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INFLUENCE OF AFFORDABILITY ON THE MICROCLIMATE OF THE ANANINDEUA-PA REGION

INFLUÊNCIA DA ARBORIZAÇÃO NO MICROCLIMA DA REGIÃO DE ANANINDEUA-PA

INFLUENCIA DE LA ASEQUIBILIDAD EN EL MICROCLIMA DE LA REGIÓN DE ANANINDEUA-PA

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ABSTRACT
This study analyzes the influence of vegetation cover on the urban microclimate, focusing on temperature and relative humidity parameters. Measurements were taken in two areas with different levels of afforestation in the municipality of Ananindeua, Pará, allowing for comparison between forested and non-forested environments. The results indicate that vegetation contributes significantly to thermal regulation, promoting a reduction in maximum daytime temperatures and an increase in relative humidity, especially during periods of greater sunlight. Furthermore, it was observed that factors such as cloud cover, paving, and land use influence microclimate variations, potentially even reversing expected trends. The research reinforces the importance of urban afforestation as an effective strategy for mitigating heat island effects, improving thermal comfort, and promoting greater environmental balance in cities.

Keywords: Microclimate. Temperature. Humidity.

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RESUMO
Este estudo analisa a influência da cobertura vegetal sobre o microclima urbano, com foco nos parâmetros de temperatura e umidade relativa do ar. As medições foram realizadas em duas áreas com diferentes níveis de arborização no município de Ananindeua, PA, permitindo a comparação entre ambientes arborizados e não arborizados. Os resultados indicam que a vegetação contribui significativamente para a regulação térmica, promovendo redução nas temperaturas máximas diurnas e aumento da umidade relativa, especialmente em períodos de maior incidência solar. Além disso, observou-se que fatores como nebulosidade, pavimentação e uso do solo interferem nas variações microclimáticas, podendo até inverter tendências esperadas. A pesquisa reforça a importância da arborização urbana como estratégia eficaz para mitigar os efeitos das ilhas de calor, melhorar o conforto térmico e promover maior equilíbrio ambiental nas cidades.

Palavras-chave: Microclima. Temperatura. Umidade.

RESUMEN
Este estudio analiza la influencia de la cobertura vegetal en el microclima urbano, centrándose en los parámetros de temperatura y humedad relativa. Se realizaron mediciones en dos zonas con diferentes niveles de forestación en el municipio de Ananindeua, Pará, lo que permitió comparar entornos forestados y no forestados. Los resultados indican que la vegetación contribuye significativamente a la termorregulación, promoviendo una reducción de las temperaturas máximas diurnas y un aumento de la humedad relativa, especialmente durante los períodos de mayor insolación. Además, se observó que factores como la nubosidad, la pavimentación y el uso del suelo influyen en las variaciones del microclima, pudiendo incluso revertir las tendencias esperadas. La investigación refuerza la importancia de la forestación urbana como estrategia eficaz para mitigar los efectos de isla de calor, mejorar el confort térmico y promover un mayor equilibrio ambiental en las ciudades.

Palabras clave: Microclima. Temperatura. Humedad.

1 INTRODUCTION

The phenomenon of urbanization is growing and global. In recent decades, cities have shown great growth in population, space, and activities, drastically transforming both the natural and the built environment (PEREIRA, 2025).

The urbanization process, defined as the increase in the population of urban areas to the detriment of rural areas, has been occurring in Brazil since the beginning of the twentieth century in all regions and biomes of the country. In the vast majority of cases, this process takes place from inadequate planning, generating disorderly growth, accompanied by the lack of infrastructure capable of guaranteeing the minimum environmental quality (OLIVEIRA, 2021).

This new built environment has been undergoing significant climate change, with damage to the quality of life of populations (LABAKI *et al*., 2011; OLIVEIRA *et al*., 2013). This disorderly growth favors the removal of a large part of the vegetation for the expansion or construction of roads, buildings and land parcels, increasing the paved coverage of this area (ABREU, 2008; PEREIRA, 2023).

In this sense, the urban environment should be a place where the user's feeling of comfort is achieved, however, in many cases, these environments do not offer adequate conditions for this, whether thermal, acoustic, luminous or visual comfort (GUSMÃO, 2025).

The city is in itself a major climate modifier, due to the large paved areas and decrease in green areas, the air layer tends to be warmer in urban areas than in rural areas (FORMIGA, 2022). In addition, human activity in cities creates profound changes in the local climate, and can also alter the temperature and rainfall regime of the region (GONÇALVES *et al*., 2012).

Vegetation cover provides several ecosystem services that help mitigate the effects of heat islands (UHI), formed by the process of urbanization and reduction of vegetation areas, helping to raise the quality of life of urban inhabitants and the sustainability of cities (ZHANGA, ESTOQUE, MURAYAMA, 2017). The transpiration of trees promotes cooling and humidification of the environments where they are inserted, in addition to being a source for latent heat flow (ZHENG *et al*., 2021).

The effect of UHIs is characterized by the development of higher temperatures, between the ranges of 3.4 and 4.5 ºC, in urban areas when compared to rural areas (ZHANGA, ESTOQUE, MURAYAMA, 2017). This effect is the result of the removal of vegetation cover and consequently the decrease in evapotranspiration, increasing the release of sensible heat (STONE *et al*., 2010; ZHENG *et al*., 2021).

This increase in the release of sensible heat causes large heat waves that act negatively on urban ecosystems and human comfort, in addition to helping the growth of electricity and water consumption for cooling; (HATVANI-KOVACS et al., 2016; STOCK; MURAYAMA; MYINT, 2017). Therefore, the presence or absence of urban forests causes, respectively, major positive or negative impacts on society and the sustainability of cities.

For all these factors, this research came from the need to quantify the contribution of urban afforestation to thermal comfort, that is, the attenuation of solar radiation by vegetation and its influences on air temperature and humidity. Thus, the objective of this work was to analyze the differences in temperature and relative humidity of the air in two distinct neighborhoods of the municipality of Ananindeua with similar characteristics of area, standing out for the difference in the existing tree vegetation, in order to subsidize the discussion of urban afforestation as a measure to mitigate the increase in temperature and favor thermal comfort.

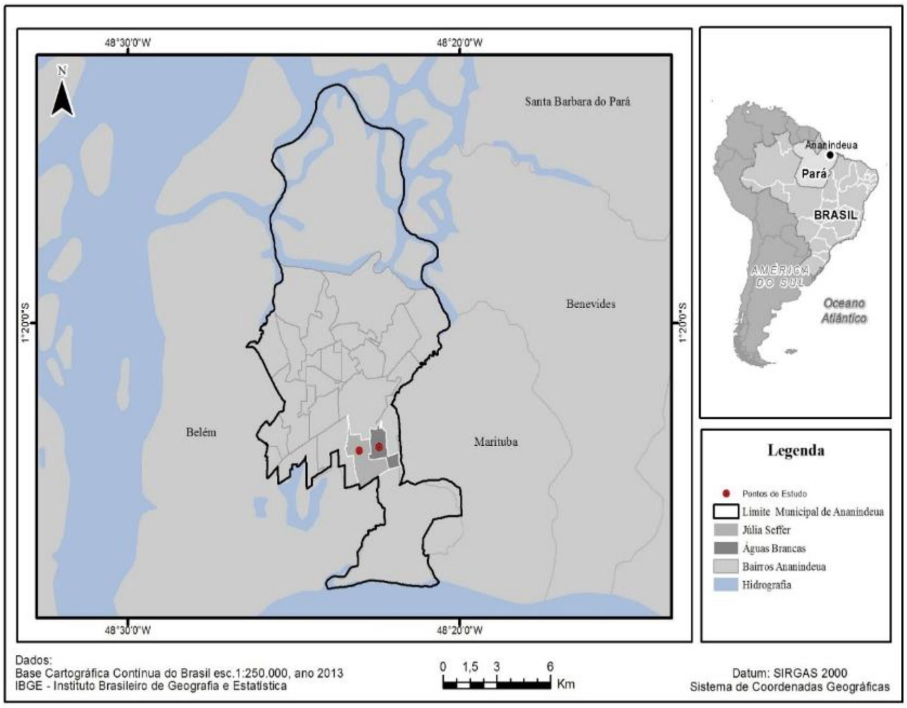
2 METHODOLOGY

2.1 CHARACTERIZATION OF THE STUDY AREA

With an area of 191.4 km², the municipality of Ananindeua is located between the geographic coordinates 01º 13' and 01º 27' south latitude and 48º 19' and 48º 26' west longitude (IBGE, 2010). The study was developed at two different points (Figure 1), the first data collection was carried out in the area of Bosque Uirapuru, an area of abundant vegetation and apparently preserved, and the second point was the area of Residencial Jardim Amazônia 2, which has significant anthropic action.

Figure 1

Map of the location of the municipality of Ananindeua/PA with the points of the Analysis



Source: Prepared by the authors, 2025.

To evaluate the influence of vegetation on thermal comfort, temperature and air humidity, measurements were carried out at two different points located in the central region of the municipality of Ananindeua, PA. The selected areas present significant differences in terms of vegetation density and types of pavement, although they share similar topographic characteristics (Figure 2). With an approximate distance of 1,500 meters between them, it is possible to consider that both are exposed to comparable climatic conditions, which favors the analysis of the effects of vegetation cover on the local microclimate.

Figure 2

Areas selected for the study

*Area 1: Uirapuru Forest, located at R. Coletora Oeste, Águas Lindas, Ananindeua – PA, Júlia Seffer set. A well-wooded place has a varied plant composition, with well-distributed medium and large trees, shrubs and flowers. Planned by the federal savings bank of Pará.
*Area 2: Area 2: Residencial Jardim Amazônia 2, Estr. for Industry - Águas Brancas, Ananindeua – PA. Housing complex where more people were observed moving around in their cars, with little movement of people during the day, with an increase in passersby in the late afternoon.
Source: Authors.

To capture the variables, the device was positioned at a height of 2.00 meters from the ground. Following the methodology of Gonçalves *et al*. (2012) modified, the data – temperature and relative humidity – were recorded every 1 hour, for 15 minutes in the central part of each area, starting the measurements in the first area at 08:00 hours and ending at 18:00 at night. For data collection, a digital Higro-thermometer (model Instrutemp ITHT-2220) was used with a temperature range of 0°C to 50°C, relative humidity range of 1.0% RH to 99% RH, accuracy with temperature: +- 0.5 ºC (+-1.8 °F) and relative humidity +- 3% RH. The data collection of the first and second areas was in the months of September, October, November and December of the year 2017, always on the 28th of the respective months, from 08:00 am to 6:00 pm, with variations in atmospheric weather, clear sky situation in the morning and rain in the afternoon, in the rainiest months such as November and December there were clouds and gusts of wind, which are directly and indirectly related to the variables analyzed in this study. Finally, the collected data were tabulated in Excel, analyzed and the graphs that composed the discussion were elaborated.

3 RESULTS AND DISCUSSION

Climate regulation by vegetation cover consists of interferences in climatic conditions close to the surface, such as sensible and latent heat and, consequently, air temperature and humidity. The amount of radiation that a surface absorbs or reflects results in a warmer or colder climate in a given region (OLIVEIRA, 2021).

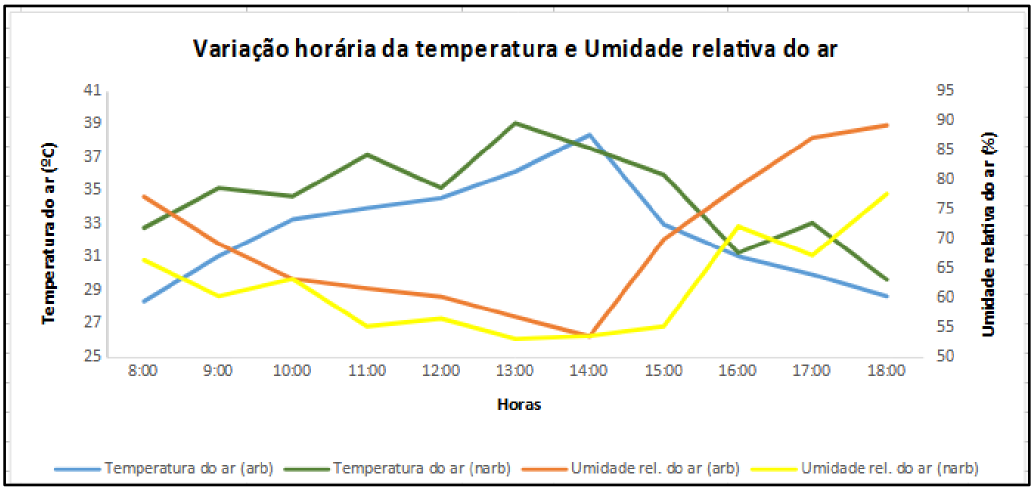
The presence of vegetation in urban environments contributes significantly to the attenuation of maximum diurnal temperatures, by reducing radiative exchanges on the soil surface. This effect manifests itself both indirectly, through the decrease in the flow of sensible heat from colder surfaces, and directly, through evaporative cooling promoted by plant transpiration. Several studies in the area corroborate the hypothesis that the scarcity of vegetation cover in cities is associated with the increase in air temperature during the day. On the other hand, large-scale afforestation initiatives have the potential to mitigate daytime district heating (ERELL *et al*., 2010).

In the wooded area, there is a reduction in air temperature and an increase in relative humidity in the wooded area, possibly associated with a higher density of vegetation cover. However, an inversion of this pattern is observed at 2 pm, with an increase in temperature and a decrease in relative humidity. Such variation indicates that, although vegetated, the area is inserted in the urban fabric, being influenced by anthropic factors such as paving, adjacent buildings and changes in land use and occupation. These elements contribute to the modification of the local microclimate, evidencing the complex interaction between the natural environment and urban dynamics (Figure 3).

Gonçalves and Paiva (2004) state that the excess of asphalt and cement, together with the impermeabilization of the soil, cause excess heat to occur in certain urban environments. Therefore, the high temperature will come from the direct incidence of the sun's rays on these elements and the degree of absorption, retention and reflection of this heat in these structures.

Figure 3

Graph referring to the measurements of air temperature and humidity in September 2017



*Blue and orange lines refer to point 1; Green and yellow lines refer to point 2.
Source: authors, 2018.

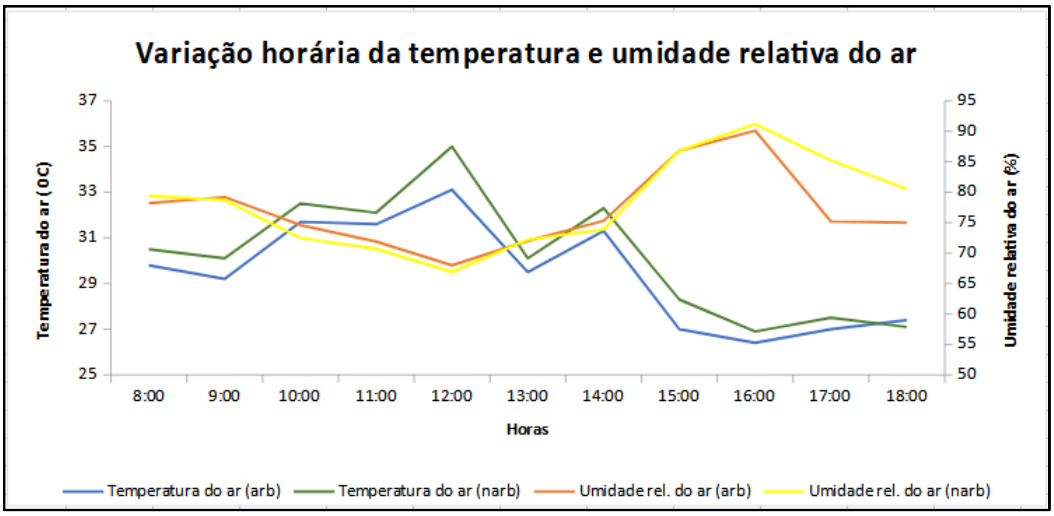
The insolation received in a given place on the Earth's surface can vary, and one of the factors responsible for this variation is cloudiness (SILVA, 2011). Because clouds cause a variation in the intensity of solar radiation incident on the surface, and because of this variation in radiation the variability of radiation incident in a region is explained (BASTOS *et al*., 2002). In addition, only part of the solar radiation reaches the Earth's surface, due to atmospheric transmissivity (PEREIRA; OLIVEIRA, 2011).

In certain periods, the air temperature in the wooded area (blue line) presented values higher than those of the non-wooded area (green line), which contradicts the expected trend. This anomaly can be explained by the presence of cloud cover over the non-wooded area, which reduced the incidence of solar radiation and, consequently, the local temperature. It is also considered that the month of October marks the beginning of the rainy season in the region (Figure 4), which may have caused specific microclimatic variations and interfered with the results obtained.

The intensity of solar radiation that reaches a horizontal surface is variable, due to the attenuation suffered when crossing the atmosphere, due to the presence of clouds, dust, pollution and others. Naturally, on a cloudy day, the intensity of solar radiation will be lower and, consequently, the performance of the module will be impaired. The opposite occurs on a clear day or with cloudless skies (MARQUES; PEAR TREE; ASSIS, 2000).

Figure 4

Graph referring to air temperature and humidity measurements in October 2017



*Blue and orange lines refer to point 1; Green and yellow lines refer to point 2.
Source: authors, 2018.

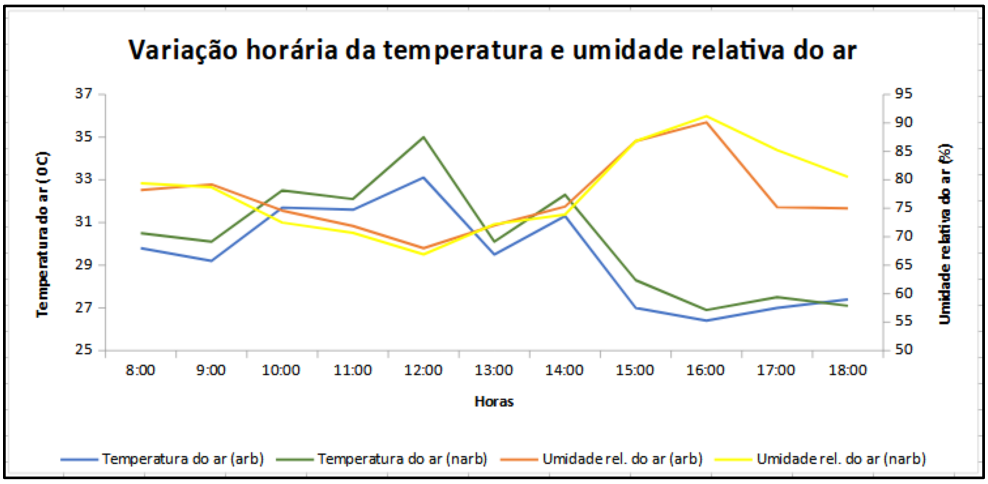
It was observed in the period of November and December that the air temperature in the wooded place (area 1) compared to the non-wooded one (area 2), was of greater divergence from early morning until noon, where we see a higher concentration of heat. A sharp increase in temperature was observed in area 1, varying up to 2 ºC degrees of difference until the beginning of rainfall in both areas. From 1 pm on, the rain began causing the heat to be controlled and dissipated in area 1, reaching close to the air temperature value of area 2, of 0.5ºC degrees, as shown in figure 5.

During the rainy season, there is a predominance of precipitation and intense cloud cover throughout the area, which results in reduced levels of solar irradiation. In contrast, in the dry season or with lower rainfall, there is an increase in the incidence of solar radiation, favored by the decrease in cloudiness and the less frequent occurrence of rainfall, which causes a difference between the first hours of the day and the peak, around noon (FERREIRA *et al*, 2023).

The influence that vegetation exerts on the climate is often addressed in several studies, although the evaluation of the parameters involved still represents a complex challenge. The energy exchanges between vegetation and the atmosphere — carried out through the radiation balance (Rn) and the fluxes of sensible (H) and latent (LE) heat — are fundamental to understand environmental dynamics. These components reflect physical processes that occur both on a local and global scale (FERREIRA *et al*, 2023).

Figure 5

Graph referring to air temperature and humidity measurements in November 2017



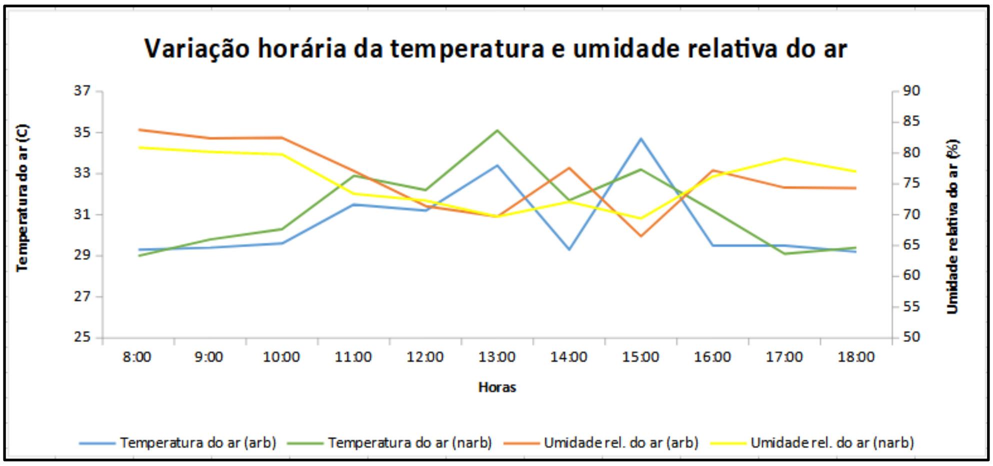
*Blue and orange lines refer to point 1; Green and yellow lines refer to point 2.
Source: authors, 2018.

As for the temperature measured in degrees Celsius (°C), in area 2, the well-wooded region with medium and large trees had an average temperature of 30.4ºC, while in area 1, devoid and with little trees, it had an average temperature of 31.2°C in December. For the air temperature, it is noted that the area with trees remained below the non-trees. The values referring to the relative humidity of the air, area 1, presented an average of 76.0%, area 2, average humidity is 62.2%. The values related to the measurements of temperature and relative humidity can be seen in figure 6.

Wooded areas tend to have higher levels of relative humidity, especially after the leaf regrowth period, when temperatures are higher and there is a higher incidence of rainfall (GOTARDO *et al., 2019). In these environments, the water accumulated in the leaves favors direct evaporation, contributing to the increase of local humidity. In contrast, regions that are poorly wooded or devoid of vegetation do not offer the same support for water retention, which can result in a drier and less stable microclimate.*

Figure 6

Graph referring to air temperature and humidity measurements in December 2017



*Blue and orange lines refer to point 1; Green and yellow lines refer to point 2.
Source: authors, 2018.

4 CONCLUSION

The results obtained demonstrate that the presence of vegetation in urban environments exerts a direct influence on the regulation of the microclimate, especially in the reduction of air temperature and in the increase of relative humidity. Wooded areas have a greater capacity to retain water in the leaves and promote evaporative cooling through plant transpiration, which contributes to the mitigation of heat. However, occasional variations, such as the increase in temperature at specific times, indicate that urban factors — such as paving, buildings, and land use — also significantly interfere with thermal dynamics, even in places with vegetation cover.

In addition, the distribution of solar radiation is affected by atmospheric elements such as cloudiness, pollution, and humidity, which alter the intensity of the irradiance received. The comparison between wooded and non-wooded areas shows that vegetation acts as a climate moderator, reducing the impacts of urban warming. Therefore, planned afforestation strategies are essential to mitigate the effects of heat islands, improve thermal comfort, and promote greater environmental balance in cities.

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