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Research article

Socioeconomic differences among resident, users and neighbour populations of a protected area in the Brazilian dry forest

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ABSTRACT

Protected areas are an important strategy to safeguard biodiversity. However, if social development is not considered, biological conservation targets may not be achieved. In this empirical study, we assess the relationship between poverty and conservation goals in dry forests within a 62,000-ha Brazilian National Park (Caatinga biome). We conducted 81 structured household interviews between January and July of 2016 to assess socioeconomic, resource management and land-use variables. We used non-parametric analysis of variance to test for differences in socioecological variables among families living inside and outside the Park and both (double dwelling). The majority of families (76%) residing inside the Park were living below the poverty line while less than 14% in outside and double dwelling residences faced the same issue. Families living inside the park had lower socioeconomic conditions such as limited water availability, poor house infrastructure, low income, and high dependence on firewood than outside and double dwelling families. They were also more dependent on external financial support and natural resources. We found that failures in protected areas inception and implementation have driven people towards a mutually reinforcing and declining situation in which negative socioeconomic outcomes are associated with nature degradation. Therefore, our results suggest that the future of dry forests, characterized worldwide by the presence of low-income populations, will be largely dependent on conservation strategies that address poverty alleviation and human well-being.

1. Introduction

Protected areas (PAs) have been the main strategy to safeguard biodiversity worldwide (Brockington and Wilkie, 2015; Laurance et al., 2012; Myers et al., 2000; Naughton-Treves et al., 2005). Due to the current and global biodiversity crisis, high loss and species extinction rate, one of the targets of the Convention on Biological Diversity is to expand PAs to around 17% of all terrestrial areas worldwide by 2020 (http://www.cbd.int/sp/targets). However, many studies have highlighted the limitations of PAs in accomplishing species conservation and distributing benefits to humans, dwellers of PAs or not (Butchart et al., 2010; Laurance et al., 2012). Additionally, PAs have generated conflicts of interest between social goals and environmental conservation policies given that, in most cases, human settlements were present before the creation of PAs (Brockington et al., 2006; Nicolle and Leroy, 2017) and a substantial proportion of natural resource allocations upon which human population is dependent is inside PAs (Chape et al., 2005). In developing countries, the negative impacts of PAs on local communities can be significant, particularly for those living in poverty prior to PA creation (Adams and Hutton, 2007; Cernea and Schmidt-Soltau, 2006).

Many studies from the last few decades have tried to understand whether PAs have created positive or negative impacts in attempts to reduce local poverty (Adams and Hutton, 2007; Brockington et al., 2006; Ferraro and Pressey, 2015; Kepe et al., 2004; Roe and Elliott, 2004; Watson et al., 2014). In Thailand and Costa Rica, governments have been investing in policies to protect biodiversity associated with poverty reduction (Andam et al., 2010; Ferraro et al., 2011). In some cases, though, human populations inside or in PA boundaries are

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incapable of escaping poverty because they are strongly resource reliant and fall into a cycle of dependence due to few opportunities to improve their socioeconomic condition (Nakamura and Hanazaki, 2016; Vedeld et al., 2012). Poverty can drastically reduce the household's capacity to invest in land management, for example, limiting the additives, tools or irrigation purchase to improve livestock and food production (Nkonya et al., 2008; Swallow et al., 2008). Poor families can also have high dependence on natural resources harvesting (Medeiros et al., 2012; Specht et al., 2015). Usually, in forest-rich areas in remote places in developing countries, people have fewer opportunities for income improvements (Wunder, 2001), low or no access to markets, and sometimes reduced water supply (Blackie et al., 2014; Top et al., 2004). As such, the socio-economic parameters of landscapes (Papadimitriou, 2012) and the mechanisms that create and maintain poverty in PAs need consideration for a successful environmental management and a local social development (Barrett et al., 2011; Ferraro et al., 2011).

There is a consensus that PAs are more effective when they are well supported by local residents; therefore, conservation plans in these areas have been increasingly considering the protected areas as coupled human-natural systems (Chen et al., 2017) or socioecological systems - SES (Wei et al., 2018). SES are defined as complex and linked systems of people and nature composed of multiple subsystems and internal variables. The concept of SES implies that PAs do not exist in isolation: they are dependent on the broader SES in which they are inserted, driven by both socioeconomic and ecological processes; in turn, PAs can influence not only ecological processes, but also local livelihoods and human well-being (Wei et al., 2018).

Since the 1980s there has been increasing emphasis on ensuring that local communities benefit from biodiversity conservation (Emerton et al., 2006). While there is evidence of support to PAs from local communities that experienced losses related to their livelihoods (Martin et al., 2018), a meta-analysis based on data from 165 PAs revealed that positive conservation outcomes are more likely to occur where PAs lead to socioeconomic benefits for the affected communities (Oldekop et al., 2016). The quantitative analysis of these benefits suggests that tourism and recreational activities contribute most to poverty alleviation (Ferraro et al., 2014), even though they are known to be limited by the few people involved and the capabilities and infrastructure required to engage in tourism (Kiss, 2004).

Payment for ecosystem services (PES) constitutes another option that, when designed appropriately, can be an alternative for delivering conservation goals in PAs while benefiting local people (Clements and Milner-Gulland, 2015; Yang et al., 2018). The central idea of PES is that conservation costs suffered by communities in target areas should be compensated to avoid impeding socioeconomic development of those local communities (Yang et al., 2018). Nevertheless, PES programs often induce the decrease in traditional livelihood activities, which can have cultural implications and affect SES resilience, i.e., its capacity of continually change and adapt yet remains within critical thresholds (Folke et al., 2010). Therefore, the most successful PES schemes are the ones that secure the continued provisioning of a critical resource while positively contributing to local livelihoods in rural communities and PAs (Grima et al., 2016).

Brazil has approximately 220 million ha covered by PAs (Bernard et al., 2014), being one of the largest protected area systems in the world (Oliveira and Bernard, 2017). National Parks (NPs) in Brazil are strict PAs where direct natural resources exploitation is not allowed (Law 9.985/2000, Brasil, 2000). Thus, local residents established before NP creation expect to be notified of Park creation, receive assistance during the process and be fairly financially compensated to leave the area in the first five years of PA inception (MMA and IBAMA, 2011). However, compensation has failed in most cases and thousands of families remain living in Brazilian NPs (in not regularized land tenure condition). In the new conditions, where livelihood becomes particularly fragile, the biodiversity and the PA's existence themselves are threatened (Bernard et al., 2014; Bragagnolo et al., 2016; Diegues, 1998). More than 60% of the NPs in Brazil created before 2000 had problems related to land tenure involving local residents (Rocha et al., 2010; Oliveira and Bernard, 2017). Nevertheless, Brazil is not unique in sustaining “paper parks”, in which the PA exists only in name (Stolton et al., 1999). Also, removing residents from PAs, although supported by law, can further represent a serious threat to human rights and exacerbate poverty especially in developing countries (Adams et al., 2004; Kipuri, 2006).

The Brazilian Caatinga is one of the world's most populated seasonally dry tropical forest. It has ~28 million inhabitants distributed over 800,000 km^2 with a history of poverty associated with water scarcity, often even for basic human needs (Barbieri et al., 2010; Redo et al., 2013; Santos et al., 2011). It is also the largest and most diverse seasonally dry tropical forest in the world (Silva et al., 2018). About 43.5% of the Caatinga population lives in rural places and most of it is comprised of small farmers living in high dependence of natural resources for their livelihoods. Thus, the socioeconomic and environmental context of the Caatinga offers an interesting opportunity to examine the relationships between poverty and conservation in PAs.

In this study, we use the Catimbau National Park, located in the Caatinga of Pernambuco state, Brazil, as a case study to assess the relationship between poverty and conservation goals. Our main objective is to evaluate whether families living inside the Park are in a worse socioeconomic condition and dependence on natural resources use more than outside families. We do this by describing socioeconomic conditions and infrastructure development, as well as use of landscape and plant resources by dwellers. We then discuss the consequences of local socioeconomic condition associated to natural resources use by local livelihoods and biodiversity conservation in the PA.

2. Materials and methods

2.1. Study area

The Caatinga's vegetation is a mosaic of xeric and thorn plant species, it is larger than the areas of Italy, Germany, and United Kingdom together (Leal et al., 2005). It harbors 3150 native species of flowering plants, although it is expected that there may be up to 40% more species that have not been sampled yet (MMA and IBAMA, 2011; Moro et al., 2014). The number of endemic biological species that offer sufficient data to make such calculations are quite astonishing, ranging from 6.0% in mammals to 52.9% in fishes (Silva et al., 2018).

Only 7.5% of Caatinga is within PAs, and less than 2% is fully protected, that means without human settlement “in theory” (MMA and IBAMA, 2011). Create and maintain those protected areas are extremely important once, nearly 46% of Caatinga's area is deforested (Beuchle et al., 2015), and it is thought that 15% of the deforested areas have been desertified due to inappropriate land use (Silva et al., 2018). The region is among the top six ecosystems with the largest intrinsic vulnerability to climate variability (Seddon et al., 2016). Caatinga's vegetation has been suffering for many decades due to the impacts of acute disturbances (i.e. habitat loss by charcoal production) and chronic anthropogenic disturbance (i.e. firewood collection and slash-and-burn agriculture) (Ribeiro et al., 2015; Segan et al., 2016; Silva et al., 2018).

Caatinga has many traditional people including “*Sertanejos* or *Catingueiros*” who are descendants of a mix between Brazilian Indigenous, European colonizers and sometimes African slaves that have lived in the region for many generations adapting to environmental restrictions, especially water irregularity. In Brazil, traditional communities use natural resources as a contribution to “their cultural, social, religious, ancestral and economic reproduction” (Brazilian Decree Nº 6.040 of 2007). The *Sertanejos* use native plants for different purposes including fuelwood, food, animal fodder and medicine (Lucena et al., 2008; Ramos et al., 2008). Most have low family income and need the social welfare and income program of the Brazilian

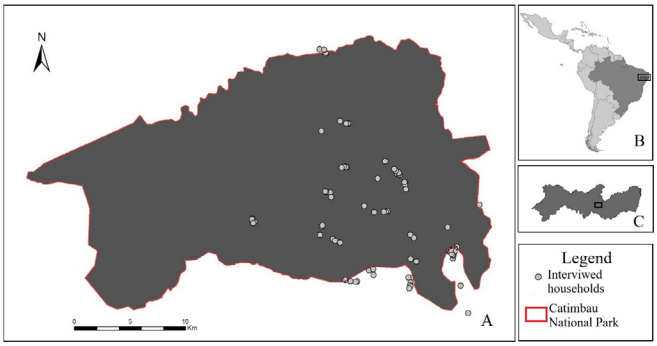

Fig. 1. Location of the study area, Catimbau National Park map (A), Pernambuco State (B), and Brazil (C). Grey dots represent households interviewed between January and July of 2016.

government the *Bolsa Família* or emergency income, to survive, especially in the dry season, when water scarcity becomes exacerbated and the food production is ceased and water storage is ending (Paiva et al., 2014). While in the Amazon there are successful PES schemes for traditional communities living within and outside PAs, such as the *Chico Mendes* law and the *Bolsa Floresta* program (Grima et al., 2016), in Brazilian dry forest PES initiatives or other economic incentives for biological conservation are absent.

Our data collection was conducted in Catimbau National Park (IUCN Category II). The park is located in Pernambuco state in Northeastern Brazil (8º24′00″ and 8º36′35″ S; 37º0′30″ and 37º1′40″ W) and it was created in 2002 to preserve its biodiversity and scenic beauty, encompassing around 62,000 ha of Caatinga vegetation (Fig. 1). The vegetation is a mosaic of low stature dry forest and shrubs, including xeric and non-xeric species with stands regenerating after slash-and-burn agriculture or livestock raising (Rito et al., 2016). The climate is semiarid, with an annual average temperature of 23 ˚C and annual mean precipitation ranging from 486 mm to 975 mm. Archaeological studies described traces of human occupation as cave paintings in some areas of the park dating to at least 4000 years ago (Oliveira, 2001).

There are approximately 300 *Sertanejos* families distributed among 17 studied communities living inside the Park (some families recognize themselves as indigenous) (Fig. 1). They remain because the process of expropriation of land has not been completed and is not advancing. There are three large communities (> 200 families in each) residing outside the Park within a 3 km radius of the Park boundary. Some families living outside the Park also have property inside, which we refer to in this study as double dwelling families. The main livelihoods of the people inside and outside the Park are goat raising, and subsistence agriculture including cultivation of vegetable species in gardens and wild plants harvested from the forest (Santos, 2015). Slash and burn agricultural practice, hunting, goat raising and selective cut of “green wood” are prohibited inside park, however, it was possible to observe these activities at several moments of our field research. There are some testimonials of residents who were fined for conducting illegal activities. These uses of natural resources by local residents was documented as leading to a significant reduction in woody plant diversity, especially in drier areas of the Park (Rito et al., 2016).

The Park rules for resource and land uses impose restrictions for tourists and residents, but control is insufficient. The park does not have a headquarters office and it has only one employee to manage all the bureaucracies and surveillance with sometimes no enough financial resources even for fill up the car tank with fuel. Due the delay in finish the process of expropriation and difficulties of management, we call the Catimbau National Park as a “paper park”. Lawfully in Brazil, a management plan must be prepared within no more than five years after PA inception, and, until the management plan is drawn up, all activities should be limited to those aimed at guaranteeing the integrity of the natural resources and the conditions and means necessary for the satisfaction of material, social and cultural needs of the resident traditional populations (Brasil, 2000). The Catimbau National Park was created 15 years ago, *sertanejos* were barely involved in its creation, expropriation started but is stagnated with no timeline for conclusion and the management plan is yet to be designed. In that way, hundreds of people are in not regularized land tenure situation. There are also no markets within the Park, which obliges residents to shop outside. The communities were present before Park creation, however the communities have grown and more residents have arrived since its inception. Unfortunately, there is no socioeconomic data of the families before the park inception. A non-governmental organization located in Catimbau National Park boundaries was created in 2002 to help people in vulnerability situation (www.amigosdobem.org). Families has been rescued from extremely poverty since then to work in a cashew plantation to generate income to maintaining a local village where children have access to educational activities.

2.2. Data collection

The data were collected between January and July of 2016. To understand the relation between poverty and conservation, we conducted inventories on socioeconomic aspects, home infrastructure, landscape uses and plant resource uses for each family. For this, we conducted 81 structured interviews: 43 with families living inside the Park, 21 outside and 17 in double dwelling condition (see Fig. 1). More interviews were conducted in the eastern region of the park due to greater climatic and soil similarity with outside families when compared to the western portion of the park, which is drier and with a different soil composition. We interviewed household representatives (woman/man or both together). We sampled about 10–20% of the houses or less when in the larger communities. The selection criteria for the participation of families was by convenience (sampling families available to participate in the study when we arrived in each community). We excluded those younger than 18 years old and in an altered stage of consciousness (i.e. after alcohol consumption) (Bernard, 2006). This study was approved by the National Council of Ethics in Research by the Ministry of Health in accordance with the requirements of current Brazilian legislation under the numbers 52759815.9.0000.5208 and 1.451.290.

2.2.1. Socioeconomic and infrastructure inventories

In order to assess the socioeconomic status of the interviewed families, we selected variables that could best represent the socioeconomic context of Caatinga's rural residents. We asked each family for their monetary income and educational level, number of people per family, home infrastructure, community relations and water supply, scoring the answers for data analysis (Table 1).

2.2.2. Landscapes and plant use inventory

To assess families' use of natural resources, we performed an inventory of the main uses of plant species for firewood, medicine, handcraft, food and animal fodder, in each backyard that includes garden and orchard, crop cultivation and forest areas including regenerating areas (regrowth forest after slash). During interviews, we assessed the percentage of people in each family involved in land work specifically agriculture or animal raising. When possible, we estimated the amount of firewood consumed per family/day using a hand balance (average day method) (Arias-Chalico and Riegelhaupt, 2002). To calculate an approximation of monthly firewood use we multiplied the number of days per week that the amount of firewood is used by 4 weeks. The variables used to assess landscape and plant uses are described in Table 1. In addition, we participated in guided tours with local experts for recognition and collection of plants used by families and later we identified botanical material with an expert botanist.

Table 1
Socioeconomic, infrastructural home variables, landscapes and plant resource use inventory based on 43 structured interviews with households of families inside, 21 outside the Catimbau National Park, Brazil, and 17 in double dwelling conditions.

Variables per family	Type of variable	Scores/ Values
Socioeconomic and infrastructural home variables:		
Community relations (syndicate, association/ cooperative, community, school, political party or church):	Ordinal	0 to 3
0- Do not participate		
1- Participate occasionally		
2- Always participate		
3- Is associated		
Education level of household (Number of years of formal education)	Continuous	0 to 16
Home infrastructure	Ordinal	3 to 10
Plumbing:		
1-Do not have		
2- Sewage gallery		
3-Septic Tank		
4- Full sewer		
Residence type:		
1-Clay overlay on timber		
2- Mixed clay with masonry		
3 – Masonry		
Toilet:		
1- Do not have		
2 – Outside		
3 - Inside		
Monthly monetary income US$* (Salary, governmental social welfare program, retirement, farm credit, overall sales, agricultural sales, animal sales, handicraft, non-governmental projects) *Conversion rate: 1 US dollar = 3.11 BRL	Continuous	150 to 4220
Number of people	Continuous	1 to 11
Water supply		
0- Does not have water tank, externally supplied water, or artesian well in the community	Ordinal	0 to 10
3- Have water tank or community artesian well		
6- Have water tank and artesian well in the community		
10- Have sufficient water to attend the basic needs and some surplus.		
Species use and dependence variables:		
Backyard species cultivation	Continuous	0 to 24
Crop species cultivation	Continuous	0 to 13
Forest/Regeneration species	Continuous	0 to 24
Monthly firewood use (Kg/month)	Continuous	0 to 600
Land management variables:		
Number of goats raised	Continuous	0 to 200
Percentage of people involved in land work	Continuous	0 to 100

2.3. Data analysis

We conducted a Kruskal-Wallis test to compare the three residence types (double dwelling, inside and outside the Park) in terms of socioeconomy, home infrastructure, plant use and land management (all variables in Table 1). We used Chi-square tests to compare the frequency of families below poverty line, families receiving support from Non-Governmental Organizations and families receiving financial support from the government for each residence type. All analyses were performed in R 3.4.0 (Team Core, 2017).

3. Results

3.1. Socioeconomic and infrastructure description of dwellings

We found that 35% of the total 81 interviewed families were living below the World Bank poverty line 2016 ($1.90 US dollars/person/day). Almost 84% of the 81 families were involved in agricultural activities on their own land but only 1% of the household income came from agricultural sales and 11% from animal sales, mainly goats. Slash-and-burn practices were the most common type of land preparation and only two households had formal training or support to improve land management and planting. Inside the Park 76% of the families were living below the poverty line, whereas less than 14% of families living outside or double dwelling were in the same condition. Most of the inside park families (72%) were receiving both support from non-governmental organizations like food, clothes, medicine and governmental income the "*Bolsa Família* program". Those families received proportionally more social assistance from NGOs than families outside the Park, but similar governmental financial support (Table 2).

Monthly monetary income of families living inside the Park was lower and their home infrastructure was worse (more clay buildings, fewer toilets and poorer sanitary conditions in general) than those families living outside the Park or double dwellers (Table 3). About 56% of the houses inside the Park were built with clay and wood, and had no sewerage or toilets. Irrespective of the type of residence, families were composed of less than 5 people and in general the households spent less than 5 years in formal education (Table 3). Families living inside the Park were more isolated due to the longer distance to the markets and city, engaged in fewer social and community activities, and were more susceptible to water scarcity (Table 3). Most families (84%) living inside the Park had no water tank or no external water supply, sharing the water extracted from an artesian well or water tank with other families in the community, in comparison with only 13% of families living outside the Park and double dwellings living with the same water restriction.

3.2. Landscapes and plants use by dwellers description

Double dwelling and inside the park families had goatherds 35 and 5 times larger than families living outside park, respectively. The percentage of adults involved in agriculture on farms was the same across the three setups and the number of species used from the forest and cultivated species in crop plantation did not differ (Table 3). However, the backyards of the families outside the Park had on average 2.8 times more species than double dwelling families and 2.3 times more than families inside the Park (Table 3). Double dwelling families used significantly less firewood monthly than families living inside and outside families (Table 3).

4. Discussion

Our results show that people living inside the Park were

Table 2
Families situated below the World Bank poverty line 2016 (1.90 US dollars/person/day)* and receiving governmental and non-governmental assistance living outside, in double dwelling conditions and inside the Catimbau National Park, Brazil.

Families situation	Outside Park	Double dwelling	Inside Park	X	df	P
Families below poverty line	4 (13.8%)	3 (10.3%)	22 (75.9%)	23.65	2	< 0.001
Families receiving NGO support	14 (24.2%)	9 (15.5%)	35 (60.3%)	19.69	2	< 0.001
Families receiving GO support	12 (33.4%)	9 (25.0%)	15 (41.66%)	1.5	2	0.47

p = level of significance, p > 0.05 means there no difference by the chance; df = degree of freedom; x = chi-square test value.

Table 3
Variables to describe socioecological system of families living inside, outside the Catimbau National Park, Brazil, and in double dwelling conditions. The values represent median (first-third quartiles); df - degrees of freedom, H - test value and *p* value -significance level. The values in bold indicate significant results ($p < 0.05$).

Socioecological variables	Outside Park	Double dwelling	InsidePark	df	H	*P* value
Socioeconomic and infrastructure						
Community relations score	3 (2–5)[ab]	3 (2–7)[a]	2 (1–4)[b]	2	6.06	**0.0481**
Years of formal education	2 (2–4)	3 (1–4)	2 (1–3)	2	1.76	0.4145
Home infrastructure score	8 (5–8)[a]	8.5 (7.75–10)[a]	6 (5–8)[b]	2	33.19	**0.0001**
Monthly monetary income (US$)	479.41 (337.62–646.30)[a]	524.75 (448.23–650.80)[a]	257.56 (135.69–501.60)[b]	2	9.42	**0.009**
Number of people in family	3 (2–4)	3 (2.75–4.25)	4 (2–5.25)	2	1.36	0.5062
Water sustainability score	6 (6–10)[a]	10 (9–10)[a]	3 (3–6)[b]	2	30.18	**0.0001**
Plants use						
Backyard species cultivation	7 (310)[a]	2.5 (1–6.5)[b]	3 (1–5)[b]	2	7.03	**0.029**
Crop species	5 (3–8)	4 (3.75–6.25)	5 (3.75–7)	2	0.11	0.9442
Forest/Regeneration species use	5 (3–8)	7 (2.5–8.5)	16 (4–10.25)	2	2.55	0.2782
Monthly firewood use (kg/month)	75 (0–200)[a]	0 (0–36)[b]	154 (40–246)[a]	2	12.79	**0.0017**
Land management						
Number of goats raised	1 (0–15)[a]	35 (8–70)[b]	7 (10–36)[b]	2	6.17	**0.0457**
Percentage of people involved in land work	100 (50–100)	50 (45–100)	100 (62.5–100)	2	3.61	0.164

experiencing lower socioeconomic conditions including more limited water availability, poorer house infrastructure, lower family income and higher dependence on firewood, even though those did not differ from outside and double dwelling families in terms of educational level and percentage of people involved in farm work. The poverty in Catimbau NP families is probably generated by the lack of infrastructure, low educational levels, low production capacity of food and poor land management for agricultural purposes, even though it is the main local activity in a context of water scarcity. Families living within the Park are stagnant in a cycle of dependence on external financial support by minimum income programs and natural resource exploitation, with poor land management, and kept below the poverty line with few opportunities to change. In contrast, the Park likely generates poverty alleviation for families living in double dwelling conditions because they have opportunities to use Park natural resources while accessing external infrastructure. Due to the lack of surveillance within the Park, the number of residents in double dwelling condition can also easily increase the natural resources use especially firewood and extensive goat farming.

Families living inside the park are even more susceptible to poverty due to land use restrictions and the inability of the Brazilian government to enforce fast and effective policies. Poverty is strongly correlated with natural resource dependence such as high dependence on firewood use by poor rural families in developing countries (Medeiros et al., 2012; Sanderson, 2005; Specht et al., 2015). In the last decade, studies showed that disturbances in Caatinga vegetation from subsistence economy (i.e. firewood collection and small-scale agriculture) are responsible for the modification of forest structure, composition and diversity (Ribeiro-Neto et al., 2016; Ribeiro et al., 2015). Also in Caatinga, animal hunting has been correlated with socioeconomic conditions because this activity provides animal protein to poor families (Alves et al., 2009). The goat farming and firewood collection by inside and double dwellers may lead the forest to chronic anthropogenic disturbances (Fernandes-Ferreira et al., 2012). Previous studies have already demonstrated biological and phylogenetic diversity reduction of woody plants communities in areas more densely occupied inside the Park (Rito et al., 2017, 2016).

One important finding of our study is less water is available for families inside the Park. Less autonomy in land management and governmental programs restrictions (i.e. National water tank's distribution program cannot occur inside the Park) for these families in illegal situation may be the explanation. Especially in dry forests, human populations are more dependent on rainfall for their economic development, including subsistence agriculture (Smith et al., 2010). By 2100 Caatinga can expect a 22% reduction in rainfall (IPCC, 2014; Pachauri et al., 2014). The FAO also suggests that the effect of climate change on agriculture and forest resources use is not receiving the attention it deserves, and immediate actions for global food security are needed (Bakkegaard et al., 2016; Campbell et al., 2016). In addition, the International Food Policy Research Institute (IFPRI) is estimating that climate change will affect 50 million people through mal-nourishment (Bakkegaard et al., 2016). In that way, the reduction of production capacity, poverty and desertification may worsen and collapse the socioecological systems in dry forests, especially for those living within PAs in situations of land irregularity (Tanner-McAllister et al., 2017).

Governments of developing countries, especially due to corruption or inability to enforce policies, often ignore conflicts between conservation efforts and social demands. Uncertain conditions like time waiting for conflict resolution between park managers and local communities, as well as restrictions on land and resource use are particularly harmful and can mean that conservation goals are threatened due to issues of non-compliance to conservation initiatives (Coad et al., 2008). Well managed PAs can contribute to poverty alleviation, as the Costa Rica case demonstrates, a country that has invested hardly in conservation. Costa Rican PAs had a positive impact on local communities because of infrastructure improvements that favored local tourism activities to accomplish the PA goals, generating opportunities for local people (Baird, 2014; Ferraro and Hanauer, 2014; Ferraro and Pressey, 2015). On the other hand, Vedeld et al. (2012) found that Park creation could generate land use restrictions and income inequalities in communities surrounding the Mikumi National Park in Tanzania. Poverty and natural resources depletion have also been found in NPs in Kenya (Cinner, 2011). Both NPs in African countries are in dry forests which is different from Costa Rican wet forests, which suggests the need for more comparative studies, because the first ones appear to be more susceptible to failure regarding human well-being and conservation goals.

Our findings indicate that there is a complex socioecological system in the Catimbau NP with a clear conflict between environmental and social dimensions. Downgrade the Park to a less restrictive category that allows people to live inside will certainly result in high environmental costs, will open case law to other protected areas and will not ensure that families escape from their poverty situation (Bernard et al., 2014; Nolte et al., 2013). Concluding as soon as possible the families' removal process may bring environmental benefits (Andam et al., 2008; Mcdonald et al., 2008), and in a perfect situation, families will quickly adapt to their new environment, improving their likelihood to escape from poverty. However, the reality, especially in developing countries, is in fact extremely multifaceted (Smith et al., 2003). Poverty might be just “exported” elsewhere, and the families will remain under poverty condition, and continuing to place uncontrolled pressure on natural resources within the region. Additionally, families' removal requires

ethical, respectful and lawful processes.

Learnings from other case studies around the world suggest that to ensure resilience of the socioecological system of the Catimbau, local residents must be formally acknowledged as part of the system as established by Brazilian federal law 9.985/2000 (Allison and Hobbs, 2004; Carpenter and Gunderson, 2001; Folke et al., 2005; Schelhas and Pfeffer, 2009; Walker et al., 2002). Families could be fully involved in the development of any direct or indirect economic activity developed in the Park, such as recreation, ecotourism, education and research. Governmental and non-governmental organizations (profitable or not) must be deeply involved in any transition process requested for social development (e.g. education, health, justice) and income generation to improve local people social condition and reduce the dependence on natural resources. While the Catimbau management plan is developed, we also strongly recommend that Park managers uphold the law where material, social and cultural needs for the families living inside the area are guaranteed. Under this scenario, we expect to see that as families are empowered in developing the future of the region, conservation outcomes will improve. The IUCN hosts a platform at www.panorama.solutions, to share stories of success in PA to inspire future action and the understanding of the socioecological context, and the potential sources of conflicts are indispensable to achieve sustainability goals.

5. Conclusions

In synthesis, our findings call attention to the fact that cumulative failures in PAs inception and implementation have driven people towards a mutually reinforcing and declining situation in which negative socioeconomic outcomes are associated with nature degradation, not nature conservation (Oldekop et al., 2016; Rito et al., 2017). The inefficiency of the Brazilian government agency in implement successfully PAs (Oliveira and Bernard, 2017), maintaining paper parks poorly managed for many years (i.e. in Catimbau, eleven years longer than allowed by law) and imposing high social costs, can threatening biodiversity. This keeping apparent trade-off between nature conservation and human well-being may become a synergy only if socioecological science, law and public administration work together (Silva-Junior and Santos, 2017). Unfortunately, Brazil has been implementing a series of austerity measures which resulted in budget cuts for science (43%) and environment (44%) (Angelo, 2017). Without political will, a more positive scenario for conservation, including its social dimension, is unlikely to be achieved, and the social and environmental future of the region remains uncertain. Finally, our results suggest that the future of dry forests, characterized worldwide by the presence of low-income populations, will be largely dependent on conservation strategies that address poverty alleviation and human well-being.

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