

# Geospatial Monitoring of Mosquito Breeding Sites in Pinheiro, Maranhão, Brazil.

Carla Cristina Rodrigues Gomes; Saulo Pereira Fróes; Bruno Lucas Cirqueira Cunha; Roure Santos Ribeiro; Hilton Costa Louzeiro; Suzanna de Sousa Silva; João Paulo Tenório da Silva Santos; Aline Bessa Veloso, Aslei Andrade da Silva, Adilson Matheus; Ailson Gomes Araujo; Daianny Rackelly Martins E Martins; Jamilly De Jesus Pereira Rodrigues; Livia Maria Pinto Oliveira; Pablo Mickael Martins Ribeiro; Ramon Vinicius Mendes Pinheiro; Sarah Khevenny Ribeiro Costa; Hennry Pyettro Campos Mendes; Jhoseph David Dos Santos Silva; João Davi de Araújo Carvalho; Maria Clara Castro Azevedo; Maria Luisa Lisboa Ribeiro; Thiago Souza Soares; Wenderson Pereira da Silva; Michel Jeferson Pinheiro Pereira.

**Teacher / Mentor:** João Paulo Tenório da Silva Santos



## Abstract

- Vector-borne diseases represent a major public health challenge in Brazil, especially in tropical regions with inadequate sanitation and unplanned urban growth. This study presents the results of geospatial monitoring of mosquito breeding sites in the municipality of Pinheiro, Maranhão, Brazil, using GLOBE Program protocols, particularly the Mosquito Habitat Mapper. The research was conducted through a citizen science approach, involving trained students in field surveys, environmental observation, photographic records, and georeferencing of breeding sites using the GLOBE Observer application. A total of 39 sites were monitored between September 2024 and March 2025, of which 19 were identified as critical areas for mosquito proliferation. The data were organized into electronic spreadsheets and analyzed using geospatial tools to generate thematic maps and heat maps. Results revealed a heterogeneous spatial distribution of breeding sites, with higher concentrations in densely populated areas characterized by inadequate waste management and water storage practices. The findings highlight the effectiveness of integrating geospatial technologies, environmental education, and community participation to support vector surveillance and public health actions. This approach strengthens local awareness and contributes to more targeted mosquito control strategies.

## Research Question

How does the spatial distribution of mosquito breeding sites relate to urban infrastructure and environmental conditions in the municipality of Pinheiro, Maranhão?

## Introduction

The control of arboviral diseases is a persistent challenge in tropical regions, where rapid and unplanned urbanization contributes to favorable conditions for mosquito proliferation. In Pinheiro, Maranhão, climatic characteristics such as high rainfall, extensive floodplains, and high humidity facilitate the persistence of natural and artificial breeding sites throughout the year. Geospatial analysis has become an essential tool for identifying critical areas of vector proliferation and supporting targeted public health interventions. In this context, citizen science plays a key role by expanding data collection coverage and promoting scientific education. This study integrates GLOBE Program protocols with student participation to analyze mosquito breeding sites and their spatial distribution within the municipality.

## Research Methods

### Planning Investigations

The study followed GLOBE Program guidelines using the Mosquito Habitat Mapper protocol. Sampling locations were selected based on information provided by the Municipal Health Department, prioritizing areas with higher risk of arbovirus transmission. Materials included mobile devices with the GLOBE Observer application, spreadsheets, and geoprocessing tools. Carrying Out

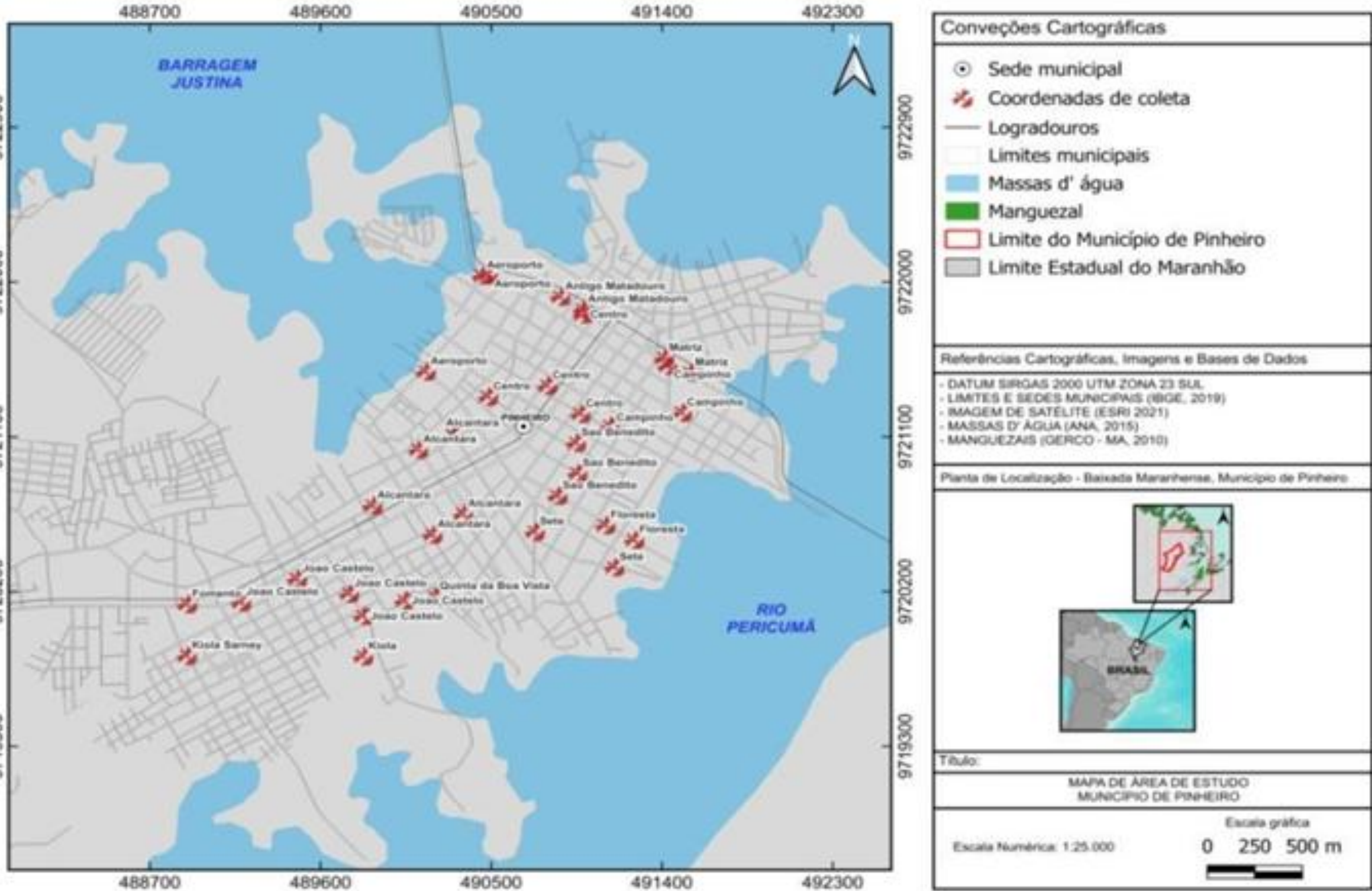
### Investigations

Trained students conducted field inspections in domestic and peridomestic environments, identifying water-holding containers such as tires, bottles, buckets, cisterns, and water tanks. Each site was georeferenced, photographed, and described regarding container type, presence of water, and mosquito larvae or adults.

### Map of Study Site(s)

The study was conducted in the municipality of Pinheiro, located in the Maranhão Lowlands, northeastern Brazil. The region is characterized by floodplains, high rainfall, and urban and peri-urban areas with heterogeneous infrastructure, including locations with inadequate drainage, irregular waste collection, and improper water storage.

**Figure 1. Study area: representation of the municipality of Pinheiro, Maranhão, Brazil, and the sampling sites.**



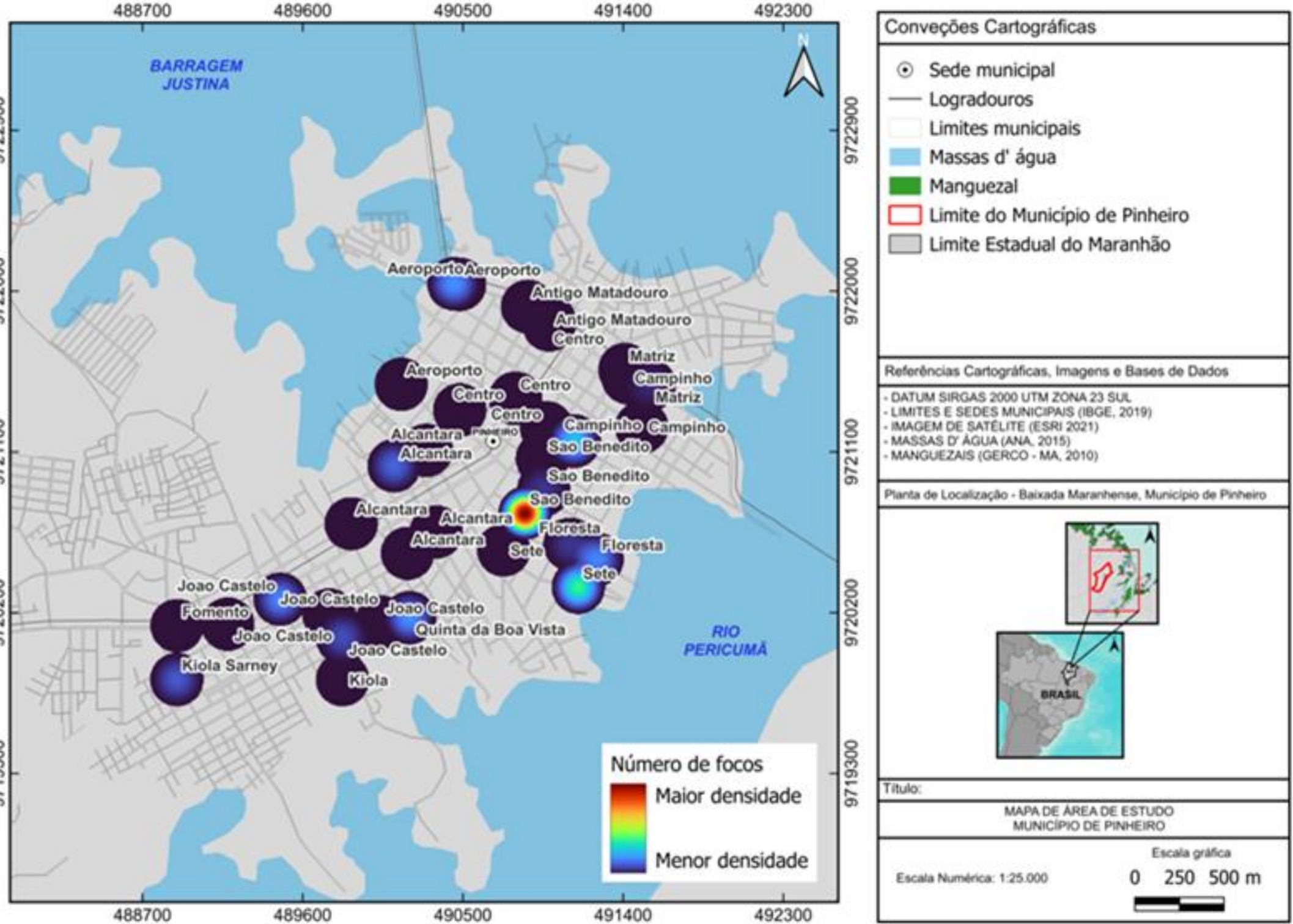
## Results

### Analyzing Data

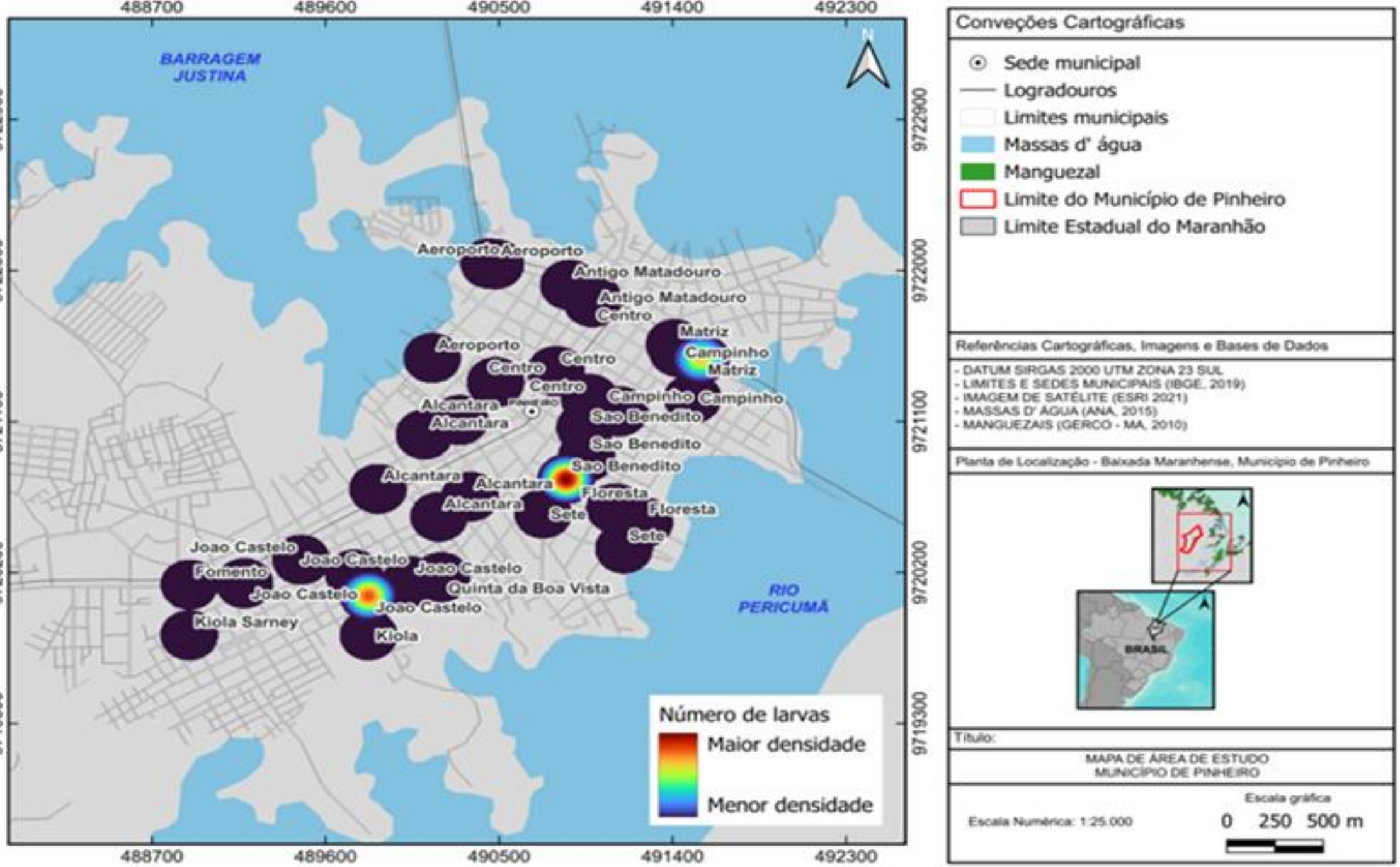
- Collected data were exported from the GLOBE platform and organized into spreadsheets. Spatial analyses were performed to create thematic maps and heat maps, allowing visualization of breeding site distribution and identification of high-risk areas. Breeding sites were classified as artificial, natural, or capture sites and analyzed by container type and environmental conditions.

- A total of 39 sites were analyzed, with a predominance of artificial breeding habitats. Nineteen sites were identified as critical areas, mainly in densely populated neighborhoods with inadequate sanitation services. Tires, plastic containers, bottles, and domestic water storage tanks were the most common breeding sites. Heat maps revealed a heterogeneous spatial distribution, highlighting clusters of mosquito breeding in socially vulnerable areas. The genus Aedes was commonly associated with small containers containing clean water, while Culex species were more frequent in environments with organic matter.

**Figure 2. Percentage of breeding sites by container type in the municipalities of Pinheiro, Maranhão, and São Bento, Maranhão, Brazil.**



**Figure 4. Percentage of breeding sites by locality type in the municipalities of Pinheiro, Maranhão, and São Bento, Maranhão, Brazil.**



## Discussion

### Interpreting Data

- The results confirm that urban infrastructure deficiencies and household practices strongly influence mosquito proliferation in Pinheiro. The integration of geospatial tools with citizen science allowed detailed mapping of breeding sites and expanded monitoring coverage. Student participation enhanced data collection and promoted environmental awareness within the community.

## Conclusions

### Drawing Conclusions & Next Steps

- The study demonstrates that mosquito proliferation in Pinheiro is closely linked to environmental conditions, waste management, and water storage practices. Geospatial mapping proved to be an effective tool for identifying critical areas and supporting targeted vector control actions. Future efforts should strengthen environmental education, improve urban infrastructure, and expand continuous monitoring using GLOBE protocols. The integration of schools, communities, and public health agencies is essential for sustainable mosquito control and disease prevention.

## Bibliography

### References

- Costa, A. I. P., & Natal, D. (1998). Spatial distribution of dengue and socioeconomic determinants in urban areas. *Revista de Saúde Pública*, 32(3), 232–236. Flauzino, R. F., Souza-Santos, R., & Oliveira, R. M. (2009). Dengue, geoprocessing and socioeconomic indicators: a review. *Revista Panamericana de Salud Pública*, 25(5), 456–461. Cavalcante, M. P. R. et al. (2013).