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Rainfall Fluctuations and Their Relationships with The La Niña Phenomenon in The Semiarid Region of Paraíba State, Northeastern Brazil

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ABSTRACT

There is a lack of studies that show a correlation between rainfall and large-scale climatic phenomena, such as El Niño and La Niña. In both phenomena, the distribution of some indexes can reflect on the water balance and water surpluses and deficiencies. The objective is to study the pluvial variability associated with its Neutral, strong, and/or weak pluvial intensities, on the action of the climatic phenomenon La Niña to the pluviometric indexes in the municipalities of Juazeirinho and Soledade located in the semiarid region of the Paraíba state, Northeastern Brazil. Monthly and annual data were statistically worked to obtain the mean, median, standard deviation, and frequency distribution parameters. The data referred to the years 1973, 1983, 1984, 1998, 1995, 1998, 2008, 2011, 2014, 2017, and 2018 provided by (APAC). Subsequently, with the graphical analysis of the averages and medians of precipitation, it was found that the average values differed from the median values. The median values were used as they are asymmetric and have better contributions than the average. To verify the La Niña fluctuations in the pluvial indexes, the annual pluvial total was compared with the median indexes of the studied years. The use of the median has greater chances of occurrences for the realization of its pluvial indexes in the phase of the La Niña phenomenon. It was found that La Niña does not influence the rainfall in the studied municipalities; the distribution of rainfall indexes was irregular, reflecting in water deficiencies and water storage. In La Niña years of strong intensity, there is a tendency to rain below expectations, although the deviations may be smaller than the standard deviation. In the Municipalities of Soledade and Juazeirinho, the performance of the El Niña phenomenon is not related to increases and/or reductions in rainfall. In the classification system of La Niña, there is a greater predominance of very dry and extremely dry classes.

INTRODUCTION

Since the semi-arid region of Northeastern Brazil (NEB) is historically more affected by large and continuous droughts, since the 16th century, there has always been a concern to study the oscillation of rainfall with the occurrence of the El Niño phenomenon Southern Oscillation. In studies carried out by Kane (1989), using a series of 137 years (1849 to 1985), he found that, of the 29 years of existence of El Niños, only 12 (41.37%) coincided with the years of drought.

França *et al.* (2018) performed the calculation of the climatological water balance for the municipalities of São Bento do Una and Serra Talhada, both in the state of Pernambuco of Brazil, and investigated the influences of the El Niño phenomenon in 2012 and 2016 and the La Niña period for the year 2008 and 2011 in the distribution of rainfall through the analysis of the water balance extract. They concluded that the El Niño episode influenced, with an increase or decrease, in the rainfall in the studied municipalities. In the La Niña episode, the distribution of these indexes was irregular, reflecting on the water balance and water surpluses and deficiencies.

Medeiros (2018) analyzed the influence of rainfall variability and the number of days with rain in the city of Recife - PE and their relationship with the El Niño and La Niña phenomena. According to the author, it was found that in the dry four-month period, which corresponds to October to January, there was no interference of El Niño La Niña (El Niño (a)) episodes in the increases and reductions of days with occurrences of rain, which are directly linked to local factors such as breeze, convective movements, and instability line. The Niño (a) phenomena have little influence on the days with the occurrence of rain in Recife, because in the months with greater intensity of these episodes, the trend rains showed absence of increase or reduction.

Alves et al. (2006) showed that rainfall in the El Niño (a) period rains less or more and that these extremes can occur regardless of the presence or absence of these phenomena. This answer can be differentiated because rainfall is influenced by other atmospheric systems and/or by the combination of oceanic conditions in the tropical Atlantic.

The rainfall regime in the semi-arid region of Northeastern Brazil is characterized by great spatial and temporal irregularity and the short rainy season occurs differently in terms of quantity, distribution, and duration (Almeida et al., 2015).

Santos et al. (2018) state that from the study of the Southern Oscillation Index and the El Niño and La Niña events, it is possible to make a forecast for the occurrence of extreme events of rain or drought, in a given region, to favor the agricultural sector, which depends on the occurrence of rain for significant production and the economic development of a region.

França et al. (2020) estimated the normal climatological water balance in the phase of El Niño and La Niña phenomena, aiming at the occurrence of erosive variability for the municipality of Amparo de São Francisco, in Sergipe state of Brazil, providing information to governmental decision-makers so that they can carry out planning aimed at containing soil losses in the region. The aridity index has the greatest contribution to the erosive process in the period of occurrence of La Niña (3.63%), followed by the periods of El Niño (21.78%) and the pluvial series (1963-2019) (35.85%).

Medeiros et al. (2016) analyzed the relationship between the number of days with rain and precipitation in the municipality of Bom Jesus, in the Piauí state of Brazil, in the period 1960-2014, and its influence between the El Niño and La Niña. Analysis of the data collection allowed us to conclude that in years where rainfall was below the average of 984.8 mm, there was a better temporal distribution of rainfall; the opposite occurred when the rainfall was above average. There was an increase in precipitation and the number of rainy days in the 1st quarter of the year, while in the 2nd and 4th quarters there was a reduction in both precipitation and the number of rainy days. The numbers of days with extreme rains that were above or below the average were not explicitly associated with the ENSO (El Niño Southern Oscillation) phenomenon.

According to Romero (2013), ENSO influences considerably the climate in places where it operates, and long periods of drought can be observed, with total rainfall above historical normalities. As a result of the actions of ENSO, in the Amazon basin occurred an intense drought with rain peaks below 60 mm in 2005. In 2009, the rainfall levels were between 100 to 200 mm above normal (MARENGO, 2008). Santos et al. (2010) stated that the South Oscillation Indexes (SOI) can contribute considerably to the prediction of extreme rain and drought events in a given region.

According to Oliveira et al. (2015), the decrease in rainfall under the effect of El Niño in the NEB is a natural climatological phenomenon that can be attributed to the increase in rainfall in the southern region of Brazil.

Medeiros et al. (2013) stated that the highest precipitation rates in La Niña are due to the precipitation trends that it presents above average, compared to El Niño periods that can show a reduction between 60-65% in the index of rainfall.

Nóbrega et al. (2014) showed the influence of Sea Surface Temperature Anomalies (SSTA) from the Tropical Pacific Ocean and the Tropical North and South Atlantic Ocean on the BNE rainfall. They also emphasize that the difference in Surface Temperature of the North and South Tropical Atlantic causes descending or ascending air movements that interfere with the region's precipitation. This thermodynamic variability influences the latitudinal position of the Intertropical Convergence Zone – ITCZ, and for this reason, it determines the quality of its rainy season.

Knowing the spatial distribution of precipitation makes it possible to evaluate the behavior of this variable applied to the hydrological modeling of watersheds, including pollutant transport, river dynamics, soil estimation and losses, water availability for agriculture, and extreme events such as floods and drought (KEENAN, 2014).

The objective of the present work was to study the pluvial variability associating its neutral, strong, and/or weak pluvial intensities, on the action of the climatic phenomenon La Niña to the pluviometric indexes in the municipalities of Juazeirinho and Soledade, located in the semiarid region of Paraíba state, Northeastern Brazil.

MATERIAL AND METHODS

The municipality of Soledade is located in the state of Paraíba, Brazil, in the micro-region of Western Curimataú, with geographic coordinates of 7º 03' 30" south latitude and 36º 21' 47" west longitude. The seat of the municipality has an approximate altitude of 521 meters. It borders on the North with the municipality of São Vicente do Seridó; on the East with the municipalities of Olivedos and Pocinhos; on the West with the municipality of Juazeirinho, and on the South with the municipalities of Gurjão and Boa Vista. Its area is 560 km² representing 0.9923% of the State, 0.036% of the Region, and 0.0066% of the entire Brazilian territory, and is crossed by perennial rivers, but with a small flow, and the groundwater potential is low. The vegetation of this unit is formed by subdeciduous and deciduous forests, typical of wild areas.

The municipality of Juazeirinho is located in the central-north region of the State of Paraíba, Meso Region Borborema, and Microregion Seridó Oriental Paraibano. It is limited to the north with the municipalities of Parelhas (RN), São Vicente do Seridó and Tenório; on the east with the municipalities of São Vicente do Seridó and Soledade; on the South with municipalities of Gurjão and Santo André; and on the west with the municipality of Assunção. The municipality of Juazeirinho has an area of 461.8 km^2 and the municipal seat is located at an altitude of 555 meters, with geographic coordinates of 07° 04' S longitude and 36° 35' W longitude (Figure 1).

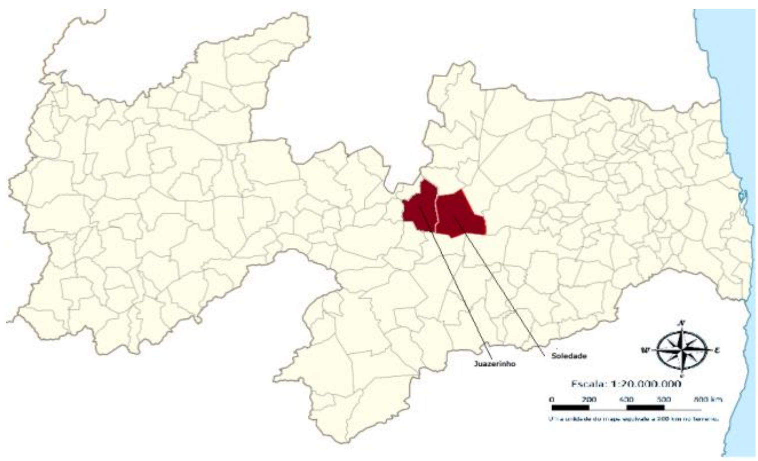

Figure 1. Location of the municipalities Soledade and Juazeirinho in the state of Paraíba, Brazil.

Source: Medeiros (2022).

The municipal area of Juazeirinho is also crossed by perennial rivers, but with a small flow, and the groundwater potential is low. The vegetation of this unit is formed by subdeciduous and deciduous forests, typical of wild areas.

According to Table 1, the climate of the cities was classified, according to the model by Köppen (1928) and Köppen et al. (1931) as being of the "BSh" type. Such classification is following the study by Alvarez et al. (2014). Thornthwaite's classification model follows the normal pattern of technical development of the Agricultural Research Corporation.

Table 1. Climatic classifications by the methods of Thornthwaite (1928); Thornthwaite & Mather (1955); Köppen (1928); Köppen & Geigen (1931) for the municipalities of Soledade and Juazeirinho – PB.

Classification								
			Thornthwaite			Köppen		
County	Longitude	Latitude	Altitude	Rainy	Dry	Regular	Normal	
Soledade	-36°36’	-7°06’	541,1	C2D'Ra'	C2E'Ra'	C2B'2Ra'	C1B'4S2a'	BSh
Juazeirinho	-36°58’	-7°06’	574,5	C2D'a'	C2E'Ra'	C2B'3a'	C1B'4S2a'	BSh

Source: Medeiros (2022).

The triggering factors for precipitation in the study area are the contributions of high-level cyclone formations when their center is over the Atlantic Ocean; the positioning of the Intertropical Convergence Zone; the instability line formations aided by the Atlantic cyclone vortices South; the heat exchange and its local effects with the help of the southeast trade wind; the contributions of the waves from the east and Maddem and Juliem; and the action of the large-scale phenomenon La Niña that increase cloudiness and cause rain above normal (MEDEIROS, 2016).

Monthly and annual precipitation series referring to the years of 1973 were used; 1983; 1984; 1998; 1995; 1998; 2008; 2011; 2014; 2017 and 2018, classified as La Niña years (AESA, 2020) (Table 2). Monthly and annual rainfall data for these locations were acquired by the Agência Executiva de Gestão das Águas do Estado da Paraíba (AESA, 2020).

Monthly and annual data were statistically analyzed to obtain the mean, median, standard deviation, and frequency distribution parameters. Subsequently, with the graphical analysis of the averages and medians of precipitation, it was found that the average values differed from the median values. For this purpose, median values were used as they are asymmetric and have better contributions than the average. To verify the La Niña fluctuations in the pluvial indexes, the annual pluvial total was compared with the median indexes of the studied years.

The relative deviation and observed percentage (Dpr) of rainfall for the La Niña years were determined by Equations 1 and 2 below.

$$\text{Dpr (mm)} = \text{total observed rainfall (mm)} - \text{median (mm)} \qquad (1)$$

$$\text{Dpr (\%)} = (\text{total observed rainfall (mm)} - \text{median (mm)} / \text{median (mm)}) \times 100 \qquad (2)$$

The standard deviation oscillates between positive and negative deviations from the mean. The criterion adopted in this study was to consider the negative contribution of the standard deviation for La Niña as rain below the normalized standard and the positive deviation as rain above the standards.

Table 2 shows the rainfall indexes in El Niño La Niña occurrences, its intensity and classification between isolated years of El Niño and La Niña.

Table 2. Classification and Intensity of El Niño La Niña – Southern Oscillation from 1972 to 2018.

Period	Classification	Intensity	Period	Classification	Intensity
1972-1973	El Niño	Strong	1997-1998	El Niño	Strong
1973-1976	La Niña	Strong	1998-2001	La Niña	Moderate
1976-1977	El Niño	Weak	2002-2003	El Niño	Moderate
1977-1978	El Niño	Weak	2004-2007	El Niño	Strong
1979-1980	El Niño	Weak	2008	La Niña	Strong
1982-1983	El Niño	Strong	2009-2010	El Niño	Weak
1983-1984	La Niña	Weak	2011	La Niña	Moderate
1984-1985	La Niña	Weak	2012	El Niño	Moderate
1986-1988	El Niño	Moderate	2013	El Niño	Strong
1988-1989	La Niña	Strong	2014	La Niña	Neutral
1990-1993	El Niño	Strong	2015	El Niño	Strong
1990-1993	El Niño	Strong	2016	El Niño	Strong
1994-1995	El Niño	Moderate	2017	La Niña	Weak
1995-1996	La Niña	Weak	2018	La Niña	Weak

Source: CPTEC/INPE

The climatic classification was carried out according to the rainfall variability described in Table 3. This table is used by the meteorological centers of the States and by the Instituto Nacional de Pesquisas Espaciais (INPE) to carry out monthly and annual classifications of rainfall in each municipality. Of NEB according to their variability in percentage deviations, for the municipalities of Juazeirinho and Soledade – PB in the phase of the La Niña phenomenon.

Table 3. Classification criteria are used to classify the Juazeirinho and Soledade municipalities according to monthly and annual percentage deviation classes.

classification criteria.

Percent	Deviation Rating
± 0.0 To 25.0%	Normal
±25.1 to 45.0%	Dry/Rainy
± 45.1 to 70.0%	Very Dry/Very Rainy
± 70.1 > 100.0%	Extremely Dry/Extremely Rainy

Source: CPTEC/INPE/meteorology centers (2010).

The El Niño conditions are determined or influenced by the temperature of the sea surface, Atlantic dipole among various mechanisms at the global, regional and local scale (Figure 2). Demonstrating the subsidence conditions hindering the formation of clouds and rain in the case of El Nino and, on the contrary, there is the formation of La Niña.

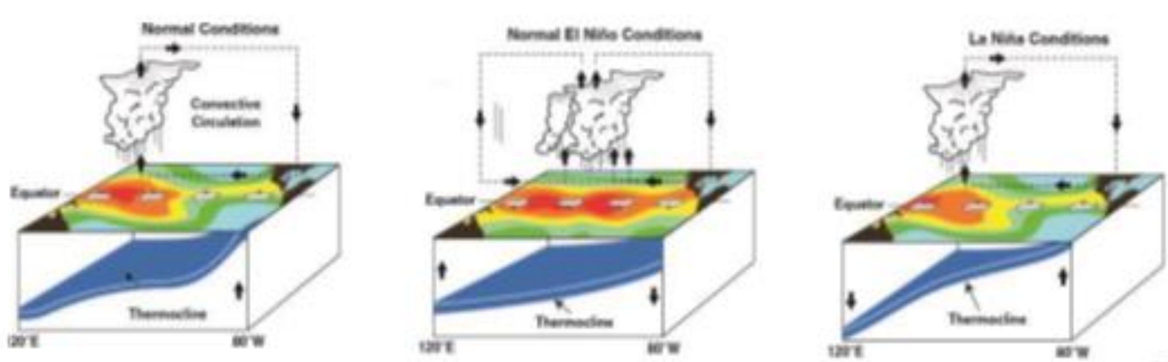

Figure 2. Demonstrate normal conditions, El Niño and La Niña conditions.

Source: CPTEC/INPE

RESULTS AND DISCUSSIONS

Figure 3 shows an irregular average rainfall with values between 1.8 mm in October and 112 mm in April; the median ranges from 20.8 mm (February) to 35.9 mm (August); the medians exceed the averages in January, June, and between August and December. The standard deviation ranges from 4.2 (October) to 82.7 mm (March). The standard deviation is higher than the average in January, February, March, and between August and December. The median exceeds the deviations between August and December, with high inter-year variability. The standard deviation exceeds the mean and medians. Therefore, the distribution model is skewed and the Person skewness coefficient is positive (Figure 3).

For Kulkarni et al. (2013) rainfall is of high importance, especially in tropical regions, and is considered the main point of convective processes that occur in the atmosphere. Marengo (2006) apud Gonzalez et al. (2013) observed, for the period 1979-2000, there were reductions in precipitation, flow, and moisture convergence in El Niño years, and increases in these variables in La Niña years.

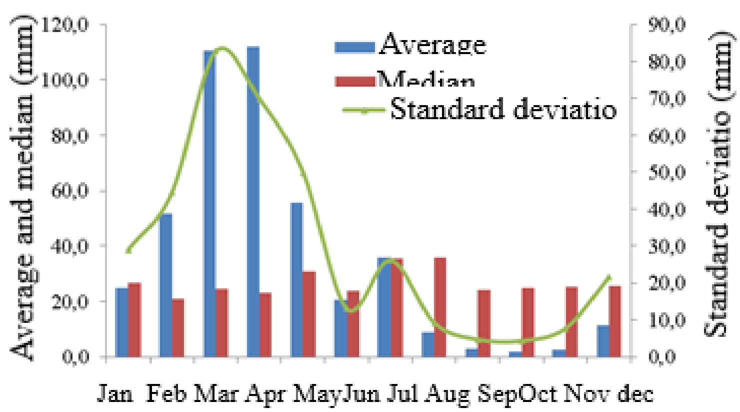

Figure 3. Monthly averages, median, and standard deviation of rainfall in the municipalities of Soledade and Juazeirinho, Paraíba state, Brazil.

Source: Medeiros (2022).

With an asymmetry curve to the rainy period between February and May, the median represents its highest rainfall values (Figure 4).

Analyzing the behavior of the medians with those of the standard deviations (Figure 4), irregularities in rainfall levels can be observed. Thus, the dispersions exceed the medians in three months and it is concluded that during the rainy season and even for the wettest month, the deviation may exceed the average median. When comparing the rainfall distributions from two different locations, differences in their amounts, durations, and distributions can be seen. In the municipalities of Juazeirinho and Soledade, for the rainy season, it was registered, respectively, 75.8% and 74.7%, of their annual totals. In the dry period, there are records of 3.4% and 2.9%, respectively, of the annual totals of Juazeirinho and Soledade.

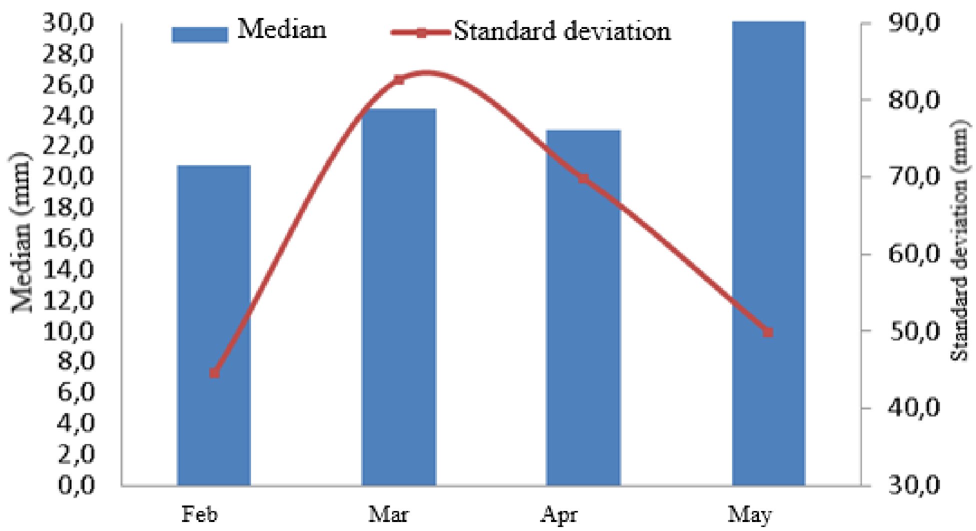

Figure 4. Monthly averages of the medians and standard deviations of rainfall, comprised between the months of the rainy season (February, March, April, and May) in the municipalities of Soledade and Juazeirinho, Paraíba state, Brazil.

Source: Medeiros (2022).

The annual rainfall irregularities recorded in the years of La Niña between the municipalities of Juazeirinho and Soledade can be seen in Figure 5. In the years of strong La Niña (1973; 1988 and 2008) the municipality of Juazeirinho recorded an annual increase in rainfall in the years 1973 and 2008, while in 1988 Soledade recorded higher rainfall. In the years classified as years of weak La Niña (1983; 1984; 1995; 2017 and 2018), the municipality of Juazeirinho presented higher annual rates than the municipality of Soledade. In the classification of moderate La Niña, in the years 1998 and 2011, Juazeirinho exceeded the rainfall in Soledade. In 2011 both municipalities matched their annual rainfall. In 2014, the rainfall index in Juazeirinho was 3.5% higher than in the municipality of Soledade, where La Niña was classified as neutral.

According to Medeiros et al. (2013), the highest precipitation rates in La Niña are due to the precipitation trends that it presents above average, compared to El Niño periods that can show a reduction between 60-65% in the index of rainfall. Pereira (2014) observed that the rainfall rate for the city of João Pessoa, Paraíba state of Brazil, is influenced by different climatological events such as the Intertropical Convergence Zone and the Atlantic Tropical Mass. This study corroborates the results presented here.

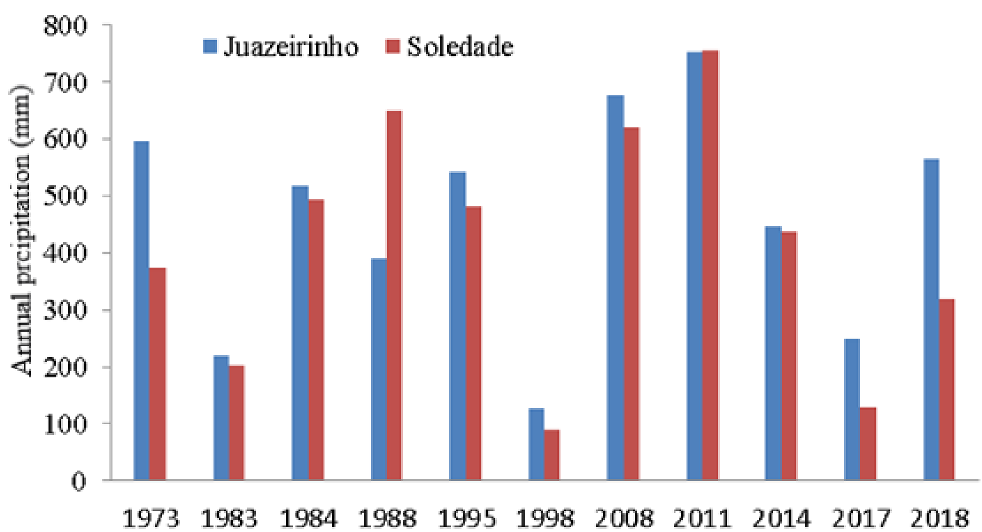

Figure 5. Total annual rainfall in La Niña years in the municipalities of Soledade and Juazeirinho, Paraíba state, Brazil.

Source: Medeiros (2022).

Santos et al. (2010) state that from the study of the Southern Oscillation Index and the El Niño and La Niña events, it is possible to make a forecast for the occurrence of extreme events of rain or drought, in a given region, to favor the agricultural sector, which depends on rainfall for significant production and economic development in a given region.

The anomalies of the total annual rainfall in La Niña years in the municipalities of Soledade and Juazeirinho, Paraíba stae os Brazil, can be seen in Figure 6. The irregularities in rainfall anomalies in the two municipalities studied have fluctuations from -300 mm to 350 mm. The years 1984, 1995 stand out with indexes of positive anomalies close to and 1998 with negative and close anomalies. With positive and negative fluctuations, the years 1973, 1988, 2014, and 2018 were registered. The years 1983, 1998, and 2017, presented negative anomalies.

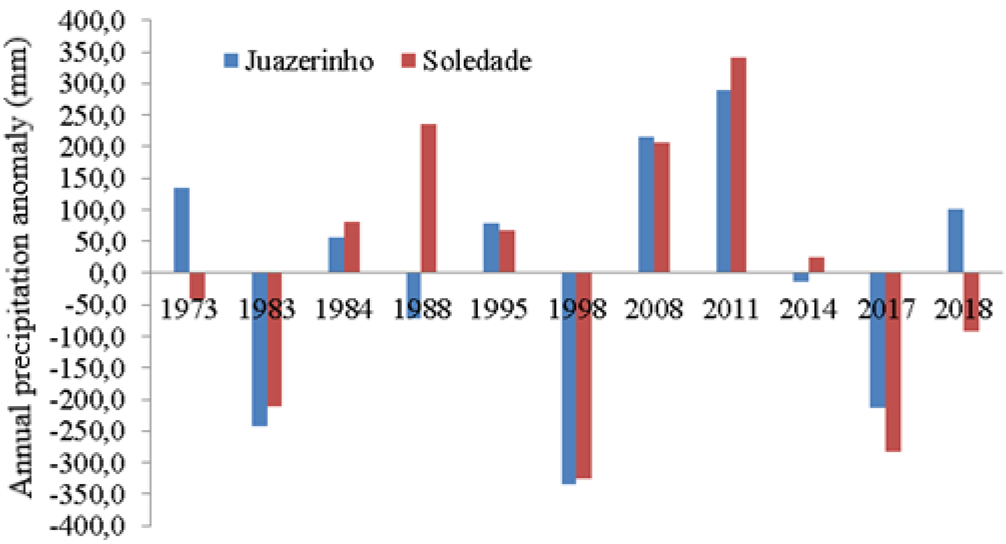

Figure 6. Total annual rainfall anomaly in La Niña years in the municipalities of Soledade and Juazeirinho, Paraíba state, Brazil.

Source: Medeiros (2022).

Ferreira et al. (2005) explain that a reduction in rainfall can be observed in the northern Northeast during the occurrence of the ENSO phenomenon, in its positive phase (El Niño), that is, the presence of heated surface waters in the central-eastern region of the equatorial Pacific, when in association with the positive Atlantic gradient. On the other hand, these authors also emphasize that in its negative phase (La Niña), which corresponds to the cooling of the waters of the Pacific Ocean, associated with the negative gradient of the Atlantic, it is normally responsible for rainy years in the region. The work corroborates the study showing the variability of El Niño(a) performance.

Long periods of drought, in addition to causing damage to agriculture in the region, especially in areas that are not irrigated, also affect the water level in springs and reservoirs, causing damage to urban supplies and electricity generation (Silva et al., 2011). Added to these facts is the direct influence of large-scale atmospheric and oceanic phenomena, which take place, simultaneously or not, on the Tropical Pacific and Atlantic Oceans (Lucena, Gomes Filho & Servain, 2011).

The rainfall variability was expressed in the characterization of the year: normal (N), dry (S), rainy (C), very dry (MS), very rainy (MC), extremely dry (ES), and extremely rainy (EC) according to with the percentage deviation from the mean, as observed in Table 4.

In the total of 11 years with La Niña activities for the municipality of Juazeirinho, there are rainy years (1973 and 2008); very dry years (1983); years classified as Normal (1984, 1988, 1995, 2014 and 2018); 1998 was classified as Extremely dry; 2011 as very rainy; and 2017 as a dry year. Monthly fluctuations show classifications from extremely dry to extremely rainy. The months of September to December are distinguished by their historical averages being low and the rainfall indexes, registered in those months, did not exceed the climatological series.

The distribution of the monthly classification in the years of La Niña predominance is shown in Table 4. Its fluctuation is related to the quantity and quality of the rainy, and dry seasons and the duration of rainfall in the studied areas, taking into account the deviation classes monthly and annual percentage.

Table 4. Classification criteria are used to classify the years and months according to monthly and annual percentage deviation classes for the municipal area of Juazeirinho in the phase of the La Niña phenomenon.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1973	C	S	N	EC	MS	S	N	ES	ES	EC	ES	ES	C
1983	N	EC	ES	ES	ES	ES	ES	ES	ES	ES	ES	ES	MS
1984	ES	ES	MC	C	N	N	C	EC	EC	ES	ES	ES	N
1988	ES	S	N	S	ES	MS	MC	N	EC	ES	ES	EC	N
1995	MC	C	N	N	EC	MC	N	ES	ES	ES	EC	MS	N
1998	C	ES	ES	ES	ES	S	S	EC	ES	MS	ES	ES	ES
2008	S	ES	EC	C	EC	MC	N	N	MC	ES	ES	N	C
2011	EC	EC	N	N	EC	EC	EC	EC	ES	ES	ES	ES	MC
2014	ES	EC	MS	N	N	N	MS	S	EC	MC	MS	N	N
2017	ES	MS	MS	MS	MS	EC	EC	ES	MC	ES	ES	ES	S
2018	N	N	MC	MC	ES	ES	ES	ES	ES	ES	ES	EC	N

Abbreviation meaning: N – Normal; MC – Very rainy; EC – Extremely rainy; ES - Extremely dry; S – Dry; C – Rainy; MS – Very dry

Source: Medeiros (2021).

In the municipality of Soledade, irregular rainfalls for the 11 years of La Niña phenomenon are shown in Table 5, for monthly and annual values. The years considered with normal rainfall (N) were 1973, 1984, 1995, 2014, and 2018. The years with classifications of very dry (MS) were registered in 1983 and 2017. The year 1988 classified was as very rainy (MC). The year 2008 was classified as a rainy year (C). The years 1998 and 2011 were classified as extremely dry (ES) and extremely rainy (EC), respectively. The variability of climatic classifications is related to large, meso, and microscale factors, in addition to their contribution to local and regional effects acting in the studied locations. These fluctuations are according to Marengo (2008).

Table 5. Classification criteria are used to classify years and months according to monthly and annual percentage deviation classes for the municipal area of Soledade in the phase of the La Niña phenomenon.

Ano	Jan	Feb	Mar	Apr	May	Jun	Jul	Agu	Sep	Out	Nov	Dec	Annual
1973	MS	S	S	EC	MS	MS	MS	ES	ES	ES	ES	EC	N
1983	ES	MC	ES	MS	ES	N	ES	EC	ES	ES	ES	ES	MS
1984	MS	ES	MC	C	N	N	N	ES	EC	ES	ES	ES	N
1988	N	EC	EC	N	MS	MS	S	MC	ES	ES	ES	EC	MC
1995	C	C	N	N	N	EC	C	ES	ES	ES	EC	ES	N
1998	S	ES	ES	ES	MS	ES	S	EC	ES	ES	ES	ES	ES
2008	S	N	EC	N	EC	N	N	MC	MC	N	ES	N	C
2011	EC	C	N	C	EC	EC	EC	EC	ES	ES	ES	ES	EC
2014	ES	MC	S	N	EC	C	N	N	EC	EC	ES	ES	N
2017	ES	ES	ES	ES	MS	N	N	ES	ES	ES	ES	ES	MS
2018	N	S	ES	EC	ES	MS	ES	ES	ES	ES	EC	S	N

Abbreviation meaning: N – Normal; MC – Very rainy; EC – Extremely rainy; ES - Extremely dry; S – Dry; C – Rainy; MS – Very dry

Source: Medeiros (2021).

For NEB, the El Niño and La Niña years, in general, are associated with rain scarcity and abundance, respectively, while opposite conditions are observed in the South and Southeast regions of Brazil. In general, these conditions are also related to the occurrences of TSM (Sea Surface Temperature) dipoles in the Tropical Atlantic. Positive (El Niño) SST anomalies in the northern sector and negative (La Niña) in the southern sector, most of the time, can also occur in El Niño years, while opposite characteristics are observed in La Niña years (Alves et al., 2006).

Annual rainfall fluctuations and their respective historical averages are shown in Figure 7 in La Niña years in the municipalities of Juazeirinho and Soledade. The annual irregularities in their indexes show that La Niña's contribution to rainfall depends exactly on the most active regional and local systems. Analogous results were obtained by some authors (Santana et al., 1980; Baracho et al., 1990; Medeiros et al., 2016).

It is recommended to use the application of the median values, instead of the mean values which have low significance. Studies such as those of some authors (Oliveira et al. 2012; Almeida et al., 2014; Almeida et al., 2015) corroborate the results found for the studied area.

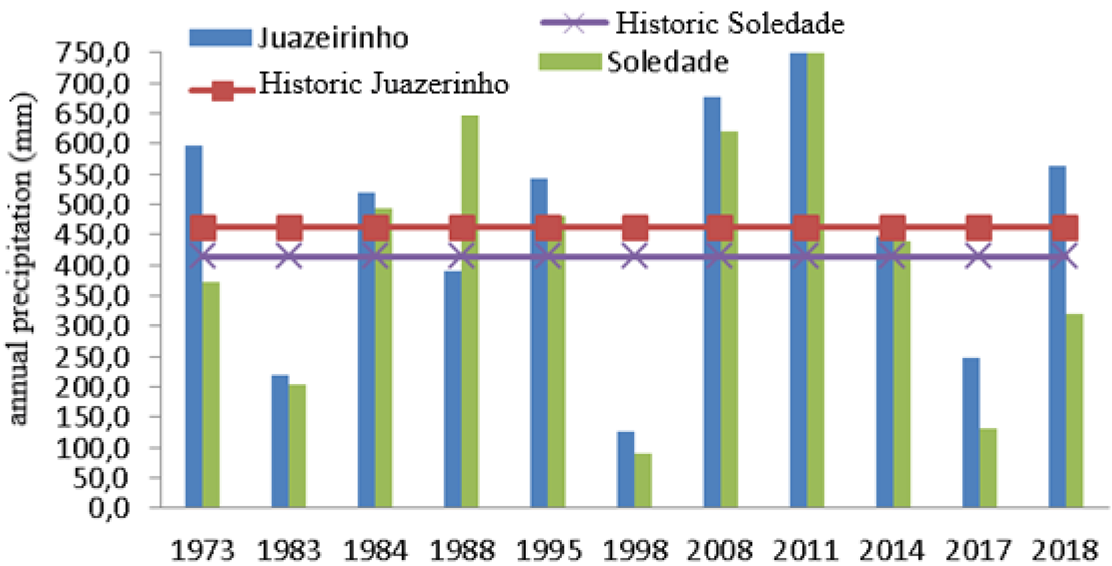

Figure 7. Total annual precipitation in La Niña years in the municipalities of Soledade and Juazeirinho, Paraíba state, Brazil.

Source: Medeiros (2022).

CONCLUSION

In the municipalities of Soledade and Juazeirinho, the performance of the El Niña phenomenon is not related to increases and/or reductions in rainfall, and it should be noted that in the classification system of La Niña there are very dry and extremely dry classes with greater predominance.

The rainfall regime, with a well-defined dry season, associated with poor rainfall distribution, during the rainy season (February to May) and poor soil nutrients, in general, require a high technical level for agricultural production, and it is recommended that adoption of management practices aimed at conserving water in the soil. Lack of water from August to December limits land use, making cultivation unfeasible at that time of year.

The use of the median has greater chances of occurrences for the realization of pluvial indexes in the phase of the La Niña phenomenon.

It was found that La Niña does not influence the rainfall in the municipalities studied, and the distribution of rainfall indexes was irregular, reflecting deficiencies in water storage.

In La Niña years of strong intensity, there is a tendency to rain below expectations, although the deviations may be smaller than the standard deviation.

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