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Decadal precipitation in São Bento Una – Pernambuco, Brazil

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Abstract

The objective is to carry out an analysis of decadal precipitation and its historical comparisons for the municipality of São Bento do Una in the period 1920-2018, which will possibly contribute to the decisions of sectors such as socioeconomic, agriculture, poultry, irrigation, energy production, resources water resources and agricultural technicians and decision makers in the event of extreme winds that may occur. The rainfall data were acquired from the Superintendence of the Development of the Northeast and from the Pernambucana Water and Climate Agency, between the years 1920 to 2016. The statistical simplified calculations were used to define, mean, standard deviation, coefficient of variance, maximum and minimum absolute values occurred, the rainy and dry seasons were defined. The rains registered between decades did not cause great inconvenience to the population, the local economy, except in months where the summer period was extended. The irregularities that occurred in the rainfall in the 1930-1939 decades; 1950-1959 and 2010-2018 were the most prominent in the contributions to livestock farmers for the production of survival agriculture, poultry and water storage in small, medium weirs and cisterns.

Keywords: Rainfall fluctuations; Provoking and/or inhibiting factors of rain; Event extreme; Decadal precipitation

1. Introduction

In the last two decades, climate change and its implications for humanity have been one of the biggest concerns of scientists around the world, regarding the factors responsible for climate variability, which have been accentuated since the beginning of the 20th century. Human activities are, in the view of some researchers, responsible for part of these changes. However, a possible natural climate variability must be taken into account, since the magnitude of the signal associated with it in the existing climate records has not yet been well determined [7 and 8].

[18] showed that the decadal rainfall variability and its comparison with the historical rainfall average for the rainfall collection microregions in the State of Piauí, were based on historical series from 1912 to 2011 and from 1962-2011. Rainfall shows its variability depending on the activities of atmospheric systems such as: South Atlantic Convergence Zone, Intertropical Convergence Zone, traces of cold fronts, Lines of instability and the formation of high-level cyclones, contributing to greater or lesser rainfall variability. The local contributions and the Intertropical Convergence Zone act with intensity in the northern sector and caused above normal rainfall in some decades. The influences of El Niño/La Niña phenomena for the decades under study in the form of adverse phenomena presented isolated contributions.

Intense rains, as well as droughts, have great impacts on many socioeconomic segments. The regions affected by excess precipitation over the years, in most cases, are concentrated in the northeast, south and southeast of the state. Precipitation is one of the main variables that influences the socioeconomic sector of the state of Piauí, mainly due to its

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strong agricultural and agribusiness nature. The state of Piauí, as well as the entire Northeast region of Brazil, is strongly influenced by the El Niño/La Niña phenomenon. [3].

[23] stated that climate fluctuations are the main cause of fluctuations in global food production in arid and semi-arid regions of tropical developing countries, according to the author, variations in heating and cooling, droughts, floods and other forms of climatic occurrences, has wreaked havoc on agriculture and had a strong economic and organizational impact on the population.

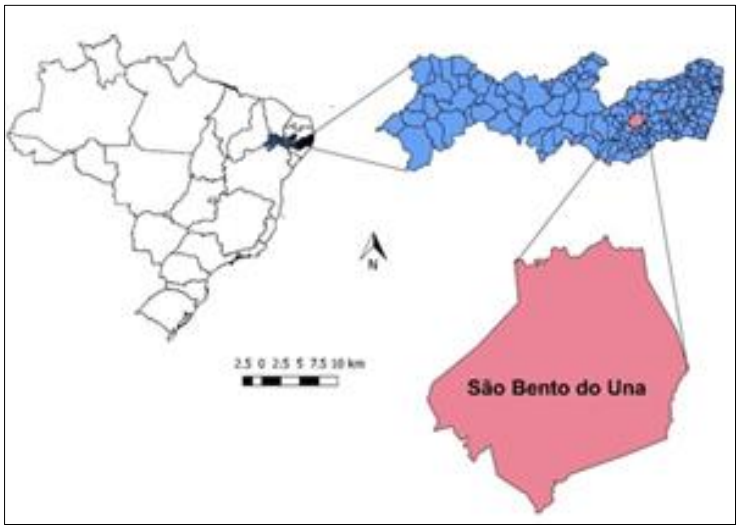
For [10], performed the climatological analysis of decadal precipitation and their historical comparisons for Recife - PE, using the historical series from 1915 to 2014 to contribute to decisions in sectors such as the economy, agriculture, irrigation, energy production, water resources, agricultural and agronomic engineering, fire brigade, civil defense and government decision makers in the event of extreme precipitation events that may occur in the future. The averages for decades were calculated and their comparison with the average climatological precipitation of the area under study. The inter-neighborhood variability of rainfall distribution and local activities in conjunction with the active meteorological factors contributed or did not contribute to agricultural productivity, human and animal storage and supply. The influences of the El Niño/La Niña phenomena, for the decades under study in the form of adverse phenomena, had their isolated contributions.

To overcome the effects of droughts, over the years, efforts have been focused on developing drought indices capable of not only detecting long periods of drought, but also classifying them in terms of intensity, according to [15]. In the literature, there is a lack of studies that assess the influence of El Niño/La Niña phenomena on the distribution of rainfall in microregions.

The objective is to carry out an analysis of the decadal precipitation and its historical comparisons for the municipality of São Bento do Una in the period 1920-2018, which will possibly contribute to the decisions of sectors such as socioeconomic, agriculture, poultry, irrigation, energy production, water resources and agricultural technicians and decision makers in the event of extreme winds that may occur.

2. Material and methods

São Bento do Una is located in the Agreste mesoregion and in the Ipojuca Valley Microregion of the State of Pernambuco, limited to the north by Belo Jardim, to the south by Jucati, Jupi and Lajedo, to the east by Cachoeirinha, and to the west by Capoeiras, Sanharó and Fisheries.



Source: Medeiros (2022)

Figure 1 Location of the municipality of São Bento do Una in the state of Pernambuco

The municipal area occupies 719.15 km2 and represents 0.72% of the State of Pernambuco. The seat of the municipality has an altitude of 614 meters and geographical coordinates of 08°31'22" south latitude and 36°06'40" west longitude. With an estimated population of 58,251 inhabitants with a population density of 74.03 inhab/km2.

According to the climate classification by [13] São Bento do Una has an As Tropical Rainy climate, with a dry summer, this classification is in agreement with [1 and 20].

The rainy season begins in February with pre-season rains (rains that occur before the rainy season) and ends at the end of August and can last until the first half of September. The rainy quarter is centered on the months of May, June and July and its dry months occur between October, November and December. The factors causing rainfall in the municipality are the contribution of the Intertropical Convergence Zone (ITCZ), formation of high-level cyclonic vortices (VCAS), contribution of the northeast trade winds in the transport of steam and moisture which condense and form clouds causing rains, from moderate to strong intensities, formation of instability lines, orography and their local and regional contributions forming clouds and causing rain [21].

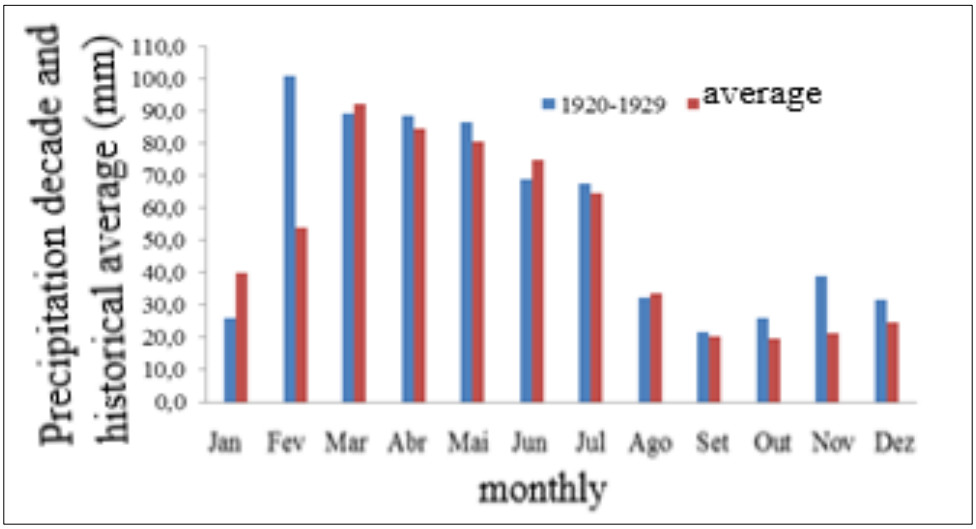
The rainfall data were acquired from the Northeast Development Superintendence (SUDENE, 1990) and from the Pernambuco Water and Climate Agency [2] between the years 1920 to 2016. The statistical simplified calculations were used to define, average, standard deviation, coefficient of variance, maximum and minimum absolute values occurred, the rainy and dry seasons were defined.

The limitation of water resources today is an important condition for economic and social development, causing numerous challenges to the planning and management of this resource in accordance with [24]. The data failures that occurred between the 90s can be explained by the exchange of responsibility in the collection of rainfall records from the former [25] to the [14] in this transition period the stations underwent maintenance and others were implemented in some cities between 1989 and 1992. For this purpose, gaps were filled, homogenization and consistency in the referred data in order to work and provide reliable information to the general public.

In the average monthly precipitation data, the software in electronic spreadsheets was used to extract the values of the monthly, annual averages, standard deviation, coefficient of variance of precipitation, maximum and minimum absolute values, anomaly, annual precipitation totals for the period from 1920 to 2018, plotting their respective graphs and trends.

3. Results and discussion

The analysis of decades of precipitation and their comparisons with the historical average are shown in figures 3 to 12. One of the most important climate variables is precipitation, its information is very important, in relation to numerous human activities, through this precipitation information proper planning can be made.



Source: Medeiros (2022)

Figure 3 Precipitation in the 1920-1929 decade and its comparison with its historical average for the municipality of São Bento do Una - PE

Figure 3 analyzes the decadal precipitation of the period 1920-1929 and its comparison with the historical precipitation of that period. Decadal precipitation exceeded the historic one in February, April, May, July and from September to December, this surpassing was due to large-scale systems with the action of the ITCZ and VCAN, followed by local and

regional contributions. In the months of January, March, June and August, the historical precipitation exceeded the decadal precipitation, which suffered atmospheric blockages and prolonged summer periods predominated.

The historical rainfall exceeded the decadal in the following months from January to May and from July to December, in the month of June the decadal precipitation exceeded the historical one, the rain-provoking systems and the local and regional contributions were not enough to raise the rainfall indices in the region, decade of 1930-1939. (Figure 4).

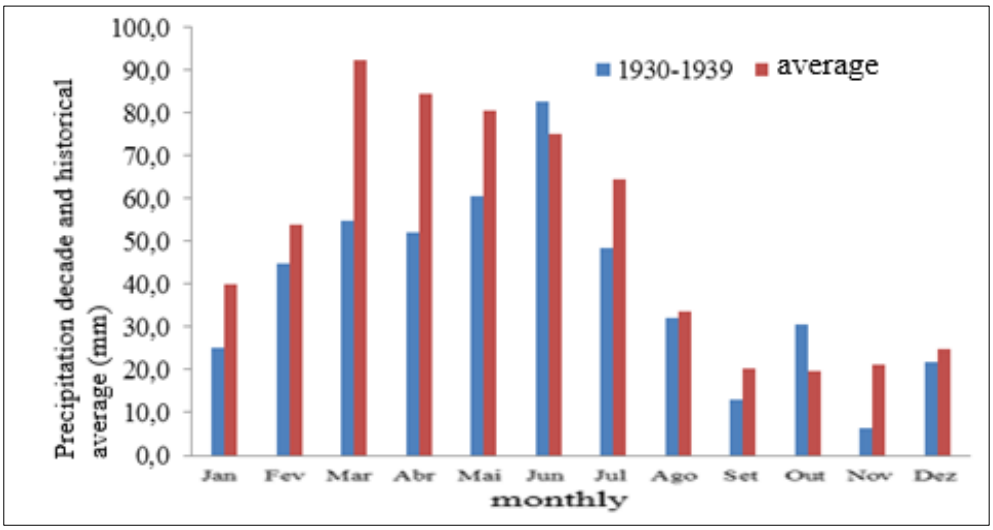
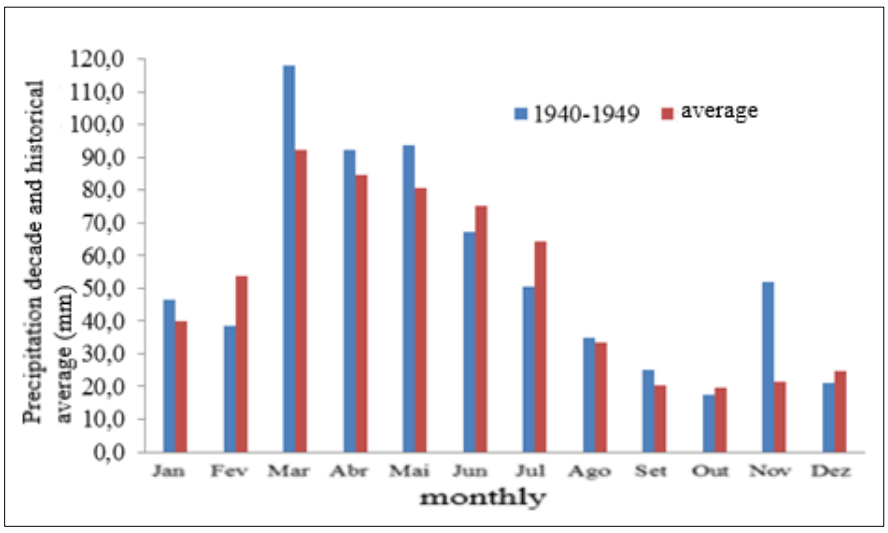


Figure 4 Precipitation in the 1930-1939 decade and its comparison with its historical average for the municipality of São Bento do Una - PE

In the decade 1949-1949 and its comparison with the historical average (Figure 5) it is observed that the decadal rains exceed the historical ones in the months of January, March to May, August, September and November, it is noteworthy that in the months of September to December the Historical rainfall has low rates and any anomalous rainfall of moderate intensity exceeds historical ones. In the months of February, June, July and October the historical rains surpassed the observed decadas. This variability is similar to that found by [10].

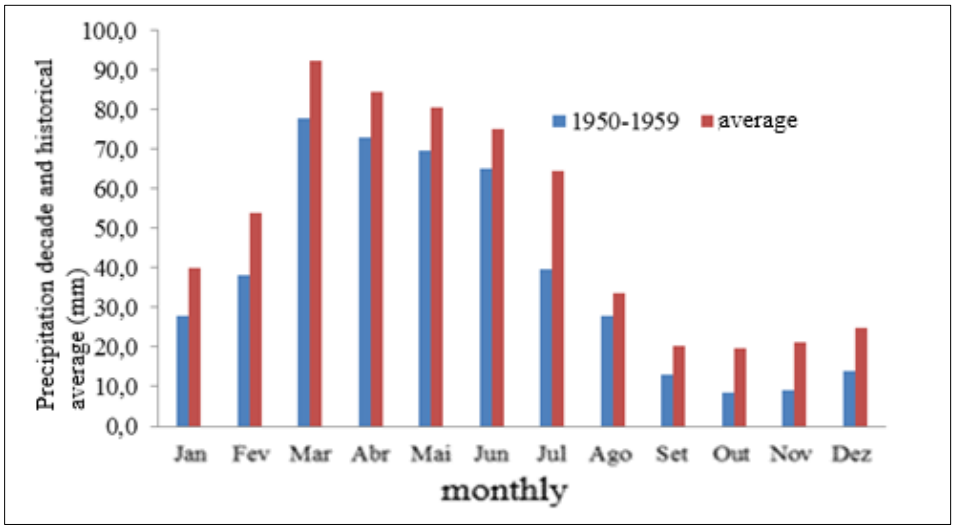


Source: Medeiros (2022)

Figure 5 Precipitation in the 1940-1949 decade and its comparison with its historical average for the municipality of São Bento do Una - PE

In figure 6, we can see the fluctuations of precipitation in the 1950-1959 decade and its comparison with its historical average for the municipality of São Bento do Una - PE. Historic precipitation exceeded rainfall in the 1950-1959 decade.

Decadal fluctuations are linked to microscale systems, with the help of local and regional effects that did not contribute to the observed rainfall, such variability is in agreement with the study by [16].

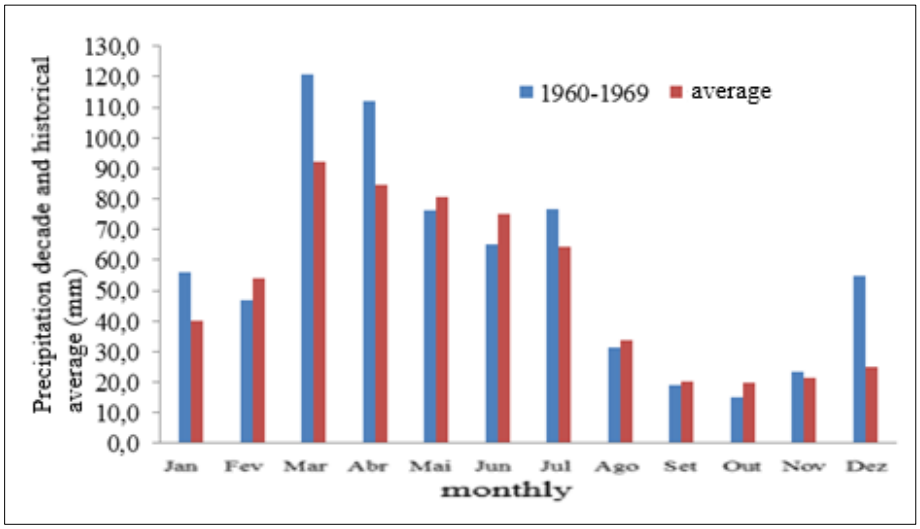


Source: Medeiros (2022)

Figure 6 Precipitation in the 1950-1959 decade and its comparison with its historical average for the municipality of São Bento do Una - PE

These overruns of historical averages may have received contributions from the following anthropic actions such as: incidence of fires, devastation of afforestation leaving the soil bare, soil compaction, erosivity, lack of agricultural and poultry planning, lack of care with water resources and groundwater. It benefits survival agriculture and has raised levels in water storage.

In figure 7 you have the variability of the decadal rains (1960-1969) and their comparisons with the historical average. Decadal rainfall exceeded historical rainfall in January, March, April, July, November and December. Historical rains were higher than decadal rains in the months of February, May, and June and from August to October. These oscillations were due to the systems that provoked and/or inhibited the rains in the studied decade.

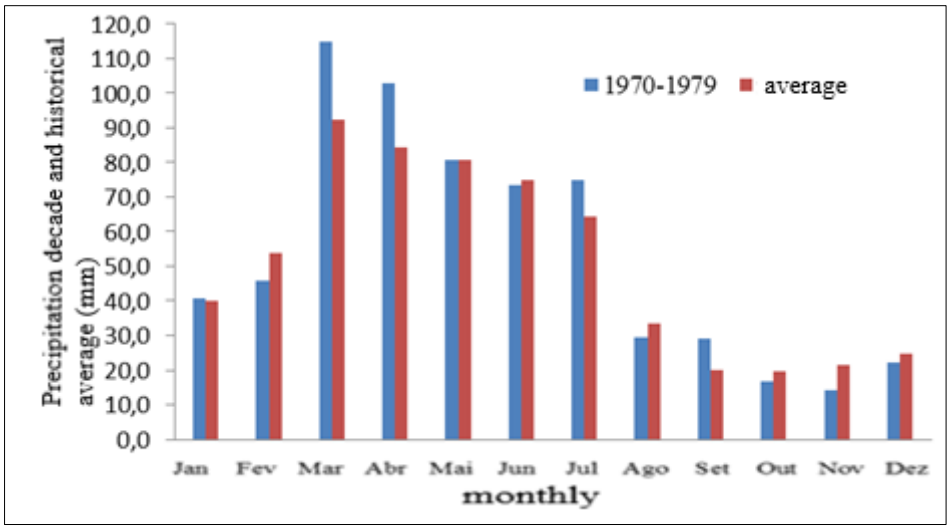


Source: Medeiros (2022).

Figure 7 Precipitation in the 1960-1969 decade and its comparison with its historical average for the municipality of São Bento do Una - PE

[17 and 22] report in their studies on the prolonged occurrence of droughts due to climate change, demonstrating the need for better understanding and prediction of occurrence. These studies corroborate the results presented here.

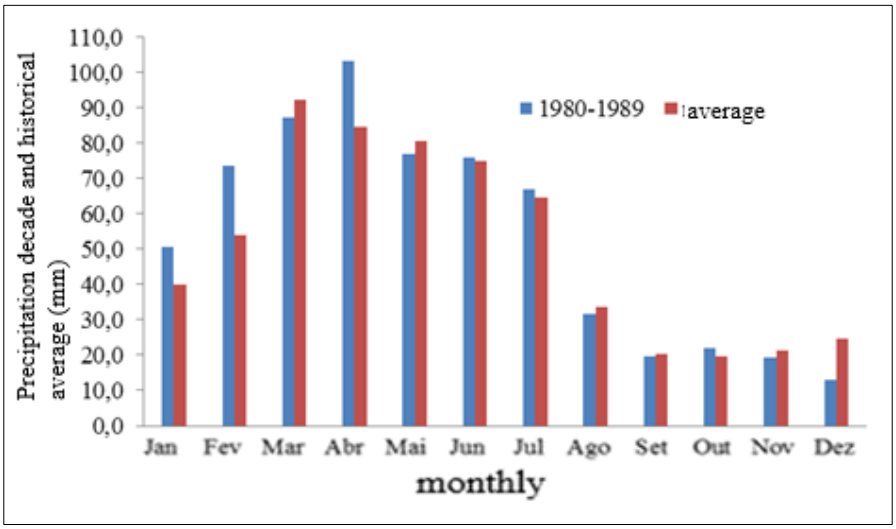
The historical rains surpassed the decadal rains (1979-1979) in the months of February, June, and August and from October to December. Decadal rains exceeded the historical ones in March, April, July and September. Rains of equal intensities and volumes were registered in the months of January and June. (Figure 8).



Source: Medeiros (2022)

Figure 8 Precipitation in the 1970-1979 decade and its comparison with its historical average for the municipality of São Bento do Una - PE

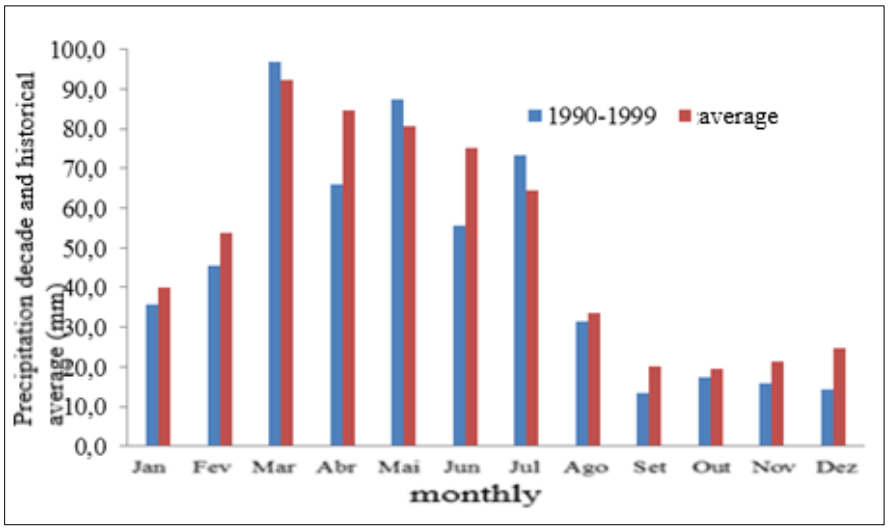
The variability of decadal and historical rainfall indices (1980-1989) (Figure 9) for the municipality of São Bento do Una - PE, is represented in figure 9. The months of January, February, April, July and October recorded higher decadal rainfall the historic. The months of March, May, August, November and December the historical rains were higher than the decadal ones. In the months of June, September, there was an equality between the rainfall indices.



Source: Medeiros (2022)

Figure 9 Precipitation in the 1980-1989 decade and its comparison with its historical average for the municipality of São Bento do Una - PE

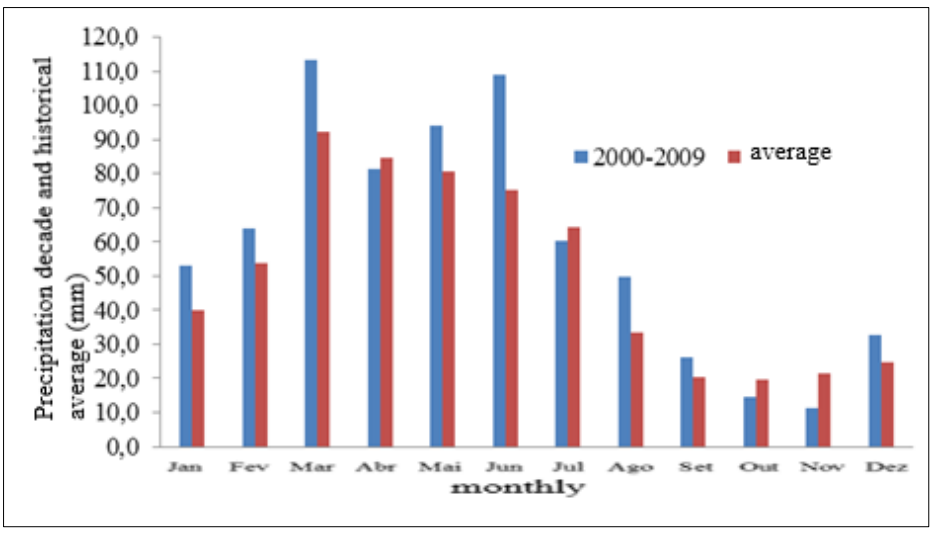
Figure 10 shows the rainfall fluctuations of the 1990-1999 decade and its comparison with its historical average for the municipality of São Bento do Una - PE. The historical rains exceeded the decadal ones in the months of January, February, April, June and from August to December. Decadal rains exceeded historical ones in March, May and July. Atmospheric systems that provoke rain remained active and caused moderate rainfall during the decade studied.



Source: Medeiros (2022).

Figure 10 Precipitation in the 1990-1999 decade and its comparison with its historical average for the municipality of São Bento do Una – PE

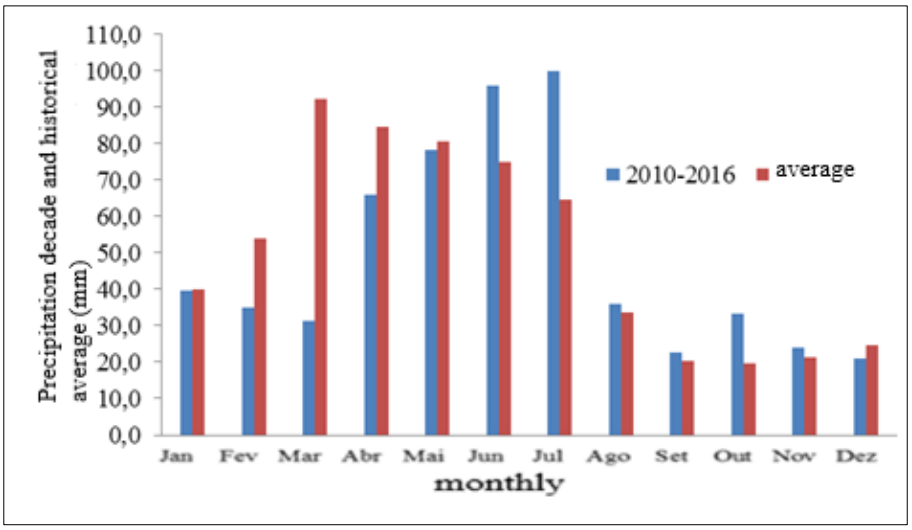
Figure 11 referring to the decade 2000-2009 and its respective historical average shows us that the months from January to March, May, June, August, September and December the decadal rains exceeded the historical ones. In the months of April, July to November the historical rains surpassed the decadas these variability were helped by the local and regional effects.



Source: Medeiros (2022)

Figure 11 Precipitation in the 2000-2009 decade and its comparison with its historical average for the municipality of São Bento do Una - PE

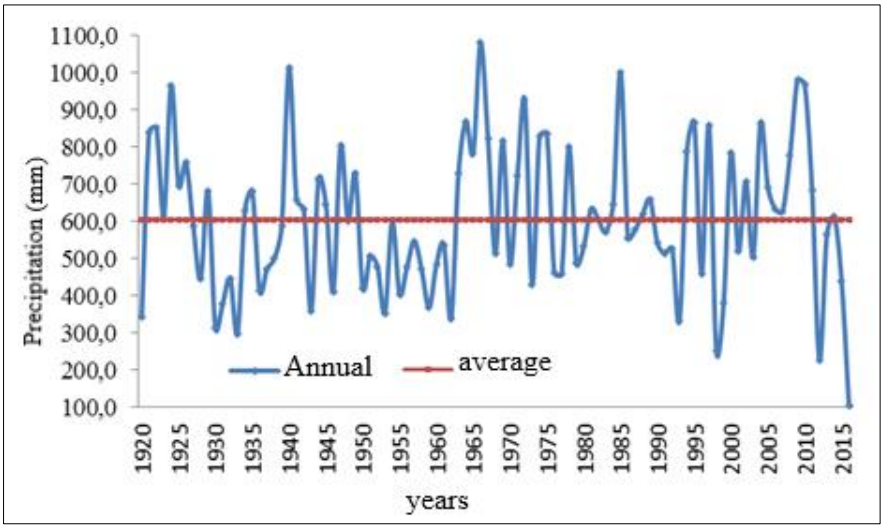
Figure 12 shows the fluctuations in rainfall for the decade 2010-2016 and its comparison with its historical average for the municipality of São Bento do Una - PE. Between the months of February to May and December the historical precipitation exceeded the decadal precipitation, in the months of June to November the decadal precipitation surpassed the historical one, emphasizes that in the months of September to November the historical precipitation has low intensities and any rain above the average exceed their values as recorded in figure 12, the month of January equaled the historical precipitation. The predominance of the large-scale El Nino phenomenon was not a primary factor for the occurrence of these variabilities.



Source: Medeiros (2022)

Figure 12 Precipitation in the 2010-2018 decade and its comparison with its historical average for the municipality of São Bento do Una - PE

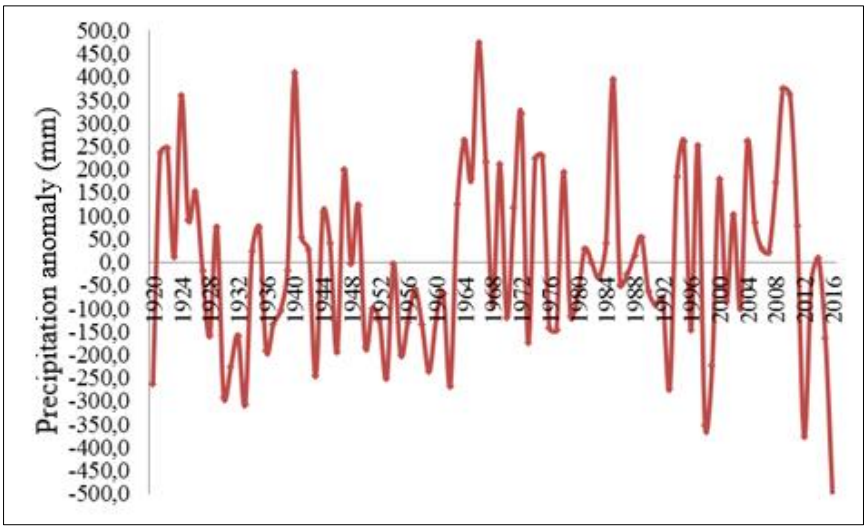
The inter-year variability of annual precipitation is represented in figure 13, with oscillations flowing between 100 mm to 1090.0 mm. Years with annual rainfall above or equal to 800 mm stand out, 1921, 1922, 1925, 1941, 1949, 1965, 1967, 1970, 1974, 1975, 1976, 1979, 1985, 1994, 1996, 2001, 2009, 2019 and 2014. The help of the provoking and/or inhibiting factors of inter-year rainfall were blocked by the meso and micro scale systems, local and regional contributions did not help in the formation of cloudiness and the occurrence of above-average rainfall.



Source: Medeiros (2022)

Figure 13 Annual rainfall for the period 1920-2018 and its historical average for the municipality of São Bento do Una - PE

Precipitation anomalies are represented in figure 14, with oscillations flowing between -500 mm to 4800 mm. The years with precipitation anomalies greater than 200 mm stand out, 1921, 1922, 1924, 1940, 1947, 1964, 1966, 1969, 1972, 1973, 1974, 1977, 1985, 1995, 1997, 2000, 2004, 2008, 2009. The years with negative anomalies less than or equal to 200 mm were: 1920, 1931, 1932, 1933, 1943, 1945, 1952, 1954, 1959, 1963, 1992, 2012 and 2016.

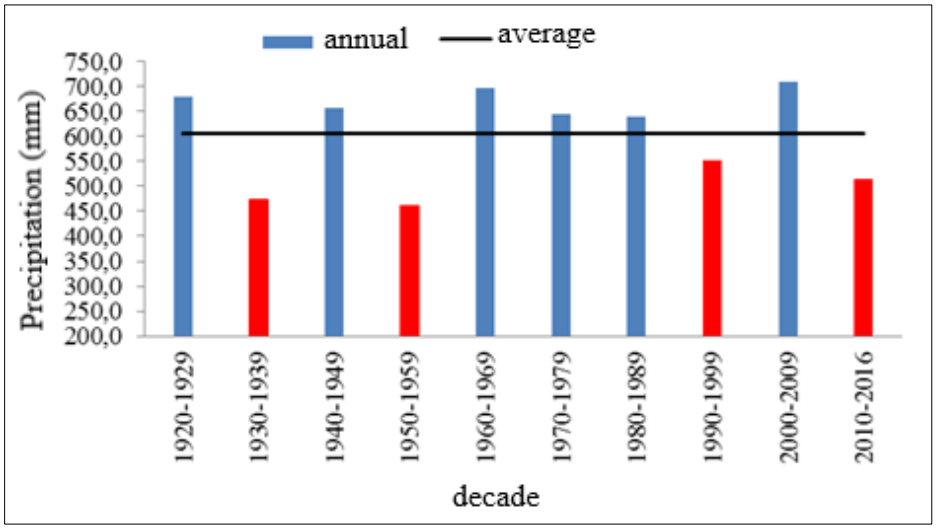


Source: Medeiros (2022)

Figure 14 Precipitation anomaly for the period 1920-2018 for the municipality of São Bento do Una – PE

These variabilities are due to the meteorological factors acting inter-year and their variabilities of the elements that provoke and/or inhibit rain in the study area. Such variability is in agreement with the statements of [16]

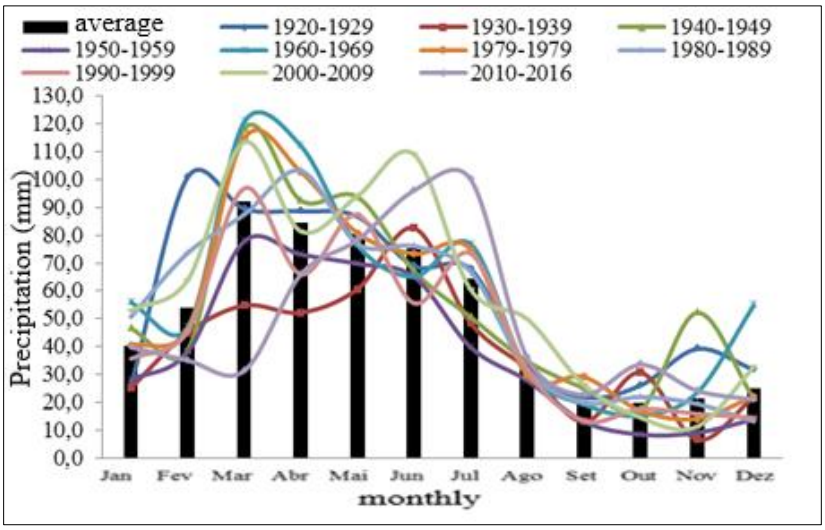
Figure 16 shows the annual variability of the decades and its comparison with the historical annual precipitation for the municipality of São Bento do Una - PE. The decades of 1930-1939; 1950-1959; 1990-1999 and 2010-2016 their annual rates were below the historical average, these oscillations were due to transient meteorological systems acting in the local and regional atmosphere, in accordance with the studies by [16].



Source: Medeiros (2022).

Figure 15 Annual rainfall by decade and its historical comparison for the municipality of São Bento do Una – PE

Figure 16 shows the variability of historical annual precipitation and by decade for the municipality of São Bento do Una - PE. The temporal variability of the decadal rains show us the irregularities of its occurrences that depend on the factors acting in the atmosphere and on the transient systems that provoke or inhibit rain in the study area. The results of this study are similar to those of [16].



Source: Medeiros (2022)

Figure 16 Historic annual rainfall and by decade for the municipality of São Bento do Una – PE

Segund [5; 6 and 27] showed that in mountainous areas there is a greater scarcity of equipment that measures rainfall, interfering with the quality of the mappings and their results, this study corroborates the results of the authors.

[9] states that the standard deviation is respectable to obtain subsidies from the "degree of dispersion of the values in relation to the average value". The coefficient of variance was used to perform checks in relative terms of the mean in percentage.

The median is the most likely value to occur. The standard deviation may interfere with positive and/or negative contributions in relation to the mean and/or median values. O Coefficient of variance with low to moderate significance level. The absolute maximum and minimum values are linked to rainfall events and local and regional effects.

Table 1 Statistical parameters of decadal rainfall for the municipality of São Bento do Una – PE

Meses/ Parâmetros	Average (mm)	Median (mm)	Standard deviation (mm)	Coefficient of variance (mm)	Maximum absolute (mm)	Minimum absolute (mm)
January	40.1	55.8	11.3	0.282	55.8	25.2
February	53.3	47.0	20.5	0.385	100.8	35.0
March	90.5	120.8	29.4	0.325	120.8	31.3
April	83.8	112.1	19.4	0.232	112.1	52.2
May	80.5	76.4	10.5	0.130	94.1	60.7
June	75.9	65.2	16.1	0.212	109.0	55.6
July	65.9	76.8	17.3	0.262	100.1	39.7
August	33.6	31.3	6.2	0.183	49.9	27.7
September	20.3	19.2	5.8	0.285	29.1	12.9
October	20.2	15.1	7.8	0.386	33.4	8.4
November	21.5	23.4	14.3	0.666	52.1	6.5
December	24.6	54.8	12.6	0.510	54.8	13.1
Annual	603.2	697.8	93.7	0.155	709.5	463.4

Source: Medeiros (2022).

[11 and 12] stated that the relative frequency of extreme events depends on changes in the standard deviation and not just on the mean. [11] supposes that a change in a climate variable that has a probability distribution may result in a change in the shape of its distribution.

Table 1 shows the statistical parameters (mean, median, standard deviation, coefficient of variance and the maximum and minimum values) of the rainfall indices for the area of the municipality of São Bento do Una.

With a historical average of 603.2 mm and its monthly oscillations flowing between 20.2 mm in September and 90.5 mm in March, the median values are not significant in relation to the average, especially between the months of January and July. The interference of the standard deviation with positive and/or negative contributions in relation to the mean and/or median values provides subsidies for the occurrence of these values in case of extreme events. The variability of the coefficient of variance does not support us for any assertion of occurrence. The occurrences of absolute maximum and minimum values were and may occur again due to atmospheric instability causing extreme effects.

Segund [4 and 26] highlighted the need and estimation of the descriptive analysis of the variables studied before any inferential analysis, the presence of outliers, the type of behavior of the analyzed variable and even typing errors in the data, comes to distort the results of the inferential analyses, causing incorrect or imprecise conclusions, a fact that corroborates the article under study.

4. Conclusion

The greatest behavior of the statistical indicators was for the dry months. It is suggested to apply new models, such as generalized linear models, which relate the random distribution of the dependent variable with the non-random part through a linkage function.

The exploratory and homogeneity analysis contributed to the prior knowledge of the data distribution, verifying that the possibility of using the sample statistics demonstrating that the median is not representative for the occurrences of values.

The variability in the distribution of decadal and local rainfall, together with the meteorological factors, contributed or did not contribute to agricultural productivity, survival agriculture, human and animal storage and supply, mainly in the poultry sector.

The rains registered between decades did not cause great inconvenience to the population, the local economy, except in months where the summer period was extended.

The irregularities that occurred in the rainfall in the 1930-1939 decades; 1950-1959 and 2010-2016 were the most prominent in the contributions to agriculturalists for the production of survival agriculture, poultry and water storage in small, medium weirs and cisterns.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

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