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Amparo De São Francisco - Se, Brazil and Its Rainfall and Straight Regression Trends

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ABSTRACT

The objective is to analyze the distributions of rainfall indexes between 1963-2019 by examining their behaviors and their linear trend lines (increasing or decreasing), taking into account the monthly assessment of the years, to identify the months of greatest and lowest rainfall, to obtain information regarding the spatial and temporal rainfall variation and the maximum and minimum monthly erosivability in Amparo de São Francisco - SE. Average monthly and annual rainfall data from the Northeast Development Superintendence and Sergipe Agricultural Development Company were used. The basic statistical parameters were applied for the referred months of the years and their respective graphs were plotted followed by the straight lines of monthly and annual trends, the calculation of the rain anomaly and the polynomial trend, as well as the calculation of the moving average for five and ten years. The municipality should carry out a strip with new afforestation to contribute to soil retention, to feed the regional and local groundwater, to retain soil transport, and to conserve native plants. It provides a tool for planning and actions that aim at the best way to manage water resources using collection and storage systems, avoiding the problem of water scarcity. So that socioeconomic development is not limited by water unavailability, it is necessary to have policies and plans for capturing and making use of rainwater, in addition to the efficient use of other natural resources in the region, changing the speech cycle that blames the climate for the lack of water, forgetting that public policies are always important to mitigate drought periods or not.

INTRODUCTION

Rainfall monitoring is a global concern and, therefore, policies for forecasting total rains have been adopted around the world to store rainwater. In this sense, several alert mechanisms regarding the scarcity or excess of water resources are becoming increasingly common, especially for the poultry and agricultural sector. According to Sun et al. (2014) believe in the evidence between the distribution of meteorological variables and the modes of climatic variability in different regions of the globe.

Medeiros (2016), in a study of the Uruçuí Preto River Basin - PI, specifically in terms of flow modeling and precipitation elements, air temperature, relative air humidity, and its climatic variability, providing technical support to decision-makers, to civil society, companies and state and municipal governments, it also suggests to farmers and the riverside population, how the information contained in meteorological data should be used, as well as advice to improve access to drinking water.

Excessive rainfall, added to other factors of the biophysical and geological environment, can cause flooding, causing flooding, falling of barriers, breaking of roads and when the rains stop, these climatological impacts result in droughts, silting up of rivers affecting productive sectors, socioeconomic and environmental (SOUZA et al., 2012).

The rain impacts are generated by the intensity of rainfall that occurred in a short period in most Brazilian cities, causing floods and landslides and gaining prominence in the media, due to the high number of homeless people, in addition to the proliferation of diseases, economic losses, and damage to the environment. Environment, deaths, among others (MONTEIRO et al., 2014).

The importance of the analysis and diagnosis of rainfall fluctuations in the Northeast Region of Brazil was shown by Medeiros et al., (2015), specifically in the State of Paraíba, especially for its irregularity, since the climatic variables are fundamental for the climatic approach. The results confirmed trends in reductions in rainfall rates, with rainfall fluctuations throughout the series studied, showing the recurrence of maximum annual precipitation values in the intervals of 15, 12, and 7 years.

Medeiros et al., (2018) analyzed the distribution of rainfall during the period from 1920 to 2016, examined the possible behaviors of the linear trend and the variability of the regression coefficient, taking into account the monthly evaluation and aiming to identify the months with higher and less rainfall, as well as its temporal variation. The study can be used as a tool for planning and actions that aim to manage water resources using systems of capture, storage and thus mitigating the problems of water scarcity.

The objective is to analyze the distributions of rainfall indexes between the years 1963-2019 by examining their behaviors and their linear trend lines (increasing or decreasing), taking into account the monthly evaluation of the years, to identify the months of greatest and lower rainfall, for information regarding the spatial and temporal rainfall variation and the maximum and minimum monthly erosivity in São Francisco.

MATERIAL AND METHOD

Amparo do São Francisco is located in the northeast region of the State of Sergipe and is limited to the municipality of Telha to the east and south, Canhoba to the west, and the State of Alagoas to the north. The municipal area of 39.8 km^2, the municipal headquarters has an altitude of 51 meters and geographical coordinates of 10 ° 08'04 "south latitude and 36 ° 55'46" west longitude. (Figure 1).

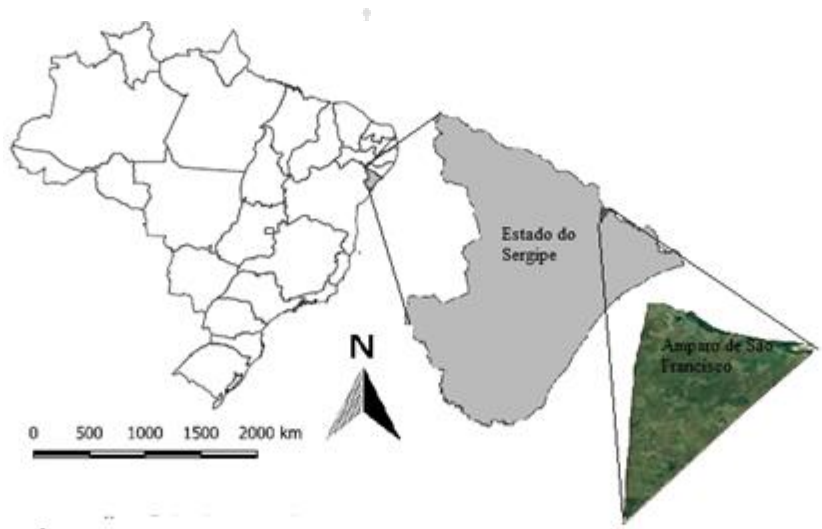

Figure No. 1. Location of Amparo de São Francisco within the state of Sergipe.

Source: France, (2021).

Amparo de São Francisco is located in a region characterized by two well-defined seasons, a rainy season fluctuating from February to August and the dry season, flowing between September to January. According to the climatic classification of Köppen (1928; 1931), the study area has an “As” climate (hot and humid rainy tropical). Average annual rainfall of 1138.2 mm and temperature of 25.9 ° C. (MEDEIROS, 2020; ALVARES et al., 2014).

It is interesting to note that the rainy season is marked by frequent and intense rainfall in a short period, favoring the appearance of floods, floods, and floods, as due to the frequency of rain in a short period, the water cannot infiltrate the soil as it should.

The study area is located in the hydrographic basin of the São Francisco River, where all the runoff from this region tends to meet the main river and thus ends up modeling the terrain. We remember that the region is marked by an intense practice of cattle raising, which ends up damaging the local vegetation in several points and unprotecting the soil and the runoff.

Data on average monthly and annual rainfall acquired from the database of the Northeast Development Superintendence (SUDENE, 1990) and Agricultural Development Company of Sergipe (EMDAGRO-SE, 2020) for the period 1963 to 2019 were used.

The basic statistical parameters for the referred months of the years were applied and their respective graphs were plotted followed by their monthly and annual trend lines, rainfall anomaly calculation, and polynomial trend, as well as the calculation of the moving average for five and ten years.

RESULTS AND DISCUSSIONS

The precipitation trend line for January (Figure 2) for the municipality of Amparo de São Francisco - SE in the period 1963-2019 has a negative slope and R2 of low significance, showing that statistically nothing can be said about increased or reduced rainfall. The study by Medeiros et al., (2016) corroborates the results discussed.

The highest rainfall rates were recorded in the years 2002 and 2004, and the lowest rainfall rates were recorded in the years 1967; 1978; 1993 to 1995; 2007; 2014; 2015, and 2017. These fluctuations are in agreement with the studies by (Marengo et al., 2015; IPCC 2014).

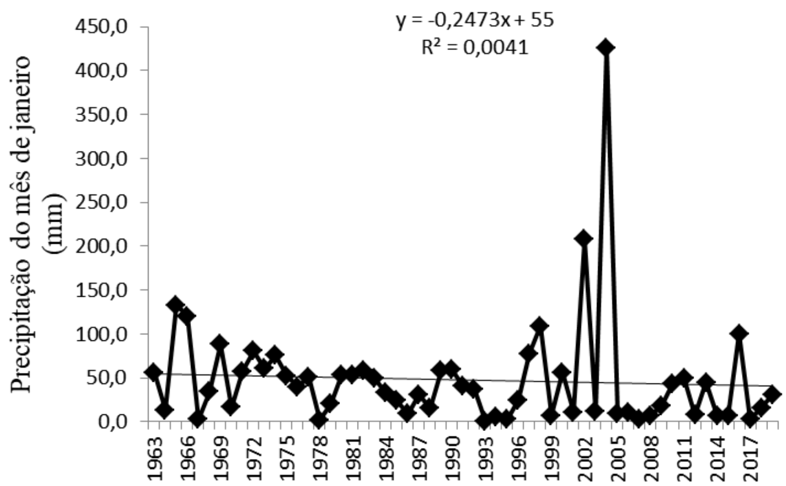

Figure No. 2. January precipitation trend line for the municipality of Amparo de São Francisco - SE in the period 1963-2019.

Source: France (2021).

With a tendency straight line of negative angular coefficient R2 as low as February (Figure 3), it recorded 550.6 mm in the year of 1966 in the year of 1981 (200 mm) and the years of 1965; 1988; 1989; 1994 to 1999; 2001; 2006; 2013 and 2017 (0.0) mm.

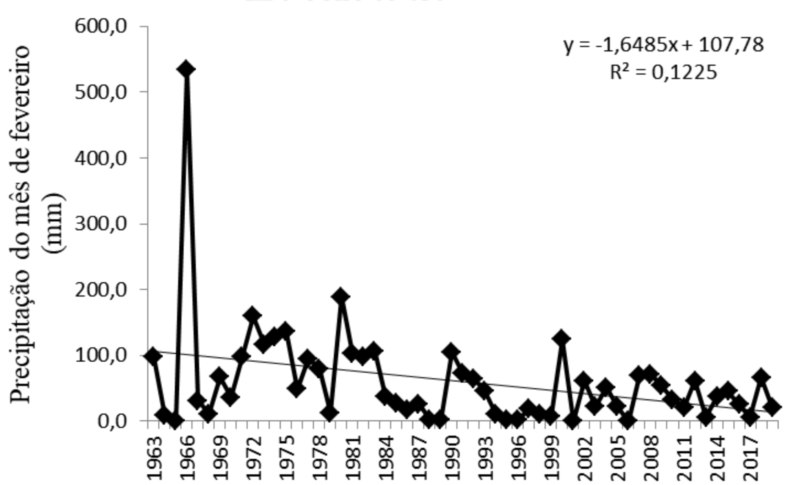

Figure 3. February precipitation trend line for the municipality of Amparo de São Francisco - SE in the period 1963-2019.

Source: France (2021)

The interplay of rain regimes becomes the main artifice for carrying out socio-economic planning and the conservation of the natural environment (SIMONI et al., 2014). According to Silva et al. (2011), the understanding of the rainfall behavior of a given region is indicated for the composition of the calendar and the implementation of agricultural projects. The analysis of the distribution and its rainfall climatic variability in hydrographic basins is of fundamental importance for the conception of the natural functioning of water systems. Studies aimed at this purpose demonstrate an important role in the human scope, guiding measures for the rational use of water resources.

Figure 4 shows the rainfall distribution for March and its trend line for the municipality of Amparo de São Francisco - SE in the period 1963-2019. The month understudy has a straight line with a negative slope and R^2 of low significance. The years of high rainfall recorded were: 1966; 2007; 2008 and 2019 and the years of low rainfall in 1965; 1993; 1995; 1999; and 2017. Studies like the one by (Marengo et al., 2008; Marengo et al., 2015; IPCC 2014; Medeiros et al., 2016) corroborate the results discussed.

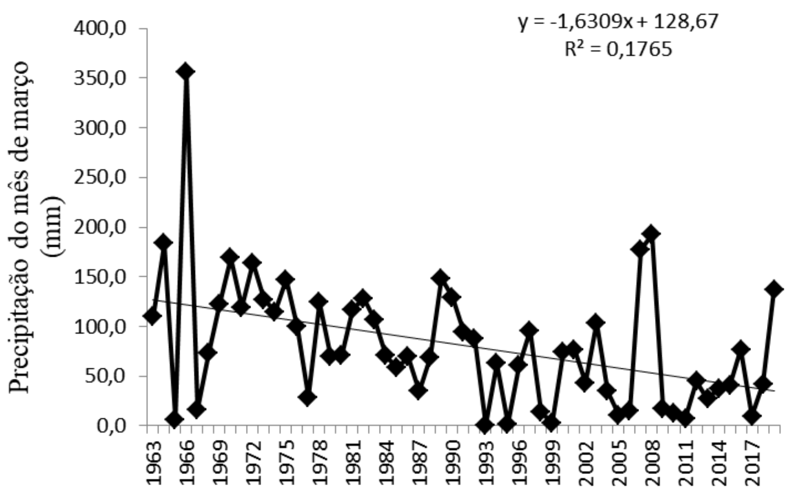

Figure 4. March line of precipitation trend for the municipality of Amparo de São Francisco - SE in the period 1963-2019.

Source: France (2021)

With a negative trend line and a low R^2 for April (Figure 5), there are the years of 1964; 1965; 1972; nineteen ninety; 2001, and 2011 with high rainfall rates and the 1980s; 1993; 1999, and 2012 as the one with low rainfall rates. These irregularities were caused by the synoptic systems operating in the region and location, according to the (IPCC 2007; IPCC 2014) these oscillations have similarities with those discussed in this article.

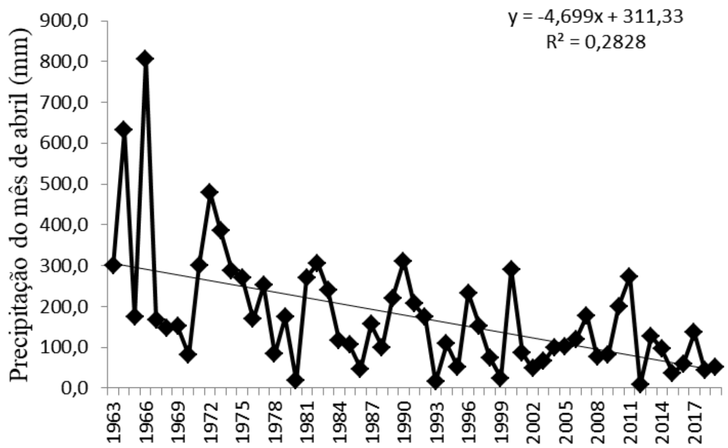

Figure 5. April precipitation trend line for the municipality of Amparo de São Francisco - SE in the period 1963-2019.

Source: France (2021)

Figure 6 shows the rainfall variability and its trend line for May in the municipality of Amparo de São Francisco - SE "between" 1963 - 2019. The irregularities recorded during May were caused by transient synoptic systems acting on regional and local circulation by the studies by (Marengo et al., (2007; Marengo et al., 2008; Marengo et al.,2015; Medeiros 2016). May is represented by a regression line with a negative slope and R^2 with low significance.

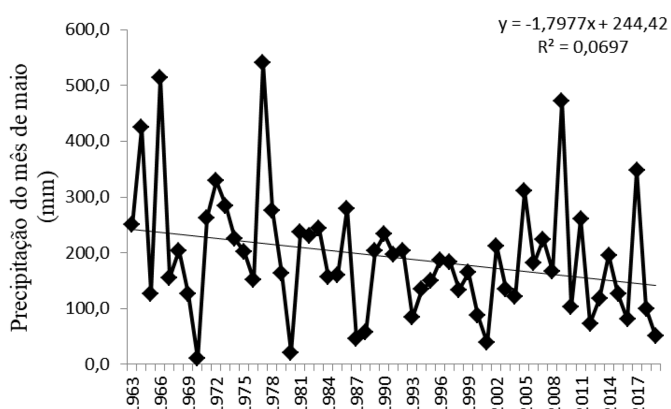

Figure No. 6. May precipitation trend line for the municipality of Amparo de São Francisco - SE in the period 1963-2019.

Source: France (2021)

The month of June for the period 1963-2019 recorded irregular rains and of varying magnitudes (Figure 7), the highest rainfall rates were recorded in the years 1964; 1989; 1995; 2001; 2009 and 2017. The lowest rainfall rates occurred in 1969; 1980; 2007; 2011 and 2016. The months of June have a regression line with negative slope and low R^2.

It is expected to occur extreme events of high magnitude and a short time interval, as stated by Marengo et al., (2015).

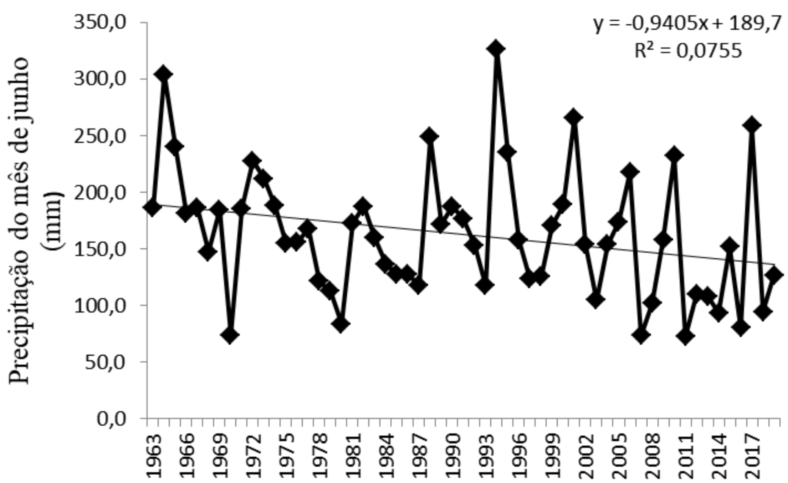

Figure No. 7. Line of the trend of precipitation in June for the municipality of Amparo de São Francisco - SE in the period 1963-2019.

Source: France (2021)

In Figure 8. Line of the trend of precipitation of July for the municipality of Amparo de São Francisco - SE in the period 1963-2019. The month of July registered a straight negative trend and low R^2. The intercensal rainfall oscillations ranged from 55.5 mm to 305.8 mm.

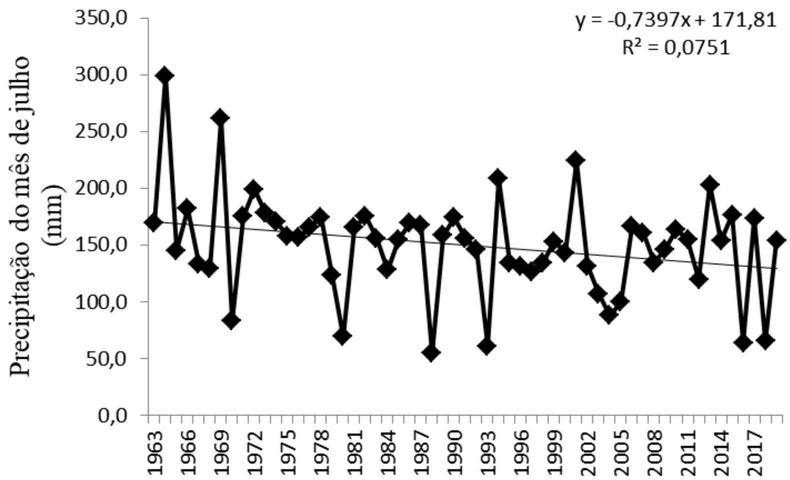

Figure No. 8. July precipitation trend line for the municipality of Amparo de São Francisco - SE in the period 1963-2019.

Source: France (2021).

The months of August between the periods of 1963-2019 registered irregular rains and varied oscillations. The lowest thermal indexes were registered in 1969; 1980; 1988 and 2018. The highest rainfall rates occurred in the years 1964; 1966; 2008 and 2010. The trend line has a low R^2 of significance and a negative slope.

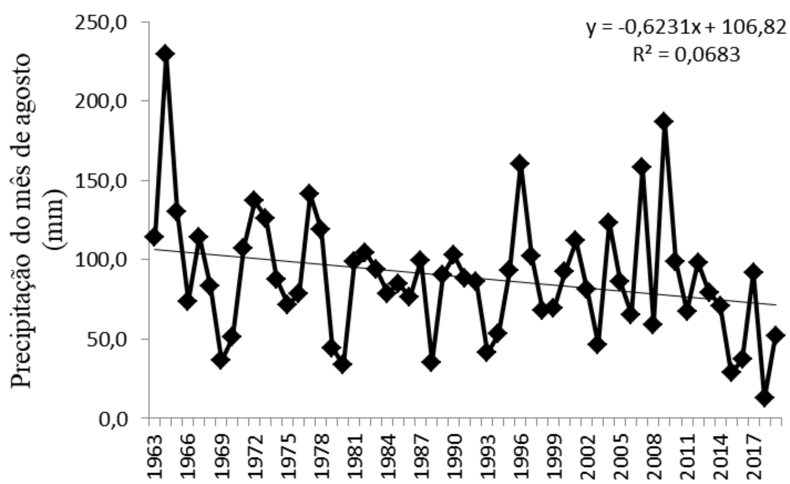

Figure No. 9. Precipitation trend line for August for the municipality of Amparo de São Francisco – SE in the period 1963-2019.

Source: France (2021).

The month of September records a range of rainfall ranging from 0.0 mm in the years 1966 and 1967 to 210.1 mm in the year 1964 and 210.5 mm in the year 2007, studies by Marengo et al. (2007; 2008 and 2015) and Medeiros (2016) are similar to the discussions in this article. The month of September registered a trend line with a negative slope and R^2 of low significance.

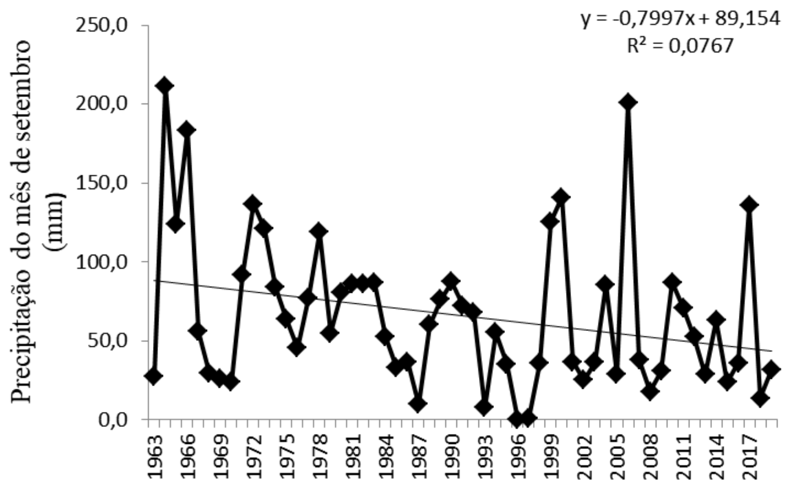

Figure No. 10. Line of the trend of precipitation in September for the municipality of Amparo de São Francisco - SE in the period 1963-2019.

Source: France (2021)

Figure 11 shows the rainfall variability in October for the municipality of Amparo de São Francisco - SE in the period 1963-2019 and its trend line with a negative slope and low R^2. The years with the highest rainfall rates were recorded in 1964; 1993 and 2014. The lowest rainfall rates occurred in the years 1963; 1967; 1997; 2004; 2005 and 2018.

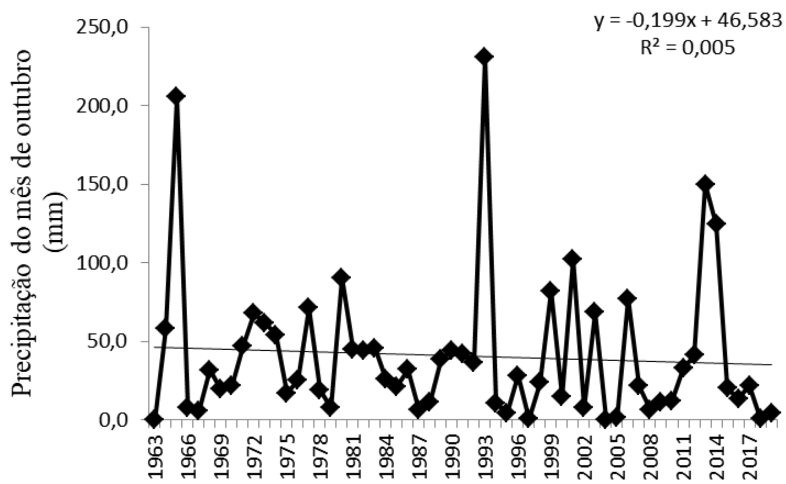

Figure No. 11. Line of the trend of precipitation in October for the municipality of Amparo de São Francisco - SE in the period 1963-2019.

Source: France (2021)

With a trend line of negative slope and a low R^2, the month of November of the period 1963-2019 (Figure 12) shows a negative trend for rainfall occurrences in the coming years. The highest rainfall in November was registered in the years: 1965 rained 158.9 mm; 1999 with 85.2 mm; 2004 (115.2 mm) and 2011 with 80.2 mm. The lowest rainfall rates occurred in the years 1966; 1998; 2007-2011 and 2015 to 2018; 2019 with 0.0 mm. These rainfall oscillations have similarities with the study by Costa et al., (2015).

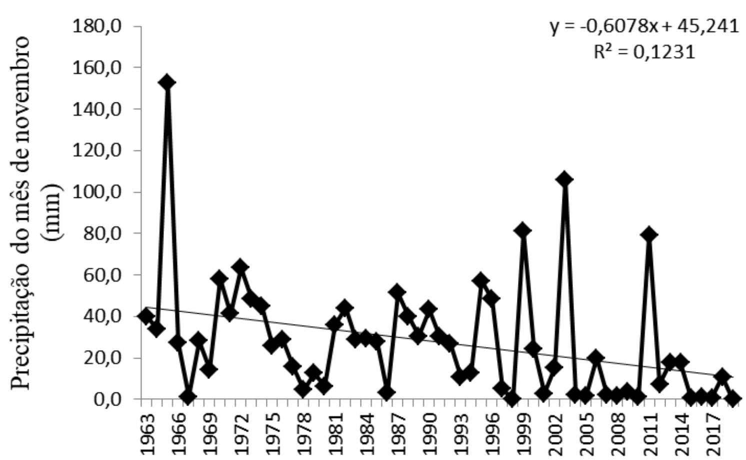

Figure No. 12. November precipitation trend line for the municipality of Amparo de São Francisco - SE in the period 1963-2019.

Source: France (2021)

Figure 13 shows the rainfall variability in December and its trend line for the municipality of Amparo de São Francisco - SE in the period 1963-2019. It is noteworthy that in the year 1963, rainfall rates of 238.5 mm were recorded and their reductions to 10.5 mm in December 2019. This variability of reductions is predicted and highlighted in the studies by (Marengo et al., 2008; Marengo et al., 2015; IPCC 2014). The month of December has a straight trend with a negative slope and R^2 of low significance.

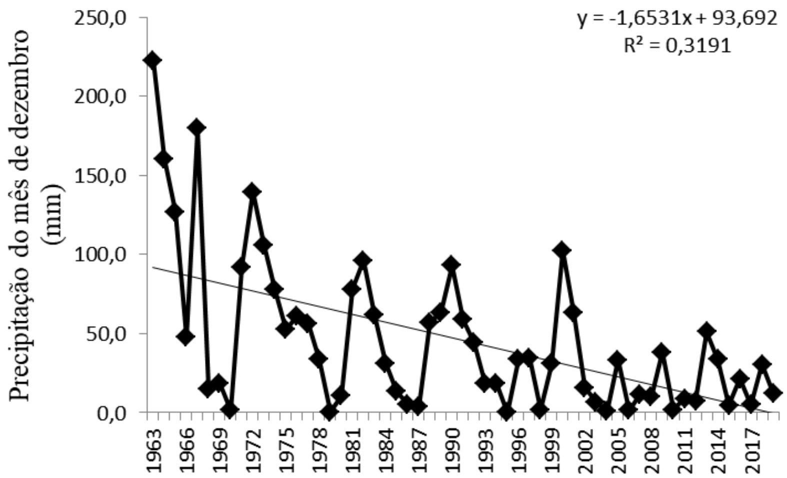

Figure No. 13. December precipitation trend line for the municipality of Amparo de São Francisco - SE in the period 1963-2019.

Source: France (2021)

Figure 14 shows the variability of the annual precipitation trend line for the municipality of Amparo de São Francisco - SE in the period 1963-2019. The oscillation of the amplitude shown demonstrates how irregular the rainfall rates are in the studied area. Between the years 1963 to 1993 the occurrences of the amplitudes were more spaced and of moderate magnitudes. In the years 1994 to 2019, this magnitude is reduced from its smaller magnitudes. Such oscillations were caused by changes in rainfall patterns caused by regional meso and microscale systems.

Studies like the one by the authors (Costa et al., 2015; Medeiros 2019; Medeiros et al., 2020) corroborate the results discussed in this article.

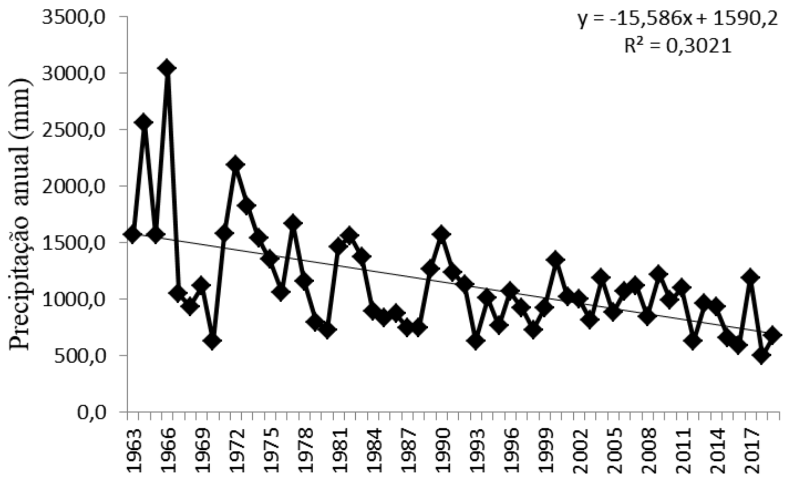

Figure No. 14. The annual precipitation trend line for the municipality of Amparo de São Francisco - SE in the period 1963-2019.

Source: France (2021)

Moving Average for Five and Ten Years

Figure 15 shows the variability of the observed precipitation and its precipitation estimated by the moving averages for 5 and 10 years for the municipality of Amparo de São Francisco - SE in the period 1963-2019.

The observed precipitation performance follows the estimates of the moving average for 5 and 10 years, the rhythm of precipitation observed with reduction of amplitude and flattening between years. The 10-year moving average estimates show values of greater significance than for the 5-year ones. Similar studies were carried out by Galvíncio (2000) in the precipitation of the São Francisco River for some sectors of the high and medium course of the river.

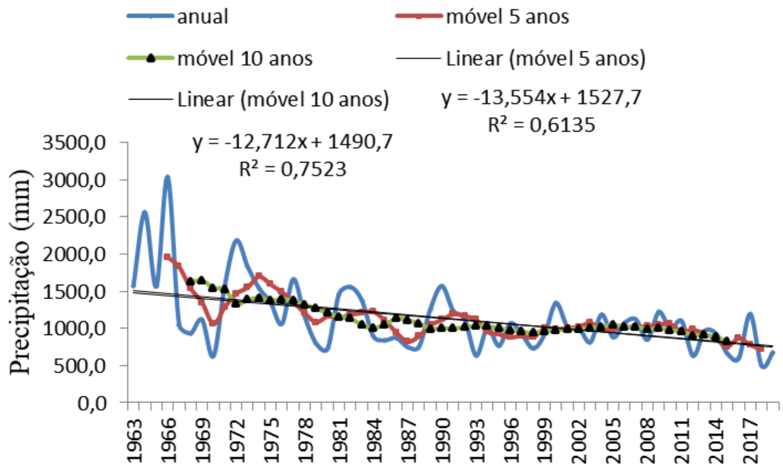

Figure No. 15. Annual precipitation trend line and moving average for 5 and 10 years for the municipality of Amparo de São Francisco – SE in the period 1963-2019.

Source: France (2021)

Figure 16 shows the variability of the annual precipitation anomaly for the municipality of Amparo de São Francisco - SE in the period 1963-2019. The years that registered the biggest and smallest anomalies were: 1964; 1966 and 1972. 2016; 2018 and 2019. It should be noted that between the years 1993 to 2019 the rainfall rates were below the historical average, that is, it rained below the expected average. Studies that showed similarities in data can be reviewed in the studies by (Medeiros et al., 2018; Marengo et al., 2015).

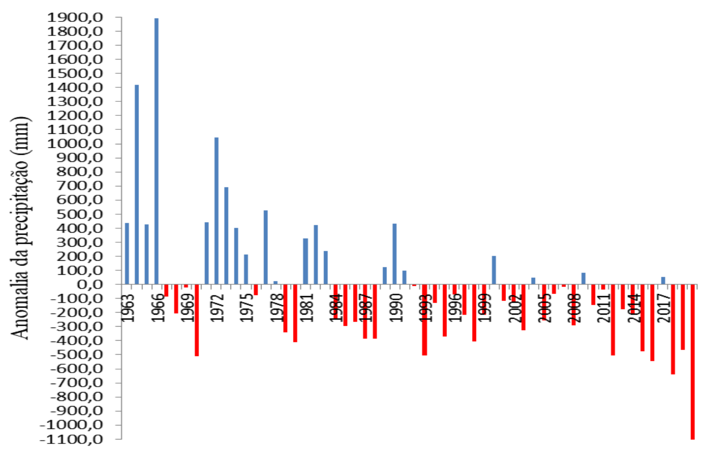

Figure No. 16. Annual rainfall anomaly for the municipality of Amparo de São Francisco – SE in the period 1963-2019.

Source: France (2021)

Statistical analysis

In Table 1, it is observed that the mean and median values were unrelated, showing that discordant extreme values were recorded in the sample. The months of maximum rainfall index in April, the lowest indexes occur between January to August respectively. It is also noteworthy that the monthly averages exceed the median values in some months. Therefore, the median provides a higher probability of occurrence than the average, following the results found by Almeida et al., (2007).

Galvani (2011) stated that the standard deviation is of paramount importance for generating information on the "degree of dispersion of rainfall values to the average value". The coefficient of variance is used to make comparisons in relative terms and expresses "the variability of each data set normalized to the average, in percentage."

Table No. 1. Statistics of average precipitation, standard deviation, coefficient of variance, absolute maximum and minimum and median (mm) for the municipality of Amparo de São Francisco - SE in the period 1963-2019.

Months	Average	Standard deviation	Variance coefficient	Absolute maximum	Absolute minimum	mediana
January	47,8	64,1	1,340	425,8	0,7	59,4
February	60,0	78,2	1,304	533,2	0,0	105,3
March	81,4	64,4	0,792	355,9	1,1	129,2
April	175,1	146,7	0,838	806,1	8,5	310,8
May	192,3	113,0	0,588	540,1	10,3	233,3
June	162,4	56,8	0,350	326,2	72,5	187,6
July	150,4	44,8	0,298	299,0	54,8	174,5
August	88,8	39,6	0,446	229,4	12,8	103,0
September	66,0	47,9	0,726	211,4	0,0	87,5
October	40,8	46,6	1,142	230,7	0,0	44,6
November	27,6	28,8	1,041	152,5	0,0	43,5
December	45,8	48,6	1,062	222,7	0,0	93,0
Yearly	1138,2	470,7	0,414	3032,8	498,8	1571,7

Source: France (2021)

Future Monthly and Annual Trends

Table 2 shows the variability of the coefficients of determination of the regression that did not show the significance for all months, this oscillation is due to the diversified complex of rainfall seasonality in the studied area.

The linear straight line equation recorded a negative slope in all months of the year, showing that the trend of rainfall rates is for reductions shortly, reducing the days with precipitation and favoring the occurrence of extreme events of high intensity and the short period.

Table No. 2. Months, linear equation, regression determination coefficient (R^2), the monthly historical average for the municipality of Amparo de São Francisco - SE in the period 1963-2019.

Months	Linear Equation	R^2	Average
January	Y=-0,2473x + 55,00	0,0041	47,8
February	Y=-1,6485x + 107,78	0,1225	60,0
March	Y=-1,6309x + 128,67	0,1765	81,4
April	Y=-4,6990x + 311,33	0,2828	175,1
May	Y=-1,7977x + 244,42	0,0697	192,3
June	Y=-0,9405x + 189,70	0,0755	162,4
July	Y=-0,7397x + 171,81	0,0751	150,4
August	Y=-0,6231x + 106,82	0,0683	88,8
September	Y=-0,7997x + 89,15	0,0767	66,0
October	Y=-0,1990x + 46,58	0,0050	40,8
November	Y=-0,6078x + 45,24	0,1231	27,6
December	Y=-1,6531x + 93,69	0,3191	45,8
Yearly	Y=-15,586x +1590,20	0,3021	1138,2

Source: France (2021)

In Figure 17, it can be seen that between March and August 74% of the annual rainfall indexes are concentrated and between September and February the rainfall indexes are 26% of the historical average value. With an average of 1138.2 mm, showing that over time the temporal variability is characteristic of the Brazilian semiarid region, demonstrating the impossibility of an annual increase in rainfall.

The histogram of the climatological rainfall average and the polynomial trend show rainfall reductions with a tendency to stabilize in the coming years. Studies like the authors (Medeiros et al., 2018; Marengo et al., 2015). They corroborate with the results discussed.

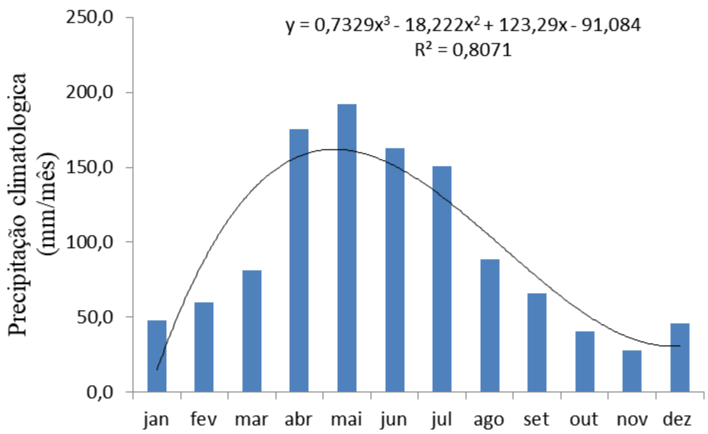

Figure No. 17. Histogram of climatological rainfall average and polynomial trend for the municipality of Amparo de São Francisco in the period 1963-2019.

Source: France (2021)

Negative trends in precipitation cores demonstrate an increase in times without rain over the years, both in the rainy season and in the dry season, subsequent studies did not assess whether there is an increasing or decreasing trend in precipitation acuity and the number of extreme events for the region semiarid region of Northeast Brazil. Thus, the need to explore further studies is clear, especially when it comes to a semi-arid region such as the Northeast, which lives with prolonged periods of drought, as stated by Costa et al., (2015).

CONCLUSIONS

The municipality should be involved in the construction of wooded strips to contribute to the retention of water in the soil, replenishment of the regional and local water table, retention of soil transport, and conservation of native plants.

It provides a tool for planning and actions that aim at the best way to manage water resources using collection and storage systems and avoiding the problem of water scarcity.

Positive anomalies are recorded in seven municipalities while negative anomalies occur in eighteen municipalities. Rain fluctuations provide proportional assistance to decision-makers to reduce climatic impacts for inhabitants.

So that socioeconomic development is not limited by water unavailability, policies with structures that are capable of capturing and using rainwater are necessary, in addition to the efficient use of other natural resources in the region, changing the habit that has indicated the climate as responsible due to the lack of water, forgetting that public policies are always important to minimize the effects of dry periods.

Works on perennial rivers, streams, streams or slopes, such as; surface and underground dams, muds, terraces with tire strips, agriculture in conservation standards, are also effective techniques for containing water in the soil in regions where intense rainfall occurs in a short period, also for a long period between rains with little annual water volume.

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