IJSRM
INTERNATIONAL JOURNAL OF SCIENCE AND RESEARCH METHODOLOGY
An Official Publication of Human Journals

Human Journals
Review Article
August 2021 Vol.:19, Issue:2

Precipitation Probabilities with Use of The Gamma Distribution for The Municipality of Barbalha-Ce, Brazil

IJSRM
INTERNATIONAL JOURNAL OF SCIENCE AND RESEARCH METHODOLOGY
An Official Publication of Human Journals

Luciano Marcelo Fallé Saboya[3], Raimundo Mainar de Medeiros*[1], Romildo Morant de Holanda[1], Manoel Viera de França[1], Fernando Cartaxo Rolim Neto[1], Wagner Rodolfo de Araújo[2]

1 Universidade Federal Rural de Pernambuco, Brasil

2 Universidade Estácio de Sá, Brasil

3 Universidade Federal de Campina Grande, Brasil

Submitted: 23 July 2021
Accepted: 31 July 2021
Published: 30 August 2021

HUMAN JOURNALS

www.ijsrm.humanjournals.com

Keywords: Probability Distribution; Rainfall Indexes; Anomalies

ABSTRACT

Studies on rainfall distribution favor the planning of the amount of water necessary for the development of human activities, whether personal, industrial, or agricultural. The objective of this work is to statistically model the monthly mean precipitation values and estimate the respective precipitation at different levels of probability, through the Gamma distribution, for the Municipality of Barbalha – Ceará, Brazil, in the period from 1973 to 2017. The Gamma Probabilistic Function Model and the adherence test monthly data were evaluated by the Kolmogorov-Smirnov test. Means range from 3.6 mm (August) to 237.4 mm (March). The four months with the highest rainfall are registered between January and April, and the one with the lowest indices occurs between June and September. The oscillation of the alpha parameter occurred from 0.829 (August/September) to 0.896 (March); the beta parameter oscillated between 0.851 (August/September) to 0.922 (March). Regarding the empirical probability for occurrences of total annual rainfall, the percentage stands out 50% and 70% with rain possibilities higher than the historical average. Positive anomaly oscillations flowed between 75 mm to 910 mm. Negative anomalies ranged from 55.5 mm in 2005 to 432 mm in 1982.

INTRODUCTION

The Brazilian semiarid region is considered the driest area in Brazil, with annual rainfall rates less than 800 mm year^{-1}, where the spatial and interannual variability of rainfall is extremely high (SÁ et al., 2010; SILVA et al., 2017; SUDENE, 2021). In addition to low rainfall, the semiarid climate still has high monthly and annual insolation and evapotranspiration rates and strong interannual rainfall variability; rains concentrated annually with well-defined dry and rainy seasons; dry periods interspersed with rainy periods, with a predominance of years with rainfall within and below the average (AB SABER, 2003; LUCENA et al., 2015).

Studies of the distribution of climatic elements are necessary to understand meteorological phenomena, determining their patterns of occurrence, enabling the predictability of climatic phenomena in an area, being an extremely important tool for the planning and management of numerous human activities involving water resources (DOURADO NETO et al., 2005).

The amount of information and/or data available for analysis increases rapidly, making available applications of new models of probability distributions to better describe the specificities of each phenomenon/experiment studied, mainly for the precipitation element.

Scholars from various scientific areas have been used the statistical tool to characterize certain phenomena, in the case of rainfall in a region, probabilistic distribution models that best fit the analyzed datasets are sought (ASSIS et al., 1996; MOURA et al., 2001; VIEIRA et al., 2010; DOURADO NETO et al., 2014; MAZUCHELI et al., 2019). Among the different probabilistic distribution models often applied to rainfall data modeling, we have the binomial distribution; the Weibull distribution; the Gauss distribution, and the Gamma distribution.

Changes in rainfall rates have been caused by extreme events such as floods and droughts, since climate variables fluctuate (SILVA, 2013), forcing us to seek probabilistic models of predictability of the rainfall regime, aiding activities planning actions to agricultural, hydrological, water resources, storage and impoundment of water for human and animal supply and energy generation, due to the great socio-economic and environmental impacts in the world (ÁVILA et al., 2009; SILVA et al., 2013; ULIANA et al., 2013; MOURA et al., 2015).

The characterization of rainfall variability in climate change has been a concern of the entire scientific and technical community, which seeks to develop tools capable of supporting planning actions for agricultural activities, human and animal supply, and energy and leisure generation. The objective of this work is to statistically model the mean monthly precipitation values and estimate the respective probable precipitations at different probability levels using the gamma distribution for the municipality of Barbalha – Ceará, between 1973 and 2017.

MATERIALS AND METHODS

Barbalha municipality is located in the southern region of the state of Ceará, Brazil, being inserted in the semiarid region of Brazil and located at latitude 7° 18’ South, longitude 39° 18’ West, at 409 m altitudes. (Figure 1).

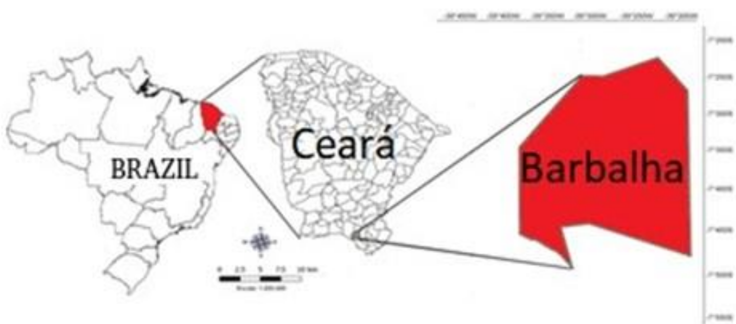

Figure No.1. Positioning of the Barbalha municipality in the southern region of Ceará state, Brazil.

Source: Saboya (2021).

The pluviometric regime has an irregular distribution, characteristic of the Brazilian Northeast (BEN), concentrates almost all of its pluvial index in five months in the rainy period, from December to April. The triggering factors for rain are the formation of instability lines, intensification of southeast/northeast trade winds, convective agglomerates, sensitivity to latent heat exchange and vice versa, orography, contributions from the formation of upper air cyclonic vortices, and having as the main system the positioning of the Intertropical Convergence Zone (ITCZ) (MEDEIROS, 2016).

According to Thornthwaite (1948) Barbalha – CE has a B2rA’a’ climate, mega thermal with no water deficit. In Köppen's classification, the climate is of the “As” type, tropical with a dry summer season (ALVARES et al., 2014).

It was statistically modeled the monthly mean precipitation values and estimated the respective precipitation at different levels of probability, through the Gamma distribution, for the Municipality of Barbalha – Ceará, Brazil, in the period from 1973 to 2017. The Gamma Probabilistic Function Model and the adherence test monthly data were evaluated by the Kolmogorov-Smirnov test.

The Alpha (α) and Beta (β) parameters of the Gamma distribution were estimated using an electronic spreadsheet and measured by the Kolmogorov-Smirnov test, at a 5% significance level (WILKS, 2006).

Estimates of probable monthly rainfall were determined for levels of 10, 20, 30, 40, 50, 60, 70, 75, 80, 90 and 95% probabilities using the Incomplete Gamma model (THOM, 1958), in which the function f(x) is given by equation 1.

$$f(x) = \frac{1}{\beta^{\alpha}\tau(\alpha)} X^{\alpha-1} e^{\frac{X}{\beta}} \quad (1)$$

Where:

β - scale parameter (mm);

α - shape parameter (dimensionless);

e - base of the neperian logarithm;

X - precipitation (mm);

Γ(α) - Gamma function.

The (α) Gamma distribution was calculated using equation 2.

$$\tau(\alpha) = \int_{0}^{\alpha} X^{\alpha-1} e^{-X} d(X) \qquad (2)$$

The Gamma F(x) cumulative distribution was determined by equation (3).

$$f(x) = \frac{1}{\beta^{\alpha}\tau(\alpha)} \int_{0}^{X} X^{\alpha-1} e^{\frac{-X}{\beta}} d(X) \qquad (3)$$

The fit elements of the Gamma distribution function, alpha (α) and beta (β) were estimated by the maximum likelihood method, with the polynomial approximation for the parameter α ^ proposed by Greenwood and Durand (1960) apud Wilks (2006), through equations 4 and/or 5.

$$\hat{\alpha} = \frac{0{,}5000876 + 0{,}1648852A - 0{,}0544274A^2}{A}, \; 0 \leq A \leq 0{,}5772; \text{ ou} \qquad (4)$$

$$\hat{\alpha} = \frac{8{,}898919 + 9{,}059950A + 0{,}9775373A^2}{17{,}79728A + 11{,}968477A^2 + A^3}, \; 0{,}5772 \leq A \leq 17{,}0. \qquad (5)$$

Calculating A by equation 6.

$$A = \ln \overline{X} - \frac{1}{n}\sum_{j=1}^{n} \ln X_j \qquad (6)$$

X = Observed values

$\overline{X}$ = Average of observed values, and

$\hat{\beta}$ given by equation 7.

$$\hat{\beta} = \frac{\overline{X}}{\hat{\alpha}} \qquad (7)$$

Then, the adequacy of the adjustment adopted in each month was verified through the Kolmogorov-Smirnov (KS) test at a significance level of 5% (WARRICK et al., 1980).

RESULTS AND DISCUSSIONS

Table 1 shows the alpha (α) and beta (β) adjustment coefficients for the Gamma distribution model in Barbalha–CE, between 1973 and 2017.

The oscillation of the alpha parameter occurred from 0.829 (August/September) to 0.896 (March), according to Botelho et al. (1999) the variation of alpha (α) is related to the monthly asymmetry, meaning that the asymmetry is inversely proportional to α. The beta parameter (β) ranged from 0.851 (August/September) to 0.922 (March). The highest monthly index β was registered in March, the month with the highest rainfall, with 237.4 mm and a standard deviation of 115.4 mm.

Table No.1. Adjustment coefficients of the Gamma distribution function for Barbalha–CE between 1973 and 2017. (AVG = Average monthly precipitation (mm); SD = Standard deviation).

Parameters				Months of the year								
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Alpha	0,877	0,881	0,896	0,866	0,837	0,834	0,830	0,829	0,829	0,830	0,832	0,839
Beta	0,902	0,906	0,922	0,891	0,860	0,856	0,852	0,851	0,851	0,853	0,855	0,862
AVG	179,3	200,2	237,4	181,3	59,4	19,2	17,9	3,6	6,7	22,6	41,1	81,6
SD	101,3	109,3	115,4	114,5	58,3	31,5	37,6	7,7	11,6	34,2	39,4	70,4

Source: Saboya (2021).

Table 2 shows the values of the Kolmogorov-Smirnov test (Ks) at 5% probability for Barbalha–CE. It was found that the Gamma distribution, with the respective alpha and beta values, presented in table 1, allowed satisfactory adjustments for estimating monthly rainfall. All calculated values, referring to each month, were below the critical value, meaning that the adjustment obtained is adequate.

Table No.2. Kolmogorov-Smirnov (Ks) test values at 5% probability for Barbalha–CE, between 1973 and 2017.

Dcritical	Observed D values											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0,203	0,04	0,055	0,05	0,043	0,051	0,130	0,040	0,130	0,130	0,130	0,130	0,130

Source: Saboya (2021).

Table 3 shows the monthly rainfall totals (mm) for the probability levels of 10, 20, 30, 40, 50, 60, 70, 75, 80, 90, and 95% for Barbalha-CE, adjusted for the distribution Range, for the period from 1973 to 2017.

Table No. 3. Probable precipitation (mm) at different probability levels (%), using the Gamma probability distribution, for Barbalha-CE, for the period between 1973 and 2017.

Levels	Probable precipitation(mm)											
(%)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
10	67,5	78,4	104,1	58,7	3,4	0,4	0,0	0,0	0,0	0,0	0,4	7,0
20	93,2	106,9	136,8	85,3	8,9	1,6	0,1	0,0	0,0	0,3	1,8	16,0
30	115,7	131,5	164,4	109,1	16,1	3,4	0,4	0,0	0,0	1,0	4,7	26,5
40	137,6	155,5	190,9	132,8	25,0	5,9	1,4	0,1	0,1	2,6	9,3	39,1
50	160,5	155,5	190,9	132,8	25,0	5,9	1,4	0,1	0,1	2,6	9,3	39,1
60	185,8	207,9	247,8	186,2	50,4	14,3	7,0	0,8	0,8	10,8	26,7	73,0
70	215,8	240,3	282,5	219,8	69,	21,2	13,7	1,9	1,9	19,5	42,2	97,5
75	233,6	259,6	303,0	240,1	81,9	25,7	19,8	3,0	3,0	26,0	52,9	113,1
80	254,6	282,2	326,9	264,1	97,3	31,6	26,3	4,5	4,5	34,8	66,9	132,4
90	315,6	347,7	395,7	334,3	146,3	50,8	53,7	10,9	10,9	66,5	114,3	192,7
95	372,4	408,5	459,9	400,5	196,4	71,1	53,7	19,1	19,1	102,8	165,8	253,6

Source: Saboya (2021).

The probability levels refer to the probability of occurrence of an exceedance water layer, thus, the increase in the estimation reliability results in a decrease of the minimum water layer to precipitate.

It is observed that, for the probability levels of 75% and 95%, the highest effective rainfall values were detected, since these values are directly related to the probable precipitation. At the 75% level, rainfall flows from 2.95 mm (August/September) to 303 mm in March. January, February, and April with indexes greater than 200 mm. December registered probable precipitation of 113.1 mm. Between May, June, July, October, and November, rainfall ranged from 19.8 mm to 81.9 mm.

At 90% and 95% levels, probable precipitations are below 54 mm and 72 mm, respectively. January, February, and April stand out with probable rains below 100 mm for the 10% and 20% levels. For levels of 10, 20, 30, 40, 50, 60, 70, 75, 80, 90 there are record irregular rainfall levels below 100 mm. Studies by Silva et al. (1988) and Bernardo (1989) corroborate the results discussed here.

Changes in rainfall, floods, droughts, and the growing need for knowledge of rainfall to carry out planning and development of agricultural activities to avoid socio-economic and environmental impacts on the Globe. These climatic variations fluctuated significantly over time, with drier years alternating with periods of intense rain, similarly observed with our data. The problem is recursive since rainfall is not punctual (SILVA, 2013).

Figure 2 shows the annual rainfall distribution, climatological average, and its anomaly for Barbalha – Ceará, between 1973-2017. With historical rainfall around 1125 mm, annual fluctuations for the highest rainfall values are observed with 2000 mm (1985), 1520 mm (1989), 1966 (420 mm), 2004 (550 mm), and the years 2008 and 1011 with 560 mm and 510 mm respectively. Such rainfall variability corroborates the studies by Marengo et al. (2015), Marengo et al. (2008), and IPCC (2014). With a peak of minimum rainfall recorded in 1981, 1982, and 2013 with 578.2 mm, 272 mm, and 595 mm, respectively, these oscillations are influenced by the pluvial systems acting in the local and regional atmosphere (MEDEIROS et al., 2020).

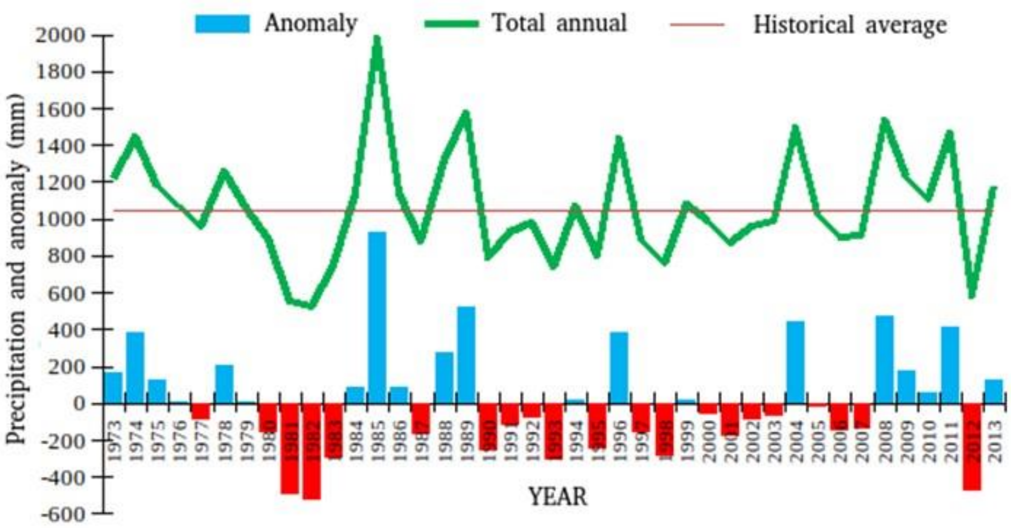

Figure No. 2. Distribution of annual precipitation, historical average, and its anomaly for Barbalha-CE between 1973 and 2017.

Source: Saboya (2021).

The fluctuation of rainfall anomalies is represented in Figure 2. With rainfall above the average, it takes 17 years. 1976, 1979, 1994, and 1999 years were the lowest rates of positive anomalies. Positive anomaly oscillations flowed between 75 mm to 910 mm. Negative anomalies ranged from 55.5 mm in 2005 to 432 mm in 1982. The study by França et al. (2020) corroborates the discussions presented here.

Table 4 shows descriptive statistics, such as mean, standard error, median, mode, standard deviation, coefficient of variation, kurtosis, asymmetry coefficient, absolute maximum and minimum, confidence level at (95%), and the respective years of occurrences of the maximum and minimum values for the precipitation data from 1973-2017 in Barbalha – Ceará, Brazil.

Averages range from 3.6 mm (August) to 237.4 mm (March). The four months with the highest rainfall are registered between January and April, and the one with the lowest indices occurs between June and September. The median has a monthly fluctuation ranging from 0.3 mm (August) to 231.3 mm (March). In the four months (January to April) with the highest rainfall, the median ranges from 156.3 mm to 231.3 mm, and in the four months from June to September its oscillations are from 0.3 mm to 8.2 mm.

Table No. 4. Monthly values of the mean, standard error, median, mode, standard deviation, coefficient of variation, kurtosis, asymmetry coefficient, absolute maximum and minimum, confidence level at (95%) and the respective years of occurrences of maximum and minimum values for precipitation data between 1973 and 2017, in Barbalha–CE, Brazil.

Months	Mean	Standard error	Median	Mode	Standard deviation	Coef. of variance	Kurtosis	Asymmetry	Maximum	Minimum	Year of maximum rain	Year of minimum rain	Trust level (95,0%)
Jan	179,3	15,1	159,1	ND	101,3	0,57	1,16	0,91	513,3	38,6	2004	2012	30,4
Feb	200,2	16,3	156,3	ND	109,3	0,55	-0,51	0,65	461,9	45,3	2004	1982	32,8
Mar	237,4	17,2	231,3	ND	115,4	0,49	0,87	0,80	593,8	32,3	2008	1995	34,7
Apr	181,3	17,1	165,5	ND	114,5	0,63	1,37	1,14	533,8	20,3	1984	1980	34,4
May	59,3	8,7	40,1	ND	58,3	0,98	2,82	1,64	267,9	0,0	2009	1998	17,5
Jun	19,2	4,7	8,2	10,8	31,5	1,65	9,54	3,00	157,3	0,0	2013	1993	9,5
Jul	17,9	5,6	6,3	0,0	37,6	2,10	28,14	4,91	238,9	0,0	2002	1980	11,3
Aug	3,6	1,2	0,3	0,0	7,7	2,15	23,31	4,37	47,2	0,0	1973	1974	2,3
Sep	6,7	1,7	2,0	0,0	11,6	1,74	4,72	2,28	49,0	0,0	1992	1981	3,5
Oct	22,6	5,1	13,2	0,0	34,2	1,51	18,02	3,69	204,3	0,0	2011	1987	10,3
Nov	41,1	5,9	30,6	0,0	39,4	0,96	3,07	1,59	182,8	0,0	1996	1983	11,8
Dec	81,6	10,5	63,6	57,1	70,4	0,86	3,50	1,70	333,9	0,0	1985	1991	21,1

Caption: (ND) values not defined or not found for the mode.

Source: Saboya (2021).

The average ranges from 3.6 mm (August) to 237.4 mm (March). The average annual rainfall in the study area is far from the statistical value of the mode (lower concentration of data), with the median in an intermediate position in the frequency distribution of rainfall values. This result is confirmed due to the average deviation of the mean and median values. The mode in the first five months did not determine their values. In June and December, values were recorded below the median and average, indicating great variation in the data.

The standard deviation is the degree of dispersion of the data relative to the mean. There are irregularities in the dispersion of the measures of this element to the mean, that is, the deviation is closer to the mean than the median. It is observed that from October to January the highest values of coefficient of variation occurred, thus showing the heterogeneity of data for these months over the years. The standard deviation is not aggregated to the mean and median data except for May. There are high values of standard deviation (115.4 mm) and coefficient of variance (CV %) in the value of 98.2 %. This fact was expected since the area under study has a different climate from the surrounding area. Analyzing the variability based on the CV (%) values, it appears that the annual precipitation values showed a low average variation between January and March (CV% < 0.7%), average in June to October (CV % greater than 1%), and high between November and December (CV % of 0.95 and 0.86) respectively indicating that there is an average dispersion between the average precipitation values in the study area. Work like those of the authors Mello et al. (2016) and Carvalho et al. (2009) who had studied the spatial variation of mean rainfall in the State of São Paulo, corroborate the discussions in this article.

The standard error exceeds expectations for December to April, exceeding the limits established by OMM (1968).

The Asymmetry and Kurtosis Measures aim to assess the normality level or deformation of a distribution. (Borges, 2003). The oscillations in the kurtosis coefficients range from -0.51 (February) to 28.14 (July), showing its negative slope with a longer flattening and with extreme values positioned to the right of its curve. Whereas in the asymmetry values there is a curve with positive asymmetry (asymmetry > 0) accentuated to the right.

The absolute maximum and minimum values registered in the study area can also be consulted in the table following their years of registration.

CONCLUSIONS

Means range from 3.6 mm (August) to 237.4 mm (March). The four months with the highest rainfall are registered between January and April, and the one with the lowest indices occurs between June and September.

The oscillation of the Alpha parameter occurred from 0.829 (August/September) to 0.896 (March); the Beta parameter oscillated between 0.851 (August/September) to 0.922 (March).

Regarding the empirical probability for occurrences of total annual rainfall, the percentage stands out 50% and 70% with rain possibilities higher than the historical average.

Positive anomaly oscillations flowed between 75 mm to 910 mm. Negative anomalies ranged from 55.5 mm in 2005 to 432 mm in 1982.

REFERENCES

1. Gomes, M.C.R, Franca, R.M. Use of multivariate analysis to support groundwater quality monitoring in the Araripe sedimentary basin, southern Ceará state, Revista Geosciences, 38, 195 – 205, 2019.
2. Holanda, R.M.; Medeiros, R.M. Climatic classification by the Köppen and Thornthwaite method in Bom Jesus do Piauí, Brazil, Revista Pantaneira, 16, 57 – 68. 2019,
3. Lucena, R.L.; Steinke, E. T. Geographical factors and atmospheric circulation patterns as a basis for understanding the warm semi-arid climate of the Northeast region. Magazine International Workshop on Water in the Brazilian Semiarid Region, vol. 1, p. 01-07, 2015.
4.Matos, R.M.; Silva, P.F., Borges, V.E., Sobrinho, T.G., Dantas Neto, J., Saboya, L.M.F, 2018, Agroclimatic potential for the crop of hose in the municipality of Barbalha - CE, Brazilian Journal of Irrigated Agriculture [online] 12, Available: 10.7127/RBAI, V12N100732.
5.Medeiros, R.M.; Holanda, R.M. Climatic classification and water balance by the Köppen and Thornthwaite method of the municipality of Barbalha, Ceará, Brazil, Revista Ecuador (UFPI), Vol, 8, Nº 3, p,19 – 43, 2019, Home: http://www,ojs,ufpi,br/index,php/equador.
6.Mazucheli, J.; Emanuell, I.P. Application of Nakagami Distribution in Precipitation Data Analysis, Brazilian Journal of Meteorology, 34(1), 17. 2019.
7.Mello, Y.R.; Oliveira, T.M.N. Statistical and Geostatistical Analysis of Average Rainfall for the Municipality of Joinville (SC), Brazilian Journal of Meteorology, São Paulo, 31(2), 229- 239. 2016.
8.Moura, M.S. B., Nephew, J. E., Son (Filho), F. Q. P., Son, F, X, O, Maia, A, J, Estimate of the maximum possible reference evapotranspiration for the municipality of Mossoró - RN, using the probabilistic distribution of Gumbel, Caatinga, Mossoró-RN, 14(1/2), 25-30, 2001.
9.Moura, Q.L.; Ruivo, M.L.P.; Rodrigues, H.J.B. Seasonal variation of bacterial and fungal population and soil ammonium nitrate contents at the LPA and PPBIO sites in the Eastern Amazon, Brazilian Journal of Meteorology, São Paulo, 30(3), 265-274. 2015.
10.Sa, I.B.; Silva, P.C.G. Brazilian semiarid: research, development, and innovation. Petrolina: EMBRAPA Semiarid, 2010.

11.Silva, A.R.; Santos, T.S.; Queiroz, D.E.; Gusmão, M.O.; Silva, T.G.F. Variations in the rain anomaly index in the semiarid region. Journal of Environmental Analysis and Progress. See 02 No. 04, 377-384, 2017.
12.Silva, I, N,; Oliveira, J, B,; Fontes, L.O.; Arraes, F.D.D. Rain frequency distribution for the Center-South region of Ceará, Brazil, Revista Ciência Agronômica , 44(3), 481-487, 2013,
13.Silva, R,O.B. (2013), Climate change trends in rainfall in the state of Pernambuco, Dissertation (Masters in Civil Engineering), Federal University of Pernambuco – UFPE, Recife,
14.Silva, S.A,, Lima, J.S.S,; Bottega, E.L. Spatial variability of rainfall for the State of Espírito Santo using multivariate methods, Revista Brasileira de Ciências Agrárias, 6(4), 703-790, 2011.
15.Silva, W.L.C.; Oliveira, C.A.S.; Morquelli, W.A. Subsidies for dimensioning irrigation systems. In: National Congress on Irrigation and Drainage, 8. ABID. Florianópolis, SC, 1988. v.1, p.535-553.
16.SUDENE, Superintendence for the Development of the Northeast. Semiarid. Available at: http://antigo.sudene.gov.br/delimitacao-do-semiarido.
17.Thornthwaite, C.W, An Approach Toward a Rational Classification of Climate, Geographical Review 38, Available: 10.2307/210739, 1948.
18.Thornthwaite, C.W.; Mather, J.R. The water balance, Publication in Climatology 8, Laboratory of Climatology, Centerton, N, J, 1955.
19.Vieira, J.P.G.; Souza, M.J.H.; Teixeira, J.M.; Carvalho, F. P. Study of monthly precipitation during the rainy season in Diamantina, Minas Gerais, Brazilian Journal of Agricultural and Environmental Engineering, Campina Grande, 14(7), 762-767, 2018.

Image *Author -1*	**Luciano Marcelo Fallé Saboya** *Federal University of Campina Grande Author Federal*
Image *Author -2*	**Raimundo Mainar de Medeiros** *Federal Rural University of Pernambuco, Brazil*
Image *Author -3*	**Romildo Morant de Holanda** *Federal Rural University of Pernambuco, Brazil*
Image *Author -4*	**Manoel Viera de França** *Federal Rural University of Pernambuco, Brazil*
Image *Author -5*	**Fernando Cartaxo Rolim Neto** *Federal Rural University of Pernambuco, Brazil*
Image *Author -6*	**Wagner Rodolfo de Araújo** *University Estácio de Sá of Pernambuco, Brazil*