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STUDY OF THE VEGETATION INDEX AND TERRESTRIAL SURFACE TEMPERATURE IN THE TRIUMPH ENVIRONMENTAL PROTECTION AREA OF XINGU (PA) USING THE GOOGLE EARTH ENGINE

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Abstract

The environmental preservation areas in the State of Pará provide with the lack of scientific studies on the effects of changes in land use and the temperature of the earth's surface. In this context, this study aims to analyze the Vegetation Index by Normalized Difference (NDVI) and to verify the behavior of the surface temperature of the land in the Environmental Protection Area (APA) Triunfo do Xingu, in the state of Pará, between the years 2000 and 2019 using a Google Earth Engine (GEE) platform. The results sought that the terrestrial surface in the study area, varied in average of 26.79º C for the year 2000 to 28.90º C for the year 2019. The NDVIs attenuated to represent the vegetation between the 20 years studied indicating changes occurred in an area of approximately 828 km² (4.93% of the total area of the APA). The results induced that despite the changes identified in the study region, much of the vegetation cover was conserved.

Keywords: Remote sensing; Vegetation Index; Earth’s surfasse temperature; Change detection.

ESTUDO DO ÍNDICE DE VEGETAÇÃO E TEMPERATURA DA SUPERFÍCIE TERRESTRE NA ÁREA DE PROTEÇÃO AMBIENTAL TRIUNFO DO XINGU (PA) UTILIZANDO O GOOGLE EARTH ENGINE

Resumo

As áreas de preservação ambiental no Estado do Pará sofrem com a falta de estudos científicos sobre os efeitos das mudanças de uso da terra e da temperatura da superfície terrestre. Neste contexto, este estudo visa analisar o Índice de vegetação por Diferença Normalizada (NDVI) e verificar o comportamento da temperatura superficial da terra na Área de Proteção Ambiental (APA) Triunfo do Xingu, no estado do Pará, entre os anos 2000 e 2019 utilizando a plataforma Google Earth Engine (GEE). Os resultados obtidos mostraram que a temperaturas da superfície terrestre na área de estudo, variou em média de 26,79º C para o ano 2000 a 28,90º C para o ano 2019. Os NDVIs mostraram diminuição representativa da vegetação entre os 20 anos estudados indicando mudanças ocorridas em uma área de aproximadamente 828 km² (4,93 % da área total da APA). Os resultados mostraram que apesar das mudanças identificadas na região de estudo, grande parte da cobertura vegetal foi conservada.

Palavras-chave: Sensoriamento remoto; Índice de Vegetação; Temperatura da superfície Terrestre; Detecção de mudança.

ESTUDIO DEL ÍNDICE DE VEGETACIÓN Y TEMPERATURA DE LA SUPERFICIE TERRESTRE EN EL ÁREA DE PROTECCIÓN AMBIENTAL DEL TRIUNFO DE XINGU (PA) UTILIZANDO EL MOTOR GOOGLE EARTH

Resumen

Las áreas de preservación ambiental en el estado de Pará dan cuenta de la falta de estudios científicos sobre los efectos de los cambios en el uso del suelo y la temperatura de la superficie terrestre. En este contexto, este estudio tiene como objetivo analizar el Índice de Vegetación por Diferencia Normalizada (NDVI) y verificar el comportamiento de la temperatura superficial del terreno en el Área de Protección Ambiental (APA) Triunfo do Xingu, en el estado de Pará, entre los años 2000 y 2019 utilizando una plataforma Google Earth Engine (GEE). Los resultados buscaron que la superficie terrestre en el área de estudio varió en promedio de 26,79º C para el año 2000 a 28,90º C para el año 2019. Los NDVIs atenuados para representar la vegetación entre los 20 años estudiados indicando cambios ocurridos en un área de aproximadamente 828 km² (4.93% del área total de la APA). Los resultados indujeron que a pesar de los cambios identificados en la región de estudio, se conservó gran parte de la cobertura vegetal.

Palabras-clave: Sensores remotos; Indice de vegetación; Temperatura de la superfície terrestre; Detección de câmbios.

1. INTRODUCTION

With the technological advancement of spatial data acquisition and processing instruments, it is possible to represent and quantify objects and phenomena on the Earth's surface, helping in their mapping. These environmentally friendly technologies represent an important tool for researchers from different areas, information for planning and decision making in subsidiary processes.

In this way, the Remote Sensing (SR) data obtained by satellites have the ability to provide information on properties of the Earth's surface. This characteristic allows deepening the extraction of information about the different targets of the terrestrial surface, as is the case of studies involving vegetation cover, temperature, and integration. According to Ferreira Júnior and Dantas (2018), due to technological advances, the use of satellites has become an extremely important tool for studies related to the configuration of the Earth's surface. Among the various studies that the SR offers, we can highlight the space - vegetation storms that detect changes in soil cover, whether due to anthropic actions or climate changes, for example. Ponzoni and Shimabukuro (2010), state that through remote detection it is possible to analyze vegetation in large areas using Vegetation Indexes.

The study of vegetation variations over the years requires that the climatic parameters that can affect the health and dynamism of the vegetation cover also be analyzed. In this sense, researchers in the area always seek to relate studies of vegetation with variations in temperature and precipitation (Gomes et al., 2019; Silva et al., 2017; Carvalho and Neri, 2018).

In this context, this work aims to study, through remote sensing, the environmental changes in the Environmental Protection Area - PA of Triunfo do Xingú between the years 2000 and 2019. The changes studied here refer to changes in vegetation cover, identified by calculating the vegetation index and changes in the Earth's surface temperature detected by processing satellite images on the Google Earth Engine platform. Data on rainfall accumulated over the 20 years of study will also be analyzed.

APA Triunfo do Xingu is a Conservation Unit (UC) that integrates the Mosaic of Conservation Units of Terra do Meio, formed by Federal and State UCs, in addition to Indigenous Lands in the Xingu region (ISA, 2012). The main objectives of APA Triunfo do Xingu are: to protect biological diversity; to discipline the occupation process and guarantee the sustainable use of natural resources. The rules for the use of public domain areas are instituted by the managing body, and private areas must follow the legislation in force (SESMA, 2017). Due to the importance of this region, studying changes in land cover in this area is essential to improve the management of local natural resources. Thus, this paper sought to study the changes in the NDVI (Normalized Difference Vegetation Index) and to verify the behavior of the land surface temperature (LST - Land Surface Temperature) and the accumulated precipitation in this APA between the years 2000 and 2019

Barbosa et al, (2019), state that NDVI is a parameter, provided by SR, important for monitoring vegetation. This index has been widely used for studies that characterize vegetation mainly through space-time analysis. Authors such as Ponzoni & Shimabukuro (2007), characterized the vegetation through the construction of profiles, seasonal and temporal, of the activities of the vegetation, generating interannual comparisons of these profiles.

In addition to the NDVI and an LST, it is also important to characterize the study region using exclusion data as this is one of the factors that cause relevant changes both in the vegetation cover and in the temperature of the region (BECERRA, et al., 2009). For the NDVI and LST studies, images such as LANDSAT 5 satellites (TM sensor), LANDSAT 8 (OLI sensor) and TERRA / AQUA (MODIS sensor) for example can be used. In this research, images of Landsat 5 and 8 were used to calculate the NDVI and MODIS images for LST.

The precipitation is a variable that can also be studied by remote sensing. The characteristics of the satellite database are alternative sources of information for large regions where conventional exclusion data is scarce or even absent (Rao et al., 2014, Funk et al., 2015, Paredes-Trejo et al., 2017). For the separation study in this research, the data set CHIRPS (Climate Hazards Group InfraRed Precipitation with Station Data) was used.

According to Funk et al., (2014), CHIRPS was developed by researchers from the United States Geological Survey (USGS) and the University of California, Santa Barbara (UCSB), supported by the United States Agency for International Development (USAID), the National Aeronautics and Space Administration (NASA) and the National Oceanic and Atmospheric Administration (NOAA). The data are available from 1981 to the present, totaling more than thirty years of data generated. Its basis of trust is formed by a set of the following systems: Climate Hazards Precipitation Climatology (CHPClim), National Oceanic and Atmospheric Administration (NOAA), Climate Prediction Center (CPC), The Tropical Rainfall Measuring Mission (TRMM) and precipitation data from surface stations of regional and national meteorological services from around the world (FUNK et al, 2014).

To process the data used in this paper, the Google Earth Engine (GEE) platform was used, which is an innovative digital image processing tool, developed by the company Google (HOROWITZ, 2015). This tool allows multitemporal and space analysis in a fast and efficient way through JavaScript and Python programming languages (GORELICK, 2017).

2. METHODOLOGY

2.1. Study area

The Triunfo do Xingu Environmental Protection Area has a total area of 1,679,280.52 ha, in which 1,102,779.30 ha (66%) are located in the municipality of São Félix do Xingu and 576,501.22 ha (34%) in the municipality of Altamira. The municipality of São Félix do Xingu has an area of 84,213 km² and the municipality of Altamira has an area of 159,533,328 km² (SESMA 2017).

According to the National Institute of Meteorology, the average annual reduction and average annual temperature of both municipalities corresponding to 2,041 mm/year and 25.5ºC for São Félix do Xingu and 2,195 mm with 26.9º C for Altamira, (INMET, 2020). Figure 1 below shows the location map of the study area.

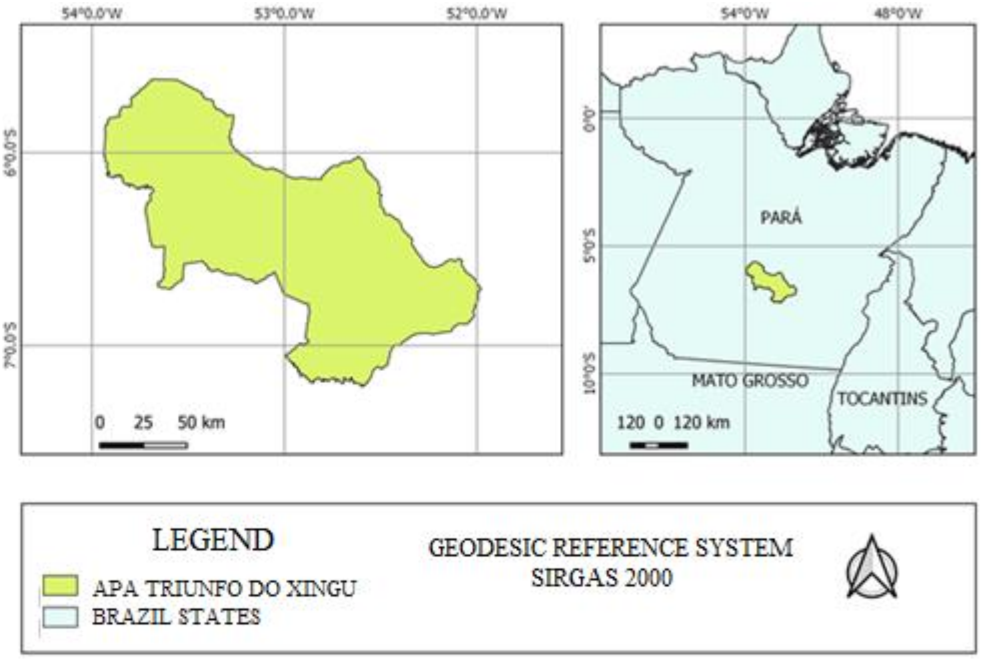

Figure 1- Location map of the study area. Source: the authors, (2020)

2.2. Data acquition

All data used were acquired through the Google Earth Engine platform. For the NDVI calculation, images were used from the Thematic Mapper (TM) sensor, with 30m spatial resolution, from the LANDSAT-5 satellite for the years 2000 to 2011 and from the OLI sensor (Operational Terra Imager), 30m spatial resolution, of the LANDSAT-8 for the years 2013 to 2019. Due to the discontinuity of the images in the LANDSAT series, the 2012 analysis was not performed due to a lack of data. For the analysis of the surface temperature, images from the MODIS sensor of the two American satellites TERRA and AQUA from the EOS Program (Earth Observing System) for the years 2000 to 2019 were used.

For the study of precipitation, CHIRPS data was used, which is a set of precipitation data over 30 years old. CHIRPS incorporates satellite images with spatial resolution of approximately 5 km with data from the field station to create time series of grid rains for trend analysis and seasonal drought monitoring (FUNK, et al., 2015). These data are made available to the GEE by bodies such as NASA (National Aeronautics and Space Administration), USGS (United States Geological Survey), UCSB (University of California, Santa Barbara).

2.3. Data processing

Data processing was performed using Javascript language programming within the Google Earth Engine platform. The platform provides basic codes for each available data set, allowing users to make the necessary changes. The data are grouped into collections and made available to users. The identification of the collections used in this research are shown below: LANDSAT / LT05 / C01 / T1_SR, LANDSAT / LC08 / C01 / T1_SR, MODIS / 006 / MOD11A1, UCSB-CHG / CHIRPS / DAILY. These collections correspond to the data LANDSAT 5, LANDSAT 8, MODIS, and CHIRPS, respectively. In Figure 2, an excerpt from the script provided by GEE and used to process data from the MODIS / 006 / MOD11A1 collection is presented.

MODIS_006_MOD11A1

```
var dataset = ee.ImageCollection('MODIS/006/MOD11A1')
                  .filter(ee.Filter.date('2018-01-01', '2018-05-01'));
var landSurfaceTemperature = dataset.select('LST_Day_1km');
var landSurfaceTemperatureVis = {
  min: 13000.0,
  max: 16500.0,
  palette: [
    '040274', '040281', '0502a3', '0502b8', '0502ce', '0502e6',
    '0602ff', '235cb1', '307ef3', '269db1', '30c8e2', '32d3ef',
    '3be285', '3ff38f', '86e26f', '3ae237', 'b5e22e', 'd6e21f',
    'fff705', 'ffd611', 'ffb613', 'ff8b13', 'ff6e08', 'ff500d',
    'ff0000', 'de0101', 'c21301', 'a71001', '911003'
  ],
};
Map.setCenter(6.746, 46.529, 2);
Map.addLayer(
    landSurfaceTemperature, landSurfaceTemperatureVis,
    'Land Surface Temperature');
```

Figure 2- Script used to generate the temperature map. Source: GEEg (2020).

Obtaining the Normalized Difference Vegetation Index (NDVI) followed the equation proposed by Rouse et al. (1973). This index presents a variation between -1 and 1 in which the positive values and closest to 1 surface revelation with greater vigor, while the negative values equivalent to water or clouds. Exposed soils and rocks reflect in the range of red and near-infrared in almost the same proportion, consequently, the NDVI approaches 0. The NDVI average for each year of study was calculated through programming.

NDVI is the indicator that detects the humidity rate in the vegetation and that was evaluated pixel by pixel through the ratio between the difference and the sum of the reflectances of the bands of the near-infrared (ρiv) and red (ρv). Bands 4 and 3 of the TM Landsat-5 and bands 5 and 4 of the OLI Landsat-8 will be used respectively. The formula for calculating the NDVI can be seen in equation 1.

$$NDVI = \frac{(\rho_{IV} - \rho_{V})}{(\rho_{IV} + \rho_{V})} \quad (1)$$

The MOD11A1 V6 product provides daily terrestrial surface temperature (LST) and emissivity values in a 1200 x 1200 mile note. These data were also reduced through the average to obtain the average land surface temperature for each year studied. The CHIRPS data, on the other hand, represent protecting as minimum 0 and maximum 1444.34 in mm / day. The separation data for each year of study was added to obtain an accumulated annual exclusion.

All scripts were developed in Java language, in which the newsletter delimited an area of study by importing a cartographic base in shapefile format from APA Triunfo do Xingú. After that, the data were filtered according to the year of study and then were calculated as averages of NDVI, temperature, and accumulated precipitation for each year.

2.4. Analysisof results

The results obtained in raster format (matrix data) generated on the GEE platform were later exported to the QGIS Software, version 2.18.16, to prepare the layout of the maps. Thematic maps and graphs of the annual variation of NDVIs and surface temperature were elaborated over the 20 years of study. For the study of precipitation, a graph was drawn up with the annual accumulated precipitation.

To enrich the results obtained about the NDVI, in addition to the graphic and visual analyzes mentioned above, the changes that occurred between the NDVI in the year 2019 and 2000 were also quantified. Also, through data in shapefile format on deforestation made available by ImazonGeo (portal of the Instituto do Homem e Meio Ambiente) areas within the APA that have been suffering the most deforestation have been identified and for better visualizing the changes in the NDVI, the image of the APA as a whole has been enlarged in this region and the results have been compared. NDVI results for the year 2000 and 2019 through visual analysis and area calculations.

The quantification of changes that occurred in the NDVI over the 20 years studied was performed using a sequence of steps proposed by Aboud Neta et al., (2018) and following the equation below.

$$NDVI = NDVI_{2019} - NDVI_{2020} \quad (2)$$

Using equation 2, the NDVI subtraction operation was applied to the images, aiming to analyze changes in the vegetation cover, between the first and the last year of study. The results obtained from this analysis indicate that the higher the value in the resulting image, the greater the increase in the incidence of vegetation between the images of 2019 and 2000. A large number of negative values indicate a greater loss of vegetation. Regions, where the image presents values close to zero, indicate areas without significant changes (LOURENÇO and LANDIM, 2004).

To characterize statistically how changes occurred, a statistical analysis was performed on the image resulting from the subtraction of NDVIs using the values of minimum and maximum, mean, and standard deviation. This analysis was used to verify the variation of the standard deviation around the mean and, with this, to detect the percentage of changes from the defined threshold.

According to Thiam (1997), values of a difference image approximate a normal distribution around the mean. In Figure 3, a normal distribution curve is shown, Since the mean (represented by μ) with a value of 0 and standard deviation (represented by the letter σ) with a value of 1. Using the standard deviation, one can control the degree of changes expected from the delimitation of the lower and upper thresholds of the distribution from the mean.

According to Thiam (1997), using a value of twice or the standard deviation (2σ) around the mean, a distribution will encompass approximately 95% of the data. Authors like Sohl (1999) affirm that the use of this 2σ threshold around the mean (μ), generates good results when produced in the NDVI difference image.

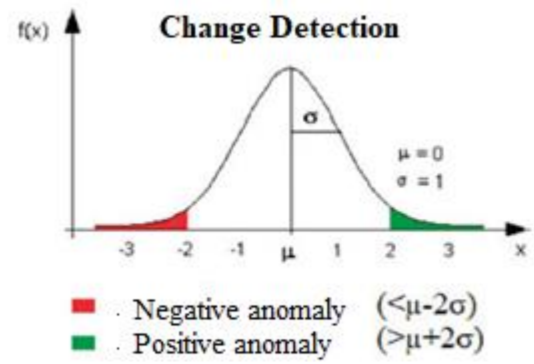

Figure 3- Normal distribution curve for analysis of detection of changes represented as negative and positive anomalies. Source: Aboud Neta et al. (2018)

In this work, the threshold of 2σ around μ was used, in which the regions of the histogram with oscillation less than -2σ around μ were called negative anomalies and regions with oscillation greater than + -2σ called positive anomalies.

The middle interval that is located in the region between μ-2σ to μ + 2σ will contain the pixels without relevant changes of changes. Negative anomalies indicating a higher positive NDVI index in the older scene, compared to the most recent image.

Positive anomalies, on the other hand, represent areas with a probable index of indication that in the oldest image there was a lower index of NDVI, compared to the most recent one. (Ferrari et al., 2011; Aboud Neta et al., 2018).

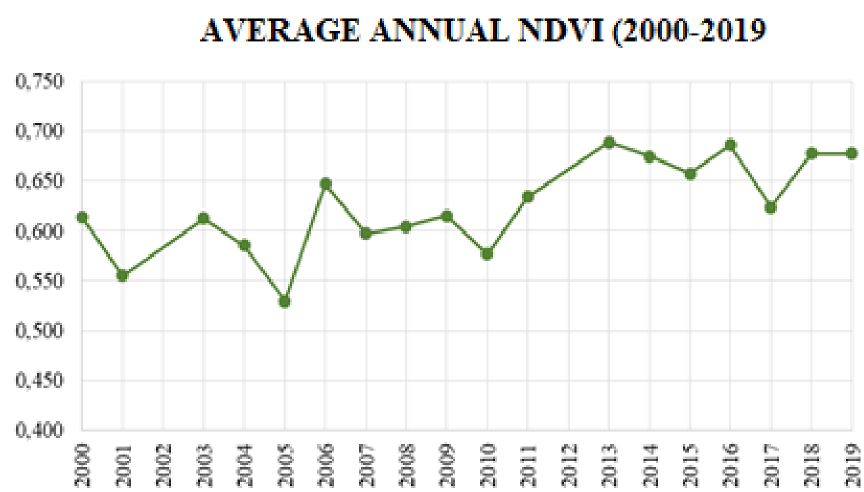

Figure 4- Average of NDVI values (2000 - 2019). Source: The authors, (2020).

Figure 5 shows the thematic map prepared in the QGIS 2.18 software in which the data were grouped into 5 distinct classes obeying the following intervals: -1 to 0, 0 to 0.21, 0.21 to 0.40, 0.40 to 0.6, 0.6 to 1.0.

Due to the large amount of clouds in the image, the year 2002 was removed from the analysis as well as the year 2012 due to the absence of satellite images for this period. In ascending order of intervals, class 1 corresponds to water bodies and rocks, class 2 represents exposed soil and undergrowth or sparse vegetation, class 3 shrubs and pastures, classes 4 and 5 represent tropical and temperate forest and other vegetation being class 5, more dense vegetation and crops at their peak of growth.

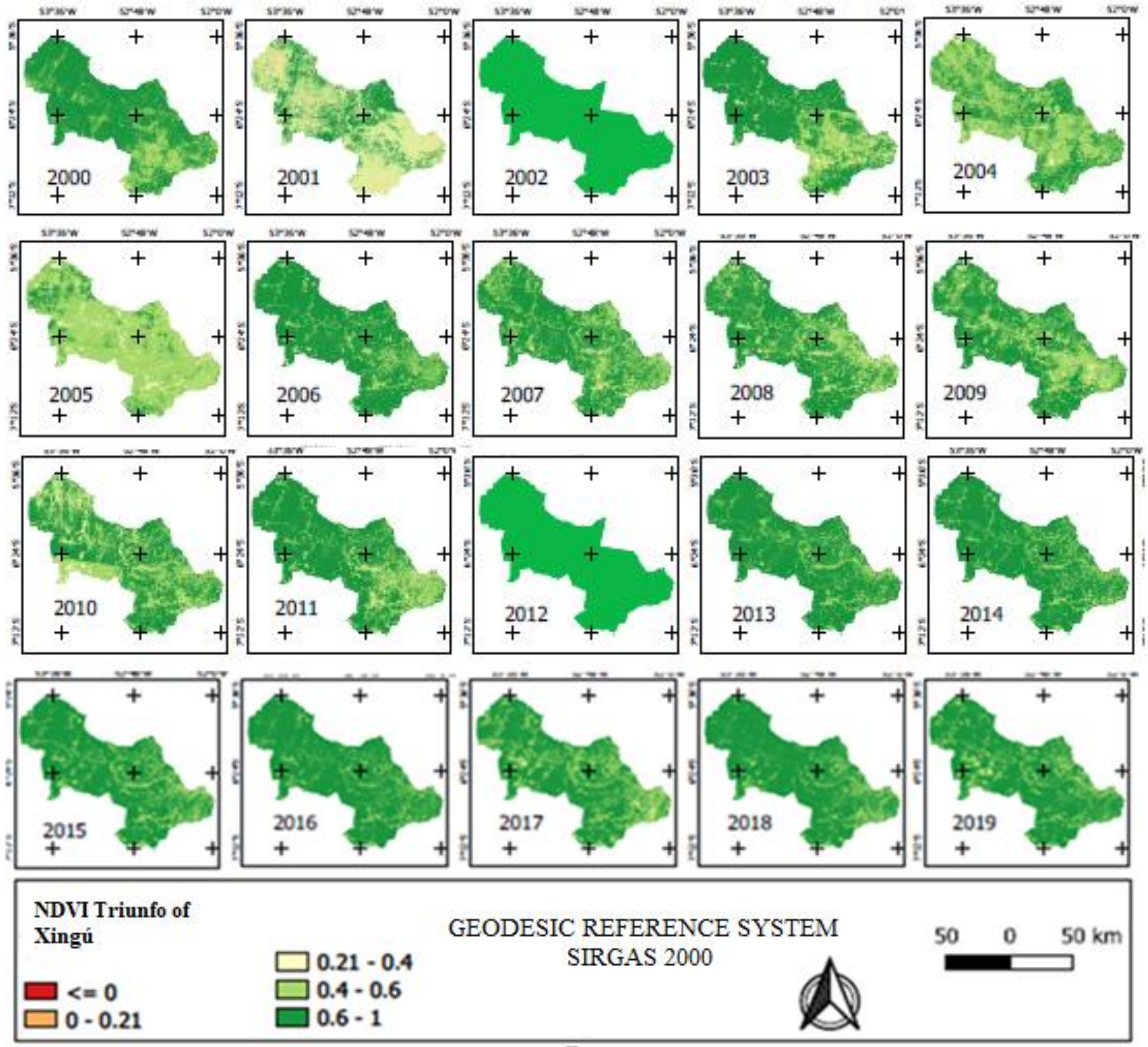

Figure 5- Thematic maps NDVI (2000 – 2019). Source: The authors, (2020).

From Figure 5, it is possible to see that the NDVI values in the years 2001 and 2005 were lower. Areas with denser vegetation have values close to 1, areas with water bodies or presence of clouds have greater reflectance in the red band than in the near-infrared band and, therefore, present values close to -1. Exposed soil or sparser and sparser vegetation have positive values, , in an interval between 0.10 to 0.20, where there is greater absorption of radiation in the near-infrared range (LIMA et al., 2009).

Through visual analysis, it is observed that it is not possible to visualize a class with values less than zero, which corresponds to physical bodies. Relevant variations were also observed in most of the municipality for the class with values greater than 0.60, mainly in the years 2000 to 2005, 2008 to 2011 which correspond to the vegetation areas.

In Figure 6, the difference image of NDVI between the years 2019 and 2000 is shown, in which the red color stands out as negative anomalies, the green color as positive anomalies, and in gray as regions without significant changes.

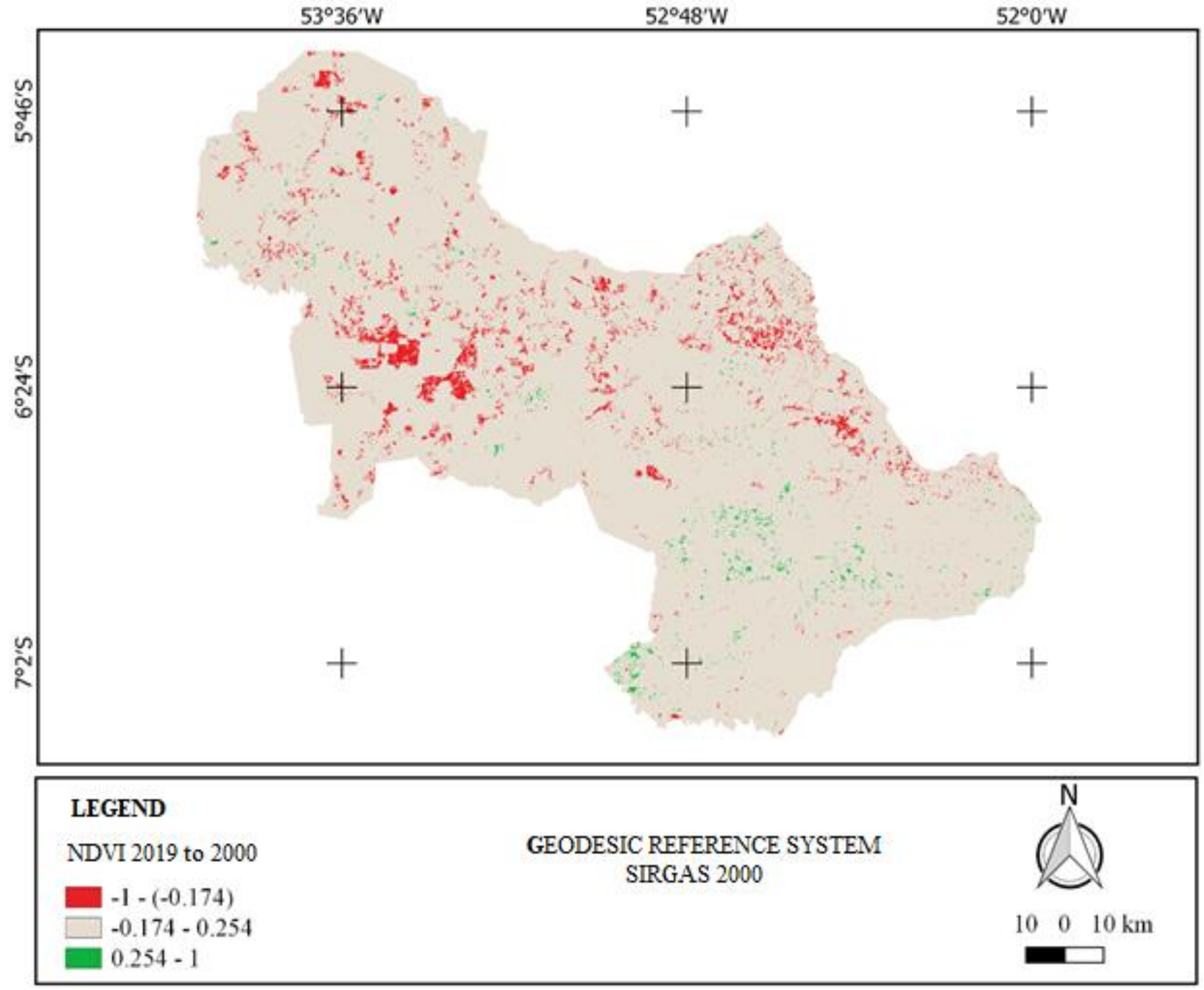

Figure 6- NDVI difference image (2019 – 2020). Source: The authors, (2020).

Through the difference image, statistical data were extracted, as shown in Table 1. The temporal evolution over 20 years studied (comparing the 2000 image with that of 2019) pointed out changes in an area of approximately 828 km² (4.93%). Of this total, about 702 km (4.18%) correspond to negative anomalies and 125 km (0.75%) to positive anomalies.

Positive anomalies indicate an increase in green vegetation, that is, pixels that in 2000 were not vegetation have become over the years. Negative anomalies, on the other hand, indicate that they indicate the decrease in pixel vegetation, which in 2000 was vegetation and which in 2019 were no longer. According to Aboud Neta et al. (2018), as positive anomalies indicated reforestation or the presence of agricultural areas, while as negative they indicate processes of deforestation and urban expansion.

To facilitate the visualization of changes in the APA, for vegetation, data in shapefile format on deforestation provided by ImazonGeo, which is a portal of the Institute of Man and Evironment, which aims to provide updated information on the situation, dynamics, and pressure on forests and protected areas in the Brazilian Amazon.

From these data in shapefile format, the areas of APA that suffer most from deforestation were identified. One of these areas corresponds to a small portion of land located in the southwest of the APA with an area of approximately 1221 km² as shown in Figure 5. To better visualize the changes in the NDVI, the image was enlarged in that region and the results of the year 2000 and 2019 were compared (Figure 7).

Table 1– Description of the difference image statistic. Source: The authors (2020).

MAGE ESTATISTICS	VALUES	DATAS	ÁREAS (Km²)
Minimum value	-0,835	Negative anomaly	702,441
Maximum value	0,462	Positive anomaly	125,670
Average (μ)	0,040	no change	15981,823
Standart deviation (σ)	0,107	total	16809,934
Negative anomaly	-0,174		
Positive anomaly	0,254		

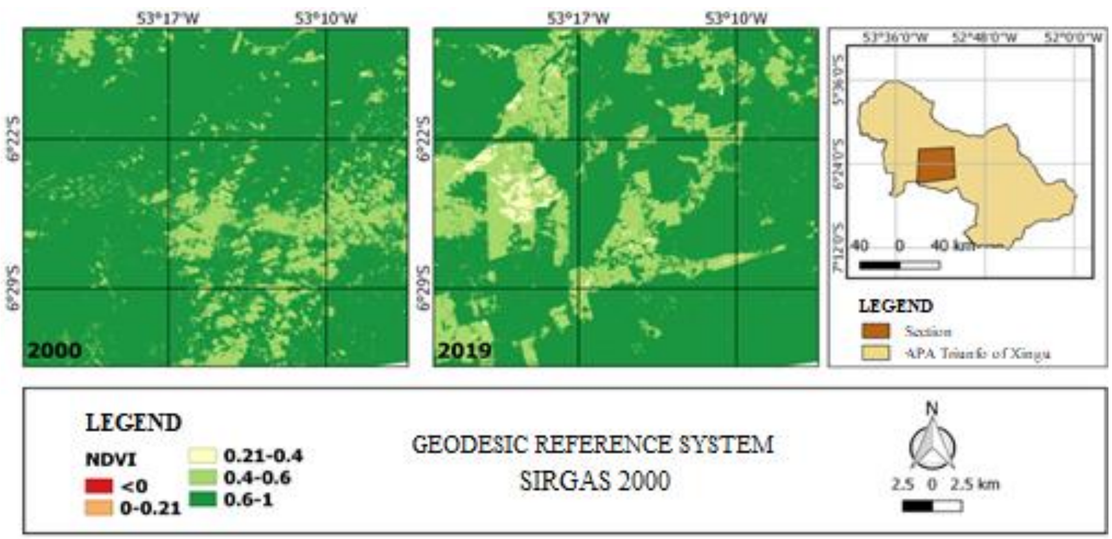

Figure 7- NDVI thematic maps southwest section of the APA. Source: The authors, (2020).

Figure 7 shows a decrease in vegetation cover in the region, corresponding to the class with values between 0.6 and 1 and an increase in the classes with values between 0.21 to 0.40, which corresponds to bushes and pastures. From these data, they were also calculated as areas corresponding to each of the 5 classes observed (Table 2).

Table 2– Description of the areas. Source: The authors (2020).

CLASSES	ÁREAS	
	ANO 2000	ANO 2019
1(<0.0)	0	0
2 (0.0-0.21)	0	0,07
3 (0.21-0.40)	2,81	19,39

4 (0.40-0.60)	191,49	276,41
5 (0.60-1.00)	1026,75	925,18

It is possible to observe that during the 20 years of study, there were relevant changes to the same area. Class 1, corresponding to water bodies, values equal to zero for the two years studied due to the absence of water bodies in this section of the APA. Class 2 increased slightly from zero in 2000 to 0.07 km² in 2019.

Class 3 had a significant increase as the areas with shrubs and pastures increased in the region. Class 4 also increased and corrected areas of already consolidated forests. In class 5, a forest area in full growth, its values were very low, confirming the deforestation data obtained by ImazonGeo.

According to Tupiassu et al., (2019), one of the main causes of deforestation in the APA Triunfo do Xingu is an irregular occupation, a consequence of the lack of land title regularization and a management plan, which demarcates as areas destined to the preservation of environmental resources, not subject to occupation.

Authors such as Pinho et al., (2017), analyzed the anthropic pressure on the APA Triunfo do Xingú between the years 2006 and 2016. The results obtained a reduction in forest cover, however despite the high rates, a deceleration of the clear cut was observed between the years 2008 to 2013, due to the insertion of policies to combat deforestation guided by the Deforestation Action and Control Plan in the Legal Amazon (PPCDAM), but as of 2014, factors such as Brazil's economic and political instability led to the growth of values at an accelerated pace.

In Figure 8 below, the graph of LST averages is shown, the results a minimum and maximum value of 26.7 ° C and 28.16 ° C, respectively. It is noted that the temperature on average has an upward trend over the years, according to Souza, Silva and Silva (2016) factors that can cause the temperature increase are: increased soil exposure, decreased vegetation, fires, and deforestation and also less rainy periods.

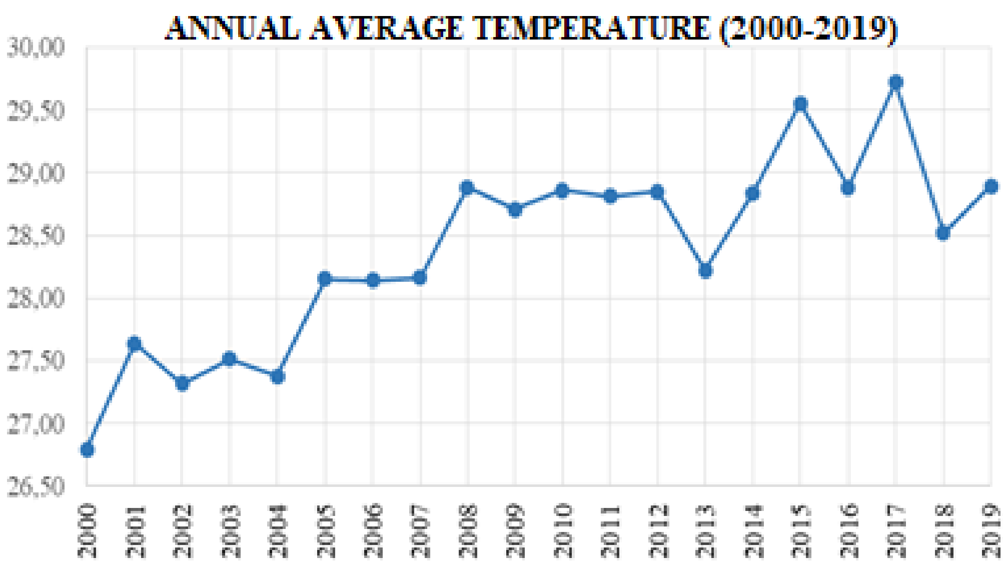

Figure 8- Average of LST Values (2000 - 2019). Source: The authors, (2020).

According to Fernandes et al. (2018) the high temperatures have an inverse relationship with the relative humidity of the air. In their study, they observed that the hot spots in the municipality of Parauapebas – PA was concentrated in the less rainy period. Figure 9 shows the LST map for the 20 years of study.

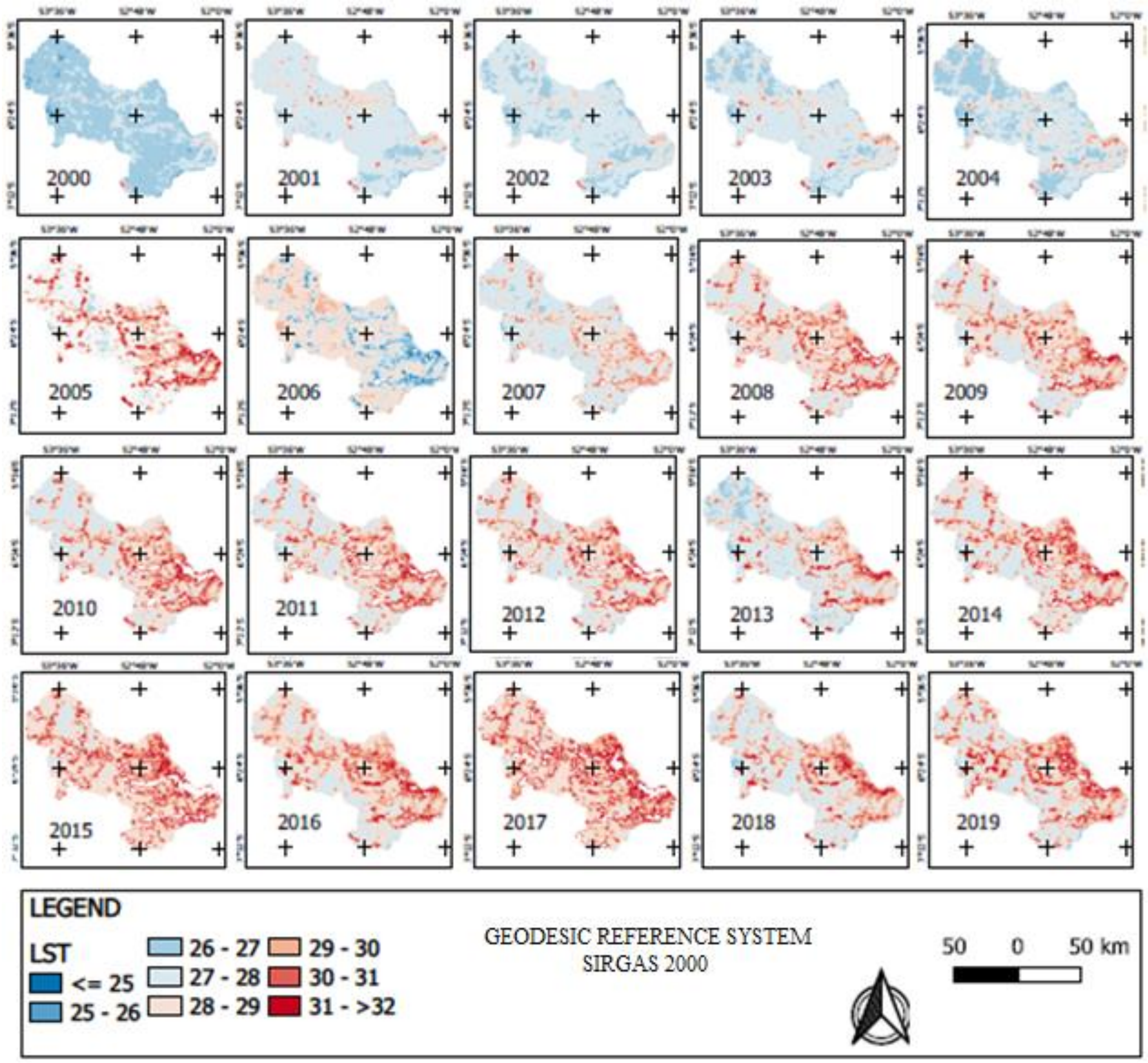

Figure 9- Average of LST Values (2000 - 2019). Source: The authors, (2020).

It is noted that between the years 2000 and 2004 the temperature in the region had lower values and over the years these values have increased. Many authors claim that both the health of the vegetation and the temperature of the surface are highly related to water variability for the region, that is, with a combination (SOUTO et al., 2018; PIRES, 2015). Souto et al., (2018) carried out a study over the Anthropic impacts affecting air temperature variation in APA Triunfo do Xingu between 2005 and 2015. The authors studied variations in temperature in the region through deforestation and burning and also found an increase in temperature over the years. According to the authors, local factors that may have influenced this increase in temperature are the lack of vegetation cover, which influences the prevailing weather conditions through direct absorption and reflection of incident solar radiation.

Also, Jiménez-Munhoz et al. (2016) state that anthropic actions associated with function mechanisms influence the local climate. In 2015, for example, the El Niño event was observed, which resulted in a shortage of rain, high temperatures, and low humidity. Events like this associated with anthropic actions such as plant suppression and burning an increasing rate of intense calorie outbreaks and plant suppression contribute to an increase in the annual temperature variation over the study region.

Figure 10 presents the results for an accumulated annual capacity extracted from CHIRPS data. These results correspond to the total separation in mm for each year of study.

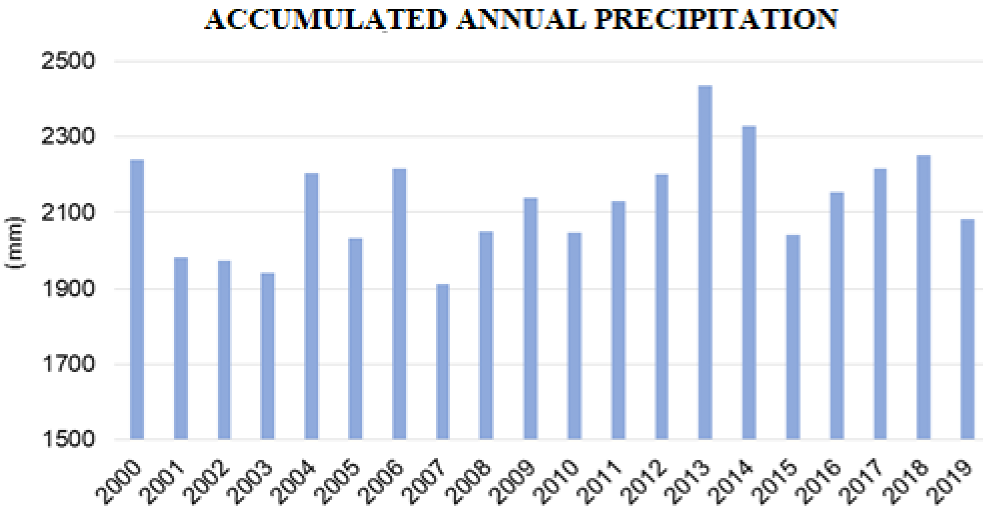

Figure 10- Annual accumulated rainfall (2000 - 2019). Source: The authors, (2020).

From this Figure, there is a relatively homogeneous rainfall regime in the region, with the year 2007 having the lowest memory (1912.17 mm) and 2013 (2436.69 mm) being the most obligatory. These results corroborate to understand the behavior of vegetation and temperature in the region. In 2005, when the lowest average NDVI was observed, it is noted that it was a year of lower accumulated capacity when compared to other years. As well as the year 2013, which presented the highest average of NDVI and a decrease in temperature and the highest value of accumulated capacity among the 20 years studied.

4. CONCLUSION

Despite being a protected area, APA Triunfo do Xingu whose main functions are to protect biological diversity, control the occupation process and ensure the sustainable use of natural resources, it has undergone significant changes in soil cover and temperature. The alterations detected point to the occurrence of vegetative loss in some stretches and an increase in temperature in the region over the past 20 years.

The use of SR techniques combined with digital image processing made it possible to analyze and identify changes that occurred in the APA Trinfo do Xingu. NDVI and LST maps of the area, over the past 20 years, associated with capacity data have made it possible to identify the environmental impact in the region, which may indicate activities such as logging, mining, livestock and urban expansion.

The results obtained can be justified by the fact that the APA was created in a region where there was already a high population concentration and a very degraded and altered environment, in addition to covering private areas within its limits. Facts like these hinder the management of the territory and the search for sustainable use of resources.

The methods used in this paper were very feasible for analyzes such as these and, when related to other sources of data sources, make it possible to obtain more complete results. In addition to exclusion data, other data must be studied in order to justify the changes found. In addition, the maps created can be easily understood both by experts in the field and by other users. Although the results provide data that contribute to a better understanding of the environmental scenario of the studied area, other more in-depth studies are still referred to better characterize changes and impacts that have occurred in the region.

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