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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 1920-2016, which possibly will contribute to the decisions of sectors such as socioeconomic, agricultural, poultry, irrigation, energy production, resources water resources and agricultural technicians and decision-makers in case of extreme winds that may occur. The pluviometric data were acquired from the Superintendence of Development of the Northeast and the Pernambuco Water and Climate Agency, comprised between the years 1950 to 2019. We used statistically simplified calculations to define, mean, standard deviation, coefficient of variance, maximums, and minimum absolute values occurred, the rainy and dry season was defined. The rains recorded between decades did not cause major disturbance to the population, the local economy except in months where the summer period extended. The irregularities that occurred in the rainfall indexes of the decades; 1950-1959 and 2010-2016 were the highlights of the contributions to farmers for the production of survival agriculture, poultry farming, and water storage in small, medium weirs, and cisterns.

INTRODUCTION

In the last two decades, climate change and its implications for humanity, has been one of the greatest apprehensions of scientists from all over the world, regarding the factors responsible for climatic variability, which have been accentuated since the beginning of the 20th century. In the view of some researchers, human activities are responsible for part of these changes. However, a possible natural climatic variability must be taken into account, since the magnitude of the signal associated with it in the existing climatic records, has not yet been well determined (IPCC, 1996; IPCC, 2001).

Medeiros (2017) showed that the decadal variability of precipitation and its comparison with the historical average rainfall for the micro-regions of precipitation collection in the State of Piauí were based on historical series from 1912 to 2011 and from 1962-2011. rains show their variability depending on the activities of atmospheric systems acting as South Atlantic convergence zone, Intertropical Convergence Zone, traces of cold fronts, instability lines, and the formation of high-level cyclones, contributing to greater or lesser rainfall variability. Local contributions and the Intertropical Convergence Zone operate with intensity in the northern sector and have caused rain above normal in some decades. The influences of the El Niño phenomena (a) for the decade's understudy in the form of adverse phenomena presented isolated contributions.

Intense rains, as well as droughts, have great impacts on many segments of the socioeconomic. The regions affected by excessive precipitation over the years, in most cases, are concentrated in the northeast, south, and southeast regions of the state. Precipitation is one of the main variables that influence the socio-economic sector of the state of Piauí, mainly due to its 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 (a) phenomenon, as stated by the authors Araújo et al. (2005).

Sivakumar et al. (2005) stated that climatic 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 events has caused damage to agriculture and strong economic and organizational impact of the population.

Holanda et al. (2016), carried out the climatological analysis of decadal precipitation and its historical comparisons for Recife - PE used the historical series from 1915 to 2014 to contribute to the decisions of sectors such as the economy, agriculture, irrigation, energy production, water resources, agricultural and agronomic engineering, fire brigade, civil defense and government decision-makers in case of extreme rainfall events that may occur in the future. The averages were calculated for decades and their comparison with the average climatological precipitation of the study area. The inter-district variability in the distribution of rainfall and local activities together with the meteorological factors that have contributed or have stopped contributing to agricultural productivity, human and animal storage, and supply. The influences of the El Niño (a) phenomena, for the decade's understudy in the form of adverse phenomena, had their contributions isolated.

To circumvent the effects of droughts, efforts have been made over the years to develop drought rates capable of not only detecting long periods of drought but also classifying them in terms of intensity according to Macedo et a*l.* (2010). There is a lack of studies in the literature that assess the influence of the El Niño (a) phenomenon on the distribution of rainfall in the context of micro-regions.

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 1920-2016, which possibly will contribute to the decisions of sectors such as socioeconomic, agricultural, poultry, irrigation, energy production, water resources, and agricultural technicians and decision-makers in case of extreme winds that may occur.

MATERIALS AND METHODS

São Bento do Una is located in the Agreste mesoregion and in the Microregion of the Ipojuca Valley of the State of Pernambuco, bordering on the north with Belo Jardim, on the south with Jucati, Jupi and Lajedo, on the east with Cachoeirinha, and on the west with Capoeiras , Sanharó and Pesqueira.

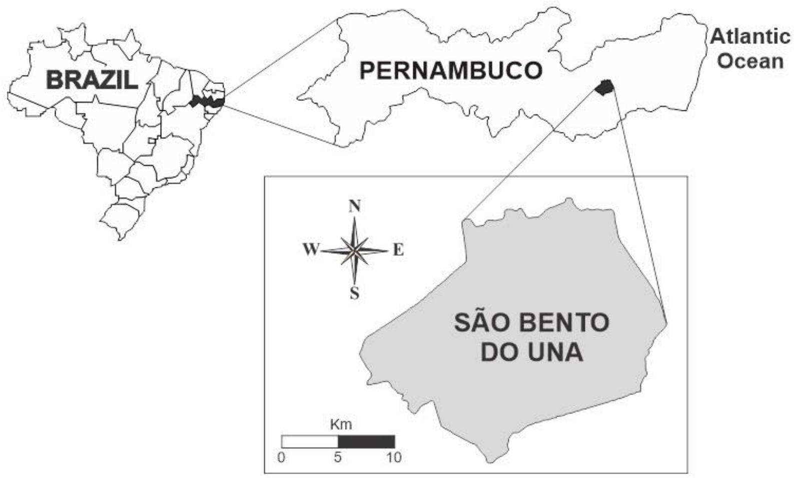

Figure No. 1. Location of the municipality of São Bento do Una in the state of Pernambuco.

Source: Medeiros (2021)

The municipal area occupies 719.15 km^2 and represents 0.72% of the State of Pernambuco. The seat of the municipality has an altitude of 614 meters and geographic coordinates of 08°31'South latitude and 36°06' West longitude. With an estimated population of 58,251 inhabitants with a population density of 74.03 inhabitants/km^2.

São Bento do Una is inserted in the geoenvironmental unit of the Planalto da Borborema, formed by massifs and high hills, with altitudes varying between 650 to 1,000 meters. It occupies an area of arch that extends from the south of Alagoas to Rio Grande do Norte. The relief is generally busy, with deep and narrow valleys dissected. For soil fertility, it is quite varied, with a certain predominance from medium to high. The area of the unit is cut by perennial rivers, however with a small flow and the groundwater potential is low. The vegetation of this unit is formed by Subcaducifolic and Deciduous Forests, typical of the wild areas.

On smooth wavy to wavy surfaces, Planosols occur, medium-deep, strongly drained, acid to moderately acidic and medium natural fertility, and also Podzolics, which are deep, clayey texture, and medium to high natural fertility. The elevations are litolic, shallow soils, clayey texture, and medium natural fertility. In the Valleys of rivers and streams, Planosols occur, medium-deep, imperfectly drained, medium/clayey texture, moderately acidic, high natural fertility, and salt problems. Rock outcrops still occur.

São Bento do Una is located, geologically, in the Borborema Province, being constituted by the lithotypes of the Serra de Taquaritinga Suite of the Cabrobó and Belém do São Francisco complexes and the Leucocratic Intrusive Peraluminous Suite.

According to the climatic classification by Köppen (1928) São Bento do Una has the climate "As" Tropical Chuvoso, with dry summer, this classification is in agreement with Alvares et al. (2014) and with Medeiros et al. (2018).

The rainy season starts in February with pre-season rains (rains that occur before the rainy season) with their end occurring at the end of August and may continue until the first half of September. The rainy quarter focuses on May, June, and July and its dry months occur between October, November, and December. The factors causing rain in the municipality are the contribution of the Intertropical Convergence Zone (ITZC), the formation of high-level cyclonic vortices (SACV), the contribution of the northeast trade winds in the transport of steam and moisture which condense and form clouds causing rain from moderate to strong intensities, formations of the lines of instability, orography and their local and regional contributions forming clouds and causing rains, according to Medeiros (2016).

The pluviometric data were acquired from the Northeast Development Superintendence (SUDENE, 1990) and the Pernambuco Water and Climate Agency (CAPA, 2018) between the years 1950 to 2019. We used the simplified calculations statistically to define, on average, standard deviation, coefficient of variance, maximum and minimum absolute values occurred, the rainy and dry season was 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 by Sousa et al. (2015). The data failures that occurred between the 90s can be explained by the shift of responsibility in the collection of rainfall records from the former SUDENE to (LAMEPE, 1992) in this transition period the stations underwent maintenance, and others were implemented in some cities since 1989 and 1992. For that purpose, fault filling, homogenization, and consistency were carried out in the referred data to work and provide reliable information to the public.

In the monthly average precipitation data, the software was used in electronic spreadsheets, to extract the values of the monthly, annual averages, standard deviation, coefficient of variance of the precipitation, maximum and minimum absolute values, anomaly, annual precipitation totals of the period of 1920 to 2016, plotting their respective graphs and trends.

RESULTS AND DISCUSSIONS

The analyzes of the decades of precipitation and their comparisons with the historical average are shown in figures 2 to 9. One of the most important climatic variables is precipitation; its information contains a lot of importance, to the countless human activities, through this information of precipitation proper planning can be done.

In Figure 2, we observe the rainfall fluctuations in the 1950-1959 decade and its comparison with its historical average for the municipality of São Bento do Una - PE. Historical rainfall exceeded the rainfall rates of the 1950-1959 decade. Decadal fluctuations are linked to microscale systems, to the help of local and regional effects that did not contribute to the observed rainfall rates; such variability is by the studies by Marengo et al. (2006).

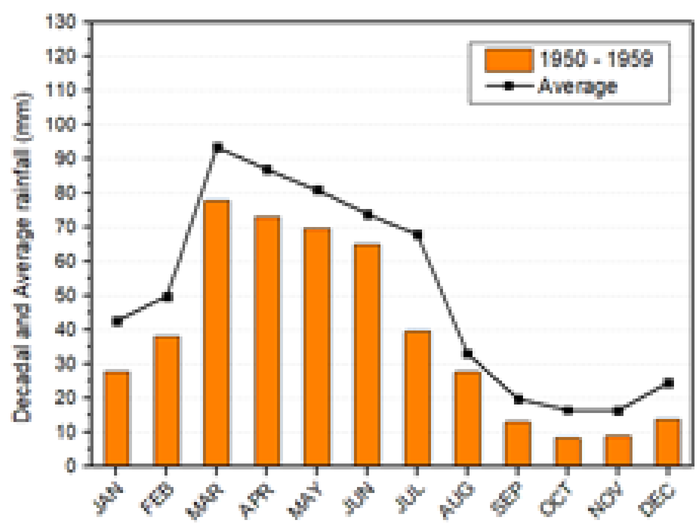

Figure No. 2. Precipitation in the 1950-1959 decade and its comparison with its historical average for the municipality of São Bento do Una - PE.

Source: Medeiros (2021).

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

In figure 3 you have the variability of the decadal rains (1960-1969) and their comparisons with the historical average. Decadal rains surpassed historical rains in January, March, April, July, November, and December. The historical rains were higher than the decadal rains in February, May, June, and from August to October. These oscillations were due to the systems that provoked and/or inhibited the rains in the studied decade.

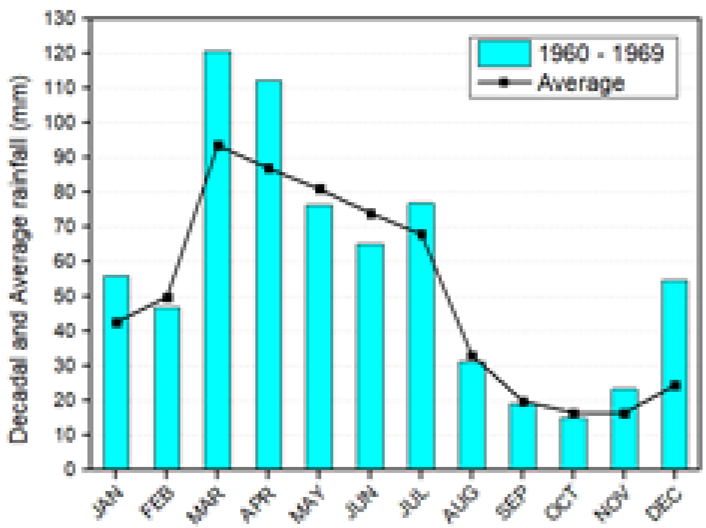

Figure No. 3. Precipitation of the 1960-1969 decade and its comparison with its historical average for the municipality of São Bento do Una - PE.

Source: Medeiros (2021).

Marengo et al. (2010) and Noronha et al. (2016) 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 overcame the decadal rains (1979-1979) in February, June, August, and from October to December. Decadal rains surpassed historical ones in March, April, July, and September. Rains of equal intensities and volumes were recorded in January, June. (Figure 4).

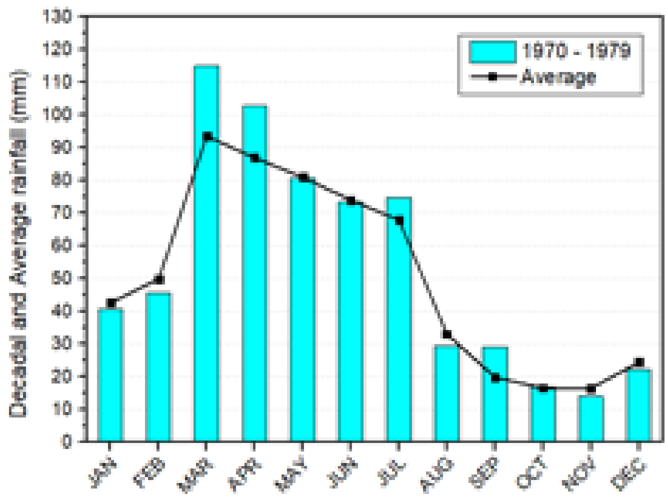

Figure No. 4. Precipitation of the 1970-1979 decade and its comparison with its historical average for the municipality of São Bento do Una - PE.

Source: Medeiros (2021).

The variability of the decadal and historical rainfall indexes (1980-1989) (Figure 8) for the municipality of São Bento do Una - PE, represented in Figure 5. The months of January, February, April, July, and October registered higher decadal rains in the historic. In March, May, August, November, and December historical rains were higher than the decadal ones. In June, September there was an equality between the rainfall indexes. The studies by Medeiros (2017) and Marengo et al. (2010) corroborate the results in discussions.

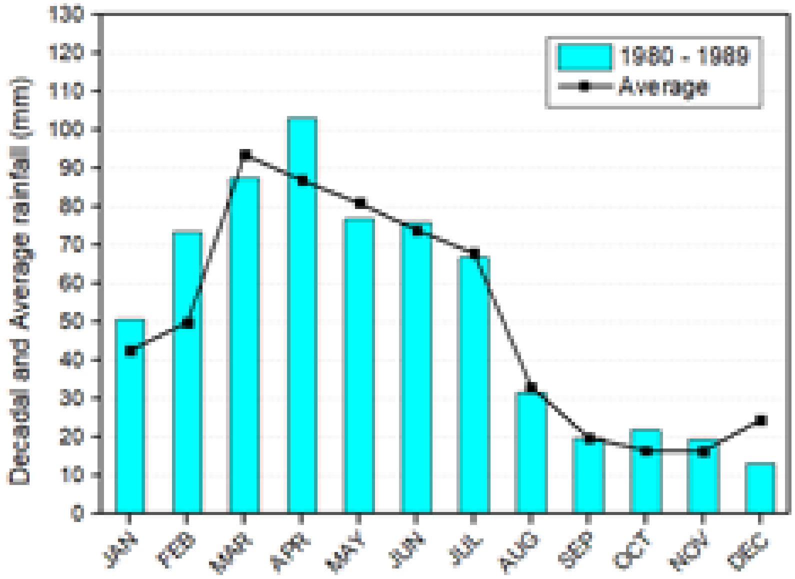

Figure No. 5. Precipitation of the 1980-1989 decade and its comparison with its historical average for the municipality of São Bento do Una - PE.

Source: Medeiros (2021).

Figure 6 shows the pluvial 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 surpassed the decades in January, February, April June, and from August to December. Decadal rains surpassed historical ones in March, May, and July. The atmospheric systems that caused rains remained active caused rain of moderate intensities during the studied decade.

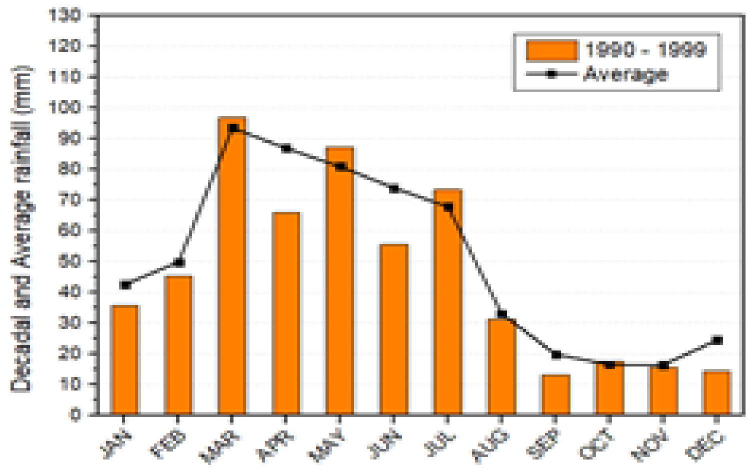

Figure No. 6. Precipitation of the decade 1990-1999 and its comparison with its historical average for the municipality of São Bento do Una - PE.

Source: Medeiros (2020).

Figure 7 referring to the 2000-2009 decade and its respective historical average shows us that in the months from January to March, May, June, August, September, and December, the annual rains surpassed the historical ones. In April, the local and regional effects aided July to November the historical rains surpassed the decades of this variability.

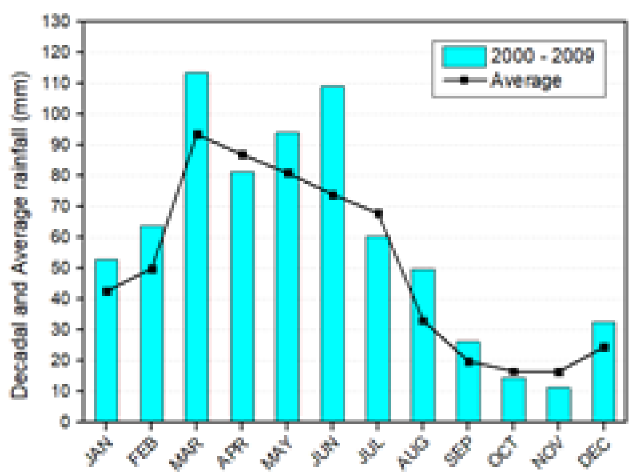

Figure No. 7. Precipitation in the 2000-2009 decade and its comparison with its historical average for the municipality of São Bento do Una - PE.

Source: Medeiros (2021).

Figure 8 shows the precipitation oscillations of the decade of 2010-2016 and its comparison with its historical average for the municipality of São Bento do Una - PE. Between February to May and December, the historical precipitation surpassed the decadal precipitation, in June to November the decadal precipitation surpassed the historical one, emphasizes that in September to November the historical precipitation has low intensities and any rain above the average exceed their values as recorded in figure 8, the month of January equaled the historical precipitation. The predominance of the large-scale phenomenon El Nino was not a primary factor for the occurrence of this variability.

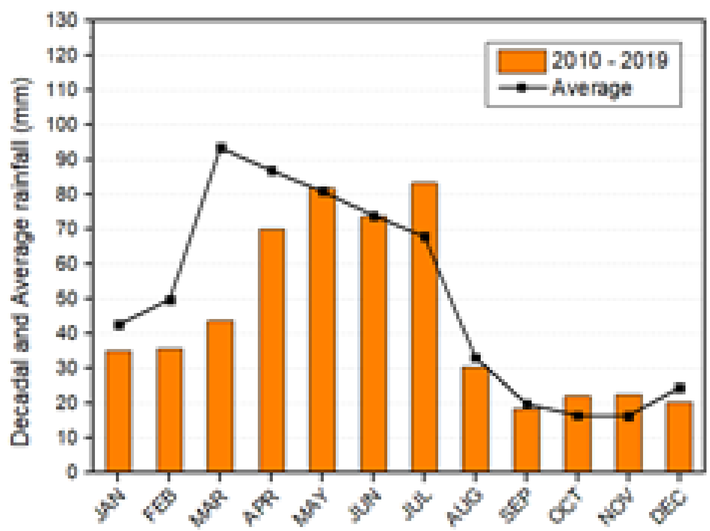

Figure No. 8. Precipitation in the decade of 2010-2016 and its comparison with its historical average for the municipality of São Bento do Una - PE.

Source: Medeiros (2021).

The variability of annual precipitation is shown in Figure 9, with oscillations flowing between 100 mm to 1090.0 mm. Noteworthy are the years with annual rainfall above or equal to 800 mm, 1921, 1922, 1925, 1941, 1949, 1965, 1967, 1970, 1974, 1975, 1976, 1979, 1985, 1994, 1996, 2001, 2009, 2010 and 2014. The help of factors that cause and/or inhibit inter-year rainfall were blocked by meso and micro-scale systems. Local and regional contributions did not help in the formation of cloudiness and the occurrence of above-average rainfall.

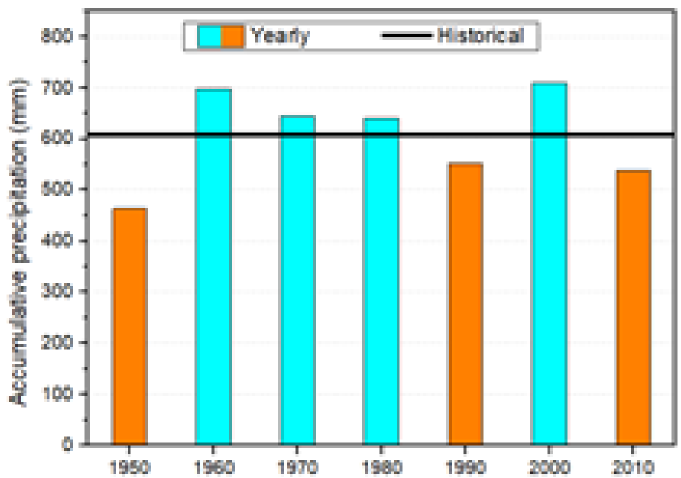

Figure No. 9. Annual rainfall for the period 1920-2016 and its historical average for the municipality of São Bento do Una - PE.

Source: Medeiros (2021).

These variabilities are due to the meteorological factors that act during the year and their variability in the elements that cause and/or inhibit rain in the study area. Such variability is by the statements of Marengo et al. (2006).

Carvalho et al (2002); Diodato et al (2005) and Viola et al (2010) 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.

Galvani (2011) states that the standard deviation is respectable to obtain subsidies on the "degree of dispersion of values to the average value". The coefficient of variance was used to perform checks in relative terms of the average in percentage.

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

Katz (1991) and Katz et al (1992) stated that the relative frequency of extreme events depends on changes in the standard deviation and not just on the average. Katz (1991) assumes that a change in a climatic variable that has a probability distribution may result in a change in the form of its distribution.

Table No. 1 shows the statistical parameters (mean, median, standard deviation, coefficient of variance, and maximum and minimum values) of the rainfall indexes for the area of the municipality of São Bento do Una.

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

Table No. 1. Statistical parameters of rainfall for the municipality of São Bento do Una - PE.

Months/parameters	Average (mm)	Median (mm)	Standard deviation (mm)	Coefficient of variance (mm)	Absolute maximum (mm)	Absolute minimum (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
Yearly	603,2	697,8	93,7	0,155	709,5	463,4

Source: Medeiros (2021).

Bussab et al (2002) and Triola (2009) highlighted the need and the estimation of the descriptive analysis of the studied variables before any inferential analysis, the presence of atypical values, the type of behavior of the analyzed variable, and even the typing errors in the data, come to distort the results of inferential analysis, leading to incorrect or inaccurate conclusions, a fact that corroborates with the article under study.

CONCLUSION

The biggest behaviors of the statistical indicators were 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 to the non-random part through a link 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 the values.

The variability in the distribution of decadal and local rains, together with the meteorological factors that acted, contributed or stopped contributing to agricultural productivity, survival agriculture, storage, and human supply, animal mainly in the poultry sector.

The rains recorded between decades did not cause major disturbance to the population, the local economy except in months where the summer period extended.

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

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