Monitoring Land Degradation in Caatinga

Washington de Jesus S. Franca-Rocha[1], Soltan Galano Duverger[2], Diego P. Costa[2], Deorgia T. M. Souza[1], Rodrigo N. Vasconcelos[1]
[1] Postgraduate Program in Earth Modeling and Environmental Sciences - PPGM, State University of Feira de Santana-UEFS, Feira de Santana, Brazil, W.F.R. (wrocha@uefs.br), D. M. S. (dtmsouza@uefs.br), R.N.V (rnv@uefs.br)
[2] GEODATIN - Data Intelligence and Geoinformation, Feira de Santana, Brazil, S. G. D. (soltan.galano@ufba.br) D. P. C. (diego.costa@uefs.br).

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The Caatinga is a unique semi-arid biome characterized by xerophytic vegetation adapted to water scarcity and a hot, dry climate. This region holds ecological and cultural significance, harboring rich biodiversity, including endemic and endangered species. Protecting the Caatinga requires a multifaceted approach, including reforestation, sustainable land and water management, promotion of sustainable agriculture, environmental education, and public policies aimed at biome protection.

The Caatinga faces significant threats due to human activities such as deforestation and unsustainable agriculture. This has led to degradation and loss of biodiversity in the region, accelerating the process of desertification.

Among the main drivers of degradation in the Caatinga are urbanization, infrastructure implementation, pasture expansion, logging, and fires. These factors lead to the loss of native vegetation and increased vulnerability to climate change. The consequences of degradation and desertification are severe, including biodiversity loss, reduced agricultural productivity, and socio-economic impacts such as poverty and forced migration.

In Brazil, areas susceptible to desertification (ASD's) have been known since 2007 and cover about 16% of the Brazilian territory (1,340,863 km2) according to estimates by the Brazilian Ministry of the Environment (MMA, 2007). ASD's are areas that can become deserts if the level of land degradation increases over time. Efforts to monitor ASD's have been made, such as the discontinued Mapbiomas Arida platform and the ongoing development of a Desertification Index.

More recently, a 2023 study by INPE/CEMADEN (TOMASELLA, 2023) even identified, for the first time, an area considered arid in Brazil (Figure 1). Consulting the Mapbiomas Água Platform, it is verified that in 7 out of the 8 municipalities within this area, there was a reduction in water surface between 1990 and 2020 (period of the INPE/CEMADEN study), with emphasis on Chorrochó and Macururé, which lost 44.92% and 43.71% of their water surface, respectively.

A novel platform is being developed to monitor degradation in vegetation: Mapbiomas Degradation. In its initial version, this platform considers the edge effect, fragmentation, biological isolation, vegetation fires, and secondary vegetation as drivers of degradation. Other modules will be added later to model the various types of degradation by biome, with the mapping of exposed soil and its frequency being essential to estimate susceptibility to desertification, along with climatic variables and vegetation spectral indices.

It is estimated that in the Caatinga there are 9 million hectares (just over 18%) to 26.7 million hectares (almost 54%) of possibly degraded vegetation.

Figure 2 shows the result of the simulation of degradation in vegetation, in the Caatinga Biome considering the edge effect with depths of 30, 60, 90, 120, 150 and 300 meters.

Considering that the edge effect in habitat patches can occur at different depths, depending on the conditions and ecological processes involved, our results indicate that, in the most optimistic scenarios, in which the depth of the edge effect varies between 30, 60, and 90 meters from the edges of the forest patches, the Caatinga Biome would present, in 2022, the following values: 14.12%, 24.25%, and 33.51%, respectively, when the central areas of the total are discounted. That is, within the optimistic scenario, with an edge depth of 90 meters, more than ⅓ of the Caatinga no longer has a core area.

When analyzing the core area of the Caatinga Biome forest fragments at different edge depths (30, 60, 90, 120, 150, 300, 600, 1000 meters), we found that the Caatinga Biome suffered, on average, a reduction of 4% 3,450,557.68 Mha in the last 37 years.

The core areas with edge depth of 150 and 300 meters showed the greatest percentage loss in area, with reductions of -6.08% (~ -540 thousand Ha) and -6.59% (~-320 thousand Ha), respectively, between 1985 and 2022.

The edge effect in savanna formations is intensified in protected areas, as observed in northern Bahia, particularly when considering limits of 60, 90, and 120 meters (Figure 3). An emblematic example is the federal conservation unit that borders the area susceptible to desertification in Jeremoabo (BA). Ideally, these protected areas should be free from the edge effect and fragmentation, which highlights the importance of effective management measures to ensure the preservation of the integrity of these ecosystems.

This situation contrasts with the area of Serra das Confusões National Park, in Piauí, a region with great preservation of Caatinga vegetation, but which, due to its proximity to the MATOPIBA agricultural frontier, already suffers from great pressure (Figure 4).

These results corroborate the studies of Antongiovanni et al. (2020), which found that the remaining Caatinga vegetation is severely threatened due to accumulated human action over time, with only about half of the original cover remaining. Furthermore, they identified a strong fragmentation effect in the biome, with smaller fragments showing greater heterogeneity and levels of degradation, while larger areas exhibit moderate disturbance. According to these authors, the Caatinga, a region under constant water stress, is highly vulnerable to climate

change, with areas to the north and west more disturbed than the eastern and southern regions.
Human activities and climate change pose significant threats to the Caatinga biome, driving degradation, desertification, and adversely affecting biodiversity, agriculture, and local communities.
Monitoring efforts, including initiatives such as MapBiomas Degradation, are in place to track these changes, but more comprehensive actions are necessary to address the root causes of degradation and ensure the long-term sustainability of the Caatinga.

Figures

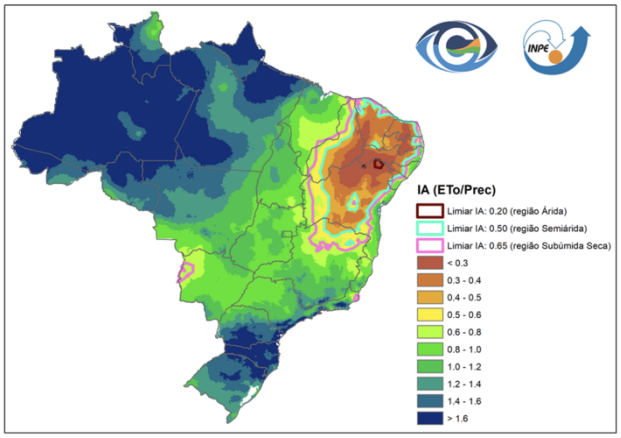

Figure 1 - Map of the Aridity Index in Brazil between 1990 and 2020, highlighting the new areas with arid climate typology.

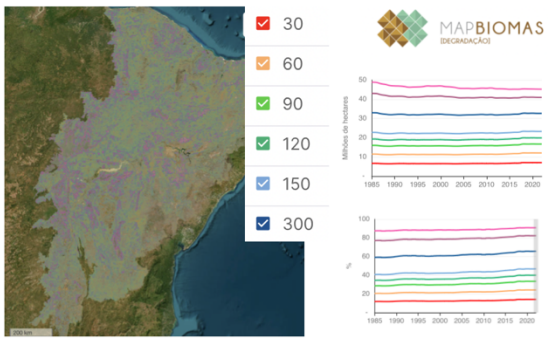

Figure 2 - Edge effect in the Caatinga Biome for different depths

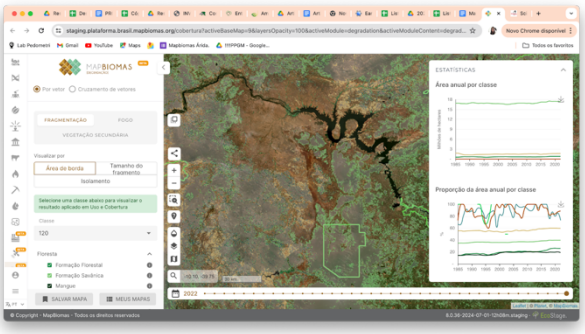

Figure 3 - Edge effect for limits of 60, 90, and 120 meters in the municipality of Jeremoabo, Bahia, Brazil

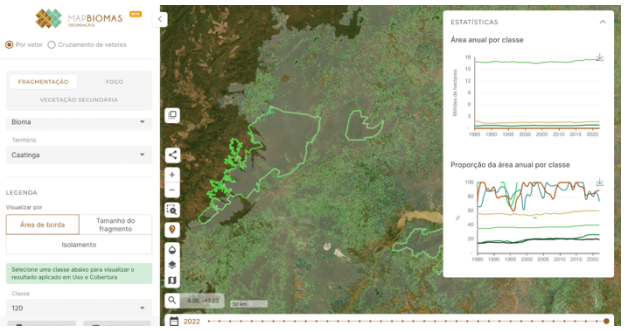

Figure 4 - Edge effect for limits of 60, 90, and 120 meters in the region of the Serra das Confusões National Park and Serra da Capivara National Park, in the southeast of the State of Piaui Brazil

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