Impacts of vegetation cover and precipitation changes on dengue fever incidence in Boa Vista do Tupim, BA: a one health approach

Carolina Cabral das Chagas Reis[21], Édson Luis Bolfe[22]

Abstract

Several studies have highlighted the importance of the One Health approach, which integrates the dimensions of human, animal, and environmental health, in understanding the dynamics of vector-borne diseases, such as dengue. The present study aimed to analyze possible correlations between the incidence of dengue, loss of vegetation, and precipitation. Annual records of dengue cases were obtained from the Information System for Notifiable Diseases (SINAN) of the Ministry of Health between 2003 and 2023. The Mapbiomas database was used to obtain native vegetation losses and gains. Annual precipitation data came from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) database. Pearson's coefficient (R) was applied to understand the correlations between the variables. Among the years analyzed, a weak positive correlation was observed between precipitation and dengue occurrence (R = 0.25) and a weak negative correlation between vegetation loss and dengue (R = -0.079). The highest number of cases was recorded in 2005, coinciding with a period of high rainfall. Although statistical correlations were weak, the results suggest a influence of precipitation on the incidence of dengue in the municipality of Boa Vista do Tupim (BA). The study reinforces the importance of integrated public policies that combine environmental conservation and vector control, in line with the principles of One Health. In the future, the aim is to deepen the analysis of socio-environmental dynamics by incorporating local data collected by the Semear Digital Group new land use and land cover change (LULC) mappings.

[21] Department of Geosciences, Institution State University of Campinas. ORCID: https://orcid.org/0000-0001-8518-5785. Email: c201080@dac.unicamp.br.

[22] Embrapa Digital Agriculture, Campinas-SP. ORCID https://orcid.org/0000-0001-7777-2445. Email: edson.bolfe@embrapa.br.

Keywords: neglected tropical diseases, deforestation, One Health, and climate.

1. Introduction

The World Health Organization (WHO) recognizes that changes in land use and land cover (LULC) have impacted human health, due to the way they intensify the interaction of humans with animal life (Zalles et al., 2021). Recent pandemics and epidemics have demonstrated a significant association between changes in LULC and human health, mainly due to the spread of pathogens hosted in vegetation (Rulli et al., 2021). To inseparably encompass human, animal, and environmental health, international organizations such as the WHO, the World Organization for Animal Health (OIE), and the Food and Agriculture Organization of the United Nations (FAO) have proposed the concept of One Health. One Health establishes practical actions aimed at preventing future diseases. These actions focus on investments in multidisciplinary approaches, raising awareness about zoonotic diseases, regulating food systems, sustainable landscape management, and monitoring land use and land cover (Adisasmito et al., 2022). Monitoring of use and conservation diseases (LULC) is crucial to prevent new disease outbreaks, as it represents the direct interface between human activity and nature. There is a gap in understanding the spread of Neglected Tropical Diseases (NTDs), which have so far infected an estimated 1.4 billion people in 147 countries (Adisasmito et al., 2022). Brazil is the country with the highest number of NTDs in the world, home to at least nine of the 17 known NTDs: Chikungunya, Dengue, Chagas disease, Schistosomiasis, Hansen's disease, Leishmaniasis, Malaria, Tuberculosis, and Zika. These diseases are called neglected because they have received little investment in research, development, control, and production of medicines and development of vaccines (Löwenberg-Neto et al., 2023).

Dengue is a viral disease transmitted by the Aedes aegypti mosquito, the incidence of which is profoundly influenced by environmental factors (Poncio et al., 2023). Recent research, such as that developed by Andrade (2024), shows that changes in vegetation cover and climate change play a significant role in the proliferation of the vector and, consequently, in the spread of dengue.

The main objective of this study is to investigate the possible correlations between changes in vegetation cover and precipitation patterns in the occurrence of dengue fever in the municipality of Boa Vista do Tupim, BA. It is assumed that both the reduction of

vegetation and the increase in rainfall are related to increases in dengue fever incidence rates, as suggested by previous studies.

2. Methods

Information on dengue consisted of the number of cases registered annually (2003 to 2023), obtained through SINAN - Notifiable Diseases Information System (Brasil, 2023). Subsequently, the incidence of cases per 100,000 inhabitants was calculated. Data on changes in vegetation cover were obtained from the MapBiomas platform. This product was generated based on the balance of losses and gains of the municipality's natural vegetation between 2003 and 2023. Annual precipitation was obtained from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) database. The methodology was divided into three stages: 1) descriptive analysis to verify the annual variation of dengue cases, precipitation, and changes in vegetation cover; 2) application of Pearson's coefficient to understand the relationships between the variables; and 3) preparation of scatter plots using the R software.

3. Results and Discussion

Between 2003 and 2023, 697 cases of dengue were recorded in the municipality of Boa Vista do Tupim-BA. In 2005, there was a higher incidence of dengue cases (1026.73). The number of dengue cases in the municipality is relatively high considering the population of ~18 thousand inhabitants (Figure 1).

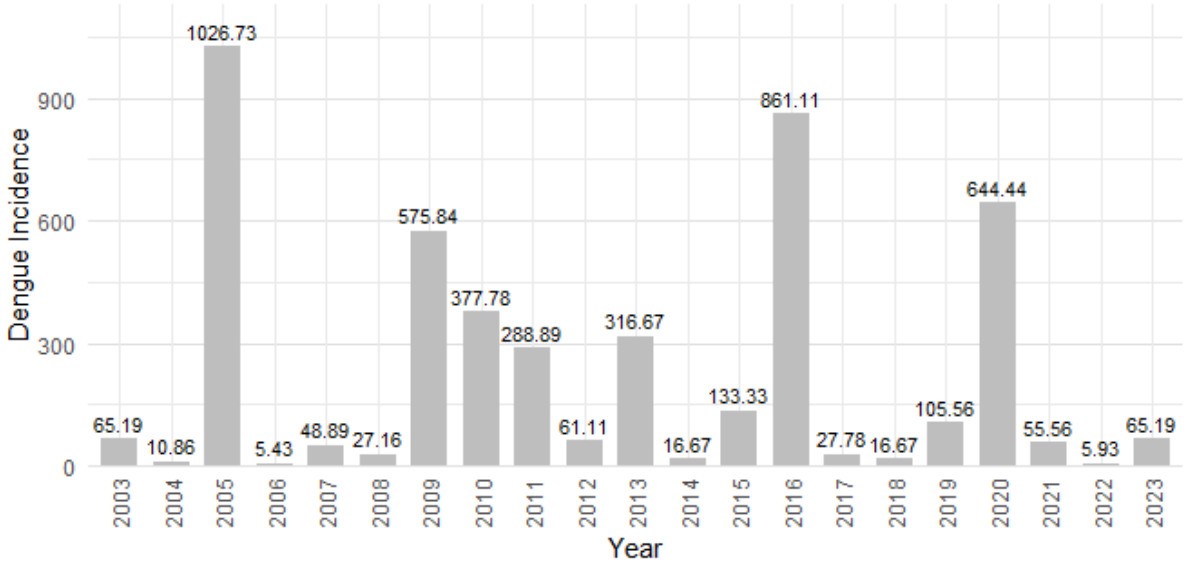

Figure 1. Annual distribution of the incidence of Dengue cases in the municipality of Boa Vista do Tupim, BA. **Source**: Brasil (2023).

Precipitation exhibited substantial variation (range = ~570 mm/year). The highest precipitation levels in recent years were recorded in 2006 and 2020, 833.55 mm/year and 870.13 mm/year. Considering changes in vegetation cover, Mapbiomas data suggest a negative balance in the deforestation balance in recent decades (gain = 21,373.69 ha and loss = 39,273.26 ha, balance = ~17,900 ha).

In general, although there were significant changes in vegetation and substantial variations in precipitation in the municipality of Boa Vista do Tupim, these variables showed a weak correlation with the incidence of dengue (Figure 2). Precipitation showed a positive correlation with the incidence of dengue in the region (R = 0.25). This suggests that high volumes of precipitation are associated with higher rates of dengue cases, as in these conditions, there is an accumulation of stagnant water, facilitating the reproduction of the transmitting mosquito. This finding is consistent with previous studies in Brazil (Rezende; Giongo, 2024).

Data on changes in vegetation cover showed a negative correlation with the incidence of dengue fever. From this perspective, the loss of vegetation may be a driver of the spread of dengue fever. Deforested areas are destined for urban settlements, creating environments conducive to the spread of dengue fever. The findings of this study

corroborate studies by Fiocruz, which suggest an amplification of the dengue fever epidemic in Brazil due to climate anomalies and increased deforestation (Barcellos et al., 2024). In this context, mitigating measures to combat the spread of dengue fever become necessary, compliance with environmental legislation and the expansion of conservation units emerge as efficient alternatives.

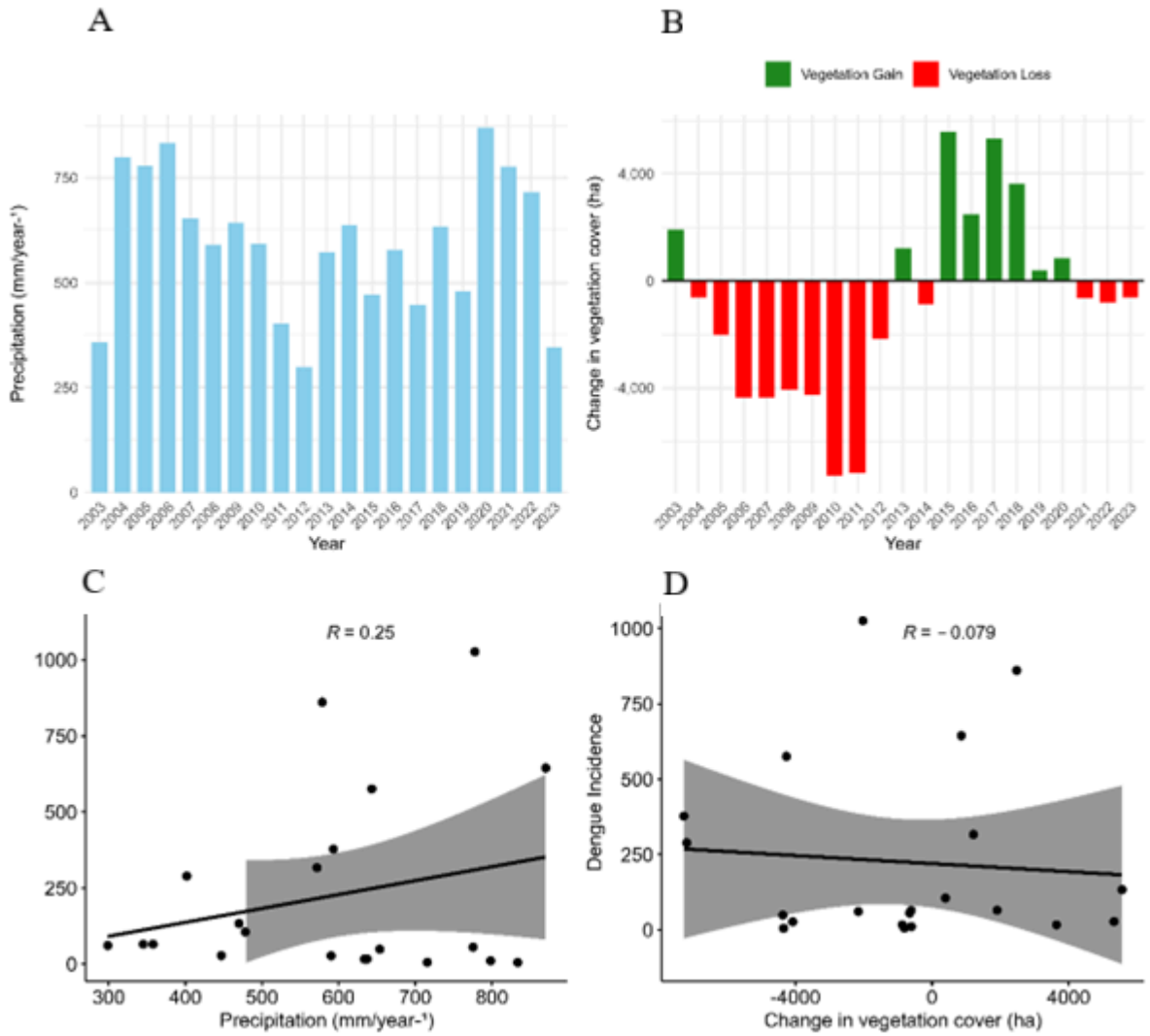

Figure 2. (A) Annual distribution of precipitation; (B) Annual distribution of changes in vegetation cover; (C) Correlation between rainfall and dengue incidence in the municipality of Boa Vista do Tupim, Bahia.; (D) Correlation between changes in vegetation cover and dengue incidence in the municipality of Boa Vista do Tupim, Bahia.

4. Conclusion

This preliminary study showed that the spread of dengue fever in the municipality of Boa Vista do Tupim/BA is associated with increased deforestation and periods of higher rainfall. The results of this study reinforce the importance of adopting integrated approaches that combine environmental conservation strategies with effective vector control measures in the fight against dengue fever. This perspective, which integrates human, animal, and environmental health, is essential for the municipality of Boa Vista do Tupim,BA, as it allows a holistic view of the factors that influence the transmission of the disease, including ecological changes, population habits, and public policies. In this sense, the Semear Digital Group will collect data in partnership with the City Hall of Boa Vista do Tupim, seeking more detailed information on socio-environmental conditions, prevention practices, and dynamics of dengue transmission in the municipality.

Acknowledgements

The authors would like to thank Fapesp (Proc. 2022/09319-9) and CAPES (Proc. 33003017080P0 for funding.

References

ADISASMITO, W. B.; ALMUHAIRI, S.; BEHRAVESH, C. B.; BILLIVOGUI, P.; BUKACHI, S. A.; CASAS, N.; BECERRA, N. C.; CHARRON, D. F.; CHAUDHARY, A.; ZANELLA, J. R. C.; CUNNINGHAM, A. A.; DAR, O.; DEBNATH, N.; DANGU, B.; FARAG, E.; GAO, G. F.; HAYMAN, D. T. S.; KHAITSA, M.; KOOPMANS, M. P. G.; MACHALABA, C.; MACKENZIE, J. S.; MARKOTTER, W.; METTENLEITER, T.; MORAND, S.; SMOLENSKIY, V.; ZHOU, L. One health: a new definition for a sustainable and healthy future. **PLOS Pathogens**, v. 18, n. 6, e1010537, 2022. DOI: https://doi.org/10.1371/journal.ppat.1010537.

BARCELLOS, C.; MATOS ,V.; LANA, R. M.; LOWE, R. Climate change, thermal anomalies, and the recent progression of dengue in Brazil. **Scientific Reports**, v. 14, n. 1, 5948, 2024. DOI: https://doi.org/10.1038/s41598-024-56044-y.

BRASIL. **Dados epidemiológicos Sinan**. 2023. Available at: https://portalsinan.saude.gov.br/dados-epidemiologicos-SINAN. Accessed on: Apr. 6, 2025.

LÖWENBERG-NETO, P.; WINKELMANN, S.; VERZOTTO, A. K. Biogeographic regionalization of human infectious diseases in Brazil based on geographically explicit data. **Tropical Medicine & International Health**, v. 28, n. 9, p. 742-752, Sept. 2023. DOI: https://doi.org/10.1111/tmi.13914.

PONCIO, L. de C.; ANJOS, F. A. dos; OLIVEIRA, D. A. de; ROSA, A. de O. da; SILVA, B. P.; REBECHI, D.; PEDROSA, J. M.; FRANCISCATO, D. A. da C.; SOUZA, C. de; PALDI, N. Prevention of a dengue outbreak via the large-scale deployment of Sterile Insect Technology in a Brazilian city: a prospective study. **The Lancet Regional Health - Americas**, v. 21, 100498, May 2023. DOI: https://doi.org/10.1016/j.lana.2023.100498.

REZENDE, N. M. C.; GIONGO, P. R. Correlação entre o uso e cobertura de solo e incidência de dengue e chikungunya no município de Quirinópolis, Goiás. **Anais do Seminário de Ensino, Pesquisa e Extensão da UEG Câmpus Sudoeste – Quirinópolis**, v. 4, p. 205-212, 2024. Available at: https://www.anais.ueg.br/index.php/sepe_sudoeste/article/view/16542. Accessed on: Apr. 6, 2025.

RULLI, M. C.; D´ODORICO, P.; GALLI, N.; HAYMAN, D. T. S. Land-use change and the livestock revolution increase the risk of zoonotic coronavirus transmission from rhinolophid bats. **Nature Food**, v. 2, n. 6, p. 409-416, 2021. DOI: https://doi.org/10.1038/s43016-021-00285-x.

ZALLES, V.; HANSE, M. C.; POTAPOV, P. V.; PARKER, D.; STEHMAN, S. V.; PICKENS, A. H.; PARENTE, L. L.; FERREIRA, L. G.; SONG, X. P.; HERNANDEZ-SERNA, A.; KOMMAREDDY, I. Rapid expansion of human impact on natural land in South America since 1985. **Science Advances**, v. 7, n. 14, p. eabg1620, 2021. DOI: https://doi.org/10.1126/sciadv.abg1620.