answers related to cluster 1 received the code E1:1.

The plant species were collected in the field, processed, identified and incorporated in the Manuel de Arruda Câmara Herbarium, at the State University of Paraíba, Campus I, Campina Grande, Paraíba. The species cited by the interviewees were identified using literature and by comparing them with herbarium specimens, and the names were confirmed by specialists. The species were classified into families and genera according to the Angiosperm Phylogeny Group IV system (APG IV, 2016).

Results and Discussion

Landscape changes – reflection of history and uses under climatic changes

The representation of the local populations in relation to their environment has been shaped in a long and complex manner between generations influenced by an array of factors, such as beliefs, traditions and practices that are sensitive to changes experienced over the years. The synchrony of the rural men and women with the environment is harmonious in relation to understanding the senses and phenomena present in their daily life. The decrease of plant species because of changes in the rainfall regime is an example that, consequently, leads to extensive damage to the environment. The changes in climatic conditions of the semiarid region are perceived by local populations as the main limiting factors in the development of some Caatinga plant species, as reported by the informants below:

> The changes are in the trees, which before it had more and today there is no more. And that all these changes are due to the man who does not know and did not know how to take care, but the hot climate also influences (E6:2).

> Before it had more, today people take out everything that is wood, the drought also helped to decrease due to lack of water (E5:2).

The Caatinga experiences climatic variability that characterizes it as having inter- and intra-annual variation, resulting in a difference in the rainfall regime in certain years, with prolonged droughts and concentrated periods of heavy rainfall (winter) and other periods with less rainfall (dry season, summer) (AMOROZO, 1996; RITO et al., 2016), as well as high evapotranspiration resulting in a negative water balance

during most of the year (MORO et al., 2014). Similar to the perspective of the rural populations in this study, Byg and Salik (2009) identified how people in a village in China felt changes in a landscape due to climate change, without being aware of this global issue (recorded in scientific studies), and noted differences in the village between the past and present due to global changes (e.g., melting in mountainous areas, which altered lifestyles).

Change over long periods of time is inevitable, but this situation has recently become more significant for the world's dry forests (LONGOBARDI et al., 2016), and those who feel the most rapid pressure on natural resources are the people who use these forests in a direct way to meet the demands of daily life (AMOROZO, 1996). These changes are being identified and adapted to throughout their lives (INJOSA, 2001; SILVA et al., 2018).

Expansion of the processes of deforestation has led to reduced rainfall in these regions and a higher degree of evapotranspiration (LONGOBARDI et al., 2016). This fact is a worrying situation among the informants, since they all identified that the removal of vegetation has negative consequences for the region. Even knowing the reality of the semiarid climate, the informants are able to associate that the decrease in species richness has caused damage and a decrease in the amount of annual rainfall, as cited by the following:

> Droughts knocked down many species of trees and this reduced many of them (E22:2).
>
> Before it had more plants than today. Because the people began to devastate the trees and they attract rain, the serene also attracts rain (E16:2).
>
> When the Serra is *cachimbada*, it is going to rain. That is why you cannot remove the vegetation from there because the wood attracts rain and the rain protects the soil (E9:3).

The sense of "cachimbada" (clogged, hooked) for the informants is related to climatic conditions that change mist to rainfall. According to Figueira (2009), this phenomenon is the ability of vegetation to precipitate the tiny droplets of water in fog, known as hidden precipitation. For this phenomenon to occur, it is essential to preserve species for the development of biodiversity, but currently an increase in anthropogenic deforestation activities in the tropics and intensive agriculture, together with the release of greenhouse gasses, are contributing to climate changes and the reduction of biodiversity. According to Stocker et al. (2013), this increase in climate change has, as in other regions of the world, resulted in changes in the amount of rainfall in areas with dry tropical forests. Brazil's semiarid region shows that climatic changes contribute to the aggravation of severe droughts, soil dryness and qualitative changes during the process of forest fragmentation (DIEGUES, 2000).

As a consequence of these actions, decreases in habitat, food and vegetation have contributed to the process of defaunation that, according to Parry et al. (2009), is intrinsically linked to the high number of low-income local populations that use hunting as a source of food in isolated forest regions (BROCARDO, 2011). This also occurs in dry forests, where there has been a decrease in animals in natural habitats since they are hunted for food and because they hurt domestic animals in neighborhoods (HARRISON, 2011). Hunting activities have serious consequences for biodiversity and directly affect ecological systems, such as problems related to seed dispersal after the elimination of fauna (HARRISON, 2011). This can be seen in the statements of informants who correlated the decrease of floristic resources with the absence of fauna.

> I think there is still a lot of plants, but before it was more closed, species like: "Aroeira" grew more and where it has more plants it attracts rain and consequently more animals, like "wolf, snake, tamanduá (*Tamandua tetradactyla)*" because there is more food for them (E23:2).
>
> Formerly it had more plants, today it is more devastated, there used to be a lot of snake (E11:2).
>
> It is important because before you had "Guará" today there is no more (E4:5).

Another climatic phenomenon identified by the informants is bioindication, which can be defined as the presence of organisms that correlate with environmental factors and are considered indicators of a particular phenomenon (SCHUBERT, 1991). Local ecological knowledge may be linked to the bioindication of rain predictability (rainfall warning), for example, based on the morphophysiological modifications that some species

of plants present at certain times of the year (INOJOSA, 2001). In this sense, seven species of plants were listed by the respondents that undergo morphophysiological changes throughout the year, which indicate the predictability of rainfall. "Cumaru" (*A. cearensis*) showed a higher frequency of predictability (Table 1). According to the interviewees, when "cumaru" does not flower it is a signal of a weak winter (low rainfall).

Caririzeiros, the name for the people in this semiarid region of Brazil, are marked by the life experience of tradition and adaptation to climatic conditions based on observations of phenomena. To better plan and organize the cultivation and harvest times, for example, *caririzeiros* use the phenological behavior of some plant species (local bioindicators) as a form of forecasting rain and drought (INOJOSA, 2001; LUCENA et al., 2007). Nowadays, these "rain prophets," as they are known, serve as ethnometeorological consultants in several countries (PENNESI, 2007).

Local ecological knowledge (LEK) about these phenomena is still present in the memory of the local people and provides important bioindicators for the entire semiarid region of Brazil. In some municipalities in this region (LUCENA, 2005; LIMA, 2010; ABRANTES et al., 2011), the indication of fruit fall of the endemic *Ziziphus joazeiro* (juazeiro) can be a signal of rainfall, based on the constant quotations observed among local populations. Currently, however, indicating the phenological behavior of these species as a form of rainfall prediction in the region has become less reliable, since local populations feel that changes are occurring both in the season and in the amount of rainfall, according to the informants cited below:

> There is difference. Before it had more rain and today has much less (E13:3).
>
> Before it had more plants. Before it had more winter and in the Serra before selling a lot of wood (E20:2).

Local observations are essential for the development of important future scientific models that prove the reality of perceptions of local phenomena, as well as those recorded through scientific research (BYG; SALIK, 2009). In this sense, local ecological knowledge can significantly contribute to programs and public policies that want to mitigate the damage climate change is causing in local communities (BYG; SALIK, 2009; SASLIS-LAGOUDAKIS; CLARKE, 2013), since local populations live within and understand the Brazilian semiarid region and can therefore propose management

TABLE 1: Species cited as bioindicators by local communities, in the municipality of São João do Cariri, Paraíba State, in the Northeast Region of Brazil.

Local Vocabulary	Scientific name (Family)	Voucher	Part used	Prophecy	Citation %
Aroeira	*Myracrodruon urundeuva* Allem o – (Anacardiaceae)	ACAM 1674	Seed	When the tree is loaded with fruit, it is a sign of rain.	1.80
Baraúna	*Schinopsis brasiliensis* Engl. – (Anacardiaceae)	ACAM 973	Entire plant	Attracts lightning bolts, it is not good to have close to the home.	3.70
Cumaru	*Amburana cearensis* (Allemão) A.C.Sm. – (Fabaceae)	ACAM 1575	Flower	When it does not flower, it is a signal of a weak winter.	33.33
Juazeiro	*Ziziphus joazeiro* Mart. – (Rhamnaceae)	ACAM 1933	Fruit	When it is full of fruit and falls on the wet earth, it is a sign of rain.	1.40
Jurema branca	*Piptadenia stipulacea* (Benth.) Ducke – (Mimosaceae)	ACAM 880	Flower	When it flowers it is a sign of rain.	7.14
Quixabeira	*Sideroxylon obtusifolium* (Roem. & Schult.) T.D. Penn. – (Sapotaceae)	ACAM 233	Flower	When the previous year was good for rain, it will flower the following year.	1.40
Umbuzeiro	*Spondias tuberosa* L. – (Anacardiaceae)	ACAM 1579	Flower	Beginning in October, when it flowers it is a sign of rain.	4.85

actions that result in development and economic autonomy. Understanding local needs and improving the socioeconomic conditions of communities can contribute to protecting the great diversity of species and functions still found in neotropical regions (LOPES et al., 2017).

The mountain as a biodiversity refuge: representation of local populations

According to the informants, the mountain should be preserved in a pristine way, with restricted access so that the native species of the Caatinga are conserved, as stated in some examples below:

> It would be important because of all native species here and so no one would enter, just so access was restricted (E7:5).
>
> It is important to make a reserve because only then nobody moved and would be important for tourism (E8:5).

The view of untouched nature, or conservation without local human participation, is still a preponderant conservation model (PIEROTTI; WILDCAT, 2000) and very representative among the local populations of this study. For many years, this idea of nature conservation without human participation was reported in the media and formally and informally taught (OLIVEIRA et al., 2018), which helped solidify this representative idea of conservation in the local populations. Diegues (2000) shows how the North American conservationist policy (top-down) was devastating to traditional populations, especially to those belonging to Third World countries, due to the false impression of relating conservation to something stagnant, without cultural involvement or the participation of sociocultural groups (extractive, riparian, farmers). In fact, present thinking in conservation and sustainability encourages the inclusion of local and traditional populations (HUNTINGTON, 2011; LOPES et al., 2017), since they are important actors for the maintenance of local biodiversity (ESMERALDO et al., 2011).

In this sense, Brazil already has protective measures for the use of resources by traditional populations, such as the national policy to combat desertification and mitigate the effects of drought (ELOY et al., 2014). This policy highlights (in Article 4, items I to II) actions of mitigation and integrated management of the democratization of knowledge, as well as the incorporation and valorization of traditional knowledge in the management and sustainable use of natural resources.

The studied region is considered a refuge for Caatinga biodiversity because it has high species richness compared to adjacent zones that are characterized by patches of fragmented habitats; in addition, high endemism and the presence of species typical of other ecosystems have been recorded in mountain ranges in the Caatinga (SILVA et al., 2014; LOPES et al., 2017). The difficulty humans have accessing these areas is a factor that positively influences the diversity (SILVA et al., 2014). Moreover, the specificity of environmental factors (e.g., soil, moisture, presence of rocky outcrops), as suggested by Lopes et al. (2017), determines the composition of the plant communities in these areas. In this way, the informants explain the importance of the mountain becoming a conservation area:

> Conserving there would help to increase rain over time and it would benefit people here (E20:5).
>
> It would be important because only then would the Serra look beautiful (E10:5).

The informants understand the importance of the mountain and its associated biodiversity in providing direct benefits to the local communities. There is a consensus among the informants' discourses about the importance of conserving Serra da Arara. About 18 informants (72%) reported that preserving mountain vegetation over the years could increase rainfall in the region, as well as favor the return of associated fauna and the conservation of unique scenic beauty:

> It would be important because the survival of some animals depends on it, but if the Serra was conserved in all cases would be balanced, the animals would feed each other. It would not benefit our site, but at least the rain would increase because of the wood (E24:5).
>
> The Serra is an important conservation area, because it helps the animals, because there is "Jabuti" and there they shelter (E6:1).

The ways that people represent such biological components present in their lives is an important issue,

since people are capable of changing their values, thoughts and actions to improve their local reality (DEL RIO; OLIVEIRA, 1996). The informants explain the representation of the mountain:

> It represents my childhood, to walk contemplating nature (E6:1).
>
> I think it is beautiful because it is a work of nature (E1:1).

The classical transformation that people experience is often linked to their level of formal and informal education, which is responsible for the transformation, reflection, rationalization and awareness related to conservationist attitudes (HEINEN, 1993). It should be emphasized that the effect of "positive" aesthetics on conservation is an important factor for consideration, as evidenced by other studies (GUNNTHORSDOTTIR, 2001; PROKOP; FANČOVIČOVÁ, 2013).

The local communities realize how much the landscape has changed over time and the consequences of this for biodiversity and their lives. According to the informants, the mountain helps recall the memories of previous landscapes, which is linked to biodiversity and the importance of the mountain as a source of resources and influence on local rainfall regimes. The conservation of this refuge of Brazilian Caatinga biodiversity represents, for the local population, more than the preservation of biodiversity. It also represents the permanence of ecosystem functions and the resilience of intrinsic values for the maintenance of the population's culture. Local ecological knowledge must be aligned with the conservation of local biodiversity since local populations have information that ensures true regional needs. Thus, future public policies should review and incorporate this information into actions related to sustainable conservation of natural resources.

Acknowledgements

We are grateful to the residents of the communities that agreed to participate in this research. SFL thanks CNPq for the financial support and productivity grant.

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