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Evaluation of environmental changes as a function of climatic variables from 2008 to 2018 in the city of Manaus- Amazonas

Wallace Cevalho da Silva;Rândrea Grazziella Verçosa Guimarães;Fabiana Rocha Pinto;David Barbosa de Alencar;Gisele de Freitas Lopes

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Wallace Cevalho da Silva
cevalho@outlook.com
FAMETRO University Center – Brazil

Rândrea Grazziella Verçosa Guimarães
grazziellavercosa@gmail.com
FAMETRO University Center – Brazil

Fabiana Rocha Pinto
fabiana.floresta@gmail.com
Engineering Coordination at FAMETRO University Center – Brazil

David Barbosa de Alencar
david002870@hotmail.com
Galileo Institute of Technology and Education of the Amazon – ITEGAM

Gisele de Freitas Lopes
gikalps@gmail.com
Galileo Institute of Technology and Education of the Amazon – ITEGAM

Abstract

El Niño intensifies the temperature increase in the Amazon region, causing heat and extreme drought in much of the Amazon, in Manaus the process of urbanization intensifies the temperature increase of the city. This study aims to perform an analysis of climatological variables of the city of Manaus-AM, from January 2008 to December 2018, through the maximum and minimum temperature, precipitation and relative humidity in order to show the increase in temperature through statistical analysis showing the temperature. year of greatest impact. According to the results obtained, in 2008 Manaus recorded the lowest minimum temperature in the period being 23.4 ° C, characterizing the minimum maximum temperature with 32 ° C, it is noted that due to the presence of the negative phase of ENSO (La Niña) in 2008 the precipitation level in the region was high, contributing to the low temperatures and the relative air humidity averaged 87%, and the highest annual average of the maximum and minimum temperature in the study period occurred in 2015. , being 33.5 ° C and 25.7 ° C, due to the positive phase of ENSO (El Niño), temperatures in the capital were high, with little precipitation during the year directly impacting the relative humidity (75%). . Therefore, the positive / negative ENSO anomalies had a major influence on the climatic variables in the year 2008 and 2015, characterizing low temperatures in 2008 and high temperatures in 2015.

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1. Introduction

Population growth has led to urban sprawl, resulting in changes in natural features, such as deforestation for land use, especially in Permanent Preservation Areas (APPS), through disorderly man-made pavements and constructions, resulting in large quantities. heat-retaining materials, incurring factors that act or optimize climate change (GARTLAND, 2011).

According to Ferreira; Coelho (2015), deforestation and disordered land occupation cause loss of biodiversity, causing environmental damage. In Brazil, this loss results in 22% of Greenhouse Gas (GHG) emissions. Allied to this, the transformation of forest into pasture directly influences evapotranspiration, especially in periods of drought, decreasing the amount of water in the atmosphere, causing a decrease in rainfall in the Amazon and, when presenting climatic phenomena, results in other Brazilian states (NOBRE , 2014). In addition, the National Policy on Climate Change - PNMC, instituted by Law No. 12,187 of 2009, was one of the series of actions that Brazil had to take to adapt to climate change (ARAÚJO, 2017).

According to Leal et al. (2014), the horizontal surface coatings in urban centers contribute to the temperature increase, causing heat islands through heat retention, being higher in regions with hot and humid climate. These impermeable surfaces not only contribute to the increase in temperature, but, according to TUCCI (2016), poor urban drainage contributes to flooding, causing water to run superficially and according to the study by SILVA et al. (2019), the altered hydrological cycle, causing this runoff to generate more flooding due to improperly accumulating waste in the soil.

The expansion of urban centers uses pavements with materials that retain a large amount of heat, with the temperature rising which, depending on the shape, becomes heat islands. The disordered growth of the city of Manaus-AM is mainly through the invasions that expand in the city limits, having as main focus the east zone and areas adjacent to the AM-010 and BR-174 highways, where the urbanization process increases the temperature of cities due to heat retention, as the structure of large urban centers when compared to vegetated areas, impacts on temperature, causing numerous problems in human and environmental health.

From the Industrial Revolution it is remarkable that the population in the big cities increased significantly in search of better living conditions. From the rural exodus, there were a total of 27 million people from 1960 to 1980, migrating from rural to urban areas (BRITO; HORTA; AMARAL, 2018). This process of these was due to the fact that technology in agriculture, given by the replacement of human labor by machines, generating economic, social and environmental problems (BAENINGER, 2016). From the 1960s, Manaus received a significant amount of people provided by the implementation of Manaus Weak Zone, receiving approximately 100 thousand people (ARAÚJO, 2017)

The large migration of people leads directly to the deficiency of basic sanitation and decent housing to serve everyone (SILVA, 2016), these in turn seek spaces and illegally expand their areas, deforesting and causing siltation of soil and springs. With the lack of information at the time, there was the use of materials in road construction and other enterprises to serve the population, which retained heat, generating optimized heat areas, therefore by these materials (GARTLAND, 2011).

Therefore, one of the main villains in temperature rise is the materials used in buildings, dark materials, which absorb more heat from the sun, failing to dissipate heat through evapotranspiration and the absence of moisture, which according to Gartland (2011).) indicates that impermeable sun-heated surfaces may have temperatures between 27 and 50 ° C, while the presence of natural vegetation would reduce to 21.1°C. In the centers of large cities there are several factors that contribute significantly to heat islands (MONTEIRO et al. 2014). With the removal of vegetation cover to meet the need for rural exodus one of the main reasons observed should be the construction of houses, buildings and streets, containing materials such as asphalt and concrete making the environment warmer (FERNANDES, 2015).

The combination of these two factors, expansion and removal of vegetation cover, can be characterized as the main causes of temperature increase in cities, causing soil sealing and consequently higher temperatures (CORRÊA, 2016).

Greenhouse Gases (GHGs) are the main causes of temperature increases in cities, and according to the National Plan on Climate Change (PNMC, 2008) in developed countries one of the main gases emitted is CO2 in the atmosphere which, in 2016 reached 403.3 ppm (WMO, 2017). This amount comes from the burning of fossil fuels to serve the population through electricity, also considering the existing industrialization process such as the production of cement and waste incineration.

In Brazil, the main sector that emits CO2 is agriculture, via land and forest use change (75%); Other factors such as industry and transportation total 9% of emissions each and fugitive emissions (1%) (PNMC, 2019).

Manaus has a large number of motor vehicles burning fossil fuels (CO2) constantly, this "population" according to the IBGE (2018) was 718,205 vehicles, tending to be larger over time, since the transportation offered to quality, encourages the purchase of own vehicles to meet their mobility, generating more and more CO2 in the city.

As the climate of the city of Manaus is hot and humid (FERREIRA; SOUZA; ASSIS, 2014), the burning of forests in the Amazon has direct application in increasing the temperature and decreasing rainfall in the region, given its carbon stock, where when If trees are cut down, all carbon that has been absorbed will be released, considerably increasing the influence on the greenhouse effect (NOBRE, 2014).

Climatic phenomena are natural processes that are becoming increasingly intensive due to direct damage caused by man, tending to become severe events that cause severe degradation. Some acquaintances, others not so much, depending on the event can occur a great flood or drought (DA SILVA DIAS, 2014).

El niño intensifies the rise in temperature in the Amazon region by warming the tropical Pacific ocean, causing extreme heat and drought in much of the Amazon (JIMÉNEZ-MUNOZ et al. 2016). In addition to the increase in temperature, this phenomenon decreases the rainfall regime in the region, affecting the hydrological regime (SOUSA et al. 2015).

Considering the way cities expand, characterized by the lack of planning, this study aims to perform an analysis of climatological variables of the city of Manaus-AM, from January 2008 to December 2018, with the purpose of showing via Statistical analyzes increase in temperature and relate to urban sprawl, demonstrating the year of greatest impact.

2. Material and Method

2.1 Study area

The city of Manaus, located in the state of Amazonas (Figure 1), located on the left bank of the Rio Negro, has its climate classification, according to Köppen (1948) as humid tropical climate or equatorial climate, characterizing the average temperature of the region in 18 ° C.

Figure 1 - Location of the city of Manaus - AM
Source: Own authorship, 2019.

According to the Brazilian Institute of Geography and Statistics (IBGE, 2010) the municipality's territorial extension is 11,401 km2, with an exponential increase in population (Figure 2).

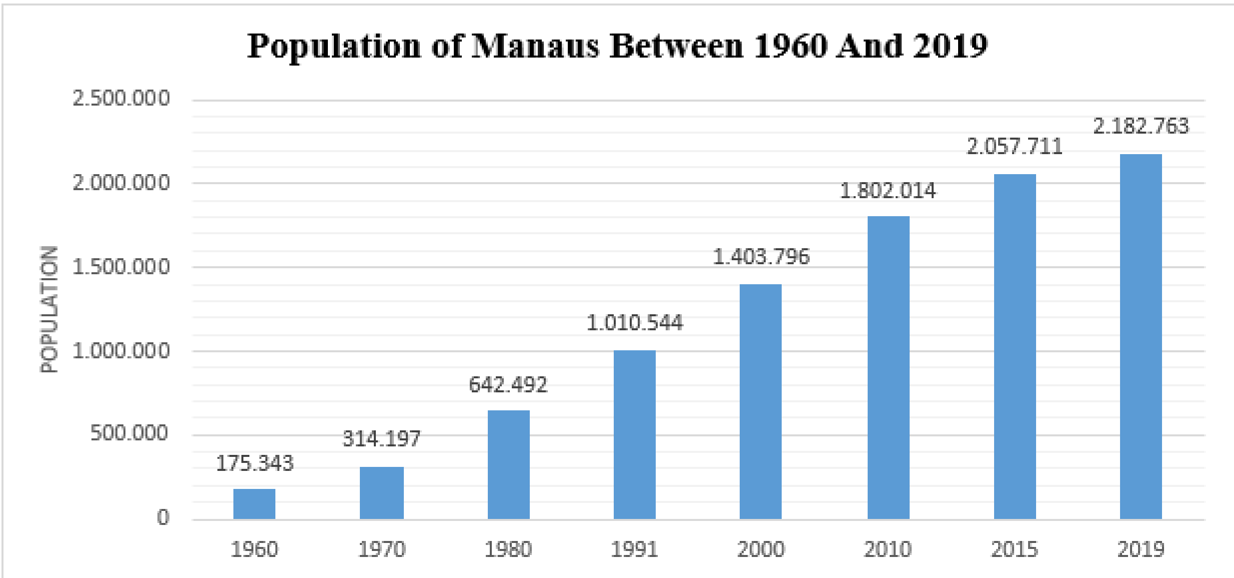

Figure 2 - Population of Manaus between 1960 and 2019.
Source: Own authorship, 2019.

2.2 Data collect

The collected data were: maximum and minimum temperature, precipitation and relative humidity of the station available on the website of the National Institute of Meteorology (INMET), located at Rua Recife, 1041 - Adrianópolis, Manaus - AM, using database of the years. from 2008 to 2018.

To guide and relate these measures evaluated in the city of Manaus over the period of 11 years (2008-2018) Anova was used by the Systat 13.1 program, for the variables collected on the INMET website.

3. Results and Discussion

According to data from the National Institute for Space Research - INPE, in 2008, the deforestation area in the Amazon was 604 km2, and in 2018 with an area of 1045 km2. This loss of vegetation cover is associated with illegal logging, illegal mining, removal of forest for grazing and, in the city of Manaus, there is the invasion of green areas to build communities illegally, in addition to urbanization through roads, construction of buildings and expansion of Manaus Free Zone, which contribute to the emergence of heat islands.

Corroborating with the study of Dos Reis; Guimarães (2017), when extreme weather events occur in the Amazon region, temperature rates tend to be higher with the presence of the ENSO (El Niño) positive phase and rainfall increases with the presence of the negative (La Niña) phase causing environmental, social and economic disasters due to flooding.

The average annual temperature of Manaus in 2015 was around 29.6 ° C, with average monthly temperature in March around 28.2 ° C and September 32.3 ° C, with the average variation between maximum and minimum, respectively. , 33.5 ° C and 25.7 ° C (INMET, 2019).

Figure 3 shows the annual average of the maximum and minimum temperature in the study period, where the highest and minimum values occurred in 2015, with 33.5 ° C and 25.7 ° C, and in 2008 with 23.4 ° C. minimum and maximum 32 ° C (La Niña). From 2008 to 2010 there was a rise in temperature in the capital, from 32 ° C to 33 ° C, remaining at an average of 32.6 ° C in the years 2011 to 2014, and in 2015 reaching the highest rate observed in the years collected. due to the presence of extreme weather event. In the years 2016 to 2018 the maximum temperature returned to average of 32.6 ° C. Pearson SYX correlation 69%, considering a moderate correlation.

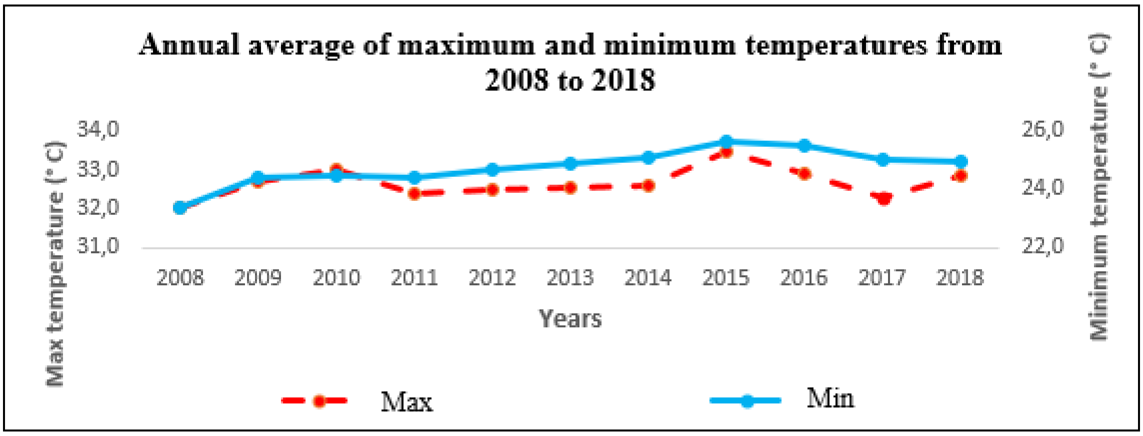

Figure 3 - Annual average of maximum and minimum temperatures from 2008 to 2018.

Source: Own authorship, 2019.

According to Figure 4, the highest rainfall occurred in 2008, with the presence of La Niña and in 2015 the lowest rate due to the presence of El Niño. Thus, the lack of cloudiness provides direct radiation, and there is no filter to disperse the radiation, where according to Cirino, Vitorino; from Holland (2019), corroborate Costa's study; Mattos (1998) who obtained the lowest temperature values in the rainy season and the highest in the dry season. Moreover, it presents a statistically significant difference between the years (F = 0.774; P = 0.653).

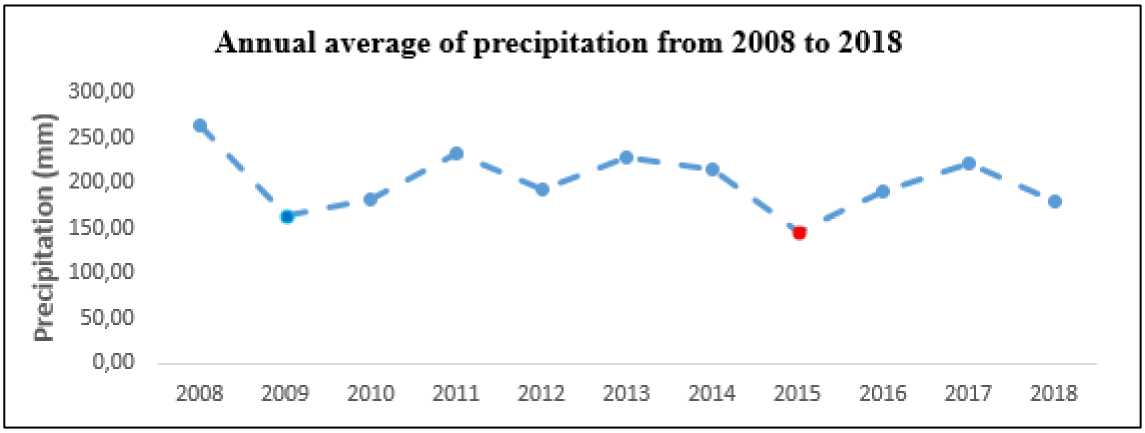

Figure 4 - Annual average of precipitation from 2008 to 2018.
Source: Own authorship, 2019.

The average relative humidity (%) for Manaus was 79%, with the highest rate of water in the atmosphere in 2008 and in 2015 and 2016 the lowest RH (%) for the capital (Figure 5), providing a hot and dry climate, which can lead to urban and rural fires, as well as damage to human health. These results corroborate the study by Monteiro et al (2014) that obtained in September 2012 an average of 72%, and 87% in March 2013. Finding values for F = 3,451 and P = 0,001, highly significant.

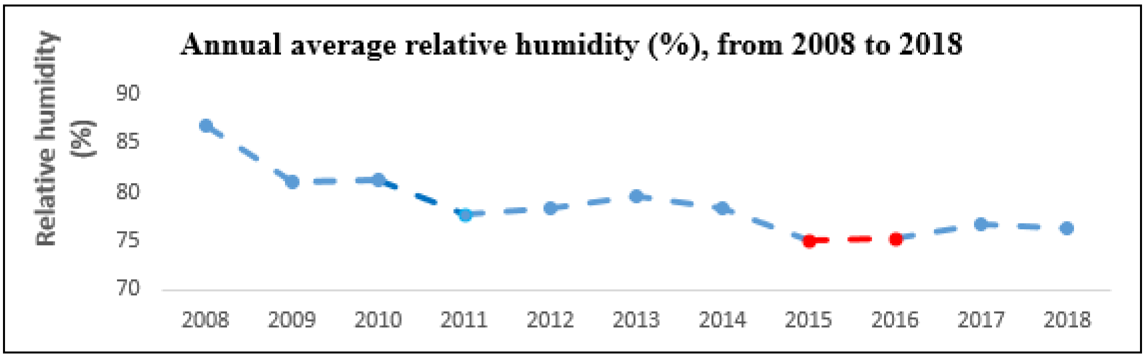

Figure 5 - Annual average relative humidity (%), from 2008 to 2018.
Source: Own authorship, 2019.

In 2015, given the presence of the El Niño climate event, high temperatures and low rainfall were obtained, which is characteristic of the phenomenon. However one must take into account the intensity of the event, which in fact has indicated sudden changes in the environment. Thus, Figure 6 shows that the maximum temperatures were lower from January to June, while the maximum minimum temperature values occurred from August to December. Years of extreme drought caused by climatological phenomena should consider little variation of minimum and maximum temperature in the dry season, explained exactly by the condition of temperature rise, optimized by the phenomenon.

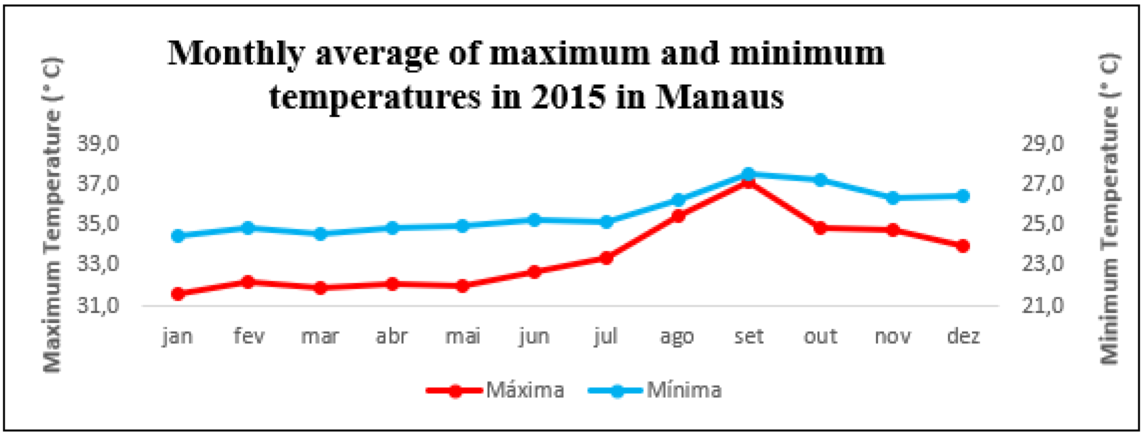

Figure 6 - Monthly average of maximum and minimum temperatures in 2015 in Manaus.
Source: Own authorship, 2019.

Thus, from the observations described by the collected data, it is noted the direct interference of / on temperature. The annual average rainfall in 2015 (Figure 7) was 144.6 (mm). From July to October, the region had rainfall below the average than in the other months, which is very similar in the Amazon region. However, once again it is worth mentioning the intensity caused by the climate phenomenon. In this period, the highest values for maximum temperature and lowest values for minimum temperature were obtained. The presence of the positive ENSO phase kept temperatures high in December due to lack of precipitation in the region (Figure 7).

In agreement with the study by Monteiro et al (2014), Manaus, presents only two seasons, the Amazonian winter between the months of November to June (rainy season) and the summer of July to October (dry season). Rainfall data show that in March there was the highest rainfall, which may be considered as the coldest month and in August with the lowest levels being the hottest (Figure 7).

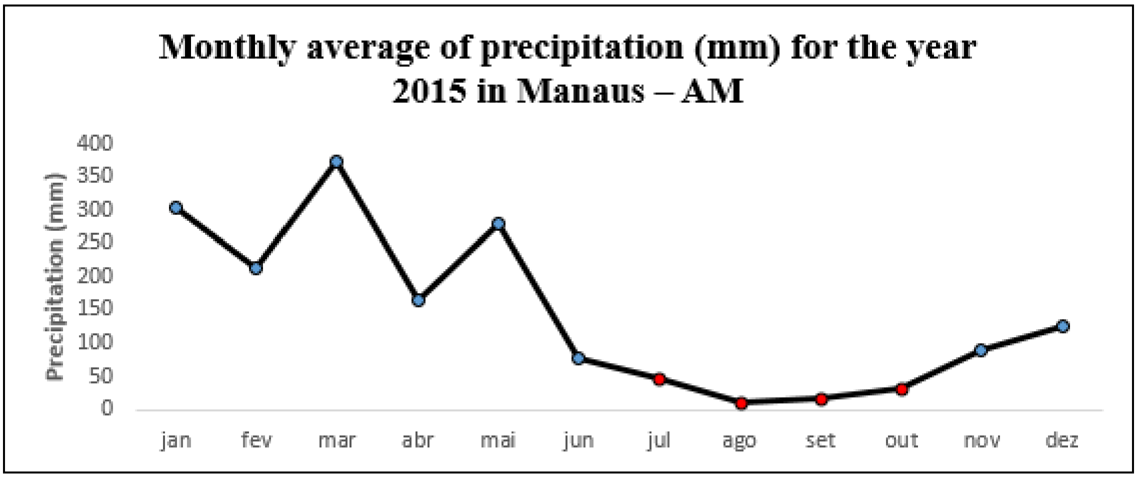

Figure 7 - Monthly average of precipitation (mm) for the year 2015 in Manaus – AM.
Source: Own authorship, 2019.

The low humidity presented in 2015 and 2016 shown in figure 8, is justified by El-Niño that decreases the precipitation rate, raises temperatures and leaves the dry climate in the Amazon region. In 2015, the months with the lowest rate were September and October, with an average of 63%. In March the relative humidity had its highest rate, reaching 85% (Figure 8). Correlating Relative Humidity (%) with Precipitation (mm) is a moderate to strong correlation of 0.731, indicating that the lower the precipitation, the lower the relative humidity.

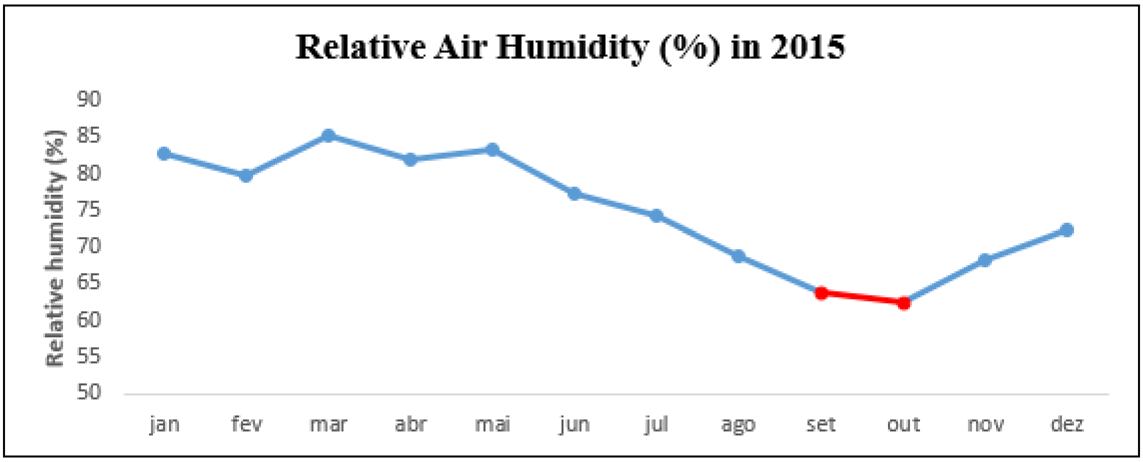

Figure 8 - Relative Air Humidity (%) in 2015.
Source: Own authorship, 2019.

4. Conclusion

The presence of positive and negative ENSO (El Niño-Southern Oscillation) anomalies influenced the climatological variables in the years 2008 and 2015 in the city of Manaus - AM. In 2008, the presence of La Niña caused low temperatures, high precipitation and relative humidity. In 2015, the capital of Amazonas suffered from high temperatures, reduced rainfall, low relative humidity and a long period of drought, characterized by the presence of the extreme El Niño weather event, which may have been prolonged during the year. Following.

Climatic phenomena have been gaining momentum with environmental changes, however it is necessary to understand the whole process, the monitoring of predictive variables and the intensity with which these events have been occurring over time, as a way to find minimization / mitigation processes, for protection, conservation and sustainability response.

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