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Monitoring of deforestation and urban occupation through the analysis of NDVI and NDBI indices in the municipality of Paraíso das Águas/MS

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ABSTRACT
This study takes in consideration one of the toughest environmental challenges we face nowadays, the deforestation. Studies on environmental control and analysis through remote sensing have already permeated the academic fields, the more information we have, the better our chances to fight outbreaks of deforestation and to preserve the native vegetation cover of a region are. Paraíso das Águas/ Mato Grosso do Sul is in the Cerrado, one of the Brazilian biomes most afflicted by deforestation, therefore, georeferencing was the tool used to monitor the problem, through the avaliation of the indices of Normalized Difference Vegetation Index (NDVI) and Normalized Difference Built-Up Index (NDBI), so that this information can be used in the future to control and orientate the process of urban and sustainable growth and Development of the municipality. Our data highlight that the most deforestation in the municipality is to open spaces for farming, which underscores the fact that these activities require a more rigorous and adequate local environment control, taking in consideration that this is their largest source of income.

Keywords: Deforestation, Normalized Difference Vegetation Index (NDVI), Normalized Difference Built-Up Index (NDBI), Paraíso das Águas.

1 INTRODUCTION

Unfavorable climate effects, silting and extinction of rivers, loss of biodiversity, among others are the consequences of one of the biggest environmental problems of today, deforestation. In the process of development and urbanization, cities and municipalities have high rates of removal of native forest and vegetation, precisely to support this growth and offer support structures for population increase such as areas for agriculture and livestock, which represent the main cause of the problem according to the survey of Changes in Land Cover and Use of Brazil by IBGE.

Paraíso das Águas/ Mato Grosso do Sul, presents great economic potential, in view of its natural riches, thus attracting companies, industries and people. These regulations, if not based on sustainable development, can become problematic regarding land use and end up repeating a flawed urbanization model, which should be a real concern on the part of both the government and the population in general. In addition, the municipality is in the Cerrado, one of the Brazilian biomes that suffers the most from disrespect for environmental legislation and that runs a serious risk of extinction, with an estimated 1.5% annual loss of native vegetation cover that corresponds, approximately, three million hectares/year (MACHADO et al., 2004).

Thus, remote sensing is an important tool for the analysis and control of environmental issues. The democratization of the Internet, the availability of free software and technological advances have favored terrestrial-environmental monitoring through satellites such as Landsat 8, which allow, at various scales, the gathering of data, both qualitative and quantitative, on the level of deterioration of the region studied.

Through the geoprocessing of satellite images, the present study performed temporal diagnoses in the years 2013 to 2017, through the evaluation of the Normalized Difference Vegetation Index (NDVI) and the Normalized Difference Index for Built Areas (NDBI), with the objective of analyzing the loss of vegetation by comparing the values related to the NDVI and analyzing the increase of the urban perimeter through the comparison of the values of NDBI, In the union of this information these surveys gain broader and more characteristic aspects, which to be carried out in such a recent stage of development of the municipality is of great importance, being able to identify patterns serving as a basis for guidelines for a more sustainable and conscious development and future studies on the subject.

2 MATERIAL AND METHODS.

The last of the municipalities of Mato Grosso do Sul was created on September 29, 2003 by a state decree, from the municipalities of Água Clara, Costa Rica and Chapadão do Sul, but was only installed administratively on January 1, 2013.

It has an area of 5,032.469 km² and the population estimated by the 2017 census is 5,350 people (IBGE, 2017) and is located in the latitude of 19º03'08" South and longitude of 52°58'06" West, is 280 km from the state capital.

Figure 1. Location of Paraíso das Águas in Mato Grosso do Sul.

Source:
https://pt.wikipedia.org/wiki/Para%C3%ADso_das_%C3%81guas#/media/File:Brazil_Mato_Grosso_do_Sul_Paraiso_das_Aguas_location_map.svg)

According to the Assomasul Association of Municipalities of Mato Grosso do Sul, Paraíso das Águas has a total of 697 permanent private households, with a population density of 1.02 hab.km². During the 2013 and 2015 censuses, the number of inhabitants grew from 4,942 to 5,150 (growth of 4%).

The largest collection of ICMS comes from the economic activities of Agriculture, which raised R $ 3,841,759.09 in 2015 (increase of 2,197.35% compared to 2013) and Livestock, which raised R $ 2,426,719.97 in 2015 (increase of 152.54% compared to 2013). Highlights for soybeans, with 60,000 hectares of harvested area and production of 172,800 tons produced, sugarcane with 11,578 hectares of harvested area and 895,988 tons produced in 2015 (preliminary data, March 2016 position) and for cattle with 244,299 head of cattle in 2014.

The method used for the analysis of the remaining vegetation in the Municipality of Paraíso das Águas – MS was the manipulation and recording of Landsat 8 satellite images, relationships or links between spatial location of environmental targets, spectral variation of the image and variation of the vegetation cover of the soils, with atmospheric correction, were analyzed, by comparing the maximum and minimum values recorded in the period from 2013 to 2017 by the Normalized Difference Vegetation Index (NDVI), as well as the Normalized Difference Vegetation Index for Built Areas (NDBI), with the use of the free software *QGis 2.14* and plotting graphs in *the Excel 2013 software*. No operations were necessary for atmospheric correction since the images were obtained by the USGS website, already with the correction.

To corroborate the results, information was collected on the socio-economic and statistical profile of the municipality, as well as the ICMS and its growth in the period from 2013 to 2015, made available by Assomasul.

2.1 CALCULATION OF NDVI

The *Normalized Difference Vegetation Index* is widely used not only in the analysis of vegetation cover, but also in different studies for the differentiation of environmental and ecological variabilities, such as the availability of nutrients in the soil, as well as its water storage capacity, which makes it very useful in the agricultural market also being able to identify the presence of pests in the plantations. With it it is possible to make different types of analyses of a plantation or vegetation cover and in the most varied scales.

One of its most common uses is for measuring the intensity of chlorophyll activity in plants, and it is possible to perform comparisons of chlorophyll activity when performing the measurement in different periods of time.

Plants are able to absorb energy in various spectra, the index then makes a calculation on these spectral bands.

Sensors installed on satellites and even *drones*, capture the spectra of this energy and apply them in an equation and an index:

NDVI = (NIR - R) / (NIR + R)

In which,

NIR - near-infrared band;

R - band in red.

The NDVI is the result of the ratio of the difference in the reflectance of infrared (IVP) and red (V) and the sum of the same variables, thus providing an index of -1 and 1. This value indicates the presence of vegetation, the higher the value, the greater the vegetation.

Negative values or values close to zero indicate areas with water, or bare soil, with low chlorophyll activity, consequently, low vegetation cover.

2.2 NDBI CALCULATION

This is used for the identification of built up areas and is expressed by equation and result of the normalized difference between the mid-infrared and near-infrared bands (ZHA ET AL., 2003).

NDBI= (MIR - NIR / MIR + NIR)

In which,

MIR – means a mid-infrared band,

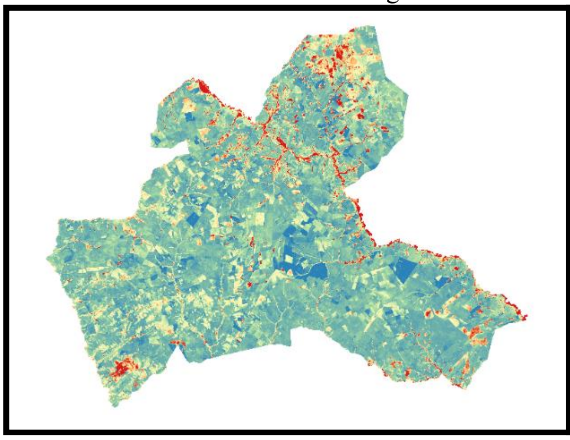
NIR – means a near-infrared band.

Thus we obtain with these indexes an image that contains only pixels with positive values for the built and sterile areas and the negative values represent pixels contained in non-built areas, such as surfaces with vegetation or all other classes of land cover, thus going from zero or -254. (JENSEN, 2009).

3 RESULTS AND DISCUSSIONS

The analysis of the Normalized Difference Vegetation Index allowed the following results:

Image 1 - NDVI 2013 Image 2 - NDVI 2014



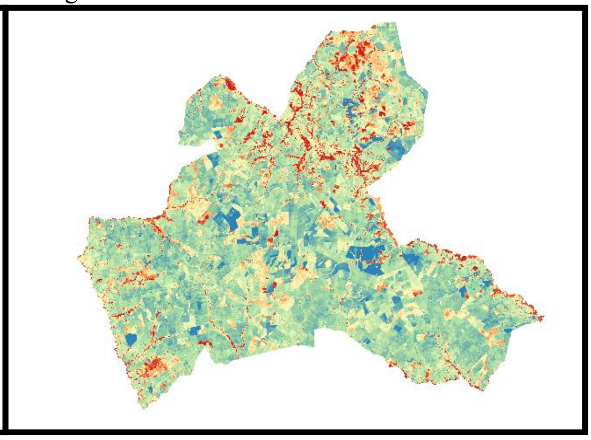
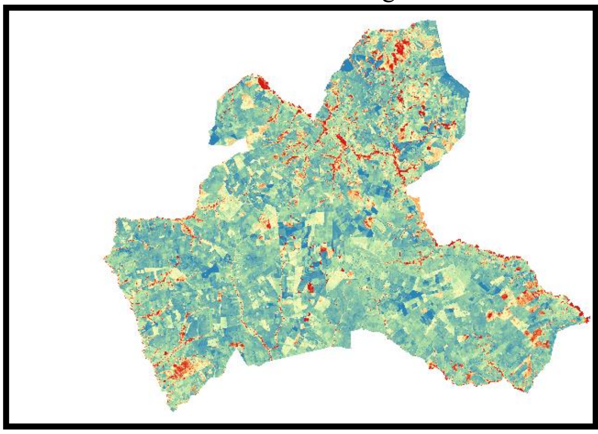


Image 3 - NDVI 2015 Image 4 - NDVI 2016



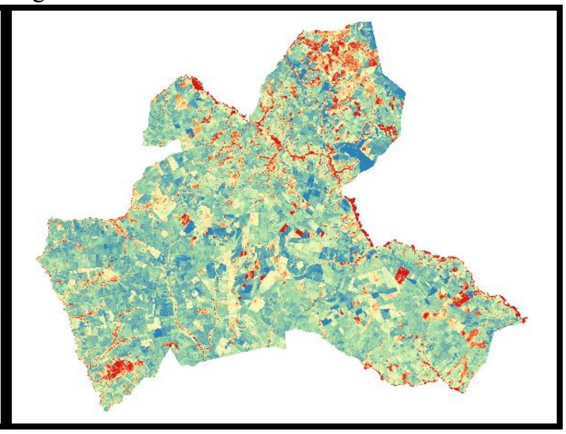
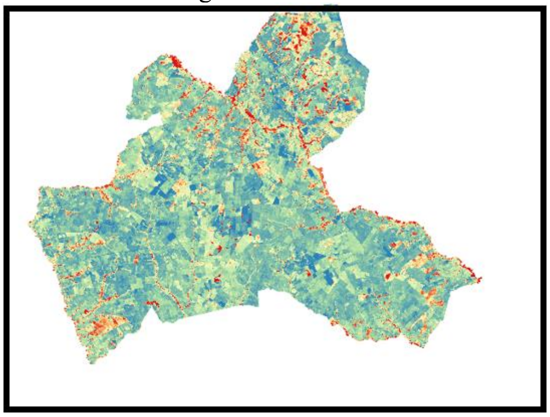


Image 5 - NDVI 2017



The analysis of the Normalized Difference Vegetation Index (NDVI) contributes to the comparison of the density of vegetation cover from 2013 to 2017, through the observation of the red color in the images, which indicates the presence of photosynthetic activity in the municipality, that is, where there is a greater amount of local flora. When comparing the images it can be seen that over the years, after its emancipation, the municipality of Paraíso das Águas presented relatively small loss of vegetation.

With this, it is observed in the images the difference in the intensity of the red coloration each year, denoting a change in the vegetation, caused by deforestation, presence of water bodies, reforestation and advancement of agriculture.

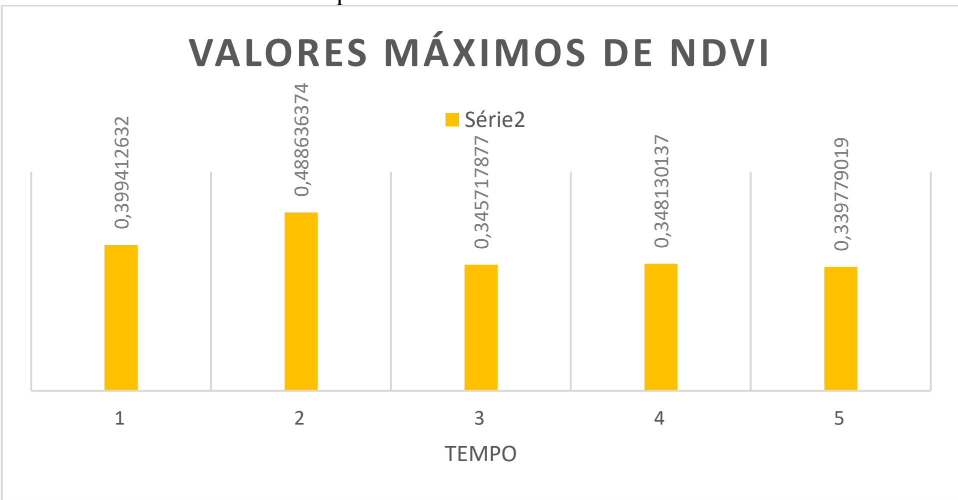
Table 1 presents the values found for the calculation of the NDVI for the years 2013, 2014, 2015, 2016 and 2017.

Table 1 – NDVI values.

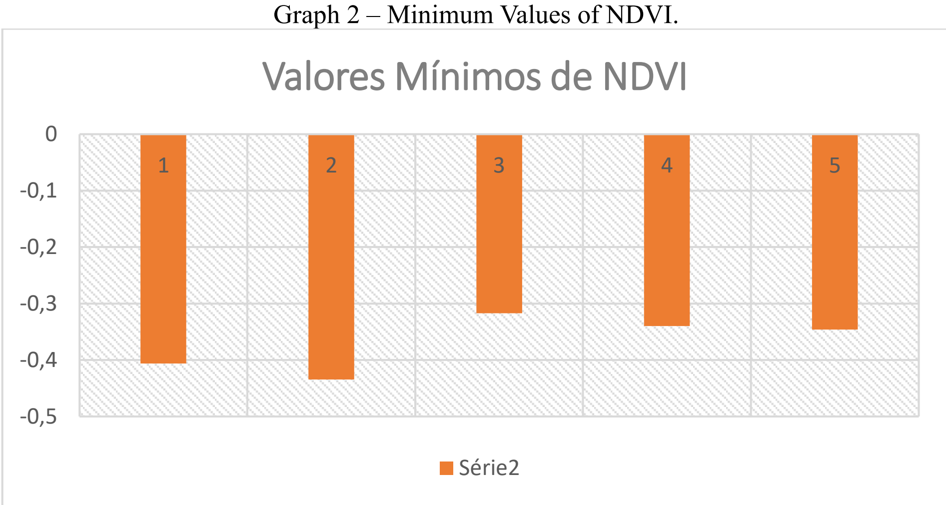
NDVI		
YEAR	Maximum	Minimum
2013	0,399412632	-0,406015038
2014	0,488636374	-0,434426218
2015	0,345717877	-0,317220539
2016	0,348130137	-0,339975089
2017	0,339779019	-0,34591195

Graphs 1 and 2 below indicate the change in values for NDVI, in which for the variable time the years 2013, 2014, 2015, 2016 and 2017 correspond respectively to the numbers 1, 2, 3, 4 and 5.

Graph 1- Maximum NDVI Values.



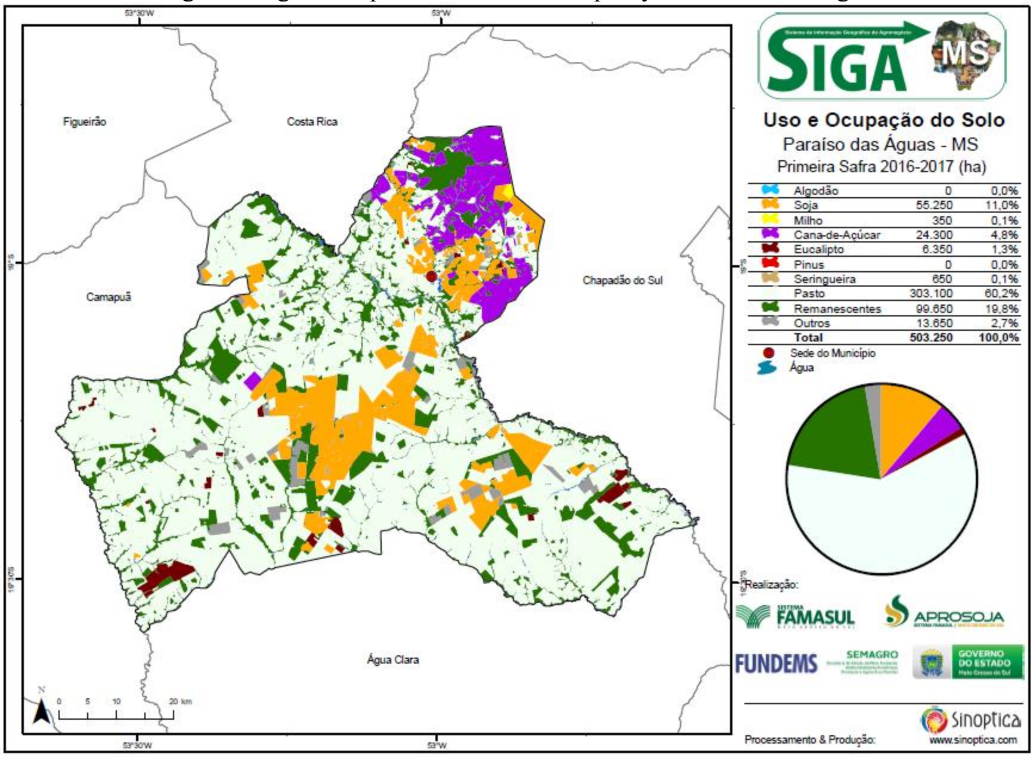
Graph 2 – Minimum Values of NDVI.



The calculation of the NDVI then allowed to ensure that after its emancipation the area covered by vegetation of the municipality of Paraíso das Águas did not suffer significant changes of increase or reduction of its vegetated area.

The image below shows the types of vegetation found in the municipality of Paraíso das Águas. When compared with image 5, the Normalized Difference Vegetation index coincides with the planting density present in the classification of image 6.

Image 6 - Vegetation present in the municipality of Paraíso das Águas.



Thus, in the year 2017, in the Southwest region of the municipality, the reddish spot indicates a vegetation composed of Eucalyptus and the spots to the north and northeast, indicate the remaining vegetation of the municipality. The predominant yellow color indicating soybean plantations, refers to the blue color in NDVI.

The vegetation index is also high near water bodies such as rivers and lakes, as shown in image 7 below, which shows the distribution of the watershed in the municipality in question. The dark lines indicate the rivers and the red spots, the vegetation.

With this it is perceived that with the advance of urbanization and consequently, creation of pasture areas for the development of agriculture in the municipality, most of the areas of the municipality are deforested. Therefore, the loss of vegetation in the municipality of Paraíso das Águas is due to the development of planting areas for agriculture and to a lesser extent, pasture areas for livestock.

Image 7- Hydrographic Basin of Paraíso das Águas.

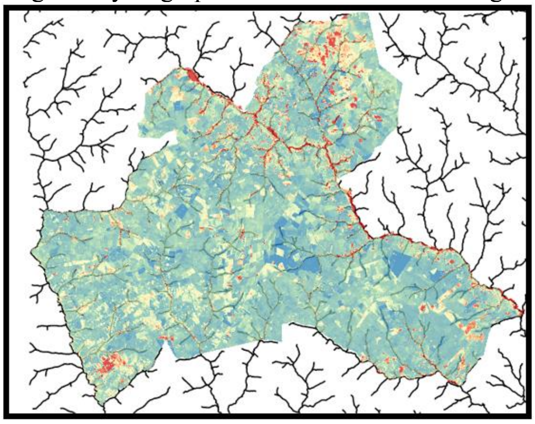


Image 7 shows the relationship of the Sucuriú River with the highest density of vegetation indicated by the red line. Thus the vegetation is more exuberant and intense, close to bodies of water.

One of the main causes of the growing deforestation in the period studied is the advance of urbanization in the municipality, with the industrialization and development of productive commercial activities in order to increase the circulation of people and financial resources.

Zha et al. (2003) proposed the NDBI or in Portuguese, Normalized Index of Difference of built up areas. This index is based on the increment of the digital number of the built areas in the intervals of band 4 and 5 of the TM. For the construction of NDBI the following formula is used: NDBI = (TM5 – TM4) / (TM5 + TM4).

Where:

TM4 = near-infrared band

TM5 = mid-infrared band.

The NDBI image is illustrated in figures 8, 9, 10, 11 and 12. In the center of the image is the urban area of Paraíso das Águas.

Figure 8 – Year 2013

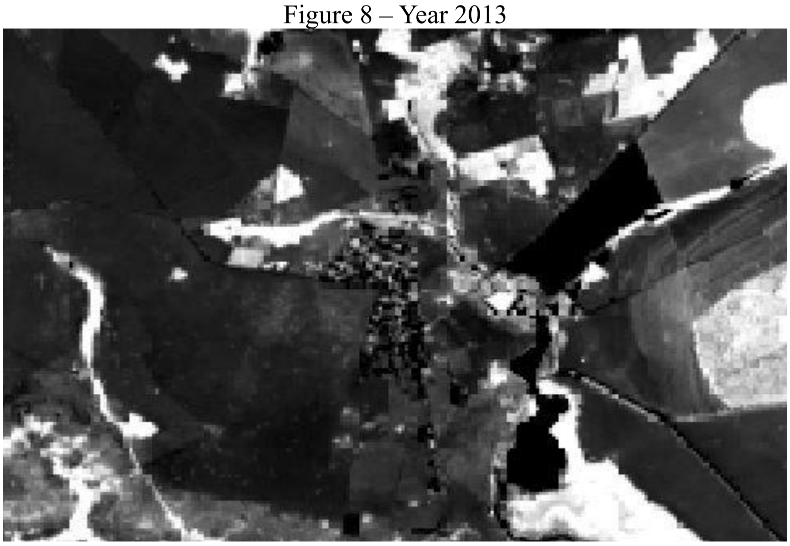


Figure 9 – Year 2014

Image 10 - Year 2015.

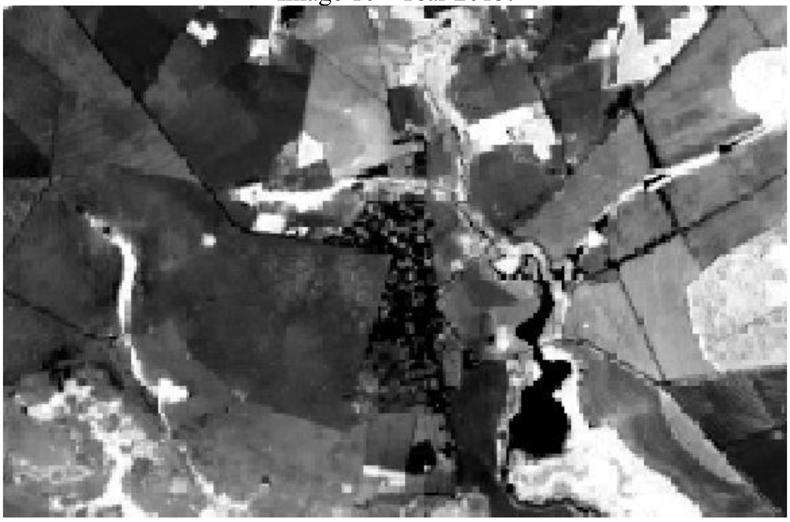


Image 11 - Year 2016.

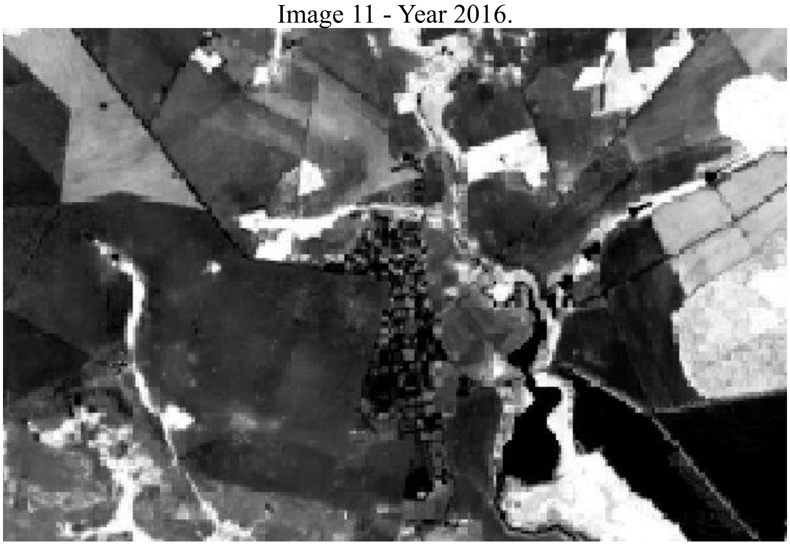


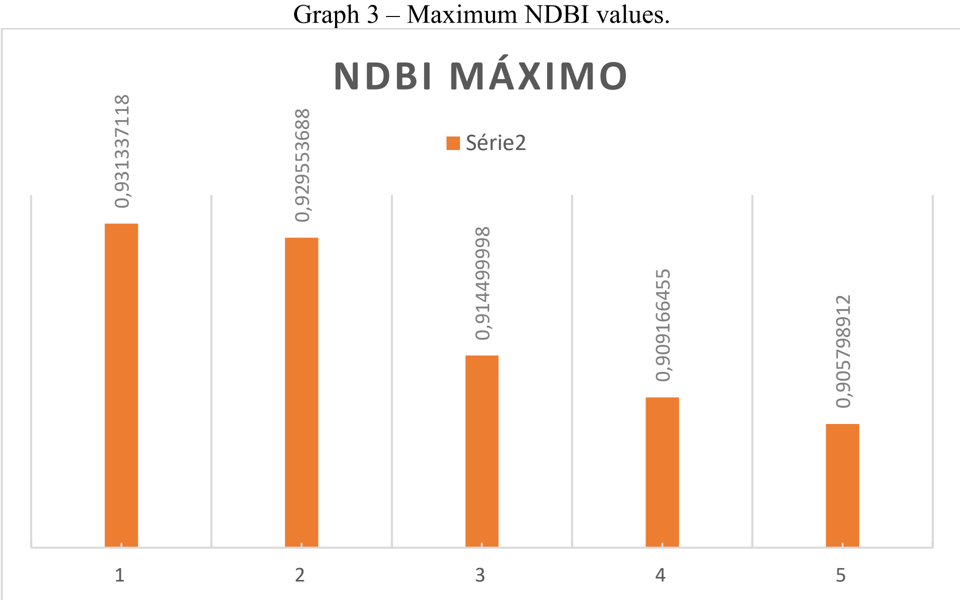
Image 12 - Year 2017.

Table 2 shows the values related to the NDBI calculated for the period studied, as well as graphs 3 and 4. In the horizontal line the numbers 1, 2, 3, 4 and 5 refer respectively to the years 2013, 2014, 2015, 2016 and 2017.

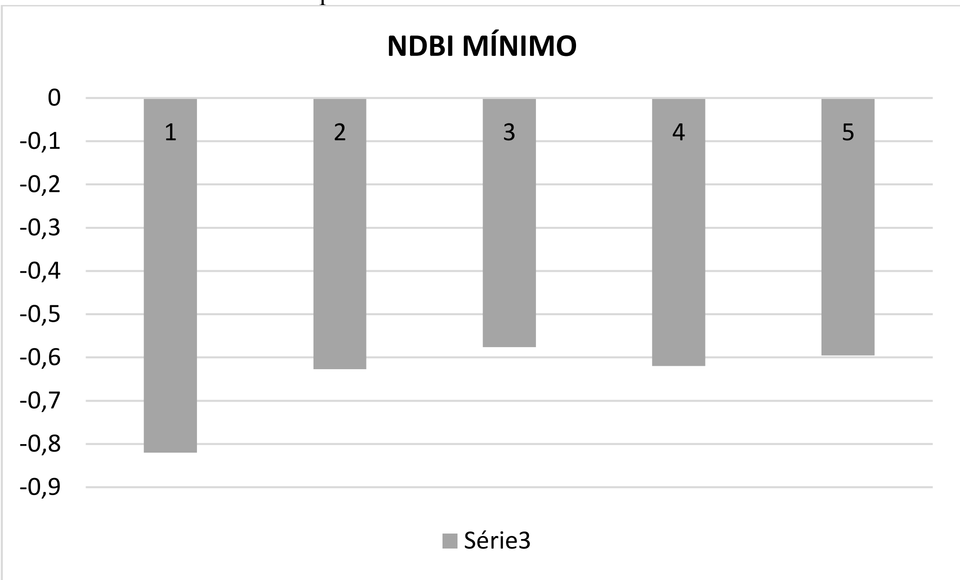
Table 2 – Maximum and minimum values calculated for the NDBI.

NDBI		
YEAR	MAXIMUM VALUES	MINIMUM VALUES
2013	0,9313371181488	-0,82028985
2014	0,929553688	-0,627254486
2015	0,914499998	-0,576086938
2016	0,909166455	-0,619718313
2017	0,905798912	-0,595113456

Graph 3 – Maximum NDBI values.



Graph 4 – Minimum Values of NDBI.



The values in the table indicate that there were no significant changes for the NDBI during the period, that is, the urban region of Paraíso das Águas did not increase or reduce its urban perimeter, even after its emancipation. The reduction of vegetation, as indicated by the NDVI analysis, is not due to the increase in urbanization, but rather to the advance of agriculture in the municipality.

4 CONCLUSION

The results showed that there was loss of vegetation, but this change is not due to the increase in urbanization in the municipality. The methodology of temporal analysis, proposed in this article, showed that green areas are giving way more and more to agriculture, demonstrated by the comparison of images and corroborated by the data of population increase, which was significantly low and the increase in ICMS that for agriculture rose precipitously. Finally, it is concluded that landscape transformations can be evaluated by comparing data from different periods, through the monitoring of satellite images of urban areas or with the use of Geoprocessing and thus become a database for laboratories of landscape observation and deforestation control, serving as a basis for a control of the advance of agriculture and livestock establishment limits, Especially in the areas near the rivers, delimiting well the areas of permanent preservation.

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