

Temporal Analysis of the Caatinga Landscape in the Hinterland of Bahia: Community Perception of Family Farmers

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Abstract: *This paper aims to attest the reduction of vegetation cover in the Caatinga because of the expansion process of agriculture. In this study, the method of mapping the areas was used. The perception of family farmers in the communities of Rompedor and Jatobá, both located in the Municipality of Curaçá-BA, was analyzed. The methodology relied on the use of satellite images, aiming to verify the transformations in the landscape during the period 1988/2018. In gathering information on the perception of family farmers, the tool used was semi-structured interviews using the Snowball technique with 32 family farmers. The results point to agricultural expansion and, consequently, retraction in areas of native vegetation. In 1988, agriculture corresponded to 0.7 % of the total area, rising to 6 % in 2018. The vegetation coverage of the two communities shows a high stage of deforestation caused by anthropic factors that have been altering the landscape. The result of the farmers' perceptions shows information that supports the data obtained by satellite images. Family farmers consider that the natural landscape of the communities has been modified over decades, due to the way the Caatinga is used and occupied.*

Keywords: Semi-arid; Agriculture; Landscape

1. Introduction

The Caatinga biome presents excellent biological diversity, with heterogeneity in its physiognomic structure; however, the natural plant landscape has suffered substantial impacts in terms of the excessive use of its resources to meet the communities' socio-economic demands. This has reduced not only its ecological characteristics but also the area of occupation/coverage [4], [15]. One of the activities responsible for this reduction is the expansion of agriculture that causes fragmentation processes in the landscape.

This loss of vegetation cover together with the advance of agriculture may accelerate the alteration of the natural vegetation of ecosystems and the failure of biodiversity [39]. Consequently, integrated studies from environmental perception and mapping of land use and land cover through agricultural activities -identifying anthropized and conserved areas --- becomes an essential tool for providing the necessary information for the recognition of landscape dynamics. Suffice to say that it also shows how the spaces are organized and how the elements are inserted, besides analyzing the current environmental impacts and the intensities already occurred [38].

The intensity and potential of land use are diverse and meet human needs, depending on each region's environmental factors. In the Northeast of Brazil, for example, 46% of native vegetation areas have been altered by extensive cattle raising, agriculture, industry, and daily uses from the consumption of firewood [28]. These factors have led to various environmental problems, such as the reduction of

vegetation and the consequent desertification of extensive areas.

Repeated actions of illegal deforestation to meet various purposes of survival have caused disturbances in the environment, bringing direct consequences on ecosystem services and the economic and welfare system of the human population, as a small and disordered occupation of soil for agricultural cultivation. This causes environmental impact, loss of biodiversity, and climate change directly influencing the ecological process [32], [34]. As a result, inadequate land use, whether for agriculture or other activities, has helped landscape fragmentation, habitat loss, and environmental degradation [25].

To better understand this process, Brazilian researchers have been using area mapping tools to follow the areas that suffer the most considerable anthropic pressure and its consequences on ecosystem conservation. The study in the Caatinga biome shows that the mapping technique is increasingly necessary, due to the potentiality of non-sustainable use and intense actions caused by human activity. It is essential to highlight that the Caatinga has been explored for several years and is considered the Brazilian biome most threatened by the intensive and inadequate use of its natural resources [1].

Although these activities are carried out by farming communities living around these fragments, we see it as necessary to map the loss of vegetation and the consequent advance of agriculture and understand how farmers learn about this process in the local environment.

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The transformations now taking place in the rural landscape involve economic and socio-cultural factors. To better understand these changes, it is also essential to know the perception of family farmers inserted in this context and their needs for natural resources to maintain their survival [40], [31].

In this sense, the main object of the study is to observe, through temporal analysis of Landsat images, the advance of agriculture in rural communities and also to know the perception of family farmers in this process of landscape change, given the need to understand land occupation and use, as well as its environmental and social impacts in these areas and to assist in disseminating information necessary for Caatinga conservation.

2. Material and Methods

2.1 Characterization of the study area and farming community

The Municipality of Curaçais located in the Northeast of Brazil, 546 km from the city of Salvador, the Capital city of the state of Bahia. It has a territorial area of 5, 935.944 km² and is inserted in the lower middle São Francisco, between coordinates 08°59'31"S and 39°54'28"W. The population is estimated at 34, 700 inhabitants [20]. According to Koeppen, the climate is classified as BSw predominant Semi-arid, with an average annual temperature of 27°C, and an average rainfall of 400 to 650 mm/year concentrated in the first three months of the year.

The area is located in the hinterland depression with characteristics of a wavy plane with open valleys. The soil varies between luvisol, planosol, and acrisol [11]. The vegetation is shrubby Caatinga, with plant species adapted to high rates of evaporation and evapotranspiration in the Municipality. They are xerophyte, woody, and deciduous, with the presence of succulent and thorny plants [11], [16], [15].

This research was carried out in the rural communities of Rompedor and Jatobá (Figure 01), 12 km from the Municipality headquarters, and about one kilometer from each other, formed by Quilombo remnants, both had their occupation process on the right bank of the São Francisco River. The estimated population of the two communities is 239 inhabitants, being 163 (48 families) from Jatobá, and 76 (24 families) from Rompedor [35].

One of the region's outstanding sectors' economy is the primary one; this one focused on agriculture and goat and sheep raising. The production developed by family farmers in the communities researched refers to the cultivation of beans, cassava, corn, and vegetables. The production is directed to their daily consumption, and supplies the local market.

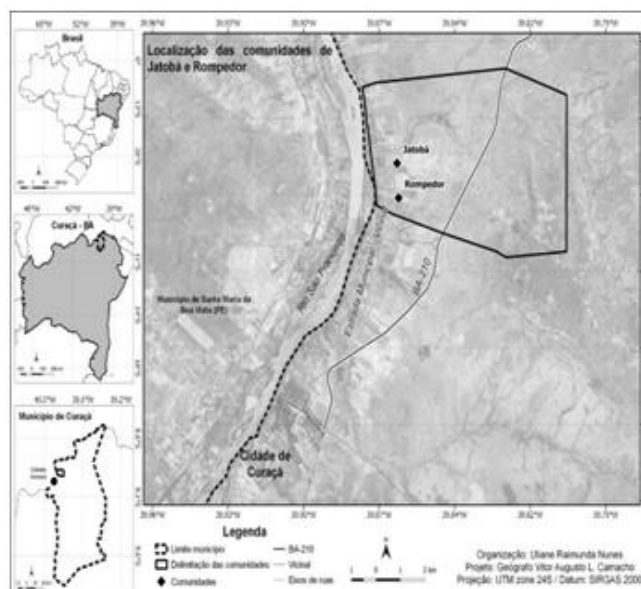


Figure 1: Location map of the Communities of Rompedor and Jatobá, both located in the Municipality of Curaçá, State of Bahia, Northeast Brazil

2.2 Mapping the Caatinga vegetation: Landscape Status

It was used Quantum GIS (QGIS) version 3.8 to map the reduction of Caatinga vegetation by agricultural activities in the region. The images come from two satellites: Landsat 5, for 1988, 1998 and 2008; and Landsat 8, for 2018, using bands 1, 2 and 3, and bands 2, 3 and 4, respectively, to build the color image, enabling the identification of different uses and land occupation. These are images obtained through the North American Earth Observation Satellite Program [8].

They are available free of charge upon prior registration at the United States Geological Survey website. In the development of the landscape status study, four maps were constructed on a time scale based on the communities' descriptive memorial data, according to the period that permanent agriculture is beginning to develop.

The period from 1998 to 2018 was selected to analyze the landscape changes that occurred to verify the expansion of agriculture in the communities under study. Over these three decades, and agriculture had a more considerable increase in the localities [10], [14]. Furthermore, this period was marked by the standardization of modern agriculture using machinery [27], reallocation of family farmers causing a change in the perspectives of farming [9] and conflicts between these agents, indigenous and landowners [12].

2.3 Family Farmers' Perception of Changes in Caatinga Vegetation Coverage

This study is an exploratory field study, with the application of semi-structured interviews conducted individually in the period from January to March 2019. It was submitted and approved by the Research Ethics Committee of the University of the State of Bahia – UNEB, Reg. No. 3.102.294, CAAE: 01949118.6.0000.0057.

Farmers from the communities developing only family

farming activities have participated in the research, totaling (N=32), 10 of which belong to Rompedor and 22 to Jatobá. The technique used to select the interviewees was Snowball, in which each farmer indicates the next to be interviewed [2].

Originally, a meeting was held at the Farmers' Association in Jatobá Community, representing the two communities to present the research and detail its stages. Sequentially, farmers were invited to sign the Term of Free and Informed Consent (TCLE), and all 32 farmers agreed to participate in the research according to rules formally convened.

2.4 Analysis of data

The imaging method is the classification of land use and manual coverage by interpreting the color images and spectral response Landsat 05 and 08. The colors based on and adapted from the technical manual of geoscience (land use) [19].

PDI - Digital Image Processing processes were performed. First, the scene selection, area cropping, and L1-C correction (Reflectance Correction at the Top of the Atmosphere), the construction of RGB images (red, green, blue) in color for manual or supervised land use identification and classification [19].

The results obtained in the classification were adjusted by visual interpretation based on photointerpretation and geographical position elements. This interpretation was essential to achieve the following classes: semi-open Caatinga, open Caatinga, pastures, farming, exposed soil, and water bodies [19]. The types of use and occupation values were presented in a table based on the following calculations performed in the R Software: total value of the area, reduction and increase, and the percentages of the current value of the classes obtained through the respective years.

Based on the results achieved on the environmental perceptions of family farmers, quantitative and qualitative analyses of the data were performed according to the number of citations and the results calculated through simple analysis (percentages). This was done to know what family farmers know about changes in caatinga vegetation cover. The differences in the responses from the Communities Rompedor and Jatobá were tested using the Chi-square (X^2) of independence.

3. Results and Discussion

Through the overlapping of vegetation maps and cultivated areas, it was possible to verify in Table 01, related to the total study area in square kilometers, that agriculture in 1988 presented 0.7% and in 2018 increased to 6%. This increase is considered extremely relevant due to the rise in the occupied areas in 30 years of analysis. Compared to the national scenario data, Brazil holds 7.6% of its territory with crops, totaling 63, 994, 479 hectares of cultivated areas [28].

The Caatinga biome occupies approximately 10% of the national territory. Considering the substitution of native

plant species by pasture and agriculture in the first area occupied by this biome, one can see the change promoted by man. According to the Space Research Institute's monitoring, 45% of the Caatinga is degraded, 7.2% has exposed soil, and crops have replaced 6.5%. Bahia is among the Northeast leading states, with 51.43% of the caatinga vegetation suppressed [21].

Table 01 shows that in 2018 the area of caatinga vegetation had a physiognomy and structure varying between semi-open and open corresponding to 40% of the total area studied, while 52% occupied pasture and 6% agriculture. In thirty years, the communities lost 11, 221 hectares of native vegetation from Caatinga, data compatible with other studies in the Semiarid region that show an increase in anthropic actions in the Caatinga biome [10], [7], [14], [23].

Table 1: Class of vegetation and land use in the Communities of Rompedor and Jatobá-Bahia, between 1988/2018

Vegetation classes	Area of occupation (ha) (%)				Variation (ha) and land-usage	
	1988	1998	2008	2018	2018	
Semi-open caatinga	6, 142	5, 083	5, 546	4, 877	-1, 265	14.57
Open caatinga	18, 532	14, 680	14, 480	8, 577	-9, 956	25.62
Pasture	8, 262	12, 446	11, 986	17, 423	+9, 161	52.04
Farming	0.235	0.708	1, 019	2, 024	+2, 023	6.05
Exposed soil	0.049	0.185	0.019	0.336	+0.287	1.01
Water body	0.014	0.012	0.006	0.006	-0.008	0.02
Total	33.234	33.11	33.058	33.246	-	99.30

One of the most significant environmental impacts caused by agriculture is the fragmentation of areas, resulting in the separation of natural landscapes, implying habitat loss, modifying ecological processes and reducing species diversity in local communities [26], [6], [22]. The fragmentation process negatively affects the diversity of plants and animals native to the biomes and on soil erosion that consequently generates problems for populations that need this resource for their survival [29], [18]. Thus, environmental perception is essential in the development of agricultural practices since this vision, regarding what is intended to be produced is closely related to the use of natural resources [31].

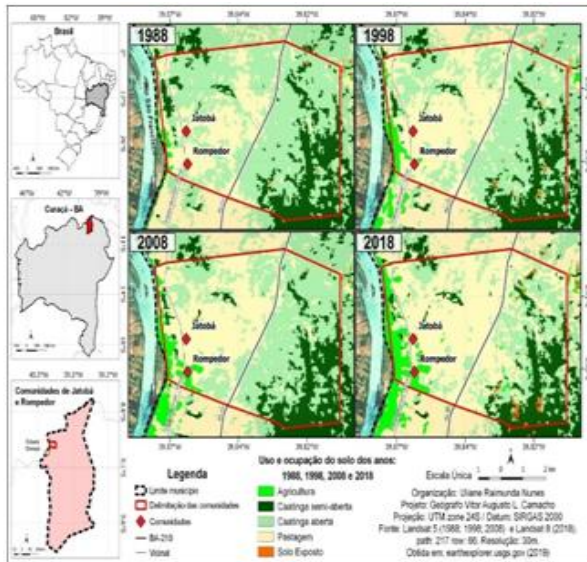


Figure 2: Overlapping vegetation and cultivated areas mapping (interpretation from Landsat TM55, Landsat TM-8; in the Communities of Rompedor and Jatobá, located in the Municipality of Curaçá, State of Bahia, Northeast Brazil.

The percentages of Caatinga's native vegetation between semi-open and open from the years 1988/1998 and 2008/2018 were in the right order (74%; 59%; 60%; 40%) and agriculture corresponded to an advance of (0.7%; 2%; 3%; 6%) each decade. From 1998 to 2008, the Caatinga vegetation managed to re-establish 1%, due to the reduction in pasture areas, although agriculture continued to advance in those periods.

The results obtained through elaborating the images at intervals of time every ten years make visible the expansion of agriculture in the communities. In 1988, this corresponded to 0.7% of the total area, a period when monoculture production started the first mango plantations and the already existing crops of family farmers. However, monoculture production advanced in the last decades, noting that in 2018 agriculture corresponded to 6% of the area on the São Francisco River banks.

Mango plantations (*Mangifera indica*, L) have been developed in the studied area. Their production is directed to the internal and external market, monopolizing the natural landscape, and fragmented the ecosystem. The information available from this production shows that, between 2008 and 2018, 10, 580 tons and 12, 600 tons were produced, while the occupied areas almost doubled in size, from 460 hectares to 800 hectares [20]. Thus, the advance of agriculture in the hinterland of Bahia has caused transformations in the landscape, and in the communities studied, this advance is only possible with the irrigation of the São Francisco River or other water bodies, due to the climatic condition of the region that presents high temperatures [18].

In the communities studied, the economic base of the population is related to subsistence agricultural production. According to [30], the land is a fundamental natural resource in social benefits, not only in terms of economic development, even though the current demand for land use has increased and caused environmental damage.

It is known, however, that the advance of agriculture in the

communities hereinabove mentioned is not related to local development, but only to the production directed in the molds of agribusiness, a model anchored in the latifundium and monoculture, having as its primary objective the accumulation of capital from the extraction of income from the land, through the exploitation of natural resources and labor force [37].

3.1 Family Farmers' Perception of Changes in Caatinga Vegetation Coverage

Regarding the socio-economic profile of the farmers participating in the research, it was observed that, concerning sexual gender, 100% of the interviewees from the Community of Rompedor are men aged between 25/84 years. In the community of Jatobá, this figure was 72.7% aged 24/74, while 27.2% are women aged 23/57. The income in both communities started from a minimum wage to 93.7%. About the time of residence, 75% of the interviewees identified themselves as a native of the region, while the other 25% migrated from different localities.

The level of education was found that 60% did not finish primary school, while 15% concluded the intermediate degree of primary school. Only 25% completed high school. Studies with farmers in the semi-arid region justify that low schooling implies environmental issues since the lack of knowledge of certain sustainable practices can harm the environment [3], [24].

When asked about changes in the vegetation coverage of Caatinga, 53% of farmers say that the changes occurred due to increased agriculture. However, 40% of them sustain that this increase was a consequence of the investment of entrepreneurs in local agriculture, intensified, and based on the agribusiness model. In comparison, 47% believe that even with an advance in agriculture, there was a reduction in family farming. 25% state that the reasons are financial conditions to produce; 10%, a decrease in rainfall; and 12% blame the departure of family farmers for serving as labor in local agribusiness enterprises.

The primary activity of family farmers is the main source of economic income of the interviewed families. The reduction in agricultural production has been pointed out by the lack of financial and technical educational investment for farmers to be able to produce profitably and sustainably [33], [24]. Given that family farmers progressively lose space and labor for agribusiness, the challenge to maintain crops in traditional communities becomes more visible due to the existence of contradictions in the area. Thus, the model of agribusiness productivity sustained from the capital causes the small producer to stay out of this process [13].

Family farmers point out that over time there have been changes in the communities' landscape over an average of 25 years, a view that is incorporated into the current context experienced in the communities. 80% relate these changes to the entry of the mango company that has been installed, while another 40% confirm that there is also the participation of local farmers in landscape changes.

Concerning the time highlighted, the transformations in the

landscape will occur through trajectories and cycles of human development. These changes occur in other places, such as in the Municipality of Potiguar, State of Rio Grande do Norte, where family farmers have also noticed changes in the landscape of their communities over an average period of 20 years; changes that have occurred due to various factors, including deforestation for multiple purposes and the advance of agriculture [5].

Regarding the use and occupation of Caatinga for family agriculture, 68% point out that there were places that were produced/planted before, having been abandoned after; 56% cited that the reason for the abandonment is related to the lack of correct handling of the land, which led to the impoverishment of the soil, making the continuity of the activity unfeasible; and 40% highlight that, due to deforestation, the rains were reducing and bringing losses in production and the impossibility of planting. However, despite these changes, 32% of farmers still cultivate in these same areas, making clear the need for technical monitoring for family agriculture production in the region, in order not to increase the area of pressure on vegetation.

Thus, it is evident that the native coverage of Caatinga in the region has been transforming agricultural practices and deforestation, contributing to the selective and shallow cutting of several species of native flora. From the farmers' perception, the gradual reduction in the occurrence of the species takes place as follows, (63%) *Schinopsisbrasiliensis* Engl. (baraúna), (35%) *Aspidospermapyriifolium* Mart. (pereiro), (32%) *Anadenantheracolubrina* (Vell. Brenan var. cebil (Griseb.) Altschul (angico), (7%) *Ziziphusjoazeiro* Mart. (juazeiro), (10%) *Sideroxylonobtusifolium* [Humb. ex Roem. &Schult. T.D. Penn. (quixabeira), (13%) *Cnidioscolusphyllacanthus* (Muell. Arg.) Pax. & K. Hoffm (favela), (14%) *Mimosa tenuiflora* (Mart.) (jurema-preta), (15%) *Croton sonderianus*Mull.Arg (marmeleiro) and (20%) *Spondiastuberosa*Arruda (umbuzeiro).

The reduction of native species transforms the natural landscape. This factor, added to the entrance of invasive species, damages the innate potential of the biomes that have become a significant threat to the biodiversity of the Caatinga. Given the above, it is assumed that degradation is occurring in the Caatinga landscape. There is a lack of understanding that poor land use contributes to the formation of erosive processes. Environmental degradation and climate change directly affect agricultural production [14], [17]. Therefore, making the soil's core use is one of the main ways to achieve sustainable agricultural production and the conservation of natural resources.

According to the analyses made to identify whether or not there are differences between the responses of family farmers in the two communities, the results show that there are no significant differences in the perception of changes in the vegetation cover of Caatinga. The values represent each quoted response on agricultural development ($\chi^2= 2.79$; $p=0.09$), on the use and occupation practice of the Caatinga ($\chi^2= 1.22$; $p= 0.26$) and time of landscape changes ($\chi^2= 1.26$; $p= 0.32$) and plant reduction ($\chi^2= 12.54$; $p= 0.12$).

4. Conclusion

There has been an intensification in agricultural practices during the last decades, in the communities studied, which has caused fragmentation of vegetation and changes in landscape/phytogeography, and related to the intensification of agriculture focused on agribusiness production, in addition to the significant increase in pastures causing desertification processes in new areas. The most considerable pressure in the ecosystem is agribusiness since family agriculture occupies much smaller areas in the region.

As in these areas, the agricultural practice is historically cultural; this study points out that one of the most significant challenges is to reconcile agricultural activities with economic development, safeguarding the sustainability of the landscape and families. This set of factors points to the need for government actions to conceive technical assistance projects, allowing to guarantee productivity and income generation with less impact on the Caatinga vegetation.

In the perception of the communities of Rompedor and Jatobá, the vegetation of Caatinga has been reduced in their localities. This contributes to reducing the quality of life, damaging the plantation due to lack of rain, although it is known that deforestation is badly needed. However, they are willing to learn new technologies that can guarantee the quality of life and economical maintenance of family farmers, considering the conservation of natural resources.

Given that one of the most significant economic development challenges is to ensure the sustainability of the landscape, there is a need to understand the perceptions of farmers in rural communities. It intends to understand the social dynamics of the population and the ecological integrity of the landscape that has been modified over time and has generated social and environmental damage.

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