Revista Nacional de Gerenciamento de Cidades
National Journal of City Management

ISSN 2318-8472, v. 12, n. 85, 2024

Analysis of urbanization in the city of Barra do Bugres/MT based on the suppression of vegetated areas using remote sensing

Natallia Sanches e Souza
PhD, UNIVAG, Brazil
natallia@univag.edu.br

Diana Carolina Jesus de Paula
PhD, UNIVAG, Brazil.
Diana.paula@univag.edu.br

Keylyane Santos da Silva Alves
PhD, UFMT, Brazil.
keylyanesds@gmail.com

Jeane Aparecida Rombi de Godoy
PhD, UNIVAG, Brazil.
urbanista.jeane@gmail.com

ABSTRACT
With the advent of the implementation of the University of the State of Mato Grosso - UNEMAT in Barra do Bugres - MT, the city began to house the university population, resulting in the suppression of vegetated areas during its process of intense urbanization. Urbanization triggers changes in land use and land cover, thus generating impacts on the relationships between energy cycles on the surface. Thus, the general objective of this research was to analyze the urbanization of Barra do Bugres-MT from the space-time relationship of the surface temperature and the vegetation index (NDVI) through TM (Thematic Mappes) images from the Landsat 5 sensor in the years 1987 and 2010. Analyzing the surface temperature distribution, it was found that the highest values were concentrated in the north and east portions, more densely urbanized portions. The lowest NDVI values were found in the eastern portion, where there is greater urban density. However, the highest NDVI values were found in regions of the western portion, where despite the greater suppression of vegetated areas from 1987 to 2010, lower urban density and greater presence of native vegetation are observed. The use of remote sensing and NDVI proved to be a viable tool for analyzing the urbanization process in Barra do Bugres-MT between the years of study.

KEYWORDS: Urban climate. Landsat. Vegetation.

1 INTRODUCTION

The growth of cities is an inevitable process and will probably be irreversible, it is estimated that by 2030 more people will have left rural areas. The highest growth rates are in developed or developing countries. It is estimated that by mid-century the total urban population of these countries will more than double, rising from 2.5 billion in 2010 to 5.3 billion in 2050 (UN, 2023).

Rapid spatio-temporal changes in land use and cover in urban environments have major impacts on the relationships between energy cycles on the surface. The main factor that contributes to these changes in surface characteristics is the replacement of vegetation by artificial materials, such as asphalt and concrete (OLIVEIRA et al., 2013).

Due to the extent of urban areas and the difficulty of monitoring physical processes using in situ instruments, sensors installed on satellites provide quantitative data on physical space at spatial and temporal resolutions. The use of images through remote sensing constitutes an important tool for analyzing and studying climate change. In urban areas, they are mainly used in relation to land use and coverage, as they make it possible to estimate parameters such as surface temperature, surface albedo and vegetation indices (SANTANA et al. 2010; SOUZA et al. 2016).

Surface temperature is one of the main data that can be estimated from thermal band images. The relationship between surface temperature and vegetation density is a growing study in the field of remote sensing (XIAN & CRANE, 2006; WENG & LU, 2008).

The state of Mato Grosso had significant population growth in the 1970s, leading to an increase in studies on inferences of urbanization in the microclimate. In the municipality of Barra do Bugres, its economic base had a great influence on the urban scenario. With the installation of the State University of Mato Grosso – UNEMAT, the city began to house the university population and thus occupy the northwest portion of the city, resulting in changes in the urban environment such as removal of vegetation and use of urban materials (CARIGNANI et al ., 2008; SANTOS et. al., 2013).

GC Revista Nacional de Gerenciamento de Cidades
National Journal of City Management

ISSN 2318-8472, v. 12, n. 85, 2024

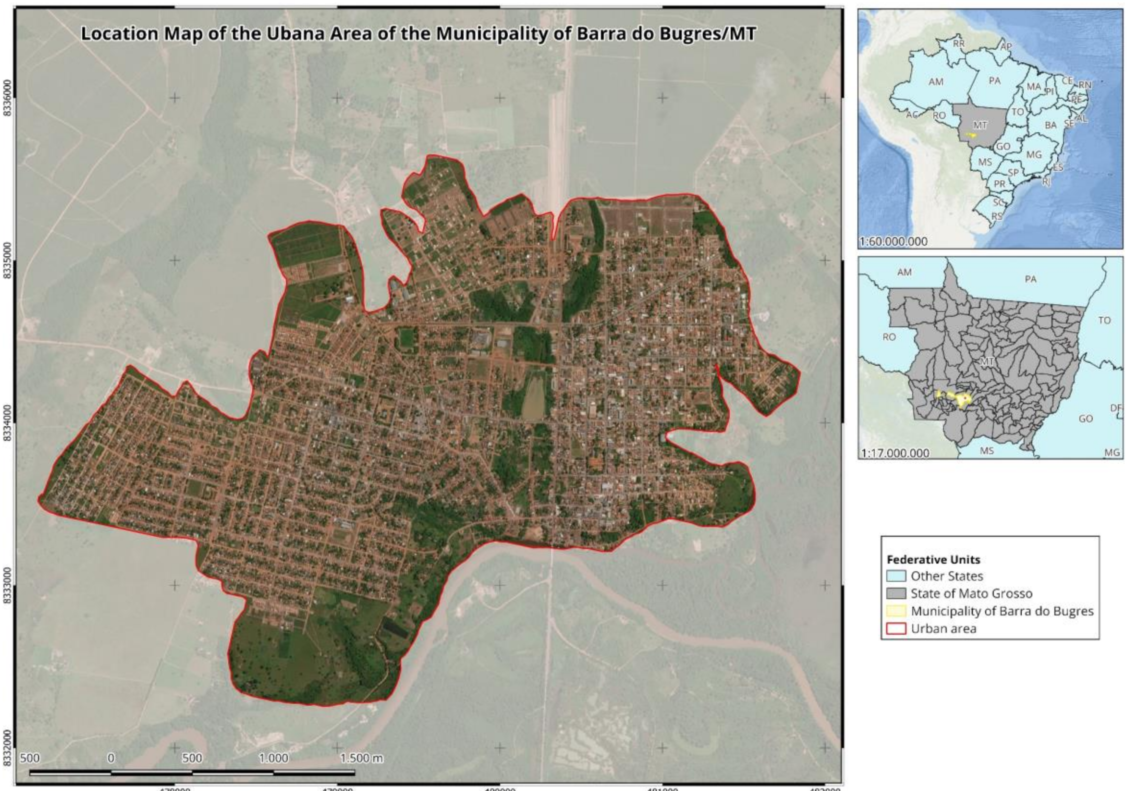
Therefore, the general objective of this research was to analyze the urbanization of Barra do Bugres-MT based on the spatio-temporal relationship of surface temperature with normalized vegetation index (NDVI) using TM (Thematic Mappes) images from the Landsat 5 sensor. in the years 1987 and 2010.

2 MATERIALS AND METHOD

2.1 Study area

The municipality of Barra do Bugres (figure 1), with coordinates of latitude 15°04'21" S and longitude 57°10'52" W, is located in the state of Mato Grosso, 160km away from the capital, Cuiabá (figure 1). The regional climate according to the Köppen classification is Aw, which represents a semi-humid tropical climate, with two well-defined seasons, a dry season (May-September) and a rainy season (November-April). Average annual temperatures range between 25°C and 26°C (SOUZA et al., 2015).

Figure 1 - Location of the urban area of Barra do Bugres, Mato Grosso, Brazil.



The municipality of Barra do Bugres has had several changes in its economic base over time, influencing the urban scenario considerably. With the opening of MT-343 in the 1970s, the city began to be divided in half, separating the center and the outskirts. After the implementation of a plant in 1980, with the industrialization of sugar cane, the city began to attract a large amount of labor and occupy the northern portion of the municipality, towards

ISSN 2318-8472, v. 12, n. 85, 2024

Tangará da Serra, whereas previously, the The largest urban concentration was on the banks of the Bugres river (BARRA DO BUGRES, 2018).

The city hall, which for several years was located on the riverbank, was transferred to the current city center in 1988, thus marking the occupation of the eastern portion of the municipality, intensified in 1994 with the installation of the UNEMAT university campus.

2.2 Satellite Images

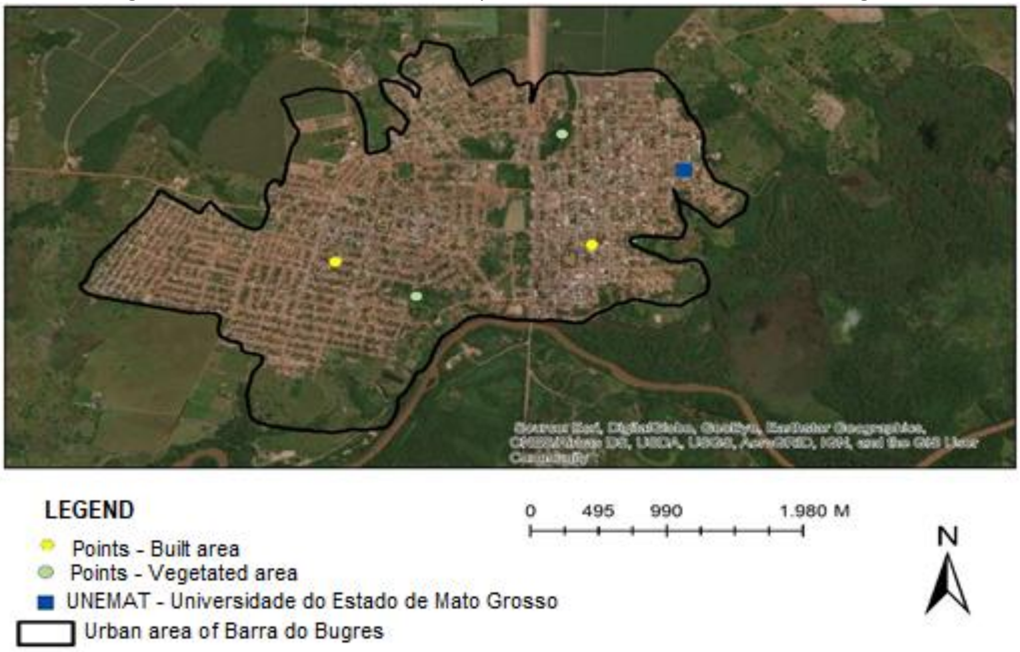
For the development of this study, images obtained from the Landsat 5 satellite (Land Remote Sensing Satellite), TM sensor (Thermatic Mapper), orbit 227, point 070, with spatial resolution of 120 m for bands 1, 2, 3, 4 were used. , 5 and 7, and 120 m for band 6, through the ESPA platform (https://espa.cr.usgs.gov/).

The images obtained were the Surface Temperature - ST and Normalized Difference Vegetation Index - NDVI obtained for Julian days 309/1987 (hot-humid period - HH), 213/1987 (hot-humid period dry - HD), 116/2010 (hot-humid period - HH), 164/2010 (hot-dry period - HD) of the urban area of the municipality of Barra do Bugres-MT.

2.3 Data Analysis

To analyze the variance of surface temperature and NDVI values in the hot-dry and hot-humid periods in the two years studied, ten points were empirically selected (figure 2).

Figure 2 – Location of data extraction points in the urban area of Barra do Bugres.



Five points represent built area and five points represent vegetated area, with coordinates in UTM according to table 1.

GC Revista Nacional de Gerenciamento de Cidades
National Journal of City Management

ISSN 2318-8472, v. 12, n. 85, 2024

Table 1 - UTM coordinates of the points studied.

Point	Longitude	Latitude	Soil cover
1	480180	8334462	vegetated area
2	480503	8334806	vegetated area
3	480035	8334657	vegetated area
4	481423	8334131	vegetated area
5	479099	8332544	vegetated area
6	478989	8334004	built area
7	480862	8334333	built area
8	480658	8333552	built area
9	478455	8333718	built area
10	481162	8334727	built area

In order to improve the classification in the NDVI and TS maps, the Sturges rule was used. This method was chosen due to its suitability for the most varied sample sizes. However, it has the purpose of determining the number of classes and the interval in each one (SPIEGEL, 1993).

Using the surface temperature and NDVI values obtained at the points, boxplot graphs were created, thus presenting the amplitudes and differences between soil covers and periods. As well as the graph of the relationship between NDVI and surface temperature together with Pearson correlation statistical analysis (p-value <0.001).

3 RESULTS / DISCUSSIONS

It was possible to observe that in both classes, that is, vegetated area and built area, the NDVI remained at higher values in the hot-humid period, as shown in Table 2.

Table 2 – NDVI and TS values related to the hot-dry (HD) and hot-humid (HH) periods between the study years according to soil cover.

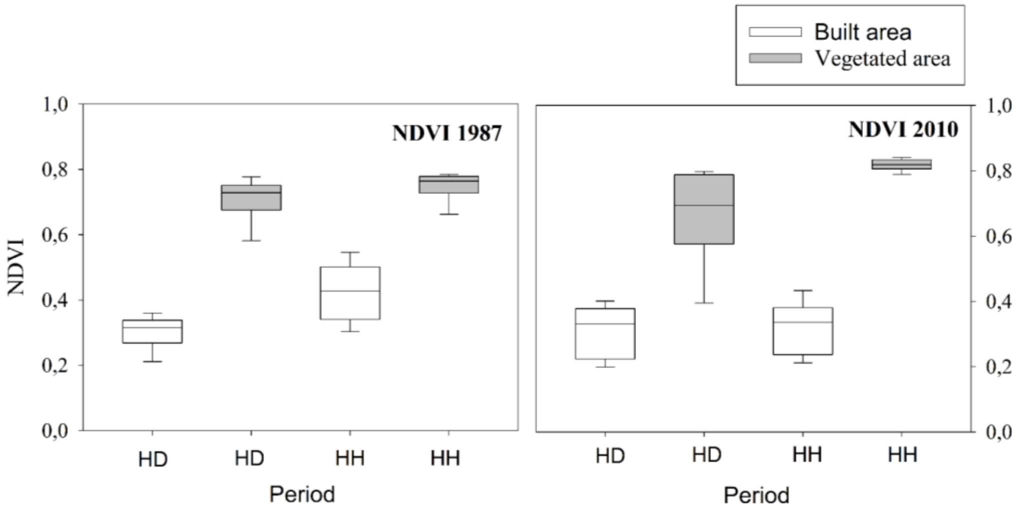
Year	Period	Soil cover	NDVI	ST
1987	Whole year	Total	0,52±0,08	22,7±0,6
1987	HH	Built area	0,41±0,04	23,6±0,5
1987	HH	Vegetated area	0,68±0,08	22,3±0,7
1987	HH - Total	-	0,55±0,09	23,0±0,6
1987	HD	Built area	0,35±0,05	23,7±0,6
1987	HD	Vegetated area	0,64±0,12	21,1±1,1
1987	HD - Total	-	0,50±0,11	22,4±1,0
2010	Whole year	Total	0,42±0,10	26,3±1,5
2010	HH	Built area	0,28±0,05	31,1±0,3
2010	HH	Vegetated area	0,77±0,02	27,9±0,7
2010	HH - Total	-	0,52±0,15	29,5±1,0
2010	HD	Built area	0,21±0,02	23,8±0,4
2010	HD	Vegetated area	0,42±0,04	22,3±0,1
2010	HD - Total	-	0,32±0,07	23,0±0,5

Observing the values for the year 1987, the built area had an increase of 41% in the NDVI value between the hot-dry and hot-humid periods, while the vegetated area showed an increase of 2% between the periods. For the year 2010, the built area had an increase of 0.03% between periods while the vegetated area had an increase of 23% in its NDVI value between periods.

ISSN 2318-8472, v. 12, n. 85, 2024

Among the years studied, there was an increase of 4% in the hot dry period and a decrease of 30% in the hot-humid period in the built area. However, the vegetated area showed a decrease of 8% in the hot-dry period and an increase of 10% in the hot-humid period (figure 3).

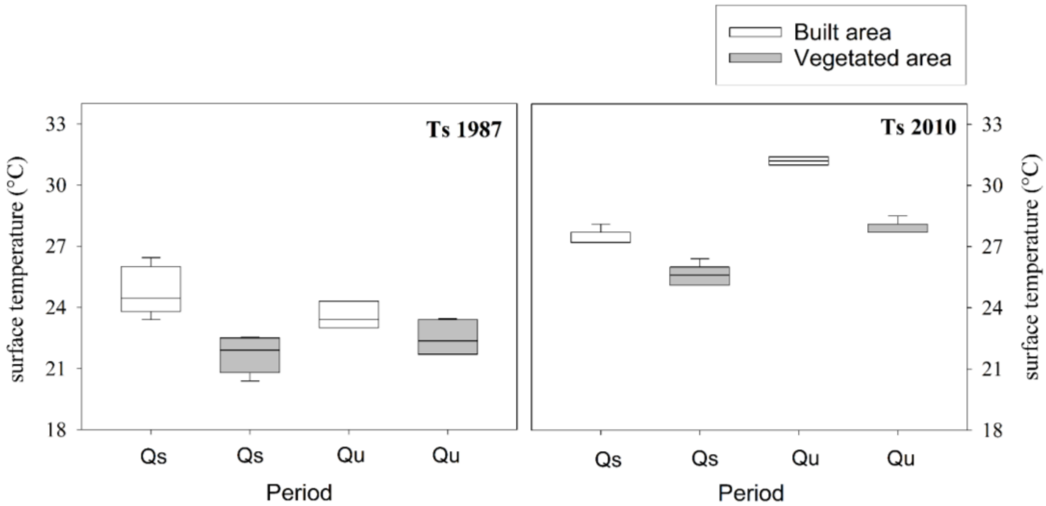
Figure 3 – Boxplot NDVI (normalized difference vegetation index) and ST (Surface Temperature) in built areas and vegetated areas in different periods in 1987.



In the hot-dry period of 2010, it was possible to observe a decrease in the minimum NDVI value of the vegetated area. This is due to the fact that in the hot-dry period, the vegetation has a lower density, which can become an area of exposed soil, with an approximate value of 0.40, classified by Chen et al. (2006) as exposed soil.

The data found allowed us to observe that the surface temperature in both classes and periods showed a lower thermal amplitude in 2010 when compared to 1987. The built area presented higher values than the vegetated area (figure 4).

Figure 4 – Boxplot NDVI and ST in built areas and vegetated areas in different periods in 1987 and 2010.



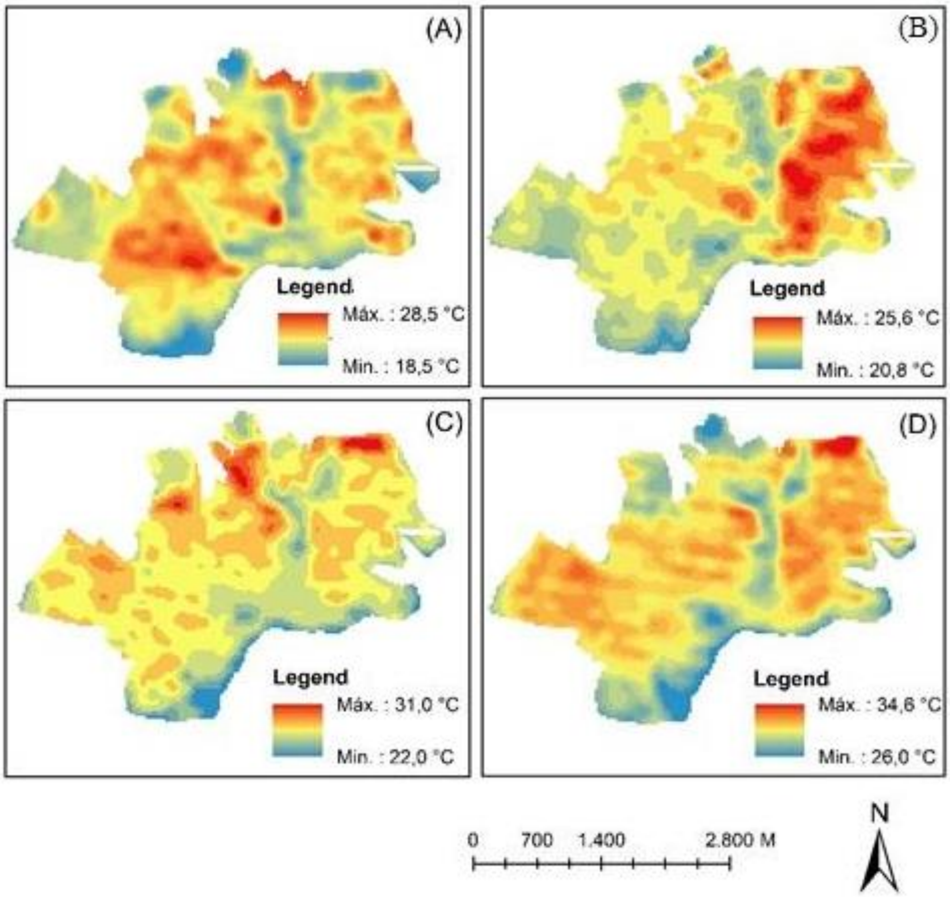
In 1987, the built area had a 5% decrease in ST between the hot-dry and hot-humid periods, while the vegetated area showed an increase of 5% between the periods. For the year

ISSN 2318-8472, v. 12, n. 85, 2024

2010, the built area had an increase of 13% while the vegetated area had an increase of 10% in its ST value between the periods.

Considering the years studied, it was possible to observe in the built area an increase of 32% in ST in the hot-humid period and 12% in the hot-dry period. While the vegetated area increased by 18% and 25%, in the hot-dry period and hot-humid period, respectively. Through the maps it was possible to observe the spatialization of surface temperature that follows the types of land use and occupation (figure 5).

Figure 5 – Spatial distribution of surface temperature (°C) (A) 1987 – HD (B) 1987 – HH (C) 2010 – HD (D) 2010 - HU.



The hot-dry period of 1987 presented a more heterogeneous distribution compared to the hot-humid period (figure 5B), but with a thermal amplitude of 10°C while the hot-humid period had an amplitude of 4.9°C. In this way, it was possible to observe the influence of the river, located to the south of the municipality, on the surface temperature, it was the portion that presented the lowest temperatures in both periods.

In the hot-humid period, the highest surface temperature is concentrated in the northeast and east portion of the municipality, where the most urbanized area is located, corroborating several studies (COSTA et al. 2010; FRANÇA & GOMES, 2014).

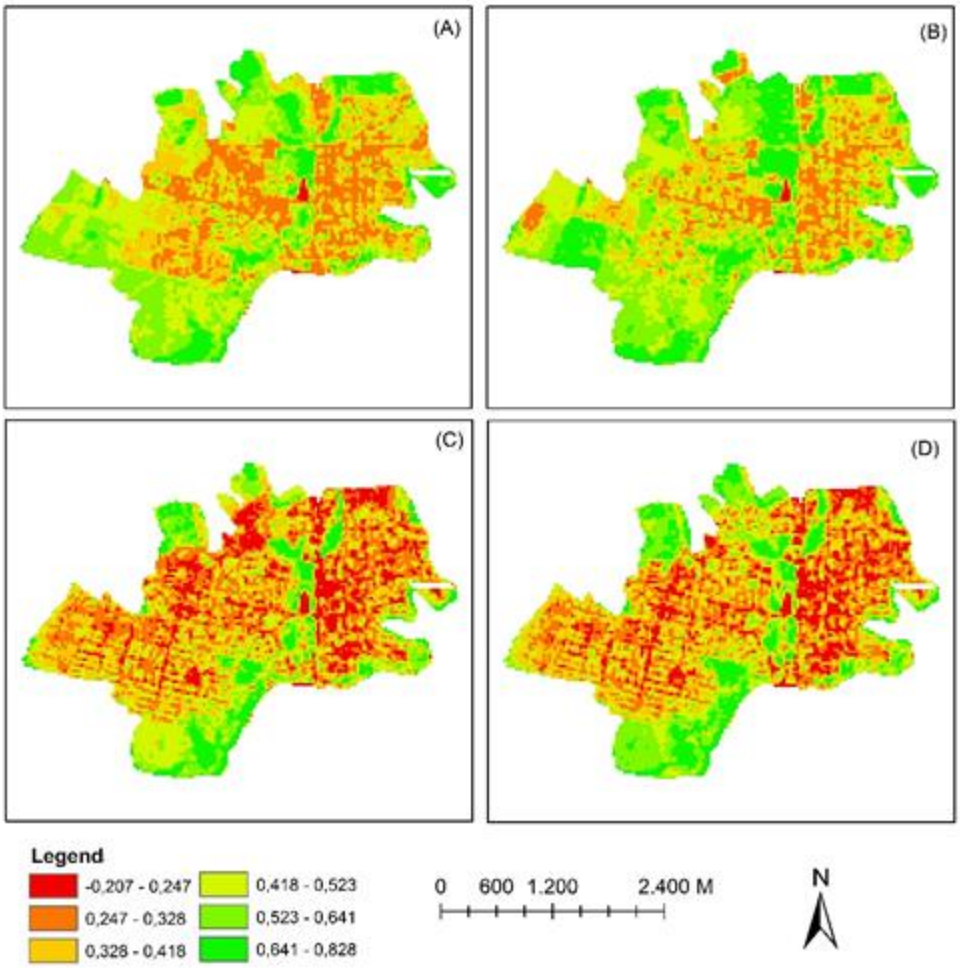
In 2010, it was possible to observe warming compared to 1987 in both periods, and the heterogeneity of surface temperature distribution, due to the growth of the city and the use of different materials covering the soil that exert influence on a microclimatic scale (SOUZA et al 2016; LUCENA et al. 2012).

ISSN 2318-8472, v. 12, n. 85, 2024

In the hot-dry period (figure 5C) the thermal variation in the urban environment was 9°C. While in the hot-humid period the variation was 8.5°C. The greatest thermal amplitudes were found in the northern and eastern portions, more urbanized regions, justified by the greater heterogeneity of surfaces, with different soil covers and different densities and arrangements (ZHOU et al. 2014).

Regarding NDVI, it was possible to observe in 1987 the highest values in the hot-humid period throughout the distribution of the municipality, mainly in the southwestern portion, where there is native vegetation. This is due to the photosynthetic absorption of red wavelength electromagnetic radiation (BEZERRA et al. 2014; ALBUQUERQUE et al. 2014) (figure 6).

Figure 6 – Spatial distribution of NDVI (A)- 1987 – Hot-dry period (B) 1987 – Hot-humid period (C) 2010 – Hot-dry period (D) Hot-humid period.



The suppression of vegetated areas was found throughout the municipality between 1987 and 2010, despite the eastern portion being the area with the highest level of urbanization, it is noteworthy that in the western portion there was greater suppression of vegetated areas.

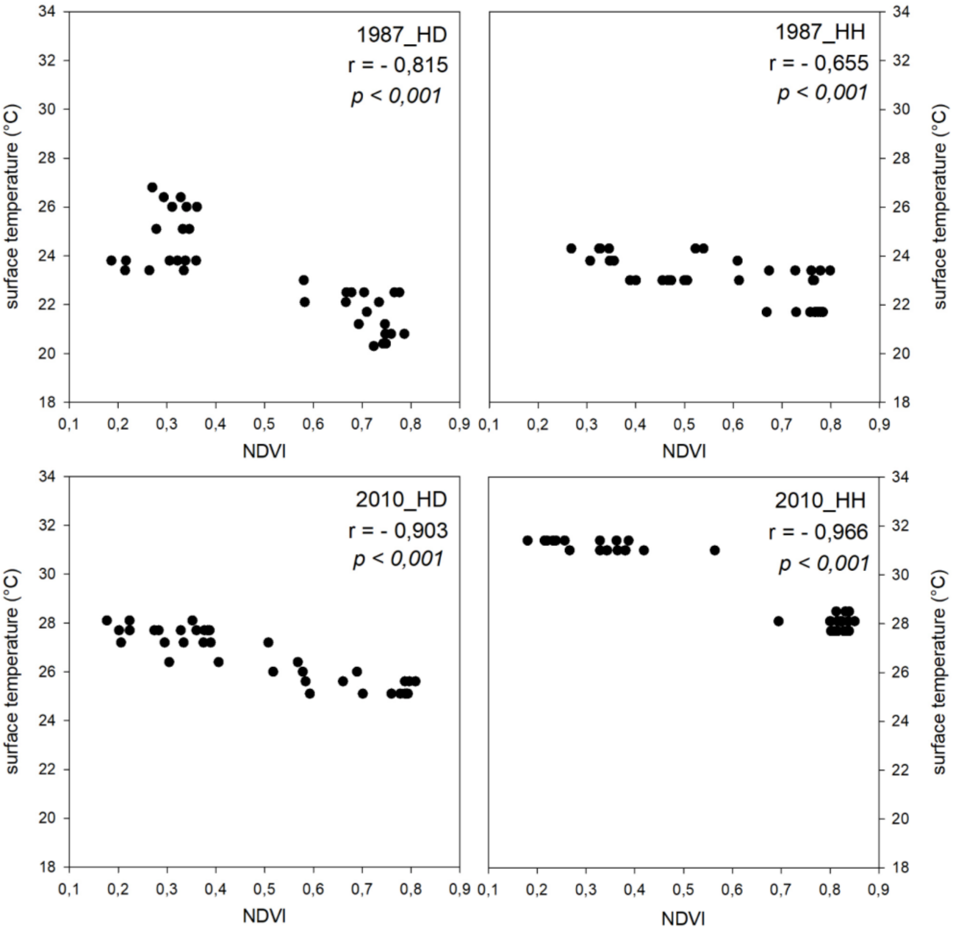
The implementation of constructions increased the areas with low NDVI values, due to the removal of the vegetated cover and its replacement with urban structures, such as asphalt and concrete. Impermeable surface materials influence the rise in temperature through the energy balance, where all energy absorbed by the surface will be stored in the materials in the

ISSN 2318-8472, v. 12, n. 85, 2024

form of heat, thereby increasing the surface temperature, which was proven in the western portion of the municipality (GABOR & JOMBACH, 2009).

Using the scatter plot, it was possible to verify the inverse correlation between the NDVI and Ts values. The increase in the NDVI value causes a decrease in the surface temperature value (figure 7).

Figure 7 – Relationship between NDVI and surface temperature (ST).



In the hot-humid periods for the years analyzed, a greater concentration of data is observed, due to the greater concentration of water vapor in the atmosphere compared to the hot-dry period, acting as a thermal regulator. It should be noted that the choice of points where data extraction occurred was based on satellite images from the year 2010, therefore, there is no way to ensure that in the year 2010 the locations considered areas built in the period 1987 could be empty land or even areas of low vegetation. This explains the lower correlation (0.655) found in the hot-humid period of 1987.

The normalized difference vegetation index (NDVI) estimated in this research were similar to the values estimated for locations in Cerrado-Amazon transition areas, in which case, the values were close to 0.7 and for Cerrado (RISSO et al., 2012). NDVI can be used as a parameter for the spatio-temporal dynamics of land use and cover, due to the high sensitivity of detecting visible and infrared radiation on the surface (BEZERRA et al. 2014).

ISSN 2318-8472, v. 12, n. 85, 2024

4 FINAL CONSIDERATIONS

The Landsat 5 satellite proved to be a suitable tool for analyzing the spatial distribution of surface temperature and NDVI. The NDVI proved to be a great instrument for observing the urbanization process in Barra do Bugres – MT between the years of study.

Analyzing the distribution of surface temperature, it was found that the highest values were concentrated in the northern and eastern portions, the most densely urbanized portions. The lowest NDVI values were found in the eastern portion, where there is greater urban density. However, the highest NDVI values were found in regions in the western portion, where despite there being greater suppression of vegetated areas from 1987 to 2010, this is still where there is lower urban density and greater presence of native vegetation.

Therefore, the methodology used in this research to analyze the urbanization process that occurred in the municipality, due to population growth influenced by the installation of the UNEMAT campus in Barra do Bugres, was satisfactory. Therefore, it allowed the observation of high surface temperature values in the most urbanized portions, due to the increase in impermeable materials and low NDVI values in portions with a decrease in vegetated areas.

REFERENCES

ALBUQUERQUE, E. M.; ANDRADE, S. C. P.; MORAIS, H. F.; DINIZ, J. M. T.; SANTOS, C. A. C. Análise do comportamento do NDVI e NDWI sob diferentes intensidades pluviométricas no município de Sousa-PB. ***Revista Estudos Geoambientais***, v. 1, p. 1-11, 2014.

BARRA DO BUGRES. **Prefeitura Municipal de Barra do Bugres**. Disponível em: http://www.barradobugres.mt.gov.br/O-Municipio/Caracteristicas/10/. Acesso em 11 de setembro de 2018.

BEZERRA, P. T.; LEITÃO, M. M. V. B. R.; AZEVEDO, P. V. Ilhas de calor e desconforto térmico no semiárido brasileiro: um estudo de caso na cidade de Petrolina-PE. ***Revista Brasileira de Geografia Física***. v. 06, n.03, p. 427-441, 2014.

CARIGNANI, G.; AZEREDO, J.; FERREIRA, A. P. ***Análise bioclimática em habitações obedecendo uma sequência temporal e diversidade de técnicas construtivas na cidade de Barra do Bugres – MT***. In. Anais XII Encontro Nacional de Tecnologia do Ambiente Construído, 2008, Fortaleza/CE.

CHEN, X. L.; ZHAO, H. M.; LI, P.X.; YIN, Z.Y. Remote sensing image-based analysis of the relationship between urban heat island and land use/cover changes. *Remote Sensing of Environment*, v. 104, p. 133–146, 2006.

COSTA, D. F.; SILVA, H. R.; PERES, L. F. Identificação de ilhas de calor na área urbana de Ilha Solteira - SP através da utilização de geotecnologias. ***Revista Engenharia Agrícola***, Jaboticabal, v.30, n.5, p. 974-985, set./out. 2010.

FRANÇA, M. S.; GOMES, E. S. Indícios de ilha de calor urbana em Sorriso/MT. ***Revista Monografias Ambientais – REMOA***, v.14, n.3, p. 3366-3376, 2014.

GABOR, P.; JOMBACH, S. The relationship between the biological activity and the land surface temperature in Budapest. ***Applied Ecology and Environmental Research***, v. 7, p. 241–251, 2009.

LUCENA, A. J.; FILHO, O. C. R.; FRANÇA, J. R. A.; PERES, L. F.; XAVIER, L. N. R. Urban climate and clues of heat island events in the metropolitan area of Rio de Janeiro. ***Springer***, p. 497-511, 2012.

OLIVEIRA, A. S.; NOGUEIRA, M. C. J. A.; SANCHES, L.; DE MUSIS, C. R. Microclima urbano – praças públicas em Cuiabá/MT/BRASIL. ***Revista Caminhos de Geografia***, Uberlândia v.13, n. 43, p. 311-325, out/2013.

ONU – Organização das Nações Unidas. ***Painel Intergovernamental sobre Mudanças Climáticas***, 2023.

ISSN 2318-8472, v. 12, n. 85, 2024

RISSO, J.; RIZZI, R.; RUDORFF, B. F. T.; ADAMI, M.; SHIMABUKURO, Y.E.; FORMAGGIO, A.R.; EPIPHANIO, R.D.V. Índices de vegetação MODIS aplicados na discriminação de áreas de soja. ***Pesquisa Agropecuária***. Brasileira, Brasília, v.47, n.9, p.1317-1326, 2012.

SANTANA, O. A.; CARVALHO JUNIOR, O. A.; PIMENTEL, C. M. M.; GOMES, R. A. T.; OLIVEIRA, S. N. Modelagem de espectros temporais NDVI-MODIS, no período de 2000 a 2008, na bacia do Rio Paracatu, Brasil. ***Revista Brasileira de Geofísica***, v. 28, n.1, p. 47-60, 2010.

SANTOS, F. M. M.; MUSIS, C. R.; NOGUEIRA, J. S.; PINTO-JÚNIOR, O. B.; NOGUEIRA, M. C. J. A. Análise da variação higrotérmica ocasionada pela influência da ocupação do solo na cidade de Cuiabá-MT. ***Revista Eletrônica em Gestão, Educação e Tecnologia Ambiental,*** v. 9, n. 9, p. 1932-1945, fev./2013.

SOUZA, J. F.; SILVA, R. M.; SILVA, A. M. Influência do uso e ocupação do solo na temperatura da superfície: o estudo de caso de João Pessoa–PB. ***Ambiente Construído***, v. 16, n. 1, p. 21-37, 2016.

SOUZA, N. S.; MIRANDA, S. A.; SANTOS, F. M. M.; NOGUEIRA, M. C. J. A. ***Conforto térmico em ambiente de ensino: estudo de caso em Barra do Bugres-MT.*** In. Anais XIII Encontro Nacional e IX Encontro Latino-americano de Conforto no Ambiente Construído, Campinas, 2015, Campinas/SP.

SPIEGEL, M. R. **Estatística**. 3. Ed. São Paulo: Books, 1993. 643p. (Coleção Schaum).

WENG, Q.; LU, D. A sub-pixel analysis of urbanization effect on land surfasse temperature and its interplay with impervious surfasse and vegetation coverage in Indianapolis, United States. ***International Journal of Applied Earth Observation and Geoinformation***, v.10, n.1, p. 68-83, 2008.

XIAN, G.; CRANE, M. An analysis of urban thermal characteristics and associated land cover in Tampa Bay and Las Vegas using Landsat satellite data. ***Remote Sensing of Environment,*** Oxford, v.104, p.147-156, 2006.

ZHOU, D.; ZHAO, S.; LIU, S.; ZHANG, L.; ZHU, C. Surface urban heat island in China's 32 major cities: Spatial patterns and drivers. ***Remote Sensing of Environment***, v. 152, p. 51-61, 2014.