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Variability of Annual Precipitation and Evapotranspiration in Amparo De São Francisco – Sergipe, Brazil

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ABSTRACT

With the need for planning that aims to know the water regime in the definition of better agricultural strategies for subsistence crops and help small and medium producers to work with the evapotranspiration that occurs in their basins, the objective is to analyze the climatic elements precipitation and evapotranspiration for the municipality of Amparo de São Francisco generating their respective graphs, the probabilities of occurrences, return period and moving averages to generate information for decision-making bodies. The basic formulations of descriptive statistics for the elements under study were applied to the data. Evapotranspiration data was generated using the Thorntwaite method. The cumulative probability and return time were applied to the data. The evapotranspiration index for the period analyzed fluctuated between levels 30 to 60% of probability of occurrence. Therefore, planning that contemplates the practice of irrigated agriculture should be adopted.

INTRODUCTION

Understanding the hydrological cycle is a way of understanding the rainfall and hydrological regime of a given place or place by monitoring infiltration processes, surface runoff, soil water storage, and evapotranspiration (CARVALHO et al.,2007).

The different models for estimating evapotranspiration are one of the biggest sources of uncertainty in hydrological studies. Different studies have also been compared with measurements of evapotranspiration determined by direct and indirect methods, as Oliveira (2008), Barros et al. (2009), Unlu et al. (2010), Schrader et al. (2013), and Gebler et al. (2015).

The reference evapotranspiration (ETo) is defined as the percentage of evapotranspiration from an extensive region covered by small green grass, 8 to 15 cm tall, in active growth, completely shading the terrain and without water shortage. There are several methods for calculating the ETo, for example, (PENMAN 1953; DOORENBOS et al., 1979).

Evapotranspiration is one of the main indicators of evaporation capacity over a hypothetical reference surface, as well as the theoretical upper limit of real evapotranspiration, which is usually the basis of real evapotranspiration (ZHANG et al., 2009b), being a determining factor. of the dry climate in some regions (HUO et al., 2013).

Medeiros et al. (2021) specified, using the kriging method, the elements precipitation, evapotranspiration, and probable evaporation at the level of 75% probability for 187 municipalities, generating their letters and information for decision-makers. The analysis carried out in this study represents an approximation of the potential in terms of climate, water resources, and the real water needs for the main activities of socio-economic importance visualized through the water balance. According to the authors, the probability of 75% in the rainfall rates was taken in the summer and autumn seasons in the coastal region, in the Mata and Agreste areas. In the spring and winter seasons, rainfall contributions were due to local effects, orography, and local scale systems, causing light to moderate rainfall in a short time interval.

Feng et al., (2017) and Rodrigues et al., (2020) showed that water quality is a limiting factor since the excess of soluble salts associated with water deficit is responsible for the depreciation of crop productivity in the regions arid and semi-arid. Underwater suppression conditions, plants reduce stomatal conductance and transpiration causing disturbances in photosynthesis and affecting plant development and production (MELO et al., 2020).

Holanda et al. (2016) performed the climatological analysis of decadal precipitation and its historical comparisons for Recife - PE aiming to contribute to the decisions of sectors such as the economy, agriculture, irrigation, energy production, water resources, agricultural and agronomic engineering, fire department, civil defense, and government decision-makers in the event of extreme precipitation events that may occur in the future. The inter-neighborhood variability of rainfall distribution and local activities together with the active meteorological factors contributed or did not contribute to agricultural productivity in storage for human and animal supply. The influences of El Niño phenomena, for the decade's understudy in the form of adverse phenomena, had their isolated contributions.

Uncontrolled human activities associated with rainfall distributions and variability have had negative consequences for socioeconomic and human survival. The growing human intervention in the physical environment has substantially increased the degree of risk of places about episodes that can turn into disasters (NUNES, 2016).

According to Medeiros et al. (2014), the Rainfall Anomaly Index can be used as a tool for monitoring the climate of a locality, in this case, the Uruçuí Preto river basin, in addition to being used for regionalization, and through this monitoring, it can also generate forecasts and diagnoses of the local climatology. From the classification criteria taken based on the percentage deviations, the months and years of the places that make up the hydrographic basin were classified, where oscillations from extremely rainy to extremely dry were obtained.

Medeiros et al. (2016) analyzed the temporal distribution and trend of precipitation for the municipality of Bom Jesus-PI with linear regression, and measures of central tendency and dispersion of monthly and annual rainfall. Based on the results, it was found that the median is the measure of central tendency most likely to occur. The rainy season lasts for six months (November to April with an average period value of 875.1 mm, corresponding to 88.86% of annual precipitation). In 55 years of observed precipitation, its historical average is 984.8 mm. According to linear regression analysis of the historical series of precipitation from 1960 to

2014, the trend of greater variability of precipitation is centered between November to April, and the lowest rainfall rates are centered between May to September which has low rainfall.

In water resources, we seek to synthesize this knowledge through models that can quantify, qualify and manage the water available in the hydrological cycle. The importance of managing and planning water resources increases in proportion to these resources being scarce, especially in semi-arid and semi-humid regions of the world where low rainfall rates, high evaporation rates, and irregular Spatio-temporal distribution of water occur. Rains. In these regions, water is a fundamental element in the socio-economic framework of the region, generating the need to rationalize its use. Therefore, the planning of water resources gains a fundamental dimension; through it, guidelines are established to be followed to provide better use, control, and conservation of these resources. (GALVINCIO2002).

Maksinovic (2001) warns that basins should be used as a planning and management unit, not only for water but also for other resources in economic and human activities, where any intervention must be studied and its beneficial consequences for the basin evaluated.

In the semi-arid, humid, sub-humid region, cerrado, cerradão, and in the transition zone of the NEB, where the rivers are intermittent, the main way to store water and make it available for the various uses that are made of it is through the construction of dams. That by blocking the watercourse, storage results.

However, the hydrological simulation of surface runoff in hydrographic basins is extremely complex; thus, to use computational models applied to their simulation, they must present some desirable characteristics Mello et al. (2008), such as being based on the physical process, on the event and the spatial distribution of variables associated with the phenomenon.

The objective is to analyze the climatic elements precipitation, evapotranspiration for the municipality of Amparo de São Francisco generating their respective graphs and the due probabilities of occurrences, return periods, and moving averages to generate information for decision-makers.

MATERIALS AND METHODS

Amparo de São Francisco is located in the northeast region of the State of Sergipe and is bordered by 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 km2, the municipal seat has geographic coordinates of 10°08'04" and south latitude, 36°55'46" west longitude, and an altitude of 51 meters. (Figure 1).

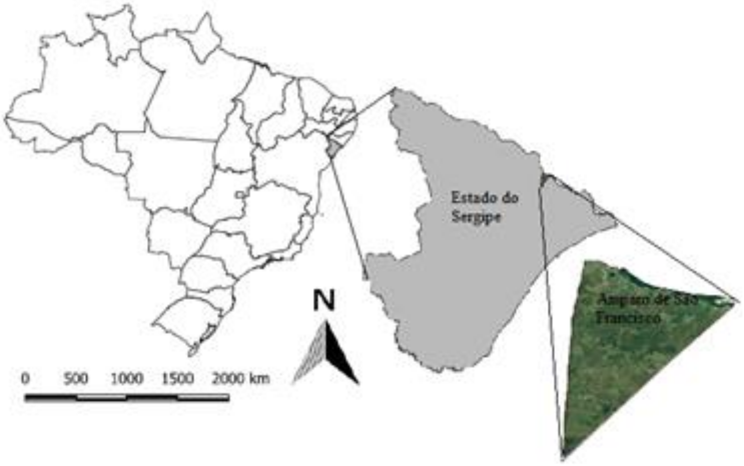

Figure 1. Location of Amparo de São Francisco within the state of Sergipe.

Source: França (2022).

Monthly and annual rainfall data provided by the Northeast Development Superintendence (SUDENE, 1990) and the Sergipe Agricultural Development Company (EMDAGRO - SE, 2021) between 1964 and 2020 were used. Monthly rainfall data (1964-2020) monthly, annual, mean, mode, median, standard deviation, coefficient of variance, asymmetry coefficient, kurtosis coefficient, absolute maximum and minimum rainfall, anomaly and their annual totals, occurrence probabilities, and return period were determined.

Amparo de São Francisco is located in a region characterized by two well-defined seasons, a rainy season ranging from February to August and a dry season, from September to January. According to the classification of (KÖPPEN 1928; KÖPPEN et al., 1931), the climate is of type “As” (hot and humid Tropical rainy). This classification was also determined by the authors (MEDEIROS, 2020; ALVARES, et al., 2014).

We used the minimum thermal data estimated by the Estima_T software for the years 1963-2020 (CAVALCANTI et al., 1994; CAVALCANTI et al., 2006, for the same rainfall period. The coefficients of the quadratic function were determined for the temperatures monthly minimums as a function of local coordinates: longitude, latitude, and altitude according to the authors Cavalcanti et al, (2006) given by:

$$T = C0 + C1\lambda + C2\text{Ø} + C3h + C4\lambda 2 + C5\text{Ø}2 + C6h2 + C7\lambda\text{Ø} + C8\lambda h + C9\text{Ø}h$$

On what:

C0, C1,..., C9 are the constants;

λ, λ2, λ Ø, λ h longitude;

Ø, Ø2, λ Ø latitude;

h, h2, λ h, Ø h height.

For statistical analysis of the data determined: frequency analysis, mean (X), median (Md), standard deviation (Dp), coefficient of variation (Cv), asymmetry coefficient (Cas), and kurtosis coefficient (Ck), in addition to the absolute maximum and minimum rainfall (BANZATTO et al, 2006; GOMES, 1985).

Frequency distribution was performed using the formula to determine the number of classes (Equation 1).

Nc=5 x log_10⁡〖Number of events〗 1

The class interval (CI) was determined by equation 2 (VIEIRA, 1980; ASSIS, 1996).

CI= (Maximum Value-(Minimum Value-1))/(Number of Classes) 2

The average is expressed in the following equation 3. (TRIOLA, 2005).

$$\bar{x} = \frac{x_1+x_2+x_3+\cdots+x_n}{n} = \frac{\sum_{i=0}^{n} x_i}{n} \qquad 3$$

The median (Md) according to Equation 4. (TRIOLa, 2005)

$$MD = \frac{n+1}{2} \qquad 4$$

The standard deviation (SD) is expressed by Equation 5. (BISQUERRA et al., 2004).

$$D_p = \sqrt{\frac{(x_i - \bar{x})^2 . fi}{\sum fi - 1}} \qquad 5$$

The coefficient of variation (Cv) is given by Equation 6. (BISQUERRA et al., 2004).

$$C_v = \frac{S}{\bar{x}} . 100\ (\%) \qquad 6$$

The asymmetry coefficient (Cas) was calculated according to Equation 7.

(BISQUERRA et al., 2004).

$$C_{as} = \frac{1}{n} \frac{xi + x}{(S^3)} \qquad 7$$

The kurtosis coefficient (Ck) using equation 8. (Bisquerra, Sarriera and Martínez, 2004)

$$C_k = \frac{1}{n} \sum \left[\frac{(xi + \bar{x})}{S} \right]^4 - 3 \qquad 8$$

Monthly and annual rainfall and evapotranspiration data correspond to the period 1964 - 2020 for the municipality studied.

The probability of occurrence (Pc) was obtained using the ascending ordering method, wherewith the data, once ordered, an empirical cumulative distribution is obtained.

$$Pc = \frac{m}{n+1} \qquad 9$$

On what

“m” is the order number of the chosen value in the ordered sequence, and

“n” is the data number of the series.

The return period or average recurrence interval (t) was obtained through the expression.

$$T = \frac{1}{1-p} \qquad 10$$

Due to the increasing ordering of the data, as suggested by PEREIRA et al., (2002). The probability analysis and the return period were estimated with values higher than the annual average minimum temperature.

MOVABLE AVERAGE MODELS

In moving average models $\bar{Y}t$ is considered linearly dependent on a finite number, q, of white noises, that is, $\bar{Y}t$ represents the linear model, but with the sum truncated in q terms. Represented by:

$$\bar{Y}t = \varepsilon t - \Theta 1\ \varepsilon t\text{-}1 - \Theta 2\ \varepsilon t\text{-}2 - \dots\dots - \Theta q\ \varepsilon t\text{-}q \qquad 11$$

Where: the Θ's are the moving average coefficients, the εt the white noise and $\bar{Y}t$ is the monthly flow of month t representing the moving average operator of order q by:

$$\Theta_q\ (B) = 1 - \sum_{j=1}^{q} \Theta j\ B^J \qquad 12$$

It can also be expressed by

$$\bar{Y}_t = \Theta_q\ (B)\ \varepsilon_t \qquad 13$$

This model contains (q+2) unknown parameters: μ, $\phi 1$, $\phi 2$,..., ϕp, $\sigma 2\varepsilon$, being estimated by the method similar to that of the regressive author; there are no statistical justifications; however, for the use of models with order q greater than 2, according to Box & Jenkins (1970).

RESULTS AND DISCUSSION

Rainfall rates flowed from 498.8 mm in 2018 to 3032.8 mm in 1966. Annual irregularities are observed, which were due to transient synoptic systems such as action of the South Atlantic Convergence Zone, aid of cold fronts and from high-level cyclone vortices, squall line formations, and local and regional contributions, caused by water surplus and deficit.

The following years stand out: 1964; 1966; 1972; 1973 with those with high rainfall and the 1970s; 1993 and 2018 as having low rainfall.

The studies by Marengo et al., (2010) and Noronha et al., (2016) on the prolonged occurrence of droughts due to climate change, demonstrate the need for better understanding and prediction of occurrence for the studied area.

The evapotranspiration (ETP) has a laminar behavior with its high values and interannual reductions, highlighting the years where the rainfall rates were higher than ETP, 1964; 1966; 1972; 1973; 1977; and with ETP close to rainfall in the years: 1965; 1971; 1974; 1982 and 1990. Similar results were detected in the study by Medeiros et al (2021) and corroborated the results discussed.

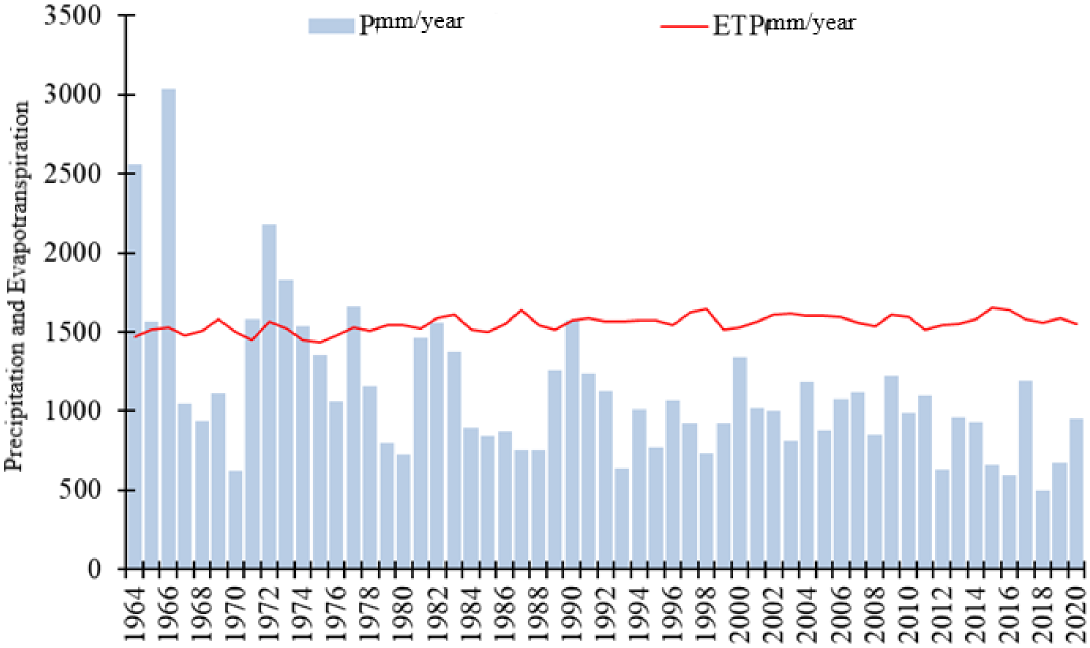

Figure 2. Precipitation, annual evapotranspiration in Amparo de São Francisco – Sergipe.

Source: França (2022).

For Oliveira et al., (2019) the high rainfall fluctuation reinforces the need for investments in irrigation systems to guarantee the productivity and quality of crops and sustainability of regional agriculture.

Medeiros (2018) highlights that the study area is located in the northeast region of the State of Sergipe. Being characterized by high evapotranspiration and rainfall rates, with up to seven months of water shortages annually, it is, therefore, essential to carry out integrated planning of water resources for investment in irrigation systems to guarantee regional agricultural production.

Figure 3 shows the return period and the accumulated probability of annual precipitation for Amparo de São Francisco – Sergipe.

The return period and cumulative rainfall probability for Amparo de São Francisco - Sergipe in the period 1963-2020. Return period and probability results were determined for the highest annual rainfall parameter 3032.8 mm with 58 years of return with a probability of 0.98. The payback period and probability of occurrence for the lowest rainfall is 1.02 years with a probability of 0.017. The remaining payback time and probability swings can be viewed. Such variability in return times is following the study by (PEREIRA et al., 2002).

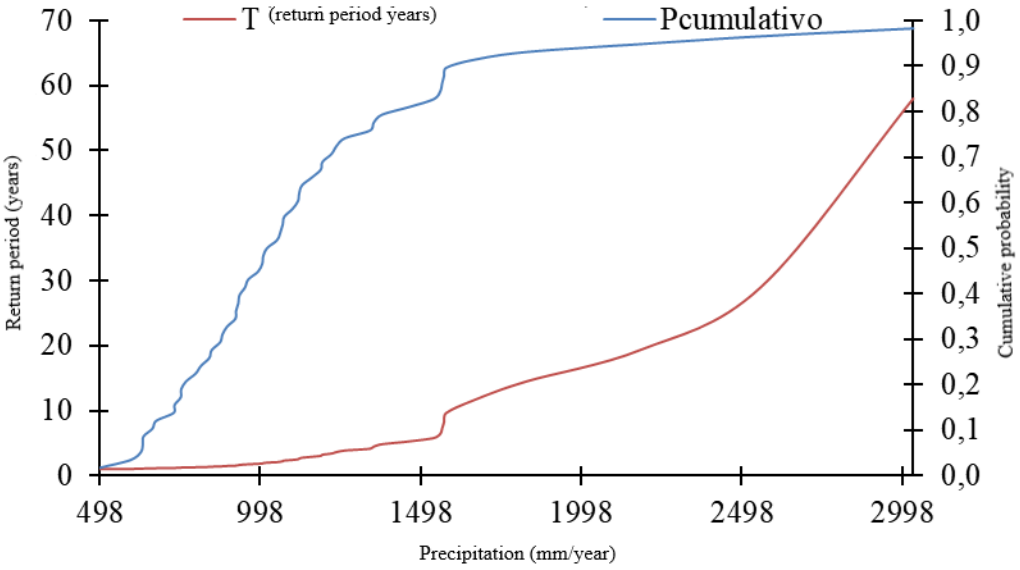

Figure 3. Return period and accumulated probability of precipitation for Amparo de São Francisco – Sergipe.

Source: França (2022).

As a rain event is a continuous random variable, it can be represented by theoretical probability distributions (GANDINI et al., 2018). According to Back (2001), even if a distribution provides a good fit for a data series, its application cannot be generalized, and it is recommended that several distributions for a data set being tested.

For Kulkarni et al. (2013) rainfall rates are of important relevance in tropical regions and are evaluated as the main convective processes that occur in the atmosphere. Therefore, its analyzed payback period is interpreted to provide reliable information to decision-makers.

Figure 4 highlights the return period and the accumulated probability of annual evapotranspiration for Amparo de São Francisco – Sergipe.

The return period and cumulative evapotranspiration probability for Amparo de São Francisco - Sergipe in the period 1963-2020. Return period and probability results were determined for the highest annual evapotranspiration parameter 1635.0 mm with 58 years of return with a probability of 0.99. The payback period and probability of occurrence for the lowest transpired value is 1.02 years with 0.02 probability. The remaining payback time and probability swings can be viewed.

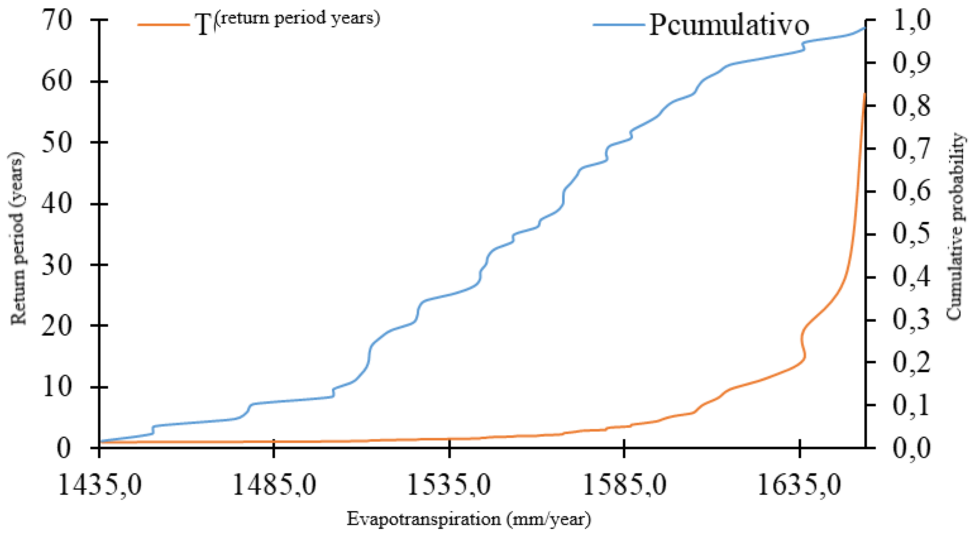

Figure 4. Return period and cumulative probability of evapotranspiration for Amparo de São Francisco – Sergipe.

Source: França (2022).

Figure 5 shows the variability of rainfall and its percentage of rainfall to annual evapotranspiration in Amparo de São Francisco – Sergipe. The fluctuations in rainfall and its percentage of rainfall to annual evapotranspiration flowed from 198.5% to 32.0%, showing that the evapotranspiration power was greater than the occurrence of rainfall rates. The years with the greatest evapotranspiration power greater than 100% stand out: 1963; 1964; 1965; 1966; 1971 to 1974; 1977 and 1990. The years with evaporative powers less than 50% were: 1970; 1980; 1987; 1988; 1993; 1995; 1997; 1998; 2012; 2015; 2016; 2018 and 2019.

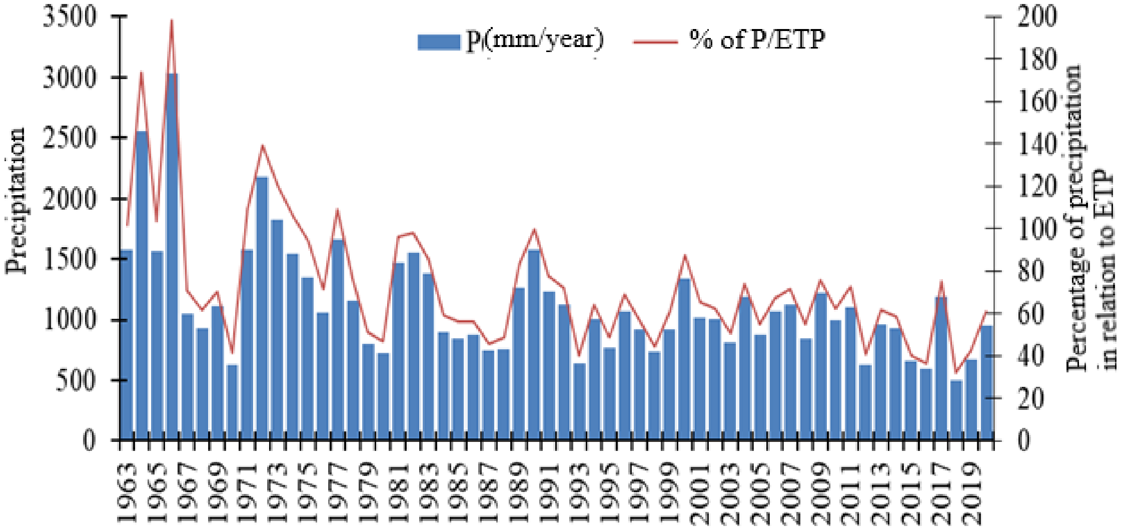

Figure 5. Precipitation and percentage of precipitation to annual evapotranspiration in Amparo de São Francisco – Sergipe.

Source: França (2022).

Marengo (2012) stated that the Northeast region of Brazil is characterized by high evaporative and evapotranspirational potential due to the wide availability of solar energy and high temperatures. Temperature increases associated with climate change resulting from global warming, regardless of what may happen to rainfall, causing greater evaporative powers of lakes, streams, ponds, streams, dams, and reservoirs and maximum evapotranspiration in plants. That is unless there is an increase in rainfall, water will become a scarcer commodity, with serious consequences for the sustainability of regional development.

Dallacort et al. (2011) stated that the probability occurrence information for the values of minimum precipitable water depths and with an additional safety edge, result in incorrectly dimensioned projects and with better available water use.

Figures 6 and 7 represent the precipitation and potential evapotranspiration estimated by moving averages for 5 and 10 years in the study area.

Figure 6 shows the moving averages of precipitation for 5 and 10 years, the values of the moving average for 10 years are the most likely to occur. It is also noteworthy that in the moving average understudy the rainfall indices show us reductions.

Similar studies were carried out by Medeiros et al., (2018) using the rainfall indices of São Bento do Una (PE) that corroborate the results discussed. Another similar study was carried out by Galvíncio (2000) on the precipitation of the São Francisco River (some sectors of the upper and middle course of the river).

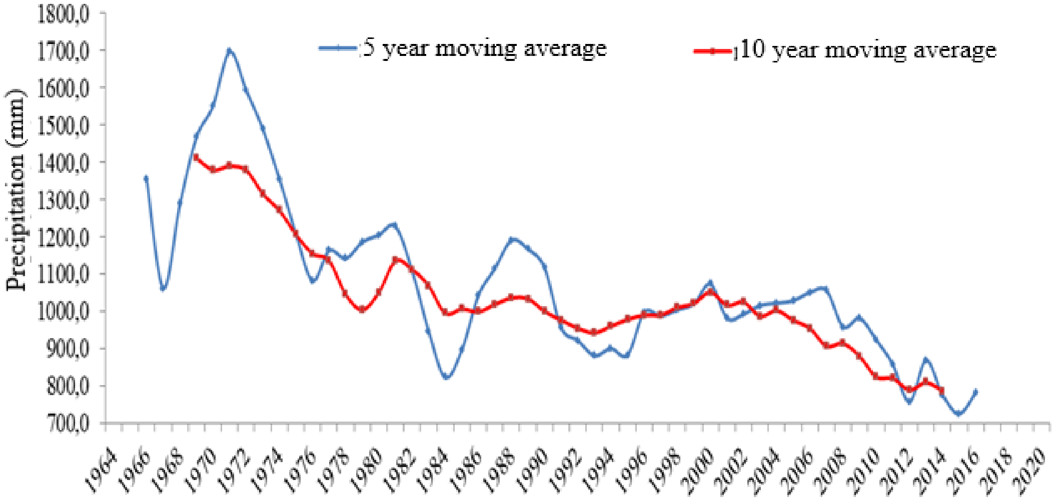

Figure 6. Moving average of 5- and 10-year precipitation for Amparo de São Francisco between 1964-2020.

Source: França (2022).

Figure 7 shows the variability of evapotranspiration of its moving average of 5 and 10 years for Amparo de São Francisco. With a smaller amplitude and a short interannual gradient, the 10-year curve is more prone to occurrences. Studies with similar results were discussed by Medeiros et al., (2020)

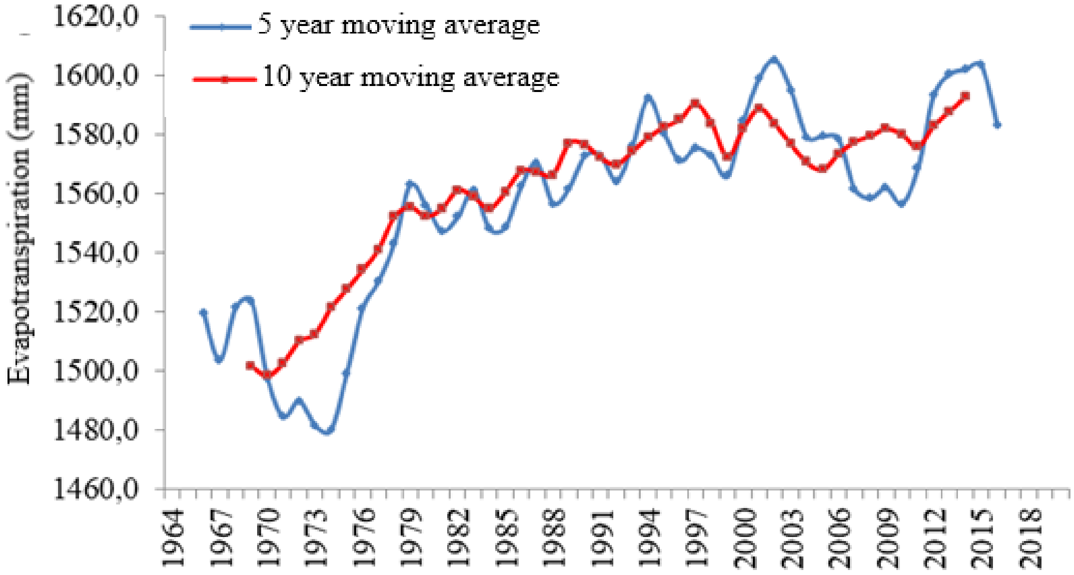

Figure 7. Moving average of 5- and 10-year potential evapotranspiration for Amparo de São Francisco between 1964-2020.

Source: França (2022).

Table 1 shows the statistical parameters of precipitation: mean, median, mode, Standard Deviation (SD), Variance, asymmetry coefficient (Cas) and kurtosis coefficient (Ck), ETP Max (absolute maximum values), and ETP Min (absolute minimum values) (mm), for Amparo de São Francisco – Sergipe.

With an average rainfall of 94.6 mm and ranging from 27.5 mm in November to 192.9 mm in May, its rainy quarter occurs between April and July, and the least rainy quarter is recorded in October. To January. From April to July, it should be noted that the instability of events suggests caution in any agricultural activity aimed at the occurrence of unexpected extreme events.

With an annual median of 83.5 mm and its buoyancy ranging from 23.1 mm in November to 182.5 mm in May. Median values are more likely to be repeated in the next three years, that is, median values are more likely to occur than mean values. The mode does not register representations in March, May, August, September, and in the annual values.

The Variance values show high variability in rainfall, deserving very careful agricultural planning, not only for rainfed activities but also with the use of irrigation, to ensure success in the activities.

The minimum rainfall oscillations flowed between 0.0 mm in February and from September to December with maximum rainfall from the minimum recorded in June with 72.5 mm and with its annual minimum value of 13.4 mm. The maximum rain flowed between 152.5 mm in November to 806.1 mm in April. These maximum fluctuations recorded in precipitation were due to the active synoptic systems and their regional and local contributions influenced by the absence of the factors causing rain and the atmospheric blockages that occurred in the studied area. A study such as that of (MEDEIROS et al., 2021; IPCC 2014 and MARENGO et al., 2005) contribute to the results discussed.

The annual skewness and kurtosis coefficients were 1.9 and 6.7.

The occurrence of extreme events with high magnitude and in a short time interval is expected according to Marengo et al. (2015) and IPCC (2014), these results are similar to the study.

Table 1. Statistical parameters of mean precipitation, median, mode, standard deviation (SD), Variance, asymmetry coefficient (Cas) and kurtosis coefficient (Ck), (Prec) Max Rainfall (absolute maximum values) and Min Rainfall (values absolute minimums) (mm), for Amparo de São Francisco – Sergipe.

Parameters	Average	Median	Fashion	SD	variance	CK	Cas	Prec Mín	Prec Máx
January	47,7	35,6	56,0	63,6	4038,9	22,2	4,1	0,7	425,8
February	59,4	37,4	10,2	77,6	6022,7	24,3	4,2	0,0	533,2
March	81,8	71,9	#N/D	63,9	4089,3	4,5	1,5	1,1	355,9
April	174,2	141,9	174,0	145,5	21177,7	6,4	2,1	8,5	806,1
May	192,9	182,5	#N/D	112,1	12563,8	1,8	1,1	10,3	540,1
June	162,3	156,7	153,8	56,3	3170,7	0,5	0,7	72,5	326,2
July	149,7	155,1	169,5	44,7	1999,0	1,9	0,3	54,8	299,0
August	88,5	86,1	#N/D	39,3	1544,3	2,2	1,0	12,8	229,4
September	65,6	55,2	#N/D	47,6	2261,7	1,4	1,2	0,0	211,4
October	40,4	24,6	7,7	46,3	2147,2	6,6	2,4	0,0	230,7
November	27,5	23,1	1,4	28,5	813,1	6,0	2,0	0,0	152,5
December	45,1	32,4	18,6	48,4	2344,8	2,9	1,7	0,0	222,7
Yearly	94,6	83,5	#N/D	64,5	5181,1	6,7	1,9	13,4	361,1

Source: França (2022).

Table 2 shows the statistical parameters of mean potential evapotranspiration, median, Standard Deviation (SD), Variance, asymmetry coefficient (Cas) and kurtosis coefficient (Ck), ETP max (absolute Max values), and ETP min (minimum Absolute min) (mm), for Amparo de São Francisco – Sergipe.

The average annual evapotranspiration is 129.4 mm and its oscillations flow between 81.7 mm (July) to 172.6 mm (March). The median oscillations follow the average trends and have the greatest possibilities of occurrences during the months, these results found have similarities with the study by (ALMEIDA et al. 2007).

The median is more likely to be represented in future years. The Standard Deviation is a measure of the dispersion of the data to the mean, irregularities in the dispersion of the measurements of this element to the mean stand out, ie the deviation is closer to the mean than the median. It is noteworthy that from October to April, the greatest oscillations of the coefficients of variations were registered, thus showing the heterogeneity of the data for these months over the years.

A statistical measure of importance in meteorological studies is the asymmetry coefficient (Cas) that indicates the degree of distortion of distribution to the symmetrical distribution, that is, in a normal distribution, the reproduced data are concentrated more centrally to the extremes. The kurtosis coefficient (Ck) measures the degree of flatness of the data to a normal distribution, for this, we have the months from May to August with negative Ck.

The fluctuations of the minimum evapotranspiration occurred between 77.4 mm (July) to 159.0 mm (March), precipitation 8.6% above the minimum annual evaporative power. The maximum ETP oscillates between 87.4 mm (July) to 193.1 mm (March), evapotranspired 26.9% with the annual average.

It should be noted that in the months from January to March and from September to December the evapotranspiration rates were higher than the rainfall and between April and August, the precipitation exceeded the evapotranspiration power.

Table 2. Statistical parameters of mean potential evapotranspiration, median, standard deviation (SD), Variance, asymmetry coefficient (Cas) and kurtosis coefficient (Ck), ETP max (max absolute values) and ETP min (minimum absolute minimum) (mm), Percentage of precipitation to evapotranspiration for Amparo de São Francisco – Sergipe.

Parameters	Average	Median	SD	Variance	Ck	Cas	ETP. Mín	ETP. Máx	100*(Prec/ETP)
January	162,1	161,1	8,3	68,7	0,6	0,4	144,4	185,0	29,4
February	155,1	154,5	6,9	47,7	0,9	0,5	141,2	176,5	38,3
March	172,6	172,4	7,3	53,6	0,4	0,4	159,0	193,1	47,4
April	148,3	148,0	5,4	29,6	0,2	0,4	137,7	163,0	117,5
May	120,1	119,7	4,2	17,7	-0,4	0,2	112,4	130,8	160,6
June	94,9	94,9	3,1	9,3	-0,8	0,1	88,6	100,4	171,0
July	81,7	81,5	2,2	4,8	-0,2	0,3	77,4	87,4	183,2
August	84,4	84,4	2,6	6,7	-0,1	0,2	78,9	90,3	104,9
September	95,9	96,2	3,2	10,5	0,8	0,0	88,1	103,8	68,4
October	130,8	130,7	5,3	27,8	0,2	0,1	117,9	144,1	30,9
November	149,3	148,9	7,2	52,4	0,1	0,2	134,0	167,0	18,4
December	157,9	157,8	8,5	73,0	0,3	0,2	139,3	179,3	28,6
Yearly	129,4	129,2	5,4	33,5	0,2	0,2	118,3	143,4	73,1

Source: França (2022).

CONCLUSION

The exploratory and homogeneity analysis contributed to the knowledge of the rainfall distribution, verifying that the median would not represent the rainfall that occurred.

The monthly ETP estimates for the studied area are dependent on the geographic location (latitude and longitude), above all, on the local topography (altitude).

In the absence of meteorological elements necessary to determine the evapotranspiration, the Thornthwaite equation can be used with reasonable precision to estimate the evapotranspiration in the studied area.

The lack of afforestation in the beds of ponds, lakes, rivers, streams, streams, dams, and water tables, as well as the vertical construction and compaction of urban and rural soil, are reducing the evaporative and evapotranspiration process.

The evapotranspiration index of the analyzed period oscillated between the levels of 30 to 60% of probability of occurrence. Thus, adequate planning for the practice of irrigated agriculture should be considered.

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