Revista Brasileira de Climatologia
Brazilian Journal of Climatology
OPEN ACCESS
BIBLIOTECA Coordenadoria de Bibliotecas Portal de Periódicos ISSN 2237-8642

DROUGHT IN NORTHEAST BRAZIL: HISTORY, CLIMATIC AND SOCIAL IMPLICATIONS

A seca no nordeste brasileiro: histórico, implicações climáticas e sociais

El Ni Sequía en el nordeste de Brasil: historia, implicaciones climáticas y sociales

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Abstract: The prospect of increasing drought occurrences in the Northeastern region of Brazil has raised concerns among various social actors, including researchers, farmers, and policymakers. This study proposes to conduct a historical analysis of droughts and their relationship with the El Niño–Southern Oscillation (ENSO) phenomenon in the Brazilian Northeast (NEB). Drought events and their effects were examined to determine their frequency and to contribute to reducing their economic, social, and environmental impacts. For detecting drought periods, we used a 119-year historical dataset based on CRU-ts4.02 data. Extreme drought events play a significant role in society due to their intensity, frequency of occurrence, socio-environmental vulnerability, adaptability, and resilience. Thus, understanding their dynamics is essential for effective climate risk management.

Keywords.: Drought. ENSO. Precipitation. Northeast.

Resumo: A perspectiva de aumento na ocorrência de secas na região Nordestina tem gerado preocupações entre diversos atores sociais, incluindo pesquisadores, agricultores e gestores. O objetivo deste trabalho é realizar uma análise histórica das secas e sua relação com o fenômeno El Niño no Nordeste Brasileiro (NEB). As secas e seus efeitos foram estudados para determinar sua frequência e contribuir para a redução de seus impactos econômicos, sociais e ambientais. Para a identificação dos períodos de seca, utilizamos uma série histórica de dados dos últimos 119 anos, por meio de conjuntos de dados do CRU-ts4.02. Os eventos extremos de seca desempenham um papel significativo na sociedade devido à sua intensidade, frequência de ocorrência, vulnerabilidade socioambiental, adaptabilidade e resiliência. Nesse sentido, compreender sua dinâmica para a gestão de riscos climáticos é de fundamental importância.

Palavras-chaves : Seca. ENOS. Precipitação. Nordeste.

Resumen: La perspectiva de un aumento de la ocurrencia de sequías en la región Noreste ha generado preocupación entre diversos actores sociales, incluyendo investigadores, agricultores y gestores. El objetivo de este trabajo es realizar un análisis histórico de las sequías y su relación con el fenómeno El Niño en el Noreste Brasileño (NEB). Las sequías y sus efectos han sido estudiados para determinar su frecuencia y contribuir a la reducción de sus impactos económicos, sociales y ambientales. Para identificar los períodos de sequía, se utilizó una serie histórica de 119 años a partir de los conjuntos de datos del CRU-ts4.02. Los eventos extremos de sequía desempeñan un papel significativo en la sociedad debido a su intensidad, frecuencia de ocurrencia, vulnerabilidad socioambiental, adaptabilidad y resiliencia. En este sentido, comprender su dinámica para la gestión de los riesgos climáticos es de fundamental importancia.

Palabras clave: Sequía. ENOS. Precipitación. Noreste.

Submetido em: 09/03/2025
Aceito para publicação em: 06/11/2025
Publicado em: 14/12/2025

1. INTRODUÇÃO

Periodic droughts in the Northeast region of Brazil (NEB) have been reported since before Portuguese colonization, although historical records remain scarce (Campos; Studart, 2001). The occupation of the Northeastern backlands had significant consequences in the early 18th century, when a royal decree prohibited cattle ranching within 10 leagues (approximately 42 km) of the coast. As a result, ranchers were forced to move their herds inland, despite the region's recurrent environmental challenges. This movement stimulated the colonization of the hinterlands and intensified the exploitation of natural resources. In this context, cattle ranching played a central role in the economic development of the semiarid region; however, frequent droughts were a constant cause of hardship for the population (Santana; Santos, 2020).

Drought is considered a natural climatic phenomenon that affects water availability, occurring when precipitation levels fall below the annual average of a given region (Marengo *et al.,* 2016; Araújo, 2021; Santos *et al.,* 2023; Souza; Oliveira, 2002). In this context, droughts may reach extreme levels when precipitation over a specific period drops significantly below climatological normals. Such events have been recurrent throughout human history, affecting ecosystems, populations, and economic sectors such as agriculture, transportation, and water supply (Barra, 2002; Heim Jr, 2002; Blain; Brunini, 2005; Brito *et al.,* 2018; Cunha, 2008; Santana; Santos, 2020, Pontes Filho *et al.,* 2020; Silva *et al.,* 2021).

Before conducting research on drought, it is essential to understand its meaning. However, establishing a universally accepted definition for this concept has been considered a major challenge due to its great complexity (Blain; Brunini, 2005). All types of drought originate from a precipitation deficit, leading to reduced water availability for human and environmental needs. Understanding its causes, spatial extent, and consequences is therefore fundamental.

It is important to highlight that there is no concrete and universally accepted definition for the concept of drought, since its interpretation varies according to the observer (Heim Jr, 2002). Because drought can be interpreted from multiple perspectives, several studies categorize it into four types: meteorological, hydrological, agricultural, and socioeconomic (Wilhite; Glantz, 1987; Almeida; Marques, 2021; Medeiros *et al.,* 2022).

In general, Meteorological drought refers to precipitation deficits relative to long-term averages (Noronha *et al.,* 2016). Hydrological drought results from reduced surface or groundwater levels (Fernandes *et al.,* 2021). Agricultural drought arises when soil moisture becomes insufficient for crop development, reducing biomass and productivity. Socioeconomic drought, in turn, is associated with the consequences of water scarcity on human activities and livelihoods (São José *et al.,* 2022; Oliveira *et al.,* 2023; Silva *et al.,* 2023).

A substantial body of research has examined the origin of the semiarid climate in the NEB and its relationship with regional air-mass circulation. In his analysis of atmospheric circulation, Nimer (1979) highlighted that the NEB is influenced by disturbed atmospheric systems originating from the South (polar fronts), North (Intertropical Convergence Zone), East (Trade Winds), and the West (Tropical Squall Lines). Mendonça and Danni-Oliveira (2017), studying the Northeast, corroborate this, emphasizing the influence of Continental Equatorial (cEc), Equatorial Atlantic (eAt), Tropical Atlantic (mTa), and Polar Atlantic (mPa) air masses, which often enter the region with insufficient humidity. More recent studies, such as Gomes and Zanella (2023), confirm these observations.

Ferreira and Melo (2005) characterized the main atmospheric systems acting on small, meso, and large scales that generate the region's precipitation regime and influence the weather and climate of the NEB, in addition to describing the role of the Pacific and Atlantic Oceans in the region's climate.

The climatic conditions of the NEB are closely linked to the influence of multiple atmospheric systems that vary throughout the year and significantly affect rainfall distribution. Changes in the dynamics of these systems may intensify natural disasters such as droughts and floods. Among the main mechanisms influencing rainfall variability in the NEB are the Intertropical Convergence Zone (ITCZ), upper-tropospheric cyclonic vortices (UTCVs), tropical easterly-wave disturbances (EWDs), the Madden–Julian Oscillation (MJO), convective instability lines (squall lines), as well as the El Niño–Southern Oscillation (ENSO) and the Tropical Atlantic Dipole (Uvo; Berndtsson, 1996; Nimer, 1989; Marengo *et al.,* 2018; Silva *et al.,* 2021; Souza; Oliveira, 2002).

Among the atmospheric systems acting in NEB, the ITCZ is the main provider of rainfall in the northern sector of Northeast Brazil. Uvo *et al.* (1998) provided a detailed assessment of its importance for regional rainfall, concluding that the position and intensity of the ITCZ are key determinants of the quality of the rainy season in the region (Lyra *et al.,* 2019).

The climate of the Northeast region presents considerable complexity, resulting from its geographic position and the interaction between different atmospheric circulation systems. The relationship between the atmosphere, relief, oceans, and regional physiography, together with variations in Sea Surface Temperature (SST) patterns in the tropical oceans, induces changes in the position and intensity of the ITCZ over the Atlantic Ocean. This dynamic significantly influences the interannual variability of rainfall in the Northeast region (Nimer, 1989; Menezes, 2010).

ENSO is a global climate phenomenon involving ocean–atmosphere interactions, related to variations in SST in the central and eastern equatorial Pacific, where positive or negative anomalies can be observed. It can be understood as a phenomenon of interannual variability, representing climate anomalies such as droughts in Indonesia, Australia, and Northeast Brazil (Marengo *et al.,* 2011; Fonseca *et al.,* 2022; Souza *et al.,* 2022). Several studies have highlighted the strong influence of ENSO on the occurrence of drought in Northeast Brazil. Authors such as Melo *et al.,* (1999); Freire (2011), Marengo, *et al.,* (2011), Buriti, *et al.,* (2020), Carmo; Lima (2020); Vasconcelos; Diniz (2020) point to the relationship between the occurrence of ENSO and a prolongation of the abnormal dry period in the region.

Anomalous changes in upper atmospheric circulation and the resulting changes in the dynamics of high and low atmospheric pressure, high and low pressure centers, and atmospheric circulation cells are mechanisms that explain the occurrence of severe droughts in Northeast Brazil (Alves, 2012).

Climate projections indicate that drought events are likely to intensify, with more severe scenarios projected for both the near and long-term future. Reduced precipitation and increased evapotranspiration are expected to diminish water availability for irrigation and human consumption (Marengo *et al.,* 2019). Analyses by Marengo *et al.* (2019), indicate that 55%, 68%, and 71% of municipalities in Northeast Brazil (NEB), totaling 1,793 municipalities, are potentially impacted by extreme and severe droughts in 2040, 2070, and 2100, respectively. Therefore, projections for the NEB suggest that future climate conditions, due to predicted changes in the hydrological cycle, will have a significant impact on regional water supply and accessibility (Cuartas, 2022).

Given this context, the present study highlights the importance of understanding the temporal patterns of drought in Northeast Brazil using data from the last 119 years. Additionally, it seeks to examine the historical relationship between drought occurrences and ENSO events. This work is in line with the actions outlined in SDG 13 – Climate Action, which proposes to "take urgent action to combat climate change and its impacts." Therefore, this objective encourages climate monitoring, adaptation, and the strengthening of resilience in the face of phenomena like El Niño, which intensify the occurrence of drought.

2. MATERIALS AND METHODS

2.1. Study Area

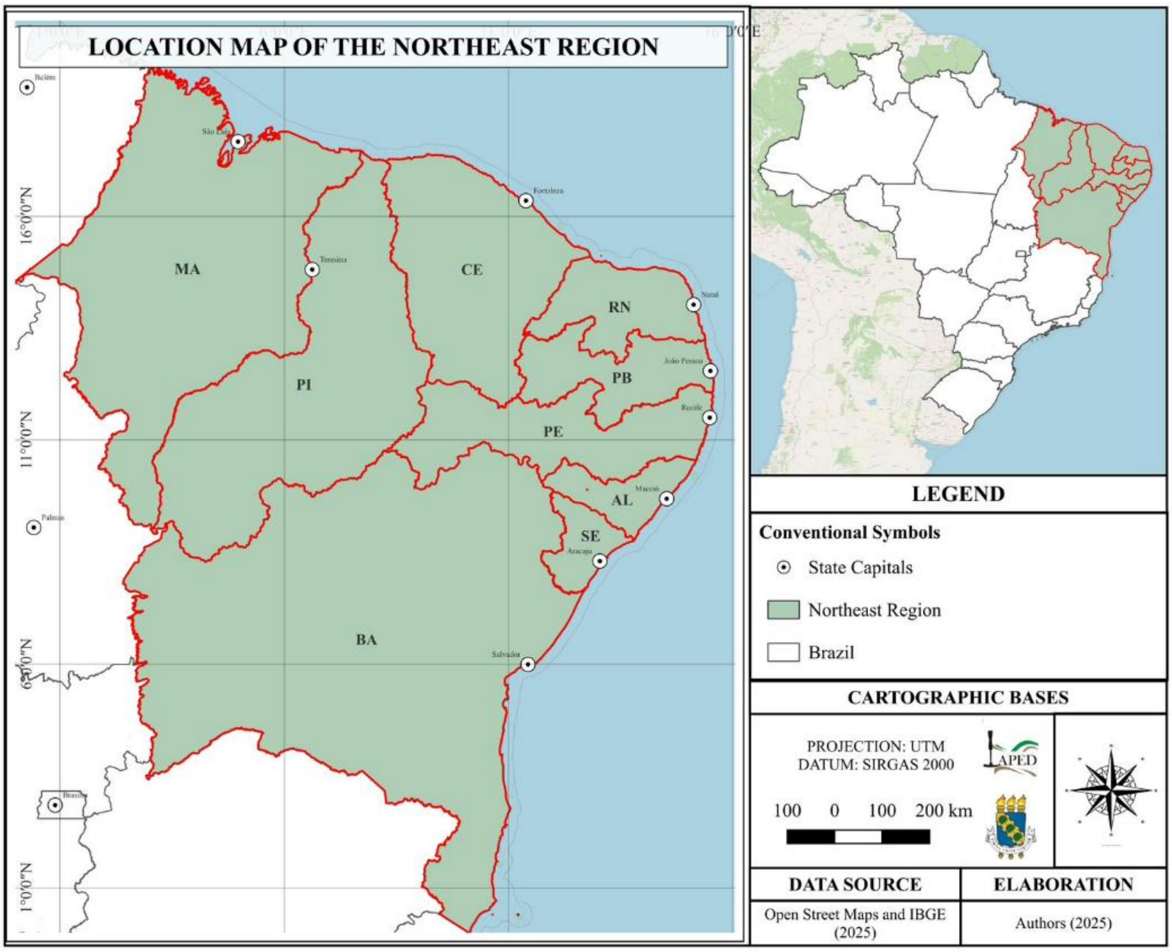
The NEB covers an area of approximately 1.56 million km² and comprises 1,793 municipalities, with an estimated population of 56.8 million inhabitants (IBGE, 2021). The region includes nine federal units: Alagoas, Bahia, Ceará, Maranhão, Paraíba, Pernambuco, Piauí, Rio Grande do Norte, and Sergipe (Ribeiro *et al.,* 2022; Sousa, 2022).

Latitude plays a significant role in determining climatic conditions, particularly solar incidence. Located between 1° and 18° South Latitude and 34° and 48° West Longitude, the NEB is strongly influenced by its proximity to the equator, which results in intense solar radiation (Lucena; Steinke, 2017). In the semiarid portion of the region, the Caatinga biome — characterized by xerophytic, deciduous, and subdeciduous vegetation — constitutes its most representative landscape (Ab'Sáber, 2003; Souza; Oliveira, 2002).

Temperature variations throughout the year are minimal, generally ranging from 2°C to 3°C, accompanied by high solar radiation. Only two distinct seasons are observed: a rainy period lasting 3 to 5 months and a prolonged dry season lasting 7 to 9 months (Angelotti, 2009). These climatic characteristics make the semiarid Northeast one of the regions most affected by climate variability. High evapotranspiration rates, which often exceed annual precipitation, contribute to recurrent negative water balances (Gondim *et al.,* 2017; Souza; Oliveira, 2002).

Additionally, average annual temperatures remain consistently high, between 25°C and 29°C, further reinforcing the semiarid climate regime. Figure 1 presents the location of the Northeast region of Brazil.

Figure 1- Location map of the Northeast region



Source: Prepared by the authors (2025).

2.2 El Niño

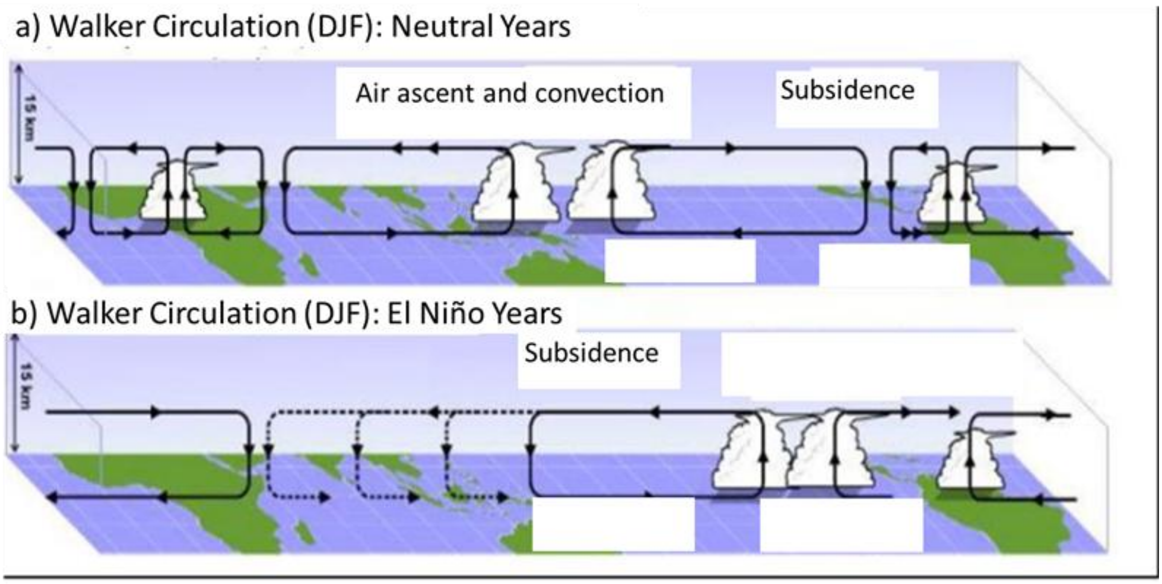
The global phenomena El Niño and La Niña exert strong influence on normal and extreme precipitation patterns (Santos *et al.,* 2023). The duration, intensity, and timing of these events critically affect the severity of natural disasters, including droughts and floods, across the NEB (Santos, 2019; Kay *et al.,* 2022).

ENSO is characterized by alterations in SST and atmospheric circulation over the equatorial Pacific. During El Niño episodes, weakened trade winds cause the accumulation of warm water along the eastern Pacific, near the Peruvian coast, and the western Pacific, near Australia. These changes have significant regional and global implications, especially for precipitation distribution in tropical and subtropical regions (Marengo *et al.,* 2011; Fonseca *et al.,* 2022; Souza *et al.,* 2022).

Regarding the nomenclature, the term “El Niño” originates from Spanish and refers to the presence of warm waters appearing annually off the Peruvian coast during the Christmas season, which local fishermen associated with the Baby Jesus (Niño Jesús). Despite extensive research, the exact mechanisms behind these anomalous SST patterns remain uncertain, and various hypotheses have been proposed without a definitive conclusion (Farias; Xavier, 2023).

The thermodynamic prerogatives present in the tropical Pacific and Atlantic Ocean basins play a crucial role in the coordination and transformation of atmospheric circulation in the region between the tropics. The Hadley and Walker cells, which act in the meridional and zonal directions, respectively, are disturbed in years characterized by SST anomalies, causing significant changes in atmospheric circulation over the tropics, as the cells are displaced from their usual climatological positions (Ferreira; Mello, 2005). Figure 2 shows the Walker circulation in different periods.

Figure 2- Schematic diagram of the Walker zonal circulation cell in DJF considering (a) neutral years and (b) years with El Niño events



Source: Adapted from http://www.personal.psu.edu/czn115/blogs/meteo241/2%20Walker%20Citculation%20and%20El%20Nino.jpe

ENSO-related oscillations in the tropical Pacific strongly influence climate variability in the NEB, primarily through changes in atmospheric circulation. This relationship manifests itself through changes in the general circulation of the atmosphere. During ENSO years, the phenomenon induces an eastward shift of the Walker circulation, with its ascending branch located in the eastern equatorial Pacific. This phenomenon results in an intensification of convection in this region (Andreoli; Kayano, 2006). El Niño episodes are generally cyclical but irregular, typically occurring at intervals of 2 to 7 years (Marengo *et al.,* 2011; Santos *et al.,* 2023).

2.3 Data

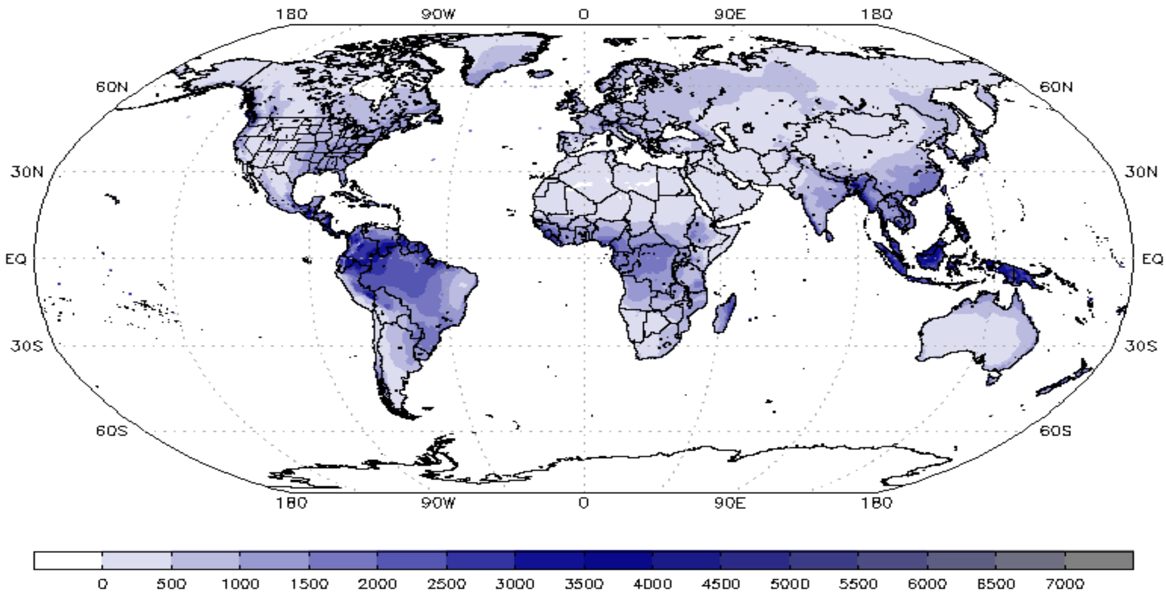
This study analyzed the spatial and temporal patterns of droughts in the NEB, using climate projections for the last 119 years from the Climate Research Unit version ts4.02 (CRU-ts4.02) dataset. The CRU TS dataset provides high-resolution monthly variables derived from terrestrial observations dating back to 1901, covering ten observed and derived variables, with a resolution of 0.5 degrees of latitude by 0.5 degrees of longitude, in various parts of the world, except Antarctica. The data are derived from interpolation analyses of monthly climate anomalies, incorporating extensive networks of observations from weather stations globally (Harris, 2020).

In this study, the most recent version of the CRU TS v4.02 dataset was used, considering the period from 1901 to 2019 as a reference. The treatment of the raw data and processing were performed in the Python environment, with the aid of the NetCDF4, NumPy, and Matplotlib libraries for reading, manipulating, and plotting the information. Annual averages and anomalies of options were calculated, in addition to the creation of the graphs used in the analysis of the results.

Access to the dataset can be obtained by requesting it from the Climate Research Unit (CRU), affiliated with the University of East Anglia in the United Kingdom, as described by Harris *et al.* (2020) in the study “Version 4 of the CRU TS monthly high-resolution gridded multivariate climate dataset”, available at: https://crudata.uea.ac.uk/cru/data/hrg/.

Figure 3 displays global precipitation distribution, highlighting that annual precipitation in the NEB ranges from approximately 500 to 1,000 mm — among the lowest values in Brazil.

Figure 3- Global precipitation observed by CRU-ts4.02



Source: Prepared by the authors (2024)

2.4. Methodology

The research adopts a mixed quantitative–qualitative approach. In the initial stage, a literature review was conducted, and a table was prepared summarizing major drought events in the 19th, 20th, and 21st centuries. The second stage involved analyzing the last 119 years of climate data from the CRU-TS4.02 dataset to identify drought patterns across the NEB. Subsequently, another table was compiled to assess the relationship between drought years and ENSO occurrences. Table 1 outlines the methodological stages of the research.

Table 1- Methodological steps of the research

Step 1	Bibliographic analysis on the topic of drought in Ceará and the Northeast.
Step 2	Construction of a table showing the main drought phenomena in the NEB.
Step 3	Understanding climate projections over the last 100 years for Northeast Brazil using CRU-ts4.02 datasets

Source: Prepared by the authors (2024).

3. RESULTS AND DISCUSSIONS

During the 20th and 21st centuries, Northeast Brazil experienced two droughts lasting three years (1930–1932 and 1941–1943), two lasting four years (1951–1954 and 2012–2015), and one lasting five years (1979–1983) (Martins; Magalhães, 2015).

Table 2 presents the major drought events of the 19th, 20th, and 21st centuries, based on sources such as Buriti *et al*. (2020), Marengo *et al*. (2017), Lima and Magalhães (2018), Medeiros (2019), Cândido (2014), Funceme (2012), Campos and Studart (2001), Duarte (2002), and the Ministry of Agriculture (2012).

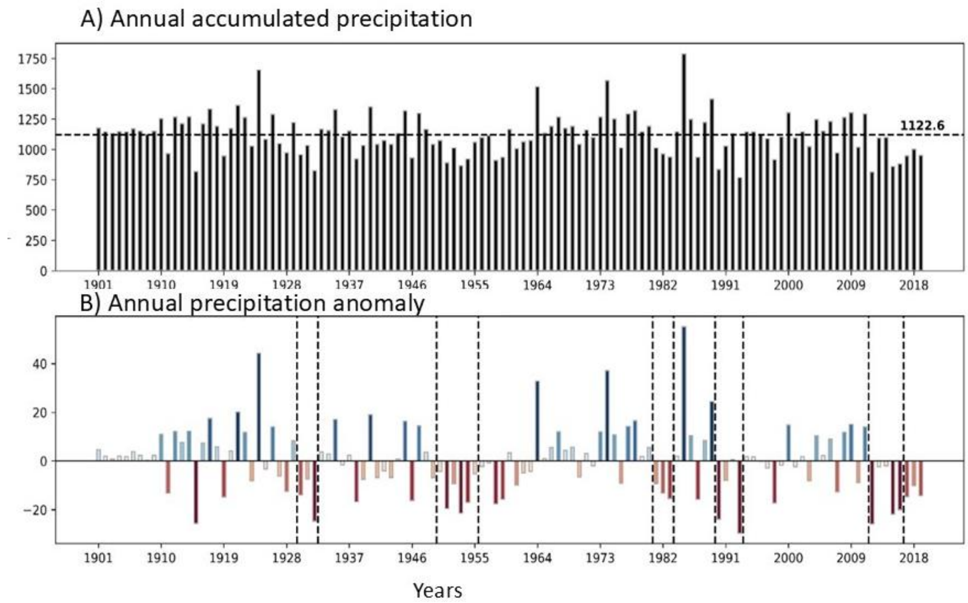
Table 2- Major drought events at the end of the 19th, 20th and 21st centuries

1877- 1879	This event is often cited as the most devastating drought in Brazilian history. It drastically affected ecosystems and caused an estimated 500,000 deaths in Ceará and surrounding areas due to hunger and disease. Its ecological and human impacts were unparalleled.
1888-1889	Brazil is at the end of the Brazilian monarchy and marking the abolition of slavery, and once again a new relationship with the lack of rain is established among the populations of the semiarid region. Reports indicate that in 1889 alone, more than 14,000 people were registered as migrants, making drought synonymous with crowds of migrants affected by hunger.
1909	Official records report the loss of approximately 2.5 million inhabitants in the "Northern States" as a consequence of drought.
1913- 1915	Known as the "Great Drought," this period was marked by the creation of concentration camps to isolate drought victims from major cities. Thousands lived under precarious conditions, facing hunger, disease, and social isolation. The Alagadiço camp alone housed more than 8,000 people.
1932-1933	The policy of concentration camps intensified. The largest of them, in the city of Crato, confined about 60 thousand people. Other locations such as Senador Pompeu, Ipu and Quixeramobim also had these areas, which were historically known as the "largest human corrals".
1941-1943	This drought triggered a humanitarian collapse. Newspapers from 1942, such as O Povo, reported waves of migrants arriving in Fortaleza and surrounding cities, with concentrations of 6,000 people in Sobral, 4,000–5,000 in Senador Pompeu, and roughly 2,000 in Canindé.
1945 -1953	The 1958 event severely affected Ceará, Rio Grande do Norte, Paraíba, and Piauí. The economic losses were significant, reaching around 10 billion cruzeiros (equivalent to US$132 million in 1957 values).
1962 a 1964	This drought was considered extremely severe in the Northeast and also stood out due to an unusual heat wave in other regions of the country, such as São Paulo, Rio de Janeiro, and Pará, which struggled with water scarcity beyond their usual patterns.
1979	One of the longest droughts on record, lasting five years and affecting more than 1,000 municipalities across an area of 1.4 million km². Approximately 9 million people were impacted. In 1982, the government designated 183 municipalities as official "Drought Pockets".
2009	In the regions of Sertão Central and Sertão dos Inhamuns, rainfall was 42% lower than expected for March. In April, rainfall across the entire state was 70% below average. In rural areas, crops are not developing and losses continue to grow. In municipalities such as Morada Nova, Independência, Boa Viagem, and Bicuitinga, losses have reached 80%.
2011	The drought caused severe agricultural losses, especially in irrigated areas along the São Francisco River, where drastic reductions in water volume also affected hydroelectric generation.
2012-2014	Considered the worst drought in the last 100 years. Nearly all municipalities in the semiarid region (around 1,262) declared a state of emergency. The crisis extended until 2016.

Source: Prepared by the authors (2025).

Precipitation is a variable of utmost importance in the hydrological cycle, playing a crucial role for humans and natural ecosystems. It contributes significantly to energy generation through hydroelectric power, to water supply, to the maintenance of ecosystems, among other essential applications. However, it is important to note that two regions with similar annual precipitation averages but different rates of Potential Evapotranspiration (PET) may experience distinct water regimes (Lima; Guimarães, 2016). Figure 4 presents the accumulated precipitation and the annual precipitation anomaly for the NEB between 1901 and 2019.

Figure 4 - Annual precipitation in the Brazilian Northeast



Source: Prepared by the authors (2024).

In Figure 4A, the average annual precipitation in the Northeast from 1901 to 2019 can be analyzed. Figure 4B shows the annual precipitation anomaly. The climatological normal used refers to the period from 1980 to 2010, and from the results, several years are observed in which the comparison of the data yields negative results compared to the climatological normal, thus proving the existence of drought.

From 1901 to 1919, the periods in which the annual rainfall exceeded the climatological average are listed. During the years 1910 to 1919, this occurrence was recorded in three specific years: 1910, 1915, and 1919. This analysis corroborates the statements of Matias and Almeida (2015), according to which historical sources reveal that in 1915, the first terrible drought struck the Northeast, causing numerous human and material losses.

This catastrophic event left an indelible mark on the history of the Northeastern people, not only due to food shortages and the death of animals, but primarily because of the struggle to survive in the face of lack of support from the authorities and the existing enclosures, which deprived people of freedoms and left them dependent on precarious sanitary conditions (Matias; Almeida, 2015). This resulted in the formation of gatherings with thousands of bodies. The drought of 1915, known as the 'Drought of 15,' was the inspiration for the writer Rachel de Queiroz to create her first and most famous novel: 'O Quinze,' as highlighted by Marengo *et al*. (2011). Notably, in the same year, the ENSO phenomenon did not occur.

Between 1920 and 1930, five negative periods were identified, characterized by rainfall indices below the climatological average, indicating low precipitation (1923, 1925, 1927, 1928, and 1930). In 1923, a weak ENSO occurred; in 1925, a strong ENSO. The years 1928 and 1930 were considered dry, according to various bibliographic records (Melo, 1999).

In the period between 1931 and 1940, four periods with negative anomalies were observed (1931, 1932, 1938, 1939). Specifically in 1932, the figure shows an anomaly below 20, confirming the classification of an extremely dry year, marking yet another major drought that affected the northeastern backlands. In that year, the concentration camps in Ceará were expanded, and new 'human corrals' were established in the municipalities of Senador Pompeu, Ipu, Quixeramobim, Crateús, and Crato (Matias; Almeida, 2015). Furthermore, this period coincided with the occurrence of ENSO (Marengo *et al.,* 2011). Regarding the year 1939, it was observed as a year of moderate drought, associated with a strong ENSO (Melo, 1999).

During the government of Getúlio Vargas, there was an attempt to implement some projects in the Northeast, but the intensity of the drought limited the actions of the Federal Inspectorate of Works Against Droughts (IFOCS) (Buriti *et al.,* 2020). For the years 1940 to 1950, five negative anomalies were recorded (1941, 1942, 1943, 1946, 1950), indicating periods of low productivity. In 1941, ENSO stood out with strong intensity and was classified as a dry year. In 1942, another severe drought occurred, followed by a weak ENSO event in 1943, also associated with a dry year. In 1944, yet another dry year persisted (Marengo *et al.,* 2011).

In the year 1946, an unusual drought situation and the occurrence of a moderate El

Niño were observed (Buriti *et al.,* 2020). During the period from 1951 to 1960, nine periods with negative anomalies were recorded (1951, 1952, 1953, 1954, 1955, 1956, 1957, 1958, 1959). According to Marengo et al. (2011), in 1951, there was a weak ENSO and a dry year. In 1952, 1953, and 1954, there was a moderate ENSO.

Between the years 1961 and 1970, four periods with negative anomalies were identified (1961, 1962, 1963, 1970), and from 1971 to 1980, there were two negative periods (1972 and 1976). Buriti *et al.* (2020) states that 1976 was a dry year with the occurrence of a weak ENSO. From 1981 to 1990, six negative periods were identified (1981, 1982, 1983, 1987, 1989, and 1990). This period was marked by a significant drought, especially from 1981 to 1983. It is important to highlight that this period was also characterized by the occurrence of a rather peculiar ENSO event in 1982/1983.

The occurrence of this phenomenon caused significant changes in the rainfall pattern, resulting in a drought considered one of the longest and most severe in the history of the Northeast, whose impact led to a number of deaths regarded as a public calamity. It is estimated that, at the time, between 700 thousand and 3.5 million people lost their lives due to the drought (Santos *et al.,* 2012).

In the period between 1990 and 2000 (1991, 1993, 1997, 1998, 1999), the occurrence of significant dry events stands out. Two severe droughts deserve special mention: those recorded in 1993 and 1998, both associated with the occurrence of a strong ENSO event. (Marengo et al., 2011). In the interval from 2001 to 2010, four periods with negative anomalies are identified (2001, 2003, 2007, 2010), and from 2011 to 2018, five negative periods are observed (2012, 2013, 2014, 2015, and 2016). These events indicate the persistence of unfavorable climatic conditions throughout these years.

Analyzing the years from 2010 to 2017, rainfall data shows conditions that can be classified as drought, with the exception of the year 2011. Since 2012, the NEB has faced the most severe drought of the last century. The effects were widespread, negatively affecting more than 23 million people living in the semiarid region. The losses have been quantified, including the death of 600 thousand animals just in Pernambuco and the declaration of a state of emergency in more than 600 municipalities (Fundaj, 2017). The table below presents the years of drought occurrence and their relation to the ENSO phenomenon, as identified in studies by Melo (1999), Marengo *et al*. (2011), and Buriti *et al*. (2020).

Table 3 - Drought years and their relationship with the ENSO phenomenon

Year	ENSO intensity	Drought condition
1902	Strong	Moderate
1903	Strong	Exceptional
1904	–	Moderate
1907	Strong	Severe
1908	–	Severe
1909	–	Moderate
1914	Moderate	Moderate
1915	Weak	Severe
1918	Strong	Dry year
1919	Strong	Severe
1925	Strong	No droughtDry year
1928	–	Dry year
1929	Moderate	–
1930	–	Dry year
1931	–	Dry year
1932	Moderate	Extreme Drought
1936	-	Moderate
1939	Strong	Moderate
1941	Strong	Dry year
1942	–	Severe
1943	Weak	Dry year
1944	Occurrence of El Niño	Severe
1946	Moderate	Abnormal condition
1951	Weak	Dry year
1958	Strong	Moderate
1959	Strong	Moderate
1965	Moderate	Severe
1969	Weak	–
1970	Moderate	Moderate
1972	Moderate	–
1976	Weak	Moderate
1979	Weak	Moderate
1980	Weak	Severe
1982	Strong	Abnormal condition
1983	Strong	Severe
1986	Weak	Moderate
1987	Moderate	–
1990	Strong	Moderate
1991	Moderate	–
1992	Strong	Severe
1993	Strong	Severe
1997	Strong	–
1998	Strong	Severe
2002	Moderate	Abnormal condition
2007	Weak	Moderate
2012	–	Extreme
2013	–	Moderate
2016	–	Severe

Fonte: Elaborado pelos autores (2024).

Thus, in the Northeast, we identified several periods with negative anomalies relative to the climatological mean, with a notable increase in occurrences over the last decade. This raises reflection on the direct cause–effect relationships between ENSO and both the onset and prolongation of drought. When the data reveal temperatures above the climatological average and precipitation below normal, we infer the presence of drought during that period. This inference is supported by records showing that nearly all municipalities in the Brazilian semiarid region (1,262) declared a state of emergency due to drought between 2012 and 2016 (Medeiros, 2019). This scenario highlights the relevance of considering not only specific climatic events, such as ENSO, but also their direct implications for regional climate variability and the resulting socioeconomic consequences.

FINAL CONSIDERATIONS

In light of the findings presented, it becomes evident that human interventions—such as the implementation of drought-mitigation strategies, including cistern construction, river perennialization, reservoir development, and artisanal wells—have not been, and historically have never been, sufficient to meet the demands of the population affected by drought. Addressing this challenge requires solutions that transcend purely structural approaches, involving broader political and social considerations that pose significant obstacles for regional administrations.

The climatic characteristics of the Brazilian semiarid region, combined with its hydrological particularities, contribute to the recurrence of water shortages, intensified by the predominance of intermittent rivers. Water-storage systems in the semiarid region serve multiple purposes; however, recurrent droughts produce substantial negative impacts on key sectors such as agriculture, industry, water supply, and energy production. These impacts underscore the need for more comprehensive and effective strategies that integrate structural, socioeconomic, and political perspectives to address the region's persistent water challenges.

Thus, it is clear that palliative measures alone cannot eliminate the long-standing problems associated with droughts in Northeast Brazil. A long-term solution requires the integration of political action, social planning, and climatic understanding. Drought constitutes a natural disaster that generates far-reaching socioeconomic consequences for communities and their livelihoods, and public policies—such as the issuance of emergency decrees—represent only temporary responses to the impacts experienced.

ACKNOWLEDGMENTS

To FUNCAP for financial support and to LAPED (Pedology and Environmental Analysis Laboratory) for assistance in carrying out the research.

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