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Local Trends in Rain and Temperatures and their Perceptions by Women from the Surroundings of the Sete Cidades National Park in Piauí, Northeast of Brazil

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RESUMO

As mudanças nos padrões de fatores climáticos como precipitação e temperatura tem afetado diretamente a vegetação quer seja, agrícola ou silvestre, favorecendo os riscos de desaparecimento de espécies. Analisar a percepção desses fatores poderá contribuir para a conservação da biodiversidade em todo o mundo. Assim, buscou-se comparar as tendências temporais em séries históricas para precipitação e temperatura com as percepções das mulheres que convivem com o Parque Nacional de Sete Cidades (PNSC), bem como registrar como elas percebem os efeitos das alterações climáticas sobre a vegetação arbórea/ arbustiva silvestre local. Realizaram-se 47 entrevistas, sendo 40 com moradoras de três comunidades do entorno e sete guias do PNSC, utilizando Formulários semiestruturados e Metodologia Participativa como linha do tempo e prancha de quantidade. Foram usados dados oficiais de precipitação diária e temperatura média mensal e as tendências lineares foram analisadas. Os resultados obtidos mostram que as percepções das mulheres apontam para um alinhamento com as informações oficiais, com resultados significativos em tendências climáticas locais. O registro de indivíduos mortos de *Caryocar coriaceum* foi apontado como consequência da diminuição dos índices pluviométricos nos últimos oito anos. Políticas públicas relacionadas às alterações climáticas devem ser elaboradas para manejo e conservação das espécies vulneráveis, valorizando a percepção feminina.

Palavras-Chave: climatologia, gênero, alterações climáticas, precipitação.

ABSTRACT

Changes in patterns of climatic factors, such as precipitation and temperature, have directly affected vegetation, whether agricultural or wild, favoring the risk of species disappearance. Analyzing the perception of these factors can contribute to the conservation of biodiversity worldwide. Thus, the main goal was to compare time trends in historical series for precipitation and temperature with the perceptions of women who live around of the Sete Cidades National Park (PNSC), as well as register how they perceive the effects of climate change on the local tree/bush vegetation. 47 interviews were conducted, 40 with residents of three surrounding communities and seven with PNSC guides, using semi-structured forms and participatory methodology as a timeline and quantity board. Official data for daily precipitation and average monthly temperature were used and linear trends were analyzed. Results obtained show that women's perceptions point to an alignment with official information, with significant results in local climate trends. Record of dead individuals of *Caryocar coriaceum* was pointed out as a consequence of rainfall decrease in the last eight years. Public policies related to climate change must be developed for the management and conservation of vulnerable species, valuing the female perception.

Keywords: climatology, gender, climate change, precipitation.

Introduction

Climate change represents one of the biggest concerns and one of the great challenges of nowadays. Studies show that this phenomenon has serious direct and indirect implications for abiotic factors (climate, water and soil) and all trophic levels of terrestrial biota (Pounds et al., 2007; Pecl et al., 2017), since changes in temperature and precipitation may also cause changes in water resources (Nóbrega, 2008).

According to the Intergovernmental Panel on Climate Change (IPCC, 2014), the temperature in the South American region has increased since the 1970s, which has generated serious impacts on the environment, with local and regional climate changes (Cook et al., 2012; Nobre et al., 2016). These changes can become the greatest threat to biodiversity, already demonstrated in many ecological systems (Garcia et al., 2012; Wiens, 2016), with the disappearance of species (Ochoa-Quintero et al., 2015; Barlow et al., 2016; Brown et al., 2016), such as birds (12%), mammals (25%) and amphibians (30%), that currently live under threat of extinction at different levels (International Union for Conservation of Nature - IUCN, 2013).

In Brazil, each region suffers specific effects of climate changes that have been occurring in the 21st century (Araújo et al., 2016). However, the Northeast presents itself as one of the Brazilian regions most vulnerable to current climate changes (Nunes, 2016), especially regarding rainfall variations, being identified as the main manifestation of climate variability in this region of the country (Marengo, 2009).

Extreme precipitation events bring socio-economic consequences that significantly affect agriculture (Campbell et al., 2016), water resources, health and housing (Alves and Povh, 2013), which can cause situations of malnutrition, due to droughts and abrupt floods (Assad et al., 2016). Besides that, periods of prolonged drought and overexploitation of aquifers can cause a reduction in the level of groundwater (IPCC, 2002, 2008; Maxwell et al., 2016; Koirala et al., 2017; Cuthbert et al., 2019), directly affecting the use of native plant species, which are highly significant in ensuring the economic structure of communities in Northeastern rural areas (Albuquerque, 2009; Albuquerque et al., 2010; Lucena et al., 2012).

These communities, which depend on natural resources and agricultural production for subsistence, are the ones that suffer most from the

adverse impacts of climate change (Mertz et al., 2009; Deressa et al., 2011; Dumenu and Obeng, 2016; Menike and Arachchi, 2016), which result in changes in temporality and durability of rain and drought periods, causing unpredictability, which affects or prevents the planning of activities in rural areas, severely compromising health and food security, intensifying poverty and severely affecting the populations of these areas.

According to (Köhler-Rollefson, 2018; Yadav and Lau, 2018; Hamidazada et al. (2019)), in a scenario of climate change, the inequality and injustice that exist in developing countries in relation to poor women are aggravated. However, they can also contribute due to their experience as maintainers of household supplies and their knowledge about the place and the community, in view of their traditional role in developing countries, like Brazil (Moraes and Rocha, 2013), making it necessary to observe female perception in these contexts.

A very characteristic example of the role of women as family maintainer, in periods of extreme climatic events, can be seen in the history of rural communities in the northeastern interior, especially in the semi-arid region, when men needed to leave their homes and coexistence with their families, migrating to large urban centers searching for financial resources to support their families. In these episodes, the woman was decisive in the management of the family, including assuming many male roles, such as activities in agriculture and livestock. We can consider these men as climatic refugees, and the current climatic conditions can bring these social and economic conditions back with great impact.

Studies have analyzed the temporal trends of precipitation (Moncunill, 2006; Santos and Brito, 2007; Assis, 2012; Silva Santos et al., 2014; Silva, et al., 2016; Silva, et al., 2018) in northeastern Brazil, and some have been conducted to analyze risks and opportunities of climate change in a gender perspective (Ferreira, 2009; Neves and Medeiros, 2013) across country.

In this sense, the present work sought to answer the following questions: What are the perceptions of women who live with the Sete Cidades National Park on climate changes that have occurred over time? What effects do these women perceive from climate change on the local tree / bush vegetation?

In short, the hypothesis was raised that women who live with the Sete Cidades National Park have an accurate perception of the climatic events that have occurred, as well as the effects and consequences that these events cause on vegetation, whether agricultural or wild. Thus, this research aimed to compare the time trends in historical series for daily precipitation and average monthly temperature with the climatic data perceived by two groups of women, one composed by the guides of the Sete Cidades National Park and another by the residents of its surroundings, as well as recording how they perceive the effects of climate change on local tree / bush vegetation.

Methodological Procedures

Study area

The study was conducted in the communities of Cachoeira (04°08'31,06"S 41°44'45,09"W), Vamos Vendo and Cigalha (04°04'35,81"S 41°40'36,38"W and 4°04'35,81"S 41°40'36,38"W, respectively), located around the Sete Cidades National Park (PNSC) - Piauí, as well as inside the conservation unit. This is located in the cities of Piracuruca and

Brasileira, Northeast Brazil (FIGURE 1). According to the Köppen classification, the climate is Aw (hot and sub-humid). It has an average annual temperature of 26.5 °C, with an average high of 28.1 °C in October and a minimum of 25.5 °C in June, with an average annual rainfall of 1,558 mm, more concentrated in the first months of the first half of the year (Oliveira, 2004). In the rainy season, mainly in the western portion of the area, streams are originated, creating large floodplains. It has several springs that constitute Piracuruca and Matos rivers, which present greater flows between January and August and throughout the rest of the year, it can dry totally or partially (Brazilian Institute for Forestry Development - IBDF, 1979), presenting water sources that feed streams of intermittent character (Santos and Pellerin, 2001). The PNSC phytophysiology is characterized by an ecotone area between Cerrado and Caatinga (Oliveira, et al., 2007). The conservation unit was created by Federal Decree No. 50744 on June 6, 1961 (Brasil, 1999), with an area of 6,221.48 ha, with an irregular hydric regime (Castro et al., 2002). This park allows development of educational activities, ecological tourism, recreation in contact with nature and scientific research.

Figure 1: Location of Sete Cidades National Park, Piauí/Brazil and Vamos Vendo and Cigalha Communities (Piracuruca) and Cachoeira (Brasileira). Source: IBGE (2010), modified by Javier Sparacino, in 2019.

The conservation unit was created by Federal Decree No. 50744 on July 8, 1961 (Brazil, 1999), with an area of 6,221.48 ha (Castro et al., 2002), whose main access roads are BR-222, Piripiri/Fortaleza part, and BR-343, Teresina/Parnaíba part (Mesquita and Castro, 2007).

Methods and techniques

Ethnobotanical data:

Data obtained through research were analyzed in a qualitative and quantitative way. The project was approved and supported by the Research Ethics Council (CEP) of the Federal University of Piauí (UFPI), with number 034867/2018, registered in the National System of Management of Genetic Heritage and Associated Traditional Knowledge (SISGEN) under No. AB6672E, and in the Biodiversity Authorization and Information System (SISBio) under No. 7154425e. Before each interview, permission was requested, as well as authorization for photographic registration, by signing the Free and Informed Consent Form (ICF).

Initial meetings were held with the communities using the *Rapport* method (Bernard, 1989), with a sample universe of 47 women, 40 of whom lived in the buffer zone and seven PNSC guides. For the analysis of issues related to vegetation, Group A was considered to be residents and Group B to PNSC guides. These numbers correspond to the percentage of 100% of the two groups. The age of the interviewed social actors ranged from 25 to 71 years.

A climatic history produced from the informants' memory was built, based on the Participatory Methodology with the timeline technique (Flick, 2009), which consisted of the construction of a vertical line drawn on a cardboard during the record of the years with great rainfall variation, with volumes of higher (flood) and lower (drought) rainfall intensities, according to the information pointed out by the participants during the workshop. In order to obtain information regarding plants threatened with disappearance and information related to the intensity of rainfall, the Quantity Board technique was used as a visual stimulus (FIGURE 2), which consists of a panel divided into quadrants, each presenting a different number of illustrations (trees and raindrops) that gradually represent very little, little, medium and a lot.

Figure 2: Quantity Board. Source: Elaborated by the author.

Images of dead individuals of the species mentioned in the interviews were obtained using Google Earth (October 2018) and local photographic records taken in the same period.

Analysis of precipitation and temperature patterns:

Daily precipitation and average monthly temperature data was obtained from the National Institute of Meteorology (INMET, 2019) for the weather station in the municipality of Piripiri-PI, whose location is the closest to the communities studied. Distant, approximately, 15 km from Sete Cidades National Park, the station presents complete data of daily precipitation since 1995, therefore, the historical analysis was made from this year, constituting a period of 23 years (1995-2018). Daily precipitation data were used to determine the beginning, end and duration of the rainy season for each year, using the methodology of Liebmann et al. (2007). Data were organized in climatological years, beginning in September (in the driest month) and ending in August of the following year. For each climatological year we calculate an amount called anomalous accumulation as follows:

$$A(j) = \sum_{i=1}^j (R(i) - \bar{R}) \quad (1),$$

where $R(i)$ is the daily rainfall on the day i , and $\bar{R}$ is the average annual daily rainfall. Day 1 is considered to be September 1st (at the beginning of the driest month) and the sum extends over one year. The beginning of the rainy season is the day after that on which $A(j)$ reaches the minimum value, and the end of the rainy season, the day on which it reaches the maximum value (Liebmann et al., 2007). Duration of the rainy season is calculated as the difference (in days) between the start and end dates. Linear trends in total precipitation by climatological year, start and end dates of the rainy season and its duration were analyzed using linear regressions.

Monthly average temperature data were used to analyze long-term linear trend in local temperatures. All results were considered significant at $P < 0.05$ and the analyses were performed using R software (version 3.4.2, R Core Team 2018).

Results and Discussion

Results obtained point to the fact that, in general, women have noticed climatic changes in the area surrounding the PNSC, both in relation to changes in the rainfall regime and in temperature (TABLE 1).

Different studies conducted around the world have pointed to the fact that studies on the perception of changes in climate, the possible impacts and possible adaptations have been shown to be essential in the decision-making processes of possible adaptive processes (Galdies et al, 2016; Menike and Arachchi, 2016; Niles and Mueller, 2016; Li et al., 2017; Carlos et al., 2019).

Regarding perceptions about changes in rainy seasons, the most frequent answer (85%) provided by the interviewees was “today it doesn’t rain anymore like the old days”. Regarding the amount (frequency) and intensity of the rains 70% of them affirm the rains are faster now and with less intensity. These perceptions were also observed by Dubreuil et al., (2017), when analyzing rainfall patterns and the perception of their changes by the populations of rural communities in the Amazon.

As for the perceived changes in the duration of the rainy season, they are associated with its temporality, since they currently perceive a late onset of the rainy season and an early completion. The beginning of the rainy season “happened” in December for 83% of the

interviewees, in contrast to what is perceived, currently, that it would be in January for 95% of them. This perception corresponds to the results of the analysis of the precipitations that show a significant linear tendency of delay for the beginning of the rainy season (13 ± 5 days/decade, $P = 0.0108$, FIGURE 3). Also, 67% of women said the end of the rainy season, in the past, happened in June, as opposed to 86% who currently perceive the rainy season ending in May. This early completion is also observed in the data from rainfall analysis, but the trend is not statistically significant ($P = 0.3728$, FIGURE 3). Additionally, the analysis of daily rainfall shows that the rainy season has a statistically significant decrease in its duration (-18 ± 6 days/decade, $P = 0.0065$, FIGURE 3), which corresponds properly with the perceptions of interviewed women.

For Marengo et al. (2017), the perception of farmers in northeastern Brazil about changes in historical rainfall patterns, has been evidenced by meteorological studies.

Changes in the rainy season’s temporality result in unpredictability that affects or impedes planning of rural activities. Different studies highlight that agricultural production in the northeast region of Brazil will be compromised and the other different problems that already affect the region will be accentuated (IPCC, 2014; Machado-Filho, 2015; Nunes, 2016), since the greatest inter-annual rainfall variability during the rainy season and the biggest temperature increase will occur in this region (Carlos et al., 2019).

Irregularity of precipitation can compromise water supply for the population (Silva et al., 2009), directly affecting vegetation, whether agricultural or wild. For Nobre (2011), these changes will have profound effects, affecting the whole world and these impacts will also be felt by human population.

When asked about the rainiest month, the majority (92%) considered that the month of March was always the one with the highest volume of rains, although 5% considered that, in the past, the month that rained the most was February, and only 2% stated that the rainiest month was April. In FIGURE 4, it can be seen that March is actually the month with the highest rainfall in the region and that seasonality is very marked, with a concentration of rainfall occurring during the months of January to May, these rainfall data confirm the perception of women interviewed in the present study. The result on the month of March with the highest rainfall was also found by Silva et

al. (2017) in an analysis of the temporal trend of rainfall in Araripina, in the semi-arid region of Pernambuco.

Table 1: Analysis of trends in temperature, rainfall and perceptions of these factors by the guides of Sete Cidades National Park and by residents of the surrounding communities.

TEMPERATURE		PRECIPITATIONS							
		Start		End		Duration		Total annual rainfall by climatological year	
Perception	Trend	Perception	Trend	Perception	Trend	Perception	Trend	Perception	Trend
Increase	$0.3 \pm 0.1 \text{ }^{\circ}\text{C}/\text{decade}^{**}$	December (Formerly) January (Currently)	$13 \pm 5 \text{ days/decade}^{*}$	June (Formerly) May (Currently)	NS	Less duration	$-18 \pm 6 \text{ days/decade}^{**}$	Less quantity	NS

NS: Not Significant; *: $P < 0.05$; **: $P < 0.01$

Figure 3: Start date (a) and end (b) of rainy season in the period from 1995 to 2018, and duration (in days) of rainy season for each year. Linear trends are also presented: (a) $13 \pm 5 \text{ days/decade}$, $P = 0.0108$; (b) $-5 \pm 5 \text{ days/decade}$, $P = 0.3728$; (c) $-18 \pm 6 \text{ days/decade}$, $P = 0.0065$.

Figure 4: Histogram of monthly rainfall considering the period from September 1995 to August 2018.

As for the climatic series produced based on perceptions of women in the timeline (1957-2018), the driest and most rainy years were recorded (Table 2).

Table 2: Rainier years and drier years indicated by the Sete Cidades National Park Guides and by residents of the surrounding communities.

Rainier years	Drier years
1964	1957
1965	1958
1967	1959
1968	1960
1974	1983
1975	1984
1985	1996
1986	1997
1995	2012
1996	2013
2008	2014
2009	2015
2010	2016
2011	

When asked about which situation generates more difficulties, they were blunt in stating that drought punishes the population more, considering that the consequences of this condition affect more prolonged survival due to scarcity in food production, animal breeding and access to water.

For Marengo et al. (2016, 2017), the drought that intensified between 2012 and 2015 affected millions of people in the semi-arid regions of the Northeast because it was considered the most severe in the last 100 years. The decrease in the

agricultural productivity related to the low pluviometric rates where indicated by Arvor et al. (2014) in amazonic communities and highlighted by different studies performed in Africa (Ncube et al., 2018; Belcore et al., 2019).

Based on the series of annual precipitation, organized by climatological year (FIGURE 5), a downward trend of -15 ± 11 mm/year is observed ($P = 0.1788$). This trend is not statistically significant due to the large amounts of rain in the years 2008/2009 and 2010/2011. The years 1995/1996 and 1998/1999 were also very rainy and all were also mentioned by the interviewees.

Although climatological years accumulate rain between September and August while the calendar years are organized from January to December, it is reasonable to compare the years mentioned by the interviewees with the second of those that identify climatological years, because rains are concentrated in the first part of the year.

The driest periods observed in the climatological series were those between 1996/1997, 1997/1998, 2004/2005 and the interval between 2011 and 2016. Among periods recorded by the series, only 2004/2005 was not mentioned by women. The years 1957, 1958, 1959, 1960, 1983, 1984 were cited by the older women as years of marked drought, but it is not possible to compare with the climatological series, as these years are outside the scope of this study. Out of these, the years 1958 and 1983 were cited by Marengo et al. (2016), in a climatological series of the northeastern region, as years of intense drought.

Figure 5: Annual rainfall organized in climatological years (September to August) from September 1995 to August 2018 and its linear trend (-15 ± 11 mm/year, $P = 0.1788$).

The year 1958 was mentioned by the older women as a year of marked drought and was also cited by farmers in Seridó/RN, in a survey conducted by Andrade et al. (2014). For Penereiro and Orlando (2013), the study of climate changes that occurred in the past favors the understanding of the variability inferred today and provides data that assist in the investigation of future climatic manifestations. However, to understand the atmospheric phenomenon that are related to the climatic variability and foresee them in order to try to mitigate their negative effects about the human way of survival constitutes in one of the great challenges (Xavier et al., 2014; Flato et al., 2017),

which become bigger when comparing physical quantities with data about perceptions (Morton 2007; Brondizio and Moran, 2008; Neethling et al. 2016).

When asked about changes in temperature, more than 80% said they perceive a significant change, in which the majority affirm the climate is warmer. This fact agrees with the series of average monthly temperature, in which a statistically significant linear trend of local temperature increase was observed (0.34 ± 0.12 °C/decade, $P = 0.0043$, FIGURE 6). For Litre et al. (2014), this perception is verified by most small producers in all Brazilian biomes.

Figure 6: Average monthly temperature from September 1995 to August 2018 and its linear trend (0.34 ± 0.12 °C/decade, $P = 0.0043$).

Perceptions about the influence of changes on vegetation:

When we relate influences of climate change on the local tree/wild bush vegetation, the two groups were asked about two equal questions: which species have been decreasing in the forests and which are the reasons that cause the decrease of these species. The first question was answered by the two groups, with four coincident species: pequi (*Caryocar coriaceum* Wittm.), bulandi (*Virola surinamensis* (Roi. Ex Rottb.) Warb.), aroeira (*Myracrodruon urundeuva* M. Allemão) and jatobá (*Hymenaea courbaril* L.), and a different species for each group. Residents also mentioned the imburana species (*Amburana cearensis* (Allemão) A.C.Sm.), and the guides cited pau-terra species (*Qualea parviflora* Mart.).

Out of the six species mentioned, aroeira (*M. urundeuva* M. Allemão) and imburana (*A. cearensis* (Allemão) ACSm.) are included in Annex I of the Official List of Endangered Brazilian Flora Species issued by the Ministry of the Environment, in September 2008, and bulandi

(*V. surinamensis*) was issued in Annex II. The latter was highlighted as one of the species with the highest importance value index by Matos and Felfili (2010) in a study on the gallery forests of the PNSC.

Regarding the second question, 15% of residents answered that they do not know the reasons and 85% answered that this fact is related to the death of individuals due to changes in the climate (lack of rain). However, 100% of the guides referred to the latter as the only answer. Information on the death of individuals of the species *C. coriaceum* (pequi) was confirmed, recorded (FIGURE 7) and georeferenced (FIGURE 8), both inside the Park (S 04°07'49.0'', W 041°42'39.5''), and in its buffer zone, at three different geographical points (NORTH ZN: S 04°03'00.1''/ W 041°42'44.3'', EAST ZN: S 04°08'43.6'' W 041°42'05.3'' and SOUTH ZN: S 04°09'48.5'' W 041°42'02.3''). This fact may be related to the lowering of the groundwater on which the PNSC and its buffer zone are based, due to the low rainfall registered in the state of Piauí for eight years from 2010 to 2017 (INMET, 2019).

**POINT 129 (SOUTH ZN): S 04°09'48.5''
W 041°42'02.3''**

**POINT 130 (EAST ZN): S 04°08'43.6''
W 041°42'05.3''**

**POINT 131 (INTERIOR): S 04°07'49.0''
W 041°42' 39.5''**

**PONTO 132 (NORTH ZN): S 04° 03'00,1''
W 041°42'44.3''**

Figure 7: Photographic record of dead individuals *C. coriaceum* (pequi) with georeferenced points of the location. Source: Authors (September 2018).

Fluctuations in groundwater throughout the year and also the impediment of water infiltration in the wetland Cerrado areas of the PNSC were recorded by Oliveira (2004). Naranjo

(1995) highlights this type of vegetation as water collecting basins, and Munhoz and Felfili (2008) argue that the drainage of wet fields can cause the loss of species or groups of species.

**POINT 129 (SOUTH ZN): S 04°09'48.5''
W 041°42'02.3''**

**POINT 130 (EAST ZN): S 04°08'43.6''
W 041°42'05.3''**

**POINT 131 (INTERIOR): S 04°07'49.0''
W 041°42' 39.5''**

**POINT 132 (NORTH ZN): S 04° 03'00,1''
W 041°42'44.3''**

Figure 8: Georeferenced points of the location of dead individuals *C. coriaceum* (pequi) in the vicinity of the Sete Cidades National Park-PI. Source: Authors (September 2018).

This biome is identified as one of the most threatened ecosystems on the planet since endemic species are more restricted in distribution, more specialized, and therefore more susceptible to extinction (Klink and Machado, 2005; Scariot, et al., 2005). Associated with this factor, there is the fact that the conservation unit is in a transitional position between Cerrado and Caatinga. This latter is pointed out by most climatic scenarios for a decrease of up to 70% in the water reserves existing in its subsoil by 2050 (IPCC, 2007).

Conclusion

Results obtained show that the analysis of the official data point to an alignment with the information perceived by investigated women. This alignment can be seen in several local climatic trends that were performed, such as the increase of the irregularity of the rains, the decrease of the duration of the rainy season and the increase of temperature. It was also verified the alignment between perceptions of the driest and the rainiest years, as well as perceptions about the effects of these factors on the wild tree/shrub vegetation, finding a considerable number of dead individuals of species *C. coriaceum*, both in and around the PNSC.

Scientific knowledge is essential to assess and predict the causes and consequences of climatic factors. However, studies like these confirm the importance of registering the perceptions of local populations, especially paying attention to the fact that women can contribute to the development of public conservation strategies

and policies based on the registration of their knowledge, favoring participation of these protagonists at the center of discussions on relevant topics.

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References

- AEA. Agência Europeia Do Ambiente, 2010. O Ambiente Na Europa - Situação E Perspectivas : Síntese. Agência Europeia Do Ambiente. Copenhagen.
- Albuquerque, U.P, 2009. How ethnobotany can aid biodiversity conservation: reflections on investigations in the semi-arid region of NE Brazil. *Biodiversity and Conservation* 18, 1, 127-150.
- Albuquerque, U.P., Lucena, R.F.P. Alencar, N.L, 2010. Métodos e técnicas para coleta de dados etnobiológicos. In: Albuquerque, U.P.; Lucena, R. F. P.; Cunha, L. V. F. C. (Eds.), Métodos e técnicas na pesquisa etnobiológica e etnoecológica. Núcleo Publicações em Ecologia, pp, 41-64.
- Alves, G.S.P., Povh, J.A., 2013. Estudo etnobotânico de plantas medicinais na

- comunidade de Santa Rita, Ituiutaba–MG. Biotemas 26, 231-242.
- Andrade, A.J.P., Silva, N.M., Souza, C.R., 2014. As percepções sobre as variações e mudanças climáticas e as estratégias de adaptação dos agricultores familiares do Seridó potiguar. *Desenvolvimento e Meio Ambiente* 31.
- Araújo, A.R., Belchior, G.P.N., Viegas, T.E.S., 2016. Os Impactos Das Mudanças No Nordeste Brasileiro. 1. Ed.
- Arvor, D., Dubreuil, V., Ronchail, J., Simões, M., Funatsu, B. M., 2014. Spatial patterns of rainfall regimes related to levels of double cropping agriculture systems in Mato Grosso, Brazil. *International Journal of Climatology*, 34, 2622-2633.
- Assad, E., Oliveira, A., Nakai, A., Pavão, E., Pellegrino, G., 2016. Impactos e vulnerabilidades da agricultura brasileira às mudanças climáticas. Modelagem climática e vulnerabilidades setoriais à mudança do clima no Brasil. Ministério da Ciência, Tecnologia e Inovação, Brasília, 127-188.
- Assis, J.M.O., 2012. Análise de tendências de mudanças climáticas no semiárido de Pernambuco. Dissertação (Mestrado). Recife. Centro de Filosofia e Ciências Humanas. Universidade Federal de Pernambuco.
- Barlow, J., Lennox, G.D., Ferreira, J., Berenguer, E., Lees, A.C., Mac Nally, R., Parry, L., 2016. Anthropogenic disturbance in tropical forests can double biodiversity loss from deforestation. *Nature* 535, 144-147.
- Belcore, E., Calvo, A., Pezzoli, A., 2019. Local migrations and climate change: the incapacity to adapt index. A case study in the West Arsi Woreda (Ethiopia). *JUNCO Journal of UNiversities and international development COoperation* 1, 1.
- Bernard, R.H., 1989. *Research Methods In Cultural Anthropology*. Sage Publications, Londres.
- Brasil. 1999. *Ações Prioritárias Para A Conservação Da Biodiversidade Do Cerrado E Pantanal*. Brasília: Mma/Funatura/Ci/Fundação Biodiversitas/Unb. Disponível Em: [Http://www.Conservation.Org.Br](http://www.Conservation.Org.Br). Acesso Em: 4 Nov. 2019.
- Brondizio, E.S., Moran, E.F., 2008. Human dimensions of climate change: the vulnerability of small farmers in the Amazon. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 363, 1803-1809.
- Brown, C.J., O'Connor, M.I., Poloczanska, E.S., Schoeman, D.S., Buckley, L.B., Burrows, M.T., Richardson, A.J., 2016. Ecological and methodological drivers of species' distribution and phenology responses to climate change. *Global change biology* 22, 1548-1560.
- Campbell, B.M., Vermeulen, S.J., Aggarwal, P.K., Corner-Dolloff, C., Girvetz, E., Loboguerrero, A.M., Wollenberg, E., 2016. Reducing risks to food security from climate change. *Global Food Security* 11, 34-43.
- Carlos, S.D.M., Cunha, D.A.D., Pires, M.V., 2019. Conhecimento sobre mudanças climáticas implica em adaptação? Análise de agricultores do Nordeste brasileiro. *Revista de Economia e Sociologia Rural* 57, 455-471.
- Castro, N.M.C.F., Pôrto, K.C., Yano, O., Castro, A.A.J.F., 2002. Levantamento Florístico De Bryopsida De Cerrado E Mata Ripícola Do Parque Nacional De Sete Cidades, Piauí, Brasil. *Acta Botânica Brasílica, Alta Floresta* 16, 61-76.
- Cook, B., Zeng, N., Yoon, J.H., 2012. Will Amazonia dry out? Magnitude and causes of change from IPCC climate model projections. *Earth Interact* 16. doi:10.1175/2011EI398.1
- Cuthbert, M.O., Gleeson, T., Moosdorf, N., Befus, K.M., Schneider, A., Hartmann, J., Lehner, B., 2019. Global patterns and dynamics of climate–groundwater interactions. *Nature Climate Change* 9, 137-141.
- Deressa, T.T., Hassan, R.M., Ringler, C., 2011. Perception Of And Adaptation To Climate Change By Farmers In The Nile Basin Of Ethiopia. *Journal Of Agricultural Science* 149, 23-31.
- Dubreuil, V., Funatsu, B.M., Michot, V., Nasuti, S., Debortoli, N., de Mello-Thery, N.A., Le Tourneau, F.M., 2017. Local rainfall trends and their perceptions by Amazonian communities. *Climatic Change* 143, 461-472.
- Dumenu, W.K., Obeng, E.A., 2016. Climate change and rural communities in Ghana: Social vulnerability, impacts, adaptations and policy implications. *Environmental Science & Policy* 55, 208-217.
- Ferreira, A.P.L., 2009. A Importância da Perspectiva Agroecológica no Empoderamento das Mulheres Camponesas: Processo Mulheres e Agroecologia como Estudo de Caso. *Revista Brasileira de Agroecologia* 4, 2114-2117.
- Flato, M., Muttarak, R., Pelsler, A., 2017. Women, weather, and woes: The triangular dynamics of female-headed households, economic vulnerability, and climate variability in South Africa. *World Development*, 90, 41-62.
- Flick, U., 2009. *Qualidade na pesquisa qualitativa: coleção pesquisa qualitativa*. Bookman Editora, São Paulo.
- Galdies, C., Said, A., Camilleri, L., Caruana, M., 2016. Climate change trends In Malta and

- related beliefs, concerns and attitudes toward adaptation among Gozitan farmers. *European Journal of Agronomy* 74, 18-28.
- Garcia, R.A., Burgess, N.D., Cabeza, M., Rahbek, C., Araújo, M.B., 2012. Exploring Consensus In 21st Century Projections Of Climatically Suitable Areas For African Vertebrates. *Global Change Biology* 18, 1253-1269.
- Hamidazada, M., Cruz, A. M., Yokomatsu, M., 2019. Vulnerability Factors of Afghan Rural Women to Disasters. *International Journal of Disaster Risk Science* 10, 573-590.
- INMET. National Institute of Meteorology, 2019. Disponível Em: [Http://Www.Inmet.Gov.Br/Portal/Index.Php?R=Bdmep/Bdmep](http://www.inmet.gov.br/portal/index.php?R=Bdmep/Bdmep). Acesso Em: 24 Jun. 2019.
- IPCC. Climate Change And Biodiversity - Technical Paper Of Intergovernmental Panel On Climate Change. Ipcc Secretariat, Geneva, 2002.
- IPCC, 2007, Climate Change 2007. The Physical Science Basis: contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.
- IPCC. Climate Change And Water, 2008. Technical Paper Of The Intergovernmental Panel On Climate Change. Ipcc Secretariat, Geneva.
- IPCC. Intergovernmental Panel on Climate Change, 2014. Part a: global and sectoral aspects. In C. B. Field, V. R. Barros (Eds.), *Climate change 2014: impacts, adaptation, and vulnerability*. Cambridge: Cambridge University Press.
- IUCN. International Union for Conservation of Nature. 2013. IUCN red list of threatened species. Version 2013.2.
- Klink, C.A., Machado, R.B.A., 2005. Conservação do Cerrado brasileiro. *Megadiversidade* 1, 1, 148-155.
- Koirala, S., Jung, M., Reichstein, M., de Graaf, I. E., Camps-Valls, G., Ichii, K., Carvalhais, N., 2017. Global distribution of groundwater-vegetation spatial covariation. *Geophysical Research Letters* 44, 4134-4142.
- Köhler-Rollefson, I., 2018. Purdah, purse and patriarchy: The position of women in the Raika shepherd community in Rajasthan India. *Journal of Arid Environments* 149, 30-39.
- Lucena, R.F.P., Medeiros, P.M., Araújo, E.L., Alves, A.G.C., Albuquerque, U.P., 2012. The Ecological Apparency Hypothesis And The Importance Of Useful Plants In Rural Communities From Northeastern Brazil: An Assessment Based On Use Value. *Journal Of Environmental Management*, 9, 106-115.
- Liebmann, B., Camargo, S.J., Seth, A., Marengo, J. A., Carvalho, L.M.V., Allured, D., Fu, R., Vera, C.S., 2007. Onset and end of the rainy season in South America in observations and the ECHAM 4.5 atmospheric general circulation model. *Journal of Climate* 20, 2037-2050.
- Li, S., Juhász-Horváth, L., Harrison, P.A., Pintér, L., Rounsevell, M.D.A., 2017. Relating farmer's perceptions of climate change risk to adaptation behavior in Hungary. *Journal of Environmental Management* 185, 21-30.
- Litre, G., Nasuti, S., Garcez, C.G., Lindoso, D., Eiró, F., Simoni, J., Silva, C., Canha, C.F., 2014. From rainforests to drylands: comparing Family farmers perceptions of climate change in three Brazilian biomes. In: Filho, W.L., Alves, F., Caeiro, S., Azeiteiro, U. (eds) *International perspectives on Climate Change. Latin America and Beyond*. Springer International Publishing, Berlin, pp 165-185.
- Machado-Filho, H.O., 2015. Climate change and its impacts on family farming in the north/northeast regions of Brazil. Brasília: International Policy Centre for Inclusive Growth, United Nations Development Programme.
- Marengo, J.A., 2009. Vulnerability, Impacts And Adaptation (Via) To Climate Change In The Semi-Arid Region Of Brazil. In: *Brazil And Climate Change: Vulnerability, Impacts And Adaptation*. Brasília: Cgee, 225-248.
- Marengo, J.A., Aragão, L.E., Cox, P.M., Betts, R., Costa, D., Kaye, N., Reis, V., 2016. Impacts Of Climate Extremes In Brazil: The Development Of A Web Platform For Understanding Long-Term Sustainability Of Ecosystems And Human Health In Amazonia (Pulse-brazil). *Bulletin Of The American Meteorological Society* 97, Boston, pp. 1341-1346.
- Marengo, J.A., Alves, L.M., Alvala, R.C.S., Cunha, A.P., Brito, S., Moraes, O.L.L., 2017. Climatic characteristics of the 2010-2016 drought in the semiarid Northeast Brazil region. *Anais da Academia Brasileira de Ciências* 90, 1973-1985.
- Matos, M.Q., Felfili, J.M., 2010. Florística, Fitossociologia E Diversidade Da Vegetação Arbórea Nas Matas De Galeria Do Parque Nacional De Sete Cidades (Pnsc), Piauí, Brasil. *Acta Botânica Brasílica* 24, 483-496.
- Maxwell, R.M., Condon, L.E., 2016. Connections between groundwater flow and transpiration partitioning. *Science* 353, 377-380.
- Menike, L.M.C.S., Arachchi, K.A.G.P.K., 2016. Adaptation to climate change by smallholder

- farmers in rural communities: Evidence from Sri Lanka. *Procedia food science* 6, 288-292.
- Mertz, O., Mbow, C., Reenberg, A., Diouf, A. 2009. Farmers' perceptions of climate change and agricultural adaptation strategies in rural Sahel. *Environmental management* 43, 804-816.
- Mesquita, M.R., Castro, A.A.J.F., 2007. Florística E Fitossociologia De Uma Área De Cerrado Marginal (Cerrado Baixo), Parque Nacional De Sete Cidades, Piauí. *Publicação Avulsa. Conservação Ecosistemas* 15, 1-22.
- Moncunill, D.F., 2006. The Rainfall Trend Over Ceara And Its Implications. In: 8ª Conferência Internacional De Meteorologia E Oceanografia Do Hemisfério Sul, Foz Do Iguaçu, pp. 315-323.
- Moraes, A.F.J.; Rocha, C., 2013. "Gendered Waters: The Participation Of Women In The 'One Million Cisterns' Rainwater Harvesting Program In The Brazilian Semi-Arid Region". *Journal Of Cleaner Production* 60, 163-169.
- Morton, J.F. 2007., The impact of climate change on smallholder and subsistence agriculture. *Proceedings of the national academy of sciences* 104, 19680-19685.
- Munhoz, C.B.R.; Felfili, J.M., 2008. Florística Do Estrato Herbáceo Subarbustivo De Um Campo Limpo Úmido Em Brasília, Brasil. *Biota Neotropica* 7, 205-215.
- Naranjo, L.G., 1995. An Evaluation Of The First Inventory Of South American Wetlands. *Vegetatio* 118, 125-129.
- Ncube, A., Mangwaya, P.T., Ogundeji, A.A., 2018. Assessing vulnerability and coping capacities of rural women to drought: A case study of Zvishavane district, Zimbabwe. *International Journal of Disaster Risk Reduction* 28, 69-79.
- Neethling, E., Petitjean, T., Quénol, H., Barbeau G., 2016. Assessing local climate vulnerability and winegrowers' adaptive processes in the context of climate change. *Mitig Adapt Strateg Glob Change* 22, 777-803. doi:10.1007/s11027-015-9698-0.
- Neves, D.P., Medeiros, L., 2013. (Org.). *Mulheres Camponesas: Trabalho Produtivo E Engajamentos Políticos*. Niterói: Alternativa, 2013.
- Niles, M.T., Mueller, N.D., 2016. Farmer perceptions of climate change: Associations with observed temperature and precipitation trends, irrigation, and climate beliefs. *Global Environmental Change* 39, 133-142.
- Nobre, C.A., Sampaio, G., Borma, L.S., Castilla-Rubio, J.C., Silva, J.S., Cardoso, M., 2016. Land-use and climate change risks in the amazon and the need of a novel sustainable development paradigm. *PNAS* 113, 10759-10768.
- Nobre, P., 2011. Mudanças Climáticas e desertificação: os desafios para o Estado Brasileiro. In: *Desertificação e Mudanças Climáticas no Semiárido Brasileiro*. Editores: R. C. C. Lima, A. M. B. Cavalcante e A. M. P. Marin, Instituto Nacional do Semiárido - INSA, pp. 25-35, ISBN: 978-85-64265-02-8.
- Nóbrega, R.N., 2008. Modelagem De Impactos Do Desmatamento Nos Recursos Hídricos Da Bacia Hidrográfica Do Rio Jamari (Ro) Utilizando Dados De Superfície E Do Trmm. Tese (Doutorado). Campina Grande. Unidade Acadêmica De Ciências Atmosféricas, Universidade Federal De Campina Grande-Pb, 2008.
- Nunes, C.R.P., 2016. As Mudanças Climáticas A Partir Da Implantação De Empresas De Capital Estrangeiro No Nordeste: Estado Regulador? In: Araújo, A.R., Belchior, G. P.N., Viegas, T. E. S. Os Impactos Das Mudanças Climáticas No Nordeste Brasileiro. Fundação Sintaf, Fortaleza, Instituto O Direito Por Um Planeta Verde, São Paulo, pp. 17-34.
- Ochoa-Quintero, J.M.; Gardner, T.A.; Rosa, I.; De Barros Ferraz, S.F.; Sutherland, W.J., 2015. Thresholds Of Species Loss In Amazonian Deforestation Frontier Landscapes. *Conservation Biology* 29, 440-451.
- Oliveira, M.E.A., 2004. Mapeamento, Florística E Estrutura Da Transição Campo-Floresta Na Vegetação (Cerrado) Do Parque Nacional De Sete Cidades, Nordeste Do Brasil. Tese (Doutorado). Campinas. Universidade Estadual De Campinas,
- Oliveira, M.E.A., Martins, F.R., Castro, A.A.J.F., Santos, J.R.S., 2007. Classes De Cobertura Vegetal Do Parque Nacional De Sete Cidades (Transição Campo-Floresta) Utilizando Imagens Tm/Landsat, Ne Do Brasil. In: Xiii Simpósio De Sensoriamento Remoto, Anais... Florianópolis: Inpe, 2007.
- Penereiro, J.C., Orlando, D.V., 2013. Análises De Tendências Em Séries Temporais Anuais De Dados Climáticos E Hidrológicos Na Bacia Do Rio Parnaíba Entre Os Estados Do Maranhão E Piauí/Brasil. *Revista Geográfica Acadêmica* 7, 5-21.
- Pecl, G.T., Araújo, M.B., Bell, J.D., Blanchard, J., Bonebrake, T.C., Chen, I.C., Falconi, L., 2017. Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being. *Science* 355, eaai9214.
- Pounds, A., Carnaval, A.C.O.Q., Corn, S., 2007. Climate Change, Biodiversity Loss, And Amphibian Declines. In: Gascon, C., Collins,

- J.P., Moore, R.D., Church, D. R., Mckay, J.E., Mendelson, J.R. Amphibian Conservation Action Plan. Cambridge: Glands.
- Santos, C.A., Brito, J.I.B., 2007. Análise Dos Índices De Extremos Para O Semi-Árido Do Brasil E Suas Relações Com Tsm E Ivdn. Revista Brasileira De Meteorologia 22, 303-312.
- Santos, J., Pellerin, J., 2001. Mapeamento Geomorfológico Do Parque Nacional Sete Cidades, Piracuruca, Piauí. In: II Congresso Sobre Planejamento E Gestão Das Zonas Costeiras Dos Países De Expressão Portuguesa, IX Congresso Da Associação Brasileira De Estudos Do Quaternário, II Congresso Do Quaternário Dos Países De Língua Ibéricas. Recife, 2001.
- Scariot, A., Souza-Silva, J.C., Felfili, J.M., 2005. Cerrado: Ecologia, Biodiversidade E Conservação. Brasília: Ministério Do Meio Ambiente.
- Silva Santos, S.M., De Assis, J.M.O., Souza, W.M., 2014. Tendências De Mudanças Climáticas Na Bacia Do Rio Una, Pernambuco—Brasil. Revista Brasileira De Geografia Física 7, 243-257.
- Silva, E.R.A.C., Galvêncio, J.D.; Nascimento, K. R.P., Santana, S.H.C., Souza, W.M.; Costa, V.S.O., 2018. Análise Da Tendência Temporal Da Precipitação Pluviométrica Interanual E Intra-Anual No Semiárido Pernambucano. Revista Brasileira De Climatologia 22, 76-98.
- Silva, F.B., Santos, J.R.N., Feitosa, F.E.C.S., Silva, I.D.C., Araújo, M.L.S.D., Guterres, C. E., Neres, R.L., 2016. Evidências de mudanças climáticas na região de transição Amazônia-Cerrado no estado do Maranhão. Revista Brasileira de Meteorologia 31, 330-336.
- Silva, M.D., Dreveck, S., Zeni, A.L.B., 2009. Estudo Etnobotânico De Plantas Medicinais Utilizadas Pela População Rural No Entorno Do Parque Nacional Da Serra Do Itajaí – Indaial. Revista Saúde E Ambiente 10, 54-64.
- Silva, R.O.B., Montenegro, S.M.G.L., Souza, W. M., 2017. Tendências De Mudanças Climáticas Na Precipitação Pluviométrica Nas Bacias Hidrográficas Do Estado De Pernambuco. Engenharia Sanitária E Ambiental 22, 579-589.
- Xavier, D.R., Barcellos, C., Freitas, C.M.D. 2014., Eventos climáticos extremos e consequências sobre a saúde: o desastre de 2008 em Santa Catarina segundo diferentes fontes de informação. Ambiente & Sociedade 17, 273-294.
- Yadav, S.S., Lal, R., 2018. Vulnerability of women to climate change in arid and semi-arid regions: The case of India and South Asia. Journal of Arid Environments 149, 4-17.
- Wiens, J.J., 2016. Climate-related local extinctions are already widespread among plant and animal species. PLoS biology 14, 12.