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Mapping of Urban Heat Islands in the Urban Conurbation of Cuiabá – Várzea Grande/MT by Remote Sensing

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Mapeamento de Ilhas de Calor Urbanas na Conurbação Urbana de Cuiabá – Várzea Grande/MT por Sensoriamento Remoto

RESUMO

Objetivo – O processo de urbanização tem provocado mudanças significativas na cobertura vegetal e, como consequência, na temperatura da superfície terrestre, resultando em anomalias térmicas caracterizadas pela formação de ilhas de calor de superfície. Dessa forma, o objetivo deste estudo foi investigar a correlação entre a expansão urbana a partir do Índice de Vegetação de Diferença Normalizada (NDVI), a Temperatura da Superfície Terrestre (LST) e as Ilhas de Calor Urbanas Superficiais (SUHI) nas cidades de Cuiabá e Várzea Grande, Mato Grosso, Brasil, comparando os períodos de 2016 e 2024.

Metodologia - A metodologia adotada consistiu na análise de imagens de satélite Landsat 8, em três etapas: (1) coleta e exportação de imagens; (2) processamento dos dados para geração do NDVI, LST e SUHI; e (3) elaboração dos mapas.

Originalidade/relevância - O estudo aborda uma lacuna teórica em pesquisas sobre ilhas de calor urbanas no Centro-Oeste brasileiro, revelando as implicações ambientais e urbanas do rápido crescimento dessas cidades por meio de diferentes métodos de sensoriamento remoto.

Resultados - Os resultados indicaram um aumento das temperaturas nas áreas urbanas, associado à expansão de superfícies impermeáveis e à redução da cobertura vegetal. Observou-se uma maior amplitude térmica no período seco e uma correlação inversa entre o NDVI e as SUHIs, especialmente no período úmido, indicando a vegetação como mitigadora das ilhas de calor.

Contribuições teóricas/metodológicas - O estudo contribui para a análise das ilhas de calor no Centro-Oeste brasileiro, correlacionando NDVI e SUHI, além de integrar sensoriamento remoto para analisar urbanização e as mudanças térmicas sazonais em cidades tropicais.

Contribuições sociais e ambientais - Evidencia-se que a preservação da vegetação urbana é fundamental para atenuar os efeitos das ilhas de calor, sendo essencial considerar esses indicadores na gestão urbana de cidades médias em expansão, situadas em clima tropical.

PALAVRAS-CHAVE: Mato Grosso. Urbanização. Sensoriamento remoto. Cidades médias. Clima tropical.

Mapping of Urban Heat Islands in the Urban Conurbation of Cuiabá – Várzea Grande/MT by Remote Sensing

ABSTRACT

Objective – The urbanization process has caused significant changes in vegetation cover and, as a consequence, in the temperature of the Earth's surface, resulting in thermal anomalies characterized by the formation of surface heat islands. Thus, the objective of this study was to investigate the correlation between urban expansion based on the Normalized Difference Vegetation Index (NDVI), Land Surface Temperature (LST) and Surface Urban Heat Islands (SUHI) in the cities of Cuiabá and Várzea Grande, Mato Grosso, Brazil, comparing the periods of 2016 and 2024.

Methodology – The methodology adopted consisted of analyzing Landsat 8 satellite images in three stages: (1) collecting and exporting images; (2) processing the data to generate NDVI, LST and SUHI; and (3) preparing the maps.

Originality/Relevance – The study addresses a theoretical gap in research on urban heat islands in the Brazilian Midwest, revealing the environmental and urban implications of the rapid growth of these cities through different remote sensing methods.

Results – The results indicated an increase in temperatures in urban areas, associated with the expansion of impervious surfaces and the reduction of vegetation cover. A greater thermal amplitude was observed in the dry period and an inverse correlation between NDVI and SUHIs, especially in the wet period, indicating vegetation as a mitigator of heat islands.

Theoretical/Methodological Contributions – The study contributes to the analysis of heat islands in the Brazilian Midwest, correlating NDVI and SUHI, in addition to integrating remote sensing to analyze urbanization and seasonal thermal changes in tropical cities.

Social and Environmental Contributions – It is clear that preserving urban vegetation is essential to mitigate the effects of heat islands, and it is essential to consider these indicators in the urban management of expanding medium-sized cities located in a tropical climate.

KEYWORDS: Mato Grosso. Urbanization. Remote sensing. Medium-sized cities. Tropical climate.

Mapeo de Islas de Calor Urbano en la Conurbación Urbana de Cuiabá – Várzea Grande/MT por Teledetección

RESUMEN

Objetivo – El proceso de urbanización ha provocado cambios significativos en la cobertura vegetal y, como consecuencia, en la temperatura de la superficie terrestre, dando lugar a anomalías térmicas caracterizadas por la formación de islas de calor superficiales. Por lo tanto, el objetivo de este estudio fue investigar la correlación entre la expansión urbana con base en el Índice de Diferencia Normalizada de Vegetación (NDVI), la Temperatura Superficial del Terreno (LST) y las Islas de Calor Urbanas Superficiales (SUHI) en las ciudades de Cuiabá y Várzea Grande, Mato Grosso, Brasil, comparando los períodos de 2016 y 2024.

Metodología – La metodología adoptada consistió en el análisis de imágenes del satélite Landsat 8, en tres etapas: (1) recolección y exportación de imágenes; (2) procesamiento de datos para generar NDVI, LST y SUHI; y (3) preparación de mapas.

Originalidad/Relevancia – El estudio aborda un vacío teórico en la investigación sobre islas de calor urbanas en el Medio Oeste brasileño, revelando las implicaciones ambientales y urbanas del rápido crecimiento de estas ciudades a través de diferentes métodos de teledetección.

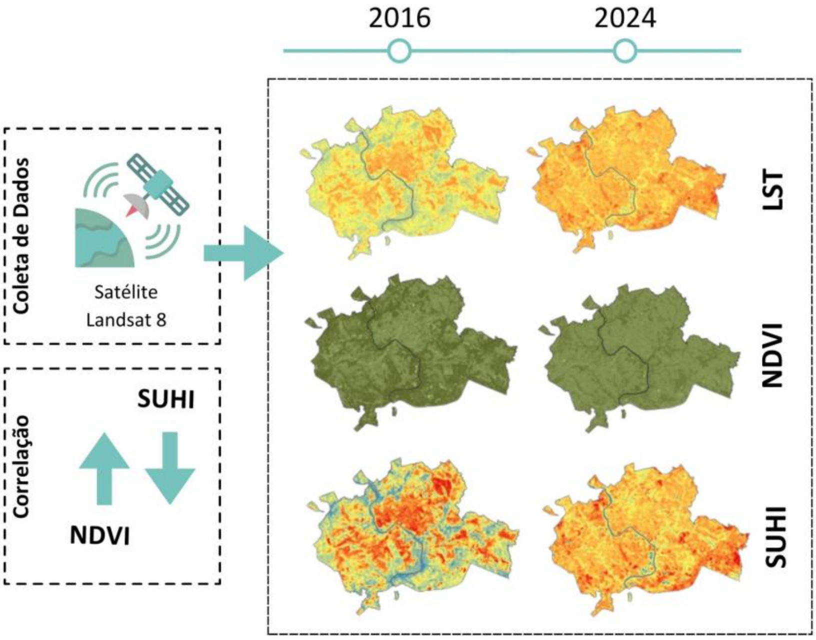
Resultados – Los resultados indicaron un aumento de las temperaturas en las zonas urbanas, asociado a la expansión de superficies impermeables y una reducción de la cobertura vegetal. Se observó una mayor amplitud térmica en el período seco y una correlación inversa entre NDVI y SUHI, especialmente en el período húmedo, lo que indica la vegetación como un mitigador de islas de calor.

Contribuciones Teóricas/Metodológicas – El estudio contribuye al análisis de islas de calor en el Centro-Oeste brasileño, correlacionando NDVI y SUHI, además de integrar teledetección para analizar la urbanización y los cambios térmicos estacionales en ciudades tropicales.

Contribuciones Sociales y Ambientales – Es evidente que la preservación de la vegetación urbana es fundamental para mitigar los efectos de las islas de calor, y es fundamental considerar estos indicadores en la gestión urbana de ciudades de tamaño mediano en expansión, ubicadas en un clima tropical.

PALABRAS CLAVE: Mato Grosso. Urbanización. Teledetección. Ciudades medianas. Clima tropical.

GRAPHICAL ABSTRACT



1 INTRODUCTION

The UN (2022) reports that by 2050 the urban population is expected to grow from 5.6 to 9.7 billion, with 70% of the world's population concentrated in urban areas. With the expansion of cities, the natural landscape is substantially modified by the large concentration of houses, industrial facilities, population density and asphalt paving, which, in turn, create conditions to alter the behavior of urban ecosystems (Rosenzweig *et al*., 2015; IPCC, 2007).

In Brazil, 87% of the population already lives in urban areas, with the majority living in medium-sized cities with populations between 250,000 and 700,000 inhabitants. This is the case of Cuiabá and Várzea Grande, in the state of Mato Grosso, with a population of 650,877 inhabitants and a population density of 150.1 inhabitants/km², and 300,078 inhabitants and a population density of 414.31 inhabitants/km², respectively (IBGE, 2022). In this way, urbanization transforms land cover, influencing spectral behavior when the Earth's surface is assessed. From this, it is possible to analyze and correlate changes in land cover with the Earth's surface temperature, using indirect data collection methods, with emphasis on remote sensing (Sharma; Ghosh; Joshi, 2013).

Remote Sensing (RS) has been widely used in urban areas for various purposes, such as heat island assessment, land cover classification, and generation of data for energy balance models between the atmosphere and the urban surface. Since the growth of cities causes changes in the spectral behavior of land cover, these changes can be characterized by means of spectral indices obtained by RS. The NDVI spectral index is widely adopted in vegetation studies, and can also be used to calculate the brightness temperature to characterize the heat island (Siqueira, 2019). Recent studies have been evaluating the correlation of the Normalized Difference Vegetation Index (NDVI) with Land Surface Temperature (LST) (Guha; Govil, 2022; Ullah *et al.*, 2023; Aghazadeh *et al.*, 2023).

NDVI is an index used to measure the density and health of vegetation, while LST is a physical parameter related to heat flow, determined by the energy absorbed and released by a material. The study by Garai *et al.* (2022) demonstrated that vegetation growth is related to surface temperature and precipitation, where vegetation plays an important microclimatic role for milder temperatures, reinforcing the prioritization of strategies to promote green areas with native vegetation in urban areas. In a similar study, images from the Landsat 8 satellite (TIRS) were extracted and processed to assess the correlation of NDVI, LST, and land use and land cover (LULC), as assessed by Ullah *et al.* (2023). The authors observed that impervious surfaces have higher LST compared to permeable surfaces, with this behavior being influenced by factors such as the cooling effect of evapotranspiration, surface roughness, albedo, and solar radiation. Furthermore, the correlation results between NDVI and LST indicated a strong negative statistical relationship in vegetated areas and a moderate correlation in bare land or built-up areas, which increases proportionally with surface moisture, according to seasonality.

Another important aspect that can be assessed is the impact of surface urban heat islands (SUHI) during the day and night, relating them to NDVI, urban soil and atmospheric pollutants. SUHIs are thermal anomalies resulting from different absorption and storage of solar energy through materials, whether artificial or natural. According to the study by Aghazadeh *et al.* (2023), during the day, there is a direct correlation between SUHI, land use, vegetation and pollutants in densely industrialized and populated areas over time. At night, all types of land use have a direct correlation with heat islands, with PM2.5 and PM10 pollutants having the highest correlations in all periods of the day. The comparison between SUHI and NDVI revealed an inverse correlation both during the day and at night. Thus, we can conclude that remote sensing and geospatial techniques have established themselves as important tools for urban analysis, allowing the efficient monitoring of complex phenomena such as heat islands and the evaluation of environmental indicators, such as NDVI.

Despite the existing scientific contributions on NDVI, LST and SUHI at a global level, there is a lack of studies focused on the Central-West region of Brazil. This absence is particularly evident in medium-sized cities, such as Cuiabá and Várzea Grande, which are the most populous in the state of Mato Grosso. Várzea Grande, in particular, stands out for having the highest population density, which intensifies environmental and urban challenges. Thus, the study seeks to evaluate the correlations between these indicators in the space-time interval from 2016 to 2024, considering the dry (winter) and wet (summer) periods, with the objective of identifying the changes that occurred over this period. A deeper understanding of the evolution of SUHI over the analyzed period can support public administrations and urban planners in decision-making. These decisions would aim at the implementation of measures that mitigate the impacts of phenomena that alter the urban climate, such as Urban Heat Islands.

2 METHODOLOGY

The research method was structured in three main phases. In Phase 1, data was collected from the Landsat 8 satellite, with the export of raster images of the urban conurbation region of Cuiabá and Várzea Grande, MT. In Phase 2, the images were processed for analysis of Land Surface Temperature (LST), Normalized Difference Vegetation Index (NDVI) and Surface Urban Heat Islands (SUHI). In Phase 3, the processed data were used to create maps and analyze the influencing variables.

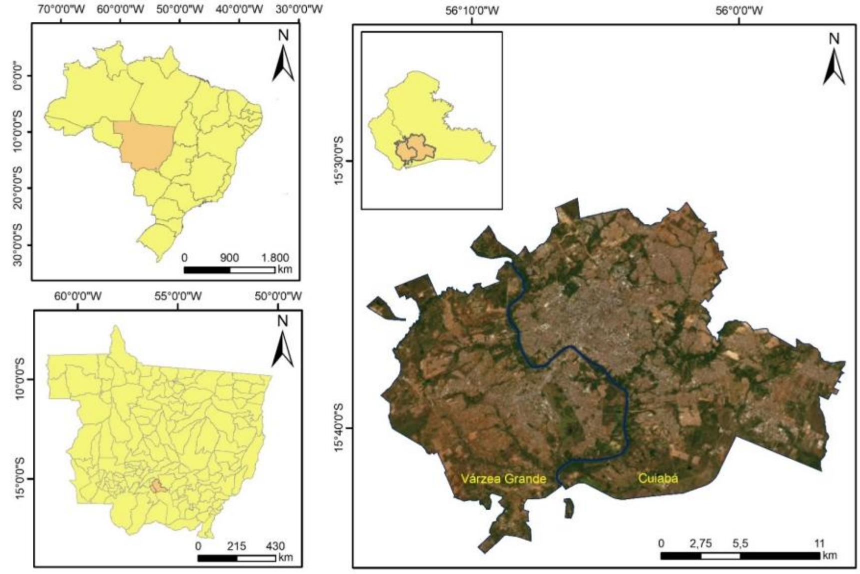
2.1 Study Area

The study area covers the urban perimeter of the conurbation of Cuiabá and Várzea Grande, located in the state of Mato Grosso, Brazil, and is part of the Metropolitan Region of the Cuiabá River Valley-RMVRC, established by Complementary Law No. 359 of 2009 and modified by Complementary Law 796 of 2024, composed of seven municipalities: Cuiabá, Várzea Grande, Campo Verde, Nossa Senhora do Livramento, Santo Antônio de Leverger, Acorizal and Chapada dos Guimarães.

The urban conurbation of Cuiabá and Várzea Grande, located in the south-central portion of the state of Mato Grosso, in the Midwest region of Brazil, is marked by the Cuiabá

River, which serves as a natural boundary between the two municipalities. Integration between them is facilitated by bridges that connect the banks, promoting greater fluidity in travel (Figure 1).

Figure 1 – Location of the urban conurbation of Cuiabá and Várzea Grande in the state of Mato Grosso, Brazil.



Source: prepared by the authors, 2024

Cuiabá and Várzea Grande are the two largest cities in the state of Mato Grosso, with populations of 650,877 and 300,078 inhabitants, respectively, according to the demographic census of the Brazilian Institute of Geography and Statistics (IBGE, 2022). Population growth, accompanied by a significant increase in the urbanization rate, was most pronounced in the 1970s and 1980s. During this period, Cuiabá doubled its population, while Várzea Grande quadrupled its number of inhabitants (Alves; Silva, 2023).

Although Várzea Grande has a smaller population compared to Cuiabá, it has a significantly higher population density, with 414.31 inhab./km² in an urbanized area of 86.24 km². On the other hand, Cuiabá has a larger urbanized area, of 126.9 km², but with a considerably lower population density, of 160.59 inhab./km² (IBGE, 2022). Considering the demographic changes in the period investigated, the comparison between the IBGE demographic censuses indicates an approximate increase of 17% for Cuiabá and 15% for Várzea Grande.

Cuiabá, the capital of the state of Mato Grosso, is known for its harsh climate and is often mentioned as the hottest city in Brazil (G1, 2024). According to the Köppen climate classification (Beck *et al.*, 2018), the study area has a semi-humid tropical climate (Aw), characterized by a hot and dry period (winter) from May to September and a hot and humid period (summer) from November to April. In Cuiabá and Várzea Grande, the average monthly temperature is 26.26 °C, the precipitation is 116.5 mm, and the solar radiation is 590.18 W/m². The predominant vegetation in the region is typical of the Cerrado, according to data from the Ministry of Mines and Energy (MME, 2024).

Both municipalities have economies focused on modern secondary and tertiary sectors, with several large companies. According to the IBGE, Cuiabá has a Gross domestic product (GDP) per capita of R$47,700.88 and a municipal Human Development Index (IDHM) of 0.785. Várzea Grande has a GDP per capita of R$34,151.42 and an IDHM of 0.734.

2.2 Data Collection

For the study, only cloud-free images in the urban perimeter of the analyzed municipalities were considered. Images from the hot-dry (winter) and hot-humid (summer) periods of 2016 and 2024 were extracted, with the aim of comparing the periods, as well as the effects of the urbanization process on urban vegetation and the temperature of the Earth's surface. Because the Landsat 8 satellite is recent, launched in 2013, and is the only one with free access to thermal bands, it was only in 2016 that it was possible to obtain raster images with the necessary parameters for the winter and summer periods. Thus, it became feasible to perform a comparative analysis with the most recent data available, from 2024. To obtain the images, the Landsat 8 satellite was used, with a spatial resolution of 30 meters. Images with proximity of 15 days for the same winter and summer periods were selected, as shown in Table 1.

Table 1 - Information about the 4 Landsat 8 images used in this study.

Landsat 8 data	Southern Hemisphere Station
April 19, 2016	Summer
September 10, 2016	Winter
April 25, 2024	Summer
August 31, 2024	Winter

Source: prepared by the authors, 2024

2.3 Normalized Difference Vegetation Index (NDVI)

The data used to calculate the NDVI were extracted from the Near Infrared (NIR) band and the Red (RED) band, corresponding, respectively, to bands 5 and 4 of the Landsat 8 OLI/TIRLS satellite from collection 2, level 2. The calculation followed Equation 1 (Sabrino *et al.*, 2004):

$$NDVI = \frac{NIR - R}{NIR + R} \quad (1)$$

NDVI values range from -1.0 to +1.0. Areas with dense vegetation, such as forests, tend to have high positive values, between 0.5 and 1.0. Sparse vegetation, such as grasses, have lower positive values, approximately between 0.2 and 0.5. Exposed soils have even lower values, generally between 0.1 and 0.2. Bodies of water exhibit negative values.

2.4 Land Surface Temperature (LST)

Temperature data were extracted from the Landsat 8 OLI/TIRS satellite, collection 2, level 2, using the primary digital number data obtained from thermal infrared band 10. However, since Landsat 8 does not provide surface emissivity calculations, it was necessary to use a land surface emissivity algorithm to estimate it based on NDVI, as described by Waleed and Sajjad

(2022). The first step in the process is to calculate the proportion of vegetation (Pv) from Equation 2.

$$Pv = (\frac{NDVI - NDVI_{MIN}}{NDVI_{MAX} - NDVI_{MIN}})^2 \quad (2)$$

From the result of the vegetation proportion (Pv), the emissivity (ε) was calculated, according to Equation 3:

$$\varepsilon = 0{,}004 * Pv + 0{,}986 \quad (3)$$

Before calculating the LST, it was necessary to convert the brightness temperature (T_B) to Kelvin (K), from Equation 5, where: Lλ corresponds to the spectral radiance; K_1 and K_2 are values extracted from the calibration constant of the satellite sensor, being 774.89 and 1321.08, respectively.

$$T_B = \frac{K_2}{ln\,(\frac{K_1}{L\lambda} + 1)} \quad (4)$$

The final calculation of the LST, in degrees Celsius (°C), was performed using Equation 5. The expression S_T is the Earth's Surface Temperature; T_B corresponds to the brightness temperature (in degrees Kelvin) extracted from band 10 of the Landsat 8 satellite; λ corresponds to the wavelength of the emitted radiance.; $\rho = 1{,}438 \times 10^{-2}$ mK.

$$S_T = \frac{T_B}{1 + (\frac{\lambda\, x\, T_B}{\rho})\, ln\, \varepsilon} - 273{,}15 \quad (5)$$

2.4 Surface Urban Heat Islands (SUSHI)

According to the literature (Naikoo, 2024; Ma; Peng, 2022), SUHIs are directly related to land use and land cover, as well as the presence of vegetation cover, showing the intensity of heat stress in geographic areas, and can be calculated independently in urban and rural areas (Faisal *et al.*, 2021). To compare SUHIs by the variations observed in LST, a normalized method was used that allows analysis in different seasons of the year. This calculation was performed using Equation 6:

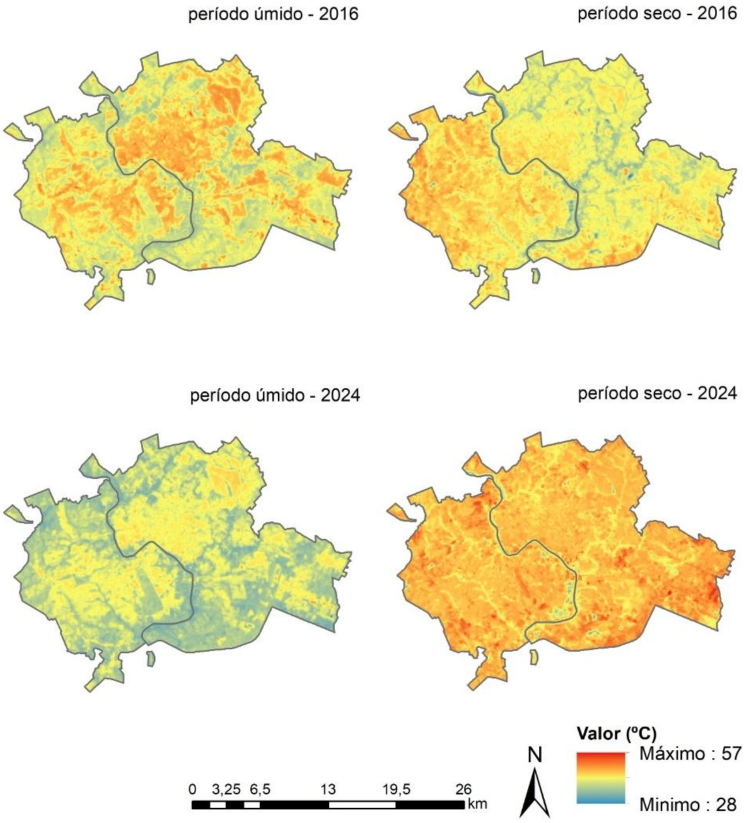
$$SUHI_N = \frac{T_S - T_M}{T_{Std}} \quad (6)$$

Where SUHIN is the normalized SUHI; T_s is the LST; T_M is the mean LST of the study area; and T_{std} is the standard deviation of the LST of the study area.

3 RESULTS AND DISCUSSION

In general, during the wet season, the average surface temperature is lower compared to the dry season. This behavior is expected due to the higher relative humidity, greater cloud cover and lower incidence of direct solar radiation (Souza, 2016). During the dry season of the two years analyzed, an intensification of the heating areas is observed, especially in areas of greater urban density and exposed soils, resulting in higher surface temperatures, reaching approximately 57 ºC, as shown in Figure 2.

Figure 2 – Surface Temperature (LST) in the urban conurbation of Cuiabá and Várzea Grande-MT



Source: prepared by the authors, 2024

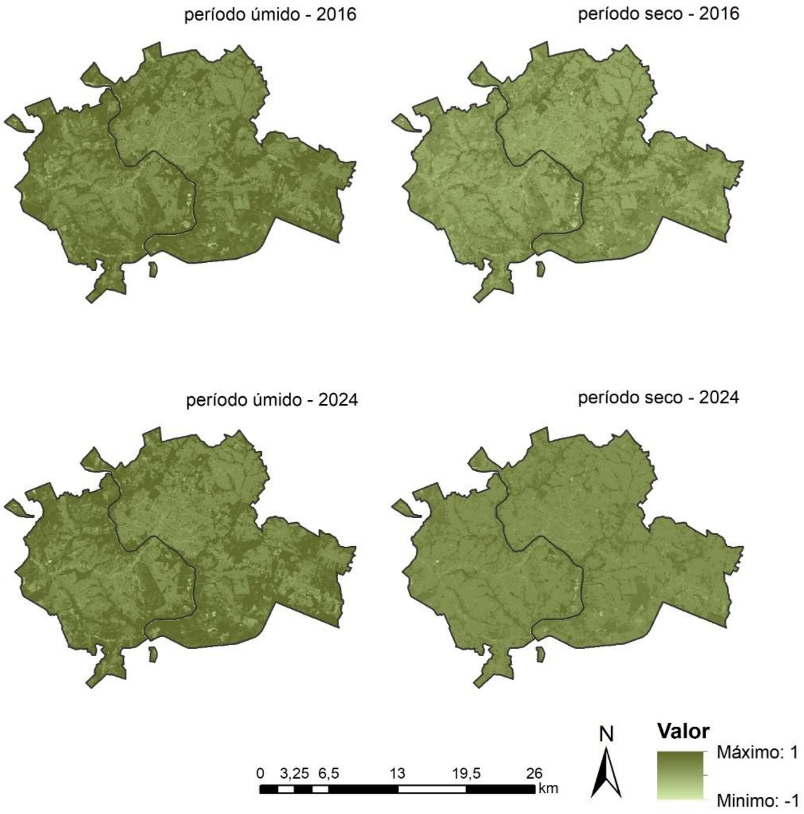
In the hot-dry period, there is an increase in exposed soil coverage, due to the absence of precipitation events, increasing urban heating, as exposed soil has lower thermal conductivity, which results in higher temperatures during the day (Silva *et al.* 2018).

Regarding the surface temperature range between periods and years, it is stated that the variation in dry periods was 29 and 26 ºC in the years 2016 and 2024, respectively. In wet periods it was 22 and 24 ºC in the years 2016 and 2024, respectively. The warmest parts of the city of Cuiabá were the western and northern portions in 2016, while in 2024 it was the southern portion. Evaluating the city of Várzea Grande, the warmest part was the northern portion in 2016, while in 2024 it presented a more distributed warming across its territory.

The temporal variation in surface temperature between 2016 and 2024 indicates the various changes in land cover that occurred during this period. The expansion of areas with higher temperatures, especially during the dry season, can be associated with the increase in impervious surfaces, resulting from the urban expansion process. This phenomenon is similar to that observed by Ullah *et al.* (2023), who highlighted the correlation between urbanization, soil impermeability and the increase in surface temperatures in urban areas.

Considering the variation of NDVI, a greater variation is observed in wet periods, with values between -0.95 and 0.99 in 2016 and between -0.98 and 0.99 in 2024, Figure 3. This greater variation is associated with favorable climatic conditions in this period, such as greater water availability and milder air temperatures compared to the dry period. Such conditions promote vegetative growth, increased leaf biomass and vegetation density (Santos *et al.*, 2023).

Figure 3 – Normalized Difference Vegetation Index (NDVI) in the urban conurbation of Cuiabá and Várzea Grande – MT.



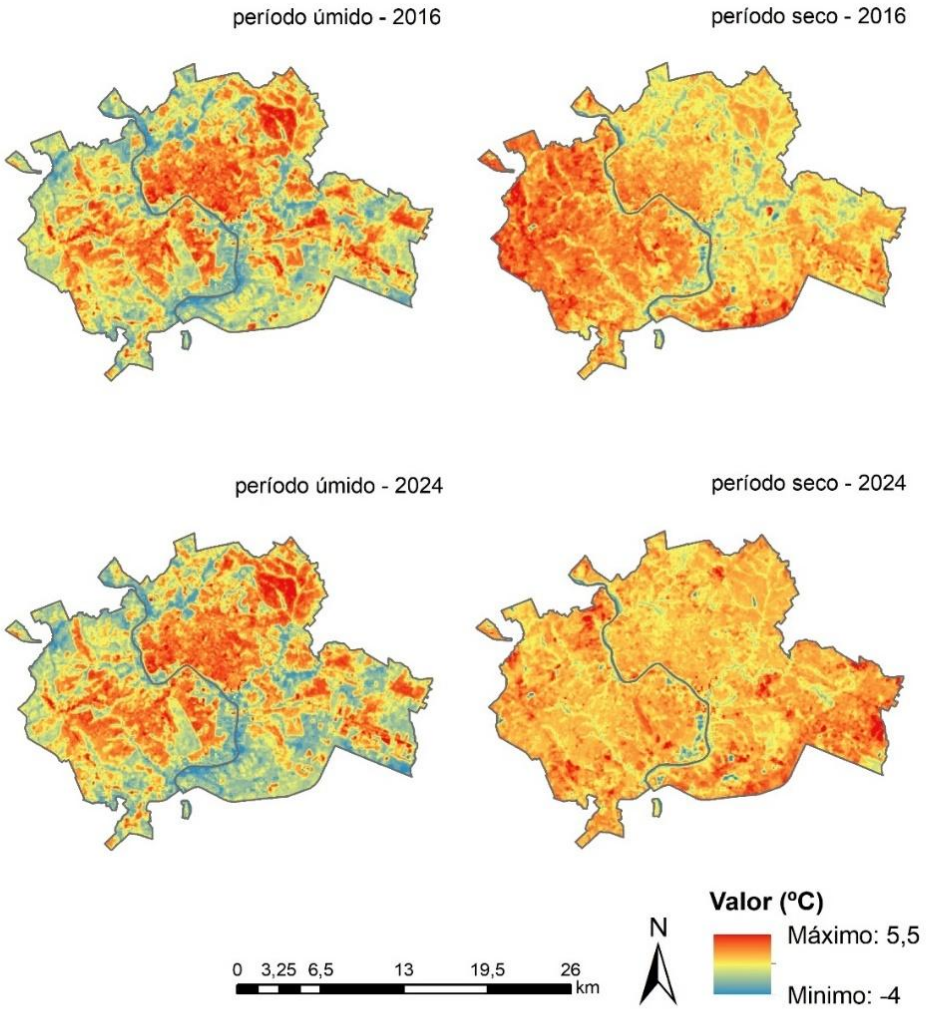
Source: prepared by the authors, 2024

Regarding the spatialization of NDVI, there is greater vegetative coverage near watercourses, especially in the city of Cuiabá. The presence of these watercourses reduces water deficit and favors the development of vegetation, contributing to higher NDVI values in these areas.

Correlating surface temperature (Figure 2) and NDVI (Figure 3), it can be seen that the difference between wet and dry periods highlights the importance of vegetation cover and soil moisture for urban thermal improvement. In the dry period, the reduction in areas with higher NDVI contributed to more intense urban heating. Between 2016 and 2024, Cuiabá recorded a population increase of approximately 17%, while Várzea Grande showed growth of approximately 15%, which also influences the reduction in vegetation cover, increase in areas of impermeable surfaces and, consequently, urban heating (Zhang *et al.*, 2013).

Observing the distribution of SUHI in relation to the periods and years analyzed, it can be seen that in 2016 there was a greater amplitude in the wet period (6.36 ºC), while in 2024 there was a greater amplitude in the dry period (6.12 ºC) (Figure 4).

Figure 4 – Surface Urban Heat Islands (SUHI) in the urban conurbation of Cuiabá and Várzea Grande-MT



Source: prepared by the authors, 2024

Considering that SUHI is data from the difference between the highest and lowest LST values, in the case of the wet period of 2016, the maximum SUHI values come precisely from the high variation of LST found.

The analysis of the spatialization of SUHIs reveals distinct patterns in Cuiabá and Várzea Grande. In Cuiabá, in 2016 and 2024, during the wet season, warming was more pronounced in the north and west regions, while during the dry season, warming was concentrated in the south region. In Várzea Grande, the greatest warming occurs in the north and east regions in the dry and wet seasons. It is worth noting that Várzea Grande has a high population density, with 414 inhabitants/km2, and the population density and, consequently, urban densification, causes an increase in anthropogenic heat and results in an increase in SUHI (Freitas; Azerêdo, 2020). The north and east regions of Várzea Grande correspond to the areas of oldest urbanization, characterized by a higher population density due to their proximity and easy access to the axes connecting the conurbation with Cuiabá.

There was an incidence of superficial urban heat islands (positive SUHI values) and superficial coolness islands (negative values), phenomena related to urban density and vegetation cover. However, in the dry season there is a greater coverage of areas with positive SUHI values, that is, with established urban heating. Regarding the presence of vegetation as a mitigating agent for phenomena such as superficial urban heat islands, it was observed that NDVI presents a greater Pearson correlation with SUHI in the wet season (-0.578) than in the dry season (-0.306). This result reinforces the role of vegetation in reducing urban heating, highlighting that its effectiveness is directly related to the tree density present in the area (Pinheiro *et al.*, 2023).

4 CONCLUSION

The analysis of surface urban heat islands (SUHI) in Cuiabá and Várzea Grande reveals the significant influence of urbanization on the rise in surface temperatures, highlighting the importance of vegetation-based mitigation strategies. The inverse correlation between the Normalized Difference Vegetation Index (NDVI) and Land Surface Temperature (LST) indicates that areas with greater vegetation cover have lower temperatures, reinforcing the critical role of urban vegetation in thermal regulation.

This study used remote sensing and geospatial analysis to map SUHI and assess seasonal and spatial variation between 2016 and 2024. The expansion of urban areas and the reduction of green areas were associated with an increase in urban heat islands, especially during the dry season. The data suggest that the revision of master plans and, consequently, of municipal land use laws, should consider local environmental constraints. Therefore, the creation of environmentally protected zones, aimed at preserving the biome, maintaining green areas, protecting water resources, improving air quality and heat stress, are essential to mitigate the effects of SUHI and promote climate resilience in tropical cities.

This work contributes to the literature on urban climate change by providing evidence that vegetation acts as an effective mitigator of SUHI, proposing relevant insights for urban managers and policy makers in contexts of accelerated urban growth.

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DECLARAÇÕES

CONTRIBUIÇÃO DE CADA AUTOR

Ao descrever a participação de cada autor no manuscrito, utilize os seguintes critérios:

- **Concepção e Design do Estudo**: FFGP e NSS.
- **Curadoria de Dados**: FFGP.
- **Análise Formal**: FFGP e NSS
- **Aquisição de Financiamento**: sem financiamento.
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- **Supervisão**: FFGP e NSS.

DECLARAÇÃO DE CONFLITOS DE INTERESSE

Nós, **Fábio Friol Guedes de Paiva e Natallia Sanches e Souza**, declaramos que o manuscrito intitulado **Mapeamento de Ilhas de Calor Urbanas na Conurbação Urbana de Cuiabá – Várzea Grande/MT por Sensoriamento Remoto**:

1. **Vínculos Financeiros**: Não possui vínculos financeiros que possam influenciar os resultados ou interpretação do trabalho.
2. **Relações Profissionais**: Não possui relações profissionais que possam impactar na análise, interpretação ou apresentação dos resultados.
3. **Conflitos Pessoais**: Não possui conflitos de interesse pessoais relacionados ao conteúdo do manuscrito.