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Incidência e padrões pluviométricos no sul do nordeste brasileiro

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RESUMO

Compreender e caracterizar o regime e intensidade de chuvas de uma determinada região é de extrema importância, tanto na gestão dos recursos hídrico-ambiental, mas também em atividades socioeconômicas da região. Tendo isso em vista, o objetivo deste trabalho foi de estudar a incidência e o padrão pluviométrico das chuvas na região do sul do Nordeste, com ênfase nos municípios que circundam a bacia hidrográfica do rio Buranhém. Caracterizando a distribuição das frequências de chuvas e sua intensidade horária, diária, mensal e anual ao longo de 14 anos. Os resultados mostraram que em Porto Seguro e Serra dos Aimorés tem suas máximas de chuvas no mês de novembro, em Almenara e Itaobim, no mês de dezembro, e mínimas entre maio e setembro para Serra dos Aimorés e Almenara, enquanto no município de Itaobim entre abril a setembro, por fim, em Porto Seguro, seu mínimo pluviométrico ocorre no mês de fevereiro. Os maiores volumes de precipitação em Porto Seguro ocorreram no período diurno nas seguintes seções 04:00-08:00, 08:00-12:00 e 12:00-16:00 e nas seções 04:00-08:00 e 08:00-12:00 para Serra dos Aimorés, enquanto em Almenara e Itaobim as maiores frequências no período noturno, nas seções 20:00-00:00 e 00:00-04:00. Palavras chave: Pluviosidade; Padrão de pluviosidade; Frequência de pluviosidade; Extremo sul do nordeste Brasileiro

Incidence and rainfall patterns in south of Brazilian northeastern

ABSTRACT

Understanding and characterizing the rainfall regime and intensity of a given region is of utmost importance, both in the management of water-environmental resources, but also in socioeconomic activities in the region. With this in mind, the objective of this work was to study the pluviometric pattern and the incidence of rainfall in the south of Brazilian northeastern, with emphasis on the municipalities surrounding the Buranhém river basin. Characterizing the distribution of rainfall frequencies and its hourly, daily, monthly and annual intensity over 14 years. The results showed that in Porto Seguro and Serra dos Aimorés have their maximum rainfall in the month of November, in Almenara and Itaobim, in the month of December, and minimum between May and September for Serra dos Aimorés and Almenara, while in the municipality of Itaobim between April and September, finally, in Porto Seguro, its rainfall minimum occurs in the month of February. The highest precipitation volumes in Porto Seguro occurred in the daytime period in the following sections 04:00-08:00, 08:00-12:00 and 12:00-16:00 and in the sections 04:00-08:00 and 08:00-12:00 for Serra dos Aimorés, while in Almenara and Itaobim the highest frequencies in the nighttime period, in the sections 20:00-00:00 and 00:00-04:00.

Key words: Rainfall; Rainfall Pattern; Rainfall Frequency; South of northeastern of Brazil

Introduction

Precipitation is an important variable in the hydrological cycle and begins when the water is given to the atmosphere in a vapor state, generated by evaporation from the soil, bodies of water (oceans, rivers, lakes),

transpiration of vegetation and sublimation of ice, and ends when it is returned to the earth's surface in a liquid or solid state Varejão-Silva (2006). Natural rains are unpredictable events, characterized by their randomness and irregular distribution in time and space (Batista, et al., 2018). Precipitation is one of

the most relevant climatic variables, especially in the tropics, so investigating the behavior of rainfall extremes on a regional scale is highly relevant and significant (Santos, et al., 2018)

Studying this variable is of great importance because it is linked to material losses, safeguarding lives, agricultural production, forestry, livestock, power generation, water resource management and environmental planning both rural and urban, because according to the WMO, (2021) in the last 50 years, climate-related disasters caused 45% of all deaths and 74% of all economic losses in the period.

However, understanding the variability of a region's rainfall becomes an important factor for good management of water resources and better development of a region Zanchi (2013), Mencia et al. (2021), as well as predicting and avoiding disasters WMO, (2021).

Climate changes in the Northeast region of Brazil results from the interaction between several meteorological systems and variations in the intensity and position of the Hadley and Walker atmospheric cell circulations (Santos et al., 2022)

According to Nobre and Molion (1988), the meteorological systems involved in the generation of precipitation in southern Northeastern Brazil are both tropical and extratropical: the Intertropical Convergence Zone (ITCZ), the South Atlantic Convergence Zone (SACZ); of synoptic scale, such as frontal systems and the High Level Cyclonic Vortices (HVCAN), and also local scale systems such as breezes. The action of these systems determines the rainy periods and the spatial distribution of precipitation over the south and extreme south of Bahia. This distribution is also linked to the characteristics of the topography, vegetation, distance or proximity to the sea, (Chaves, 1999). According to, Kousky and CHU (1978) and RAO and Hada (1990), the main rainy period of the south of Northeast occurs between the November and January, with climatological maximum in December related to the SACZ and the VCAN. Another characteristic period of rainfall in southern Bahia occurs from February to April, through the latitudinal displacement of the ITCZ, which is located further south (Chaves, 1999).

Aceituno (1988) and Kousky (1984)

show that the interannual variability of precipitation over the south of Brazil's northeast is also affected by El-Niño and La-Niña (ENSO) phenomena.

Rao et al. (1997) analyzing the interannual variability of normalized precipitation anomalies, found that in El-Niño years precipitation was lower than mean, while in La-Niña years precipitation was above mean.

The southern region of Bahia has many inhabitants who depend on the supply of the region's rivers both for human consumption and for agriculture and local industries (Silva et al 2021). Understanding the spatial distribution and characterization of precipitation in this region is strategic for local activities and development (Nobre and Molion, 1988 and Silva et al, 2020). Studies about the climatological behavior of micro-regions have become increasingly important to diagnose the effects of the action of its factors in an economic and socio-environmental way. The characterization of the rainfall of the Southern Bahia region is necessary for the following reasons: The regional geomorphological conditions combined with the availability of precipitation in the region, impose the need for a certain flow of surface water, that is, any variation in the water regime in the basins, may indeed affect all management of water resources in this region, for having a relatively rugged relief, the rivers of the southern region of Bahia from source to mouth (Silva et al, 2020, Silva et al, 2021, Mencia et al 2021 and Mencia et al, 2022).

Agriculture is one of the main socioeconomic activities in northeastern Brazil, the success of crops planted depends on the regularity and quantity of rainfall (Silva et al., 2011).

Excessive precipitation contributes to the occurrence of flooding, increasing damages, as water accumulates in undesired areas, especially in urban areas. The occurrence of precipitation extremes has increased and will continue to increase due to climate change (IPCC, 2020). On the other hand, climate change, represented by lack or little rainfall accompanied by high temperatures, elevates competition for water resources, where it can lead to a potentially catastrophic crisis, with the poorest farmers being the most vulnerable (Marengo & SILVA Dias, 2006). Understanding the

characterization of rainfall, can economically ensure and improve the quality of life of an entire region, because the resilient crops, agricultural production and supply, change an entire management, the use and occupation of a region.

Under the hypothesis that the distribution of rainfall in the Buranhém basin will present distinct variations and patterns over the years, this study sought to understand the crucial role of rainfall behavior in the region and to identify possible rainfall trends over time the objective was to analyze the incidence and rainfall pattern of rainfall patterns of rainfall in the southern region of the State of Bahia and northern Minas Gerais with special emphasis on the municipalities located near the Buranhém river basin. Characterizing the distribution of

rainfall frequencies and their hourly, daily, monthly annual intensity over 14 years.

Material and methods

Study Area

The water resources management units that make up the extreme south of Bahia include the basins of the Mucuri River in the south, the Buranhém River in the center and the Jequitinhonha River in the north (Figure 1). Its main source is the Buranhém river, which originates in the municipality of Santo Antônio do Jacinto, east of the state of Minas Gerais, where it passes through the municipalities of Guaratinga, Eunápolis and Porto Seguro in southern Bahia, being of great importance for the economic and social development of the region.

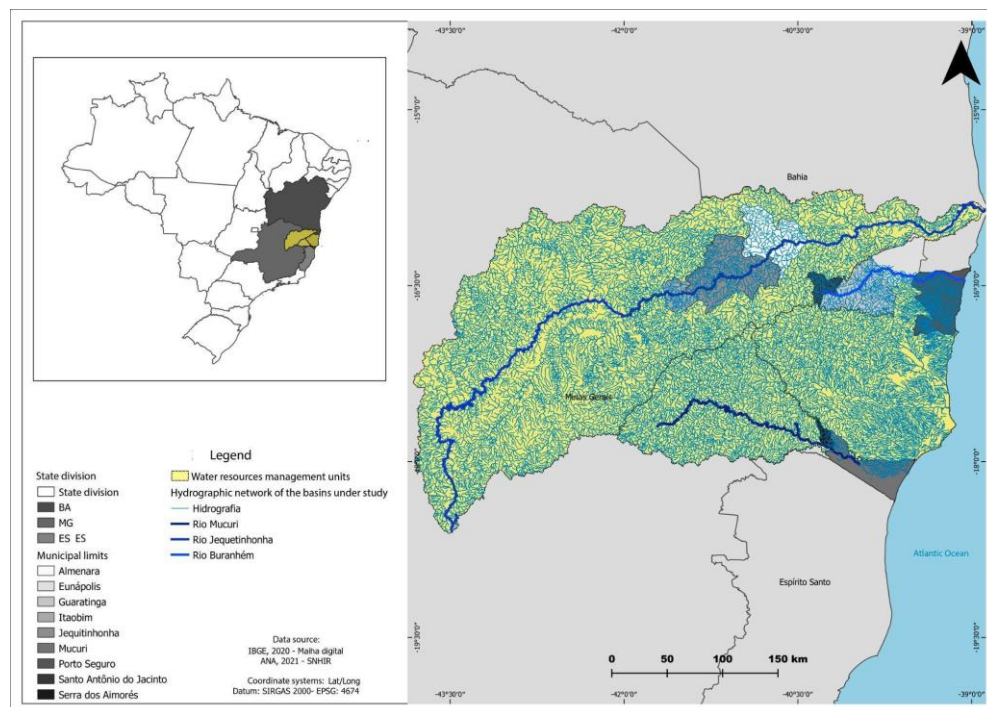


Figure 1: Map showing the location of rainfall measurements in the Buranhém River Basin and Water Resources Management Units.

Methodology

Precipitation measurements were collected using a tipping bucket rain gauge (Didcot Instruments Company, Abingdon, UK) installed at automatic weather stations located in southern Bahia and northwestern Minas Gerais, connected to an automatic datalogger, where data are read every 10 seconds and recorded every 60 minutes. These collection stations are located in the municipalities of Porto Seguro, Almenara, Itaobim, and Serra do Aimorés (Table 1). The

data are provided by the National Institute of Meteorology (INMET) and Veracel Station. The data series are available on the automatic stations data platform, however, some stations have data collection started in different periods. In this case, only data from the year 2008 to December 2021 were used, whose series are complete for all available stations.

Table 1. Location and data collection period of the weather stations in southern Bahia

Station	O		A		Altitude	Start in
	MM	co	Latit	Lon		
	de	ude		gitude		
Porto Seguro-A427	86	-	-	-	8	10/07/2008
	745	16.388977°	39.182389°	6 m		
Almenara-A508	86	-	-	-	1	09/12/2002
	743	16.166773°	40.687756°	86 m		
Itaobim-A550	86	-	-	-	2	05/09/2007
	742	16.575667°	41.485588°	72 m		
Serra dos Aimorés - A522	A	-	-	-	2	21/08/2006
	522	17.798799°	40.249933°	12 m		

Methodology

To perform a temporal analysis of precipitation, as well as its highest frequency of occurrence, the data were organized into classes of local hour (LT) intervals every 4 hours, which sectioned the day into a sequence of six parts (00:00-04:00; 04:00-08:00; 08:00-12:00; 12:00-16:00; 16:00-20:00; 20:00-

00:00), in order to separate the hours into shifts, also used by OLIVEIRA et. al. (2001). This method is based on the duration of regional precipitation. Thus, the analyses showed which variations refer to the dry and rainy seasons and the intensities for each period.

The data were collected through the online platform of the National Institute of Meteorology (INMET), for the municipality of Porto Seguro, data provided by the Veracel company from the RPPN Veracel station, which is 1.3 km away, were used from July to December 2008 and September 2020 to December 2021 to complement the failures that occurred during data collection at the INMET station. The other stations, there were failures during data collection. These failures were not filled, because there were no other stations nearby that could provide the data, so the data that presented failures or indicative of "null", were discarded for these other stations.

At the Itaobim weather station there were no data recorded in 2017, in Almenara

in the months June and July 2011, January and February 2017 and 2019, August 2020, and September 2017 and 2020. In Porto Seguro, there were no data in July and August 2014, April 2015, November 2016, and January and February 2017. Finally, in the municipality of Serra dos Aimorés in June 2011, December 2015, January and February 2016, September and October 2017, February to June 2018, and November 2020. These data collection failures are due to communication errors, which can be caused by lack of maintenance at the stations.

The data were organized in tables for the analysis, considering the following variables: total annual precipitation, total monthly precipitation, average precipitation expressed in months, average monthly precipitation segmented into classes (LT), comparison between the average monthly precipitation, maximum, minimum values and standard deviation, in addition to the frequency of occurrence of precipitation in classes (LT) for all years and selected collection sites. To determine whether the data has a statistically significant time trend, the non-parametric method Mann-Kendall Test (Mann, 1945; Kendall, 1975) was adopted. The Mann-Kendall statistical test (S) is calculated using equation (1):

The value of S is the result of the sum of the counts of $(x_j - x_i)$; x_j is the first value after x_i , n is the number of data from the evaluated time series. In each pair of evaluated data, the following values are assigned using equation (2):

$$sng(x_j - x_i) = \{+1 \text{ se } x_j - x_i > 0 \text{ } 0 \text{ se } x_j - x_i = 0 \text{ } -1 \text{ se } x_j - x_i < 0$$

The variance of S is given using equation (3):

$$var = \frac{1}{18} \left[n(n-1)(2n+5) - \sum_{t=1}^p f_t(f_t-1)(2f_t+5) \right]$$

Where n represents the number of data points, p represents the number of tied groups, and f is the frequency in which t appears

The statistic used in the Mann-Kendall test is based on the Z value, calculated according to equation (4):

$$z = \{(S - 1)/se, S > 0, S = 0 (S + 1)/se, S < 0\}$$

Being if the square root of var . Furthermore, a significance level $\alpha = 0.05$ was adopted, that is, the hypothesis of no trend was rejected the moment the p -value was less than the value of α .

Results and discussion

In the municipality of Porto Seguro, the years with the highest occurrence of precipitation were 2009 and 2013, being much higher than the mean value for the region of Porto Seguro, with 1786.8 and 2014 mm, respectively. In 2015, a year of strong El Niño, the lowest rainfall was recorded (984.4 mm). According to ACEITUNO (1988) and KOUSKY (1984) El Niño years, are years that promote a reduction in precipitation for this region, where it caused a strong drought in it, reducing the rainfall index throughout the basin (SILVA et al, 2021), in La Niña years the opposite was observed, as we see in

2011-13 and 2020-21 (Figure 2). It was noticed that for the municipalities of Porto Seguro, Almenara and Itaobim, due to the El Niño-Southern Oscillation (ENSO) event that occurred in 2015, all these municipalities had a lower rainfall index in this period, except for Serra dos Aimorés, which had a lower volume occurring in 2016, but which also suffered the effects of El Niño, in the first months of the year.

After applying the Mann-Kendall test (Mann, 1945; Kendall, 1975) in the municipalities studied (Table 2), with a significance level $\alpha = 0.05$, and considering two hypotheses: H_0 (null hypothesis), which indicates the absence of a trend in the data, and H_A (alternative hypothesis), which points to the existence of a trend in the data, either increasing or decreasing, it was found that the data did not show a statistically significant temporal trend for any of the municipalities analyzed. Therefore, the null hypothesis (H_0) was accepted.

Table 2. Mann-Kendall test to evaluate trend in the time series for the municipalities of Serra dos Aimorés (MG), Porto Seguro (BA), Almenara (MG) and Itaobim (MG).

Municipality	Mann-kendall test		Trend
	Z-statistic	P-value	
Almenara	0	1	No trend
Itaobim	-0,10	0,91	No trend
Porto Seguro	0	1	No trend
Serra dos Aimorés	-0,87	0,38	No trend

When evaluating the highest precipitation rates in relation to the mean for the period, it was observed that they occurred in 2011 for Serra dos Aimorés with variations

of 58.1%, Porto Seguro was 2013, varying by 40.1% and in 2021, Almenara and Itaobim increased by 58.6% and 55.5%, respectively (Figure 2).

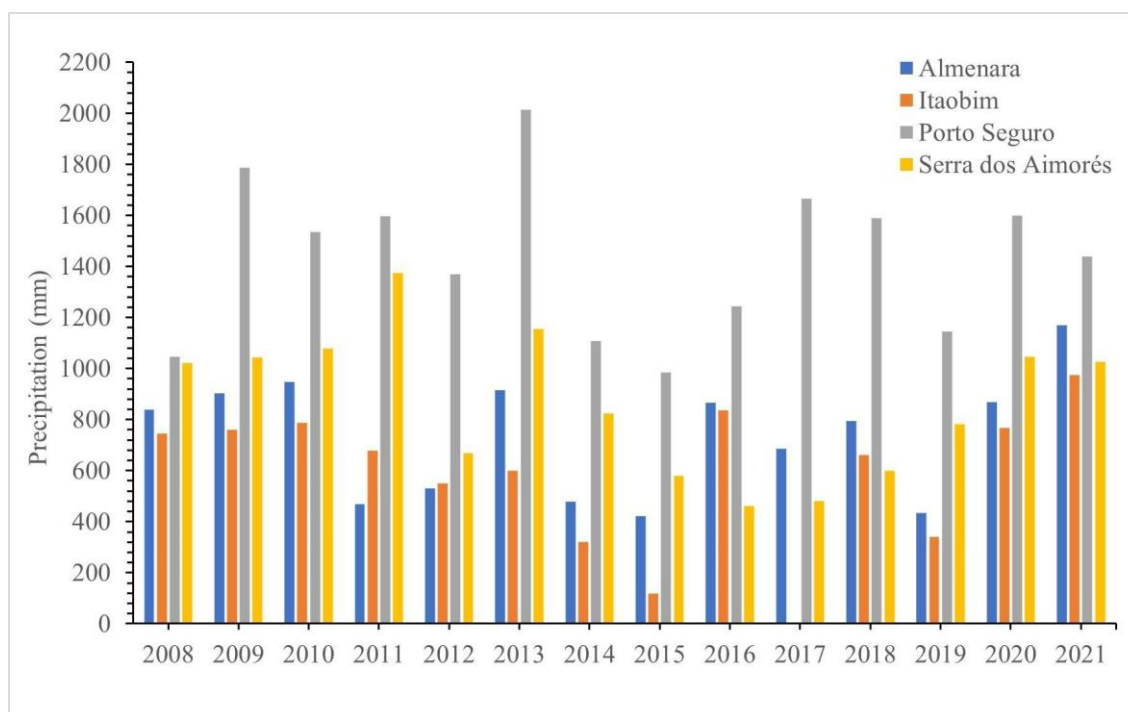


Figure 2: Total precipitation in millimeters in the years 2008 to 2021 from the weather station in (A) Almenara; (B) Itaobim; (C) Porto Seguro; (D) Serra dos Aimorés

The mean precipitation value for Almenara was 737.3 mm and for Itaobim 626.1 mm, whose areas suffer more from the reduction of precipitation coming from the ocean, due to the altimetric barriers (MENCIA, et al 2021), which characterize the effects of anabatic winds in the region.

The other research sites had lower mean rainfall values compared to the station closest to the coast (Porto Seguro). According to NOBRE and MOLION (1988) and SILVA et al 2021, the meteorological systems active in the generation of precipitation in southern Northeast Brazil are both tropical and extratropical: as the Intertropical Convergence Zone (ITCZ), South Atlantic Convergence Zone (SACZ); of synoptic scale, as the frontal systems and the High Level Cyclonic Vortices (HVCAN), and also local scale systems as the breezes that can generate a large source of water for the region and thus proximity of Porto Seguro with the ocean provided a higher rainfall in relation to the other researched sites.

According to MENCIA et al, (2021), using the isohyets method for the extreme

southern region of Bahia, the lowest precipitation was in the southwest and northwest region with a minimum of 878.8mm/year. On the other hand, Northeast and southeast the precipitation rates of the coastal zone of Bahia, show mean annual rainfall of 1363 mm/year.

The highest monthly rainfall occurred in different periods in the studied locations. In Almenara, the highest volume recorded was in December 2021, totaling 535 mm, while in Itaobim, the peak also occurred in December 2021, with 448 mm of rain. Regarding Porto Seguro, the month of May 2012 recorded the highest monthly volume of precipitation, reaching 390.6 mm. In contrast, in the Serra dos Aimorés region, the highest index occurred in November 2008, with a total of 344.6 mm of rain. We observe that the region presents particularities and distinct effects when we analyze the precipitation patterns in each locality (Figure 3). MOURA and SHUKLA (1981) & MENCIA, et al. (2021), establish that warmer sea surface temperatures and increased evaporation over the oceans influence the convergence of moisture flow and precipitation over the northeast.

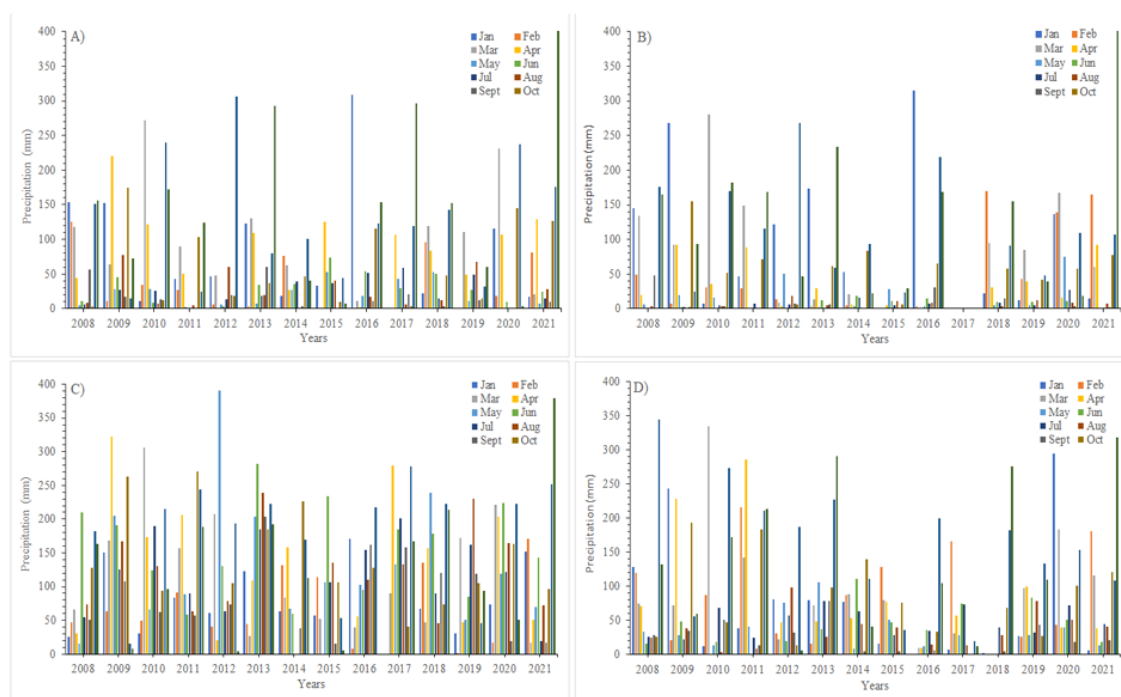


Figure 3: Total monthly precipitation in (mm) in the years 2008 to 2021. (A) Almenara; (B) Itaobim; (C) Porto Seguro; (D) Serra dos Aimorés.

Evaluating the mean monthly rainfall for the studied sites (Figure 4), it is observed that the highest precipitation rates occur in

November for Serra dos Aimorés and Porto Seguro, and December for Almenara and Itaobim.

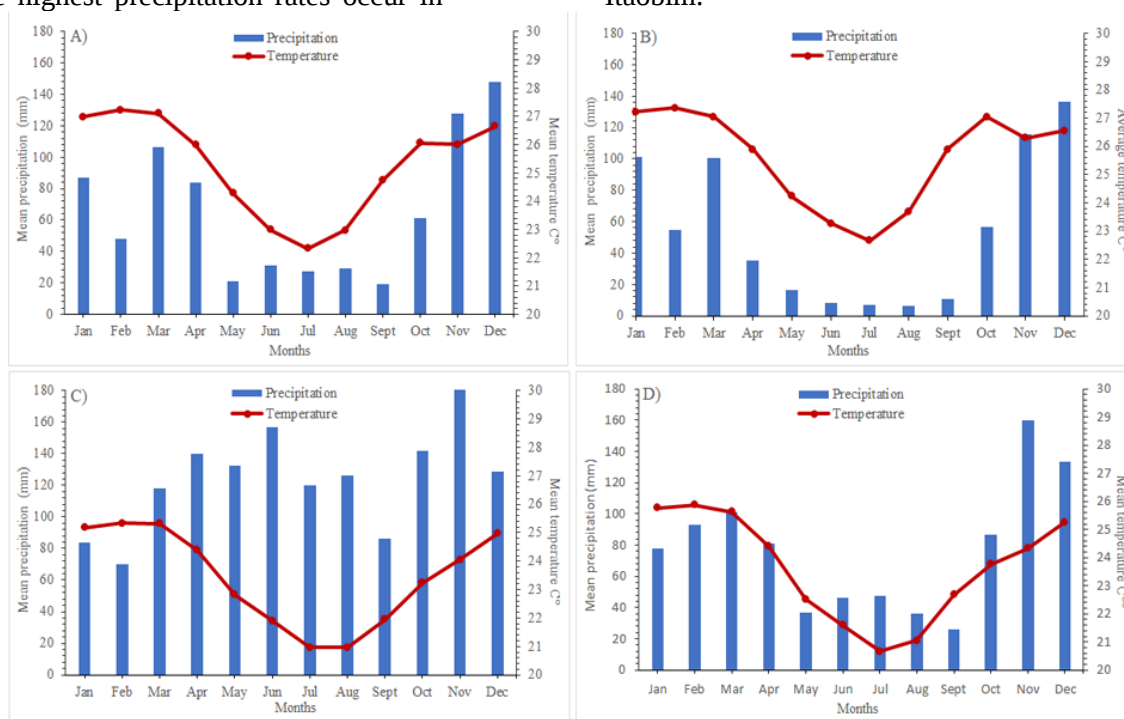


Figure 4: Mean Monthly Precipitation (mm) (2008 - 2021) (A) Almenara; (B) Itaobim; (C) Porto Seguro; (D) Serra dos Aimorés.

The municipality of Porto Seguro has a low annual variability of precipitation, with precipitation throughout the year, due to its location in coastal areas, with the main rainy period during the months of April to June, associated with the intensification of

trade winds, RAO et al. (1993). On the other hand, MENCIA et al. (2021), in a study on the climatic characterization, establishes for the region of the Discovery Coast, the rainy period between October and December, with precipitation above 100mm/month.

Therefore, it can be seen that even with different factors that led to several variations of rainfall in the sites, November proved to be more balanced as to its rainfall index during the 14 years studied as the month maintained the mean 180.98 mm of rainfall for Porto Seguro. Therefore, the month of February characterized the period with the lowest rainfall index in the municipality. As for the lowest rainfall indexes, the municipalities of Almenara and Itaobim, presented lower accumulated values in relation to the others.

Analyzing the values obtained for average rainfall, standard deviation, maximum and minimum for each

municipality investigated (Table 3), we were able to identify their respective rainfall behaviors.

In Almenara, a very apparent variation was observed in relation to the average monthly rainfall. January showed a significant value, followed by a drop in February, with a further increase in March and April. Between May and September, there was a period of low precipitation, characterizing a dry season in the municipality. Between November and December, there was a period of more intense rainfall in the region.

Table 3. Mean monthly precipitation ($\bar{x}$), standard deviation (σ), minimum (Min) and maximum (Max) in mm, (2008 - 2021) for the municipalities of Serra dos Aimorés (MG), Porto Seguro (BA), Almenara (MG) and Itaobim (MG).

Months	Almenara				Itaobim				Porto Seguro				Serra dos Aimorés			
	$\bar{x}$	σ	Min.	Máx.	$\bar{x}$	σ	Min.	Máx.	$\bar{x}$	σ	Min.	Máx.	$\bar{x}$	σ	Min.	Máx.
Jan	86,92	88,38	10,60	308,40	101,31	103,50	0,20	315,00	83,72	49,34	25,82	171,20	77,65	93,00	2,40	294,60
Feb	48,06	43,32	3,80	125,40	54,78	64,44	3,00	169,60	70,26	53,51	0,80	170,23	93,21	67,70	15,20	215,60
Mar	106,48	78,35	11,40	271,60	100,47	80,61	8,60	280,80	118,11	87,48	16,75	306,00	101,46	87,49	10,00	334,20
Apr	84,14	59,52	1,60	220,20	35,14	34,22	0,60	92,20	139,62	97,27	20,20	323,00	81,12	82,55	1,20	285,80
May	20,75	18,35	1,40	53,20	16,54	22,48	1,20	74,60	132,62	97,95	15,68	390,60	36,54	28,21	7,80	105,20
Jun	31,23	20,73	3,80	73,60	8,27	6,40	0,00	18,60	157,04	68,54	59,00	281,60	46,53	39,31	16,00	143,59
Jul	27,42	18,35	1,60	59,00	7,02	7,34	0,40	27,40	120,00	56,69	18,76	201,60	47,33	21,77	18,76	77,80
Aug	29,00	26,23	4,60	77,40	6,31	5,26	0,20	18,20	126,43	61,45	45,80	238,60	36,27	28,25	3,00	98,60
Sept	18,97	19,38	0,60	59,60	10,73	15,05	0,40	47,40	86,05	60,05	15,60	203,40	26,08	21,93	4,80	78,40
Oct	61,23	59,26	3,20	174,40	56,43	40,33	0,40	154,40	141,70	70,05	41,30	270,00	86,39	58,75	13,00	192,60
Nov	127,79	88,64	14,60	305,80	115,57	74,53	22,80	268,60	180,99	82,39	16,00	278,00	159,94	93,20	19,40	344,60
Dec	147,77	147,04	1,60	535,00	136,12	118,91	18,20	448,00	128,74	105,55	4,40	378,60	133,46	121,52	0,00	378,60
Total	789,75	55,63			648,69	47,76			1485,27	74,19			925,98	61,97		

In relation to Itaobim, the results revealed a considerable variation in average monthly rainfall. The months of November and December correspond to the rainy season of the region, while between April and September there is a drop in precipitation, characterizing the dry season.

It was noted that the standard deviation for the months of January, February and May is slightly above average, indicating greater dispersion of the data in these periods. In the other months, the values showed greater balance in relation to the average.

In Porto Seguro, it is possible to observe a small variability in precipitation rates throughout the year. The months from March to August present a higher precipitation index, with values higher than 110 mm. In addition, the month of November records the highest volumes of rain in the region. On the other hand, the months of January and February represent a period with a lower precipitation index.

The standard deviation presents a low value, indicating the homogeneity of the data. In Serra dos Aimorés, the rainy season is concentrated in

the months of November and December, while between May and September, the decline in precipitation is evident, characterizing the dry season.

Regarding the standard deviation, it was observed that it directly follows the value of the average, which shows the homogeneity in the analysis of the data. Serra dos Aimorés records its lowest precipitation values in the month of September.

It was found that the average rainfall, divided into hourly classes, in the four locations surveyed, showed a higher volume of rain in the sections 04:00-08:00, 08:00-12:00 and 12:00-16:00 for the municipality of Porto Seguro. Then, in Serra dos Aimorés, higher volumes of rain were recorded in the sections of 16:00-20:00, 20:00-00:00 and 00:00-04:00.

Consequently, Itaobim and Almenara present a similarity between the periods, with higher precipitation volumes in the 20:00-00:00 and 00:00-04:00 sections. It is observed that the sections with the highest concentration of rainfall during the daytime period are

predominantly close to the coast, while the nighttime sections are concentrated in more

distant municipalities (Figure 5).

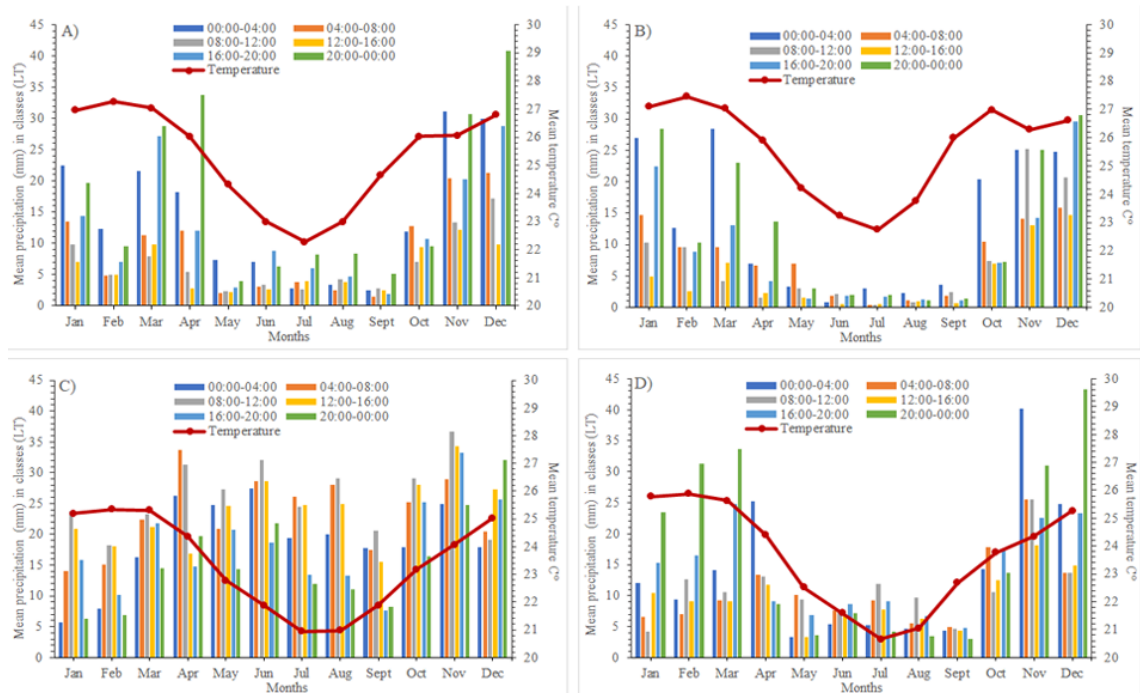


Figure 5: Mean monthly precipitation (mm) in hour-local (LT) class (2008 - 2021) for the municipalities of (A) Almenara; (B) Itaobim; (C) Porto Seguro; (D) Serra dos Aimorés.

The study by KOUSKY (1980), concludes that the daily variability, in coastal areas the maximum convective activity occurs between the night period until early morning 21:00-09:00 LT, being a consequence of convergence between the mean flow of air near the surface that derives from the ocean, in addition to the surface flow of the continent to the sea, associated with the land breeze, while in areas adjacent to the coast occurs between 15:00-21:00 LT due to the penetration of breeze associated with surface warming.

We can see a notable difference in the results obtained in this research compared to the findings of KOUSKY (1980). In the regions farthest from the coast, the maximum rainfall was recorded at night, while the municipality located in the coastal region showed high rainfall during the daytime period. One of the factors that could explain the variation between the maximums between the periods, are the study regions, since Kousky's studies concentrate on the central, northern and southern regions of Bahia, while this study

investigated the daily variability in the southern region of Bahia.

Figure 6 illustrates the distribution of rainfall frequency in the LT classes throughout the period studied for the experimental sites. It is observed that records occurred at all times of the day during this period, with the maximum frequencies being observed in the 20:00-00:00 and 00:00-04:00 classes for the municipalities of Almenara and Itaobim, and in the 04:00-08:00 and 08:00-12:00 classes for Porto Seguro and Serra dos Aimorés. In Almenara and Itaobim, there is a similarity in the monthly distribution of frequencies, with peaks occurring in the months between October and December. On the other hand, in the other municipalities, there is a more balanced distribution of frequencies, with peaks occurring between June and November for Porto Seguro, and between October and December for Serra dos Aimorés. In addition, it is important to note that, although Porto Seguro presents a higher frequency of rainfall in the months of June to August, the months with the highest rainfall are still October and November.

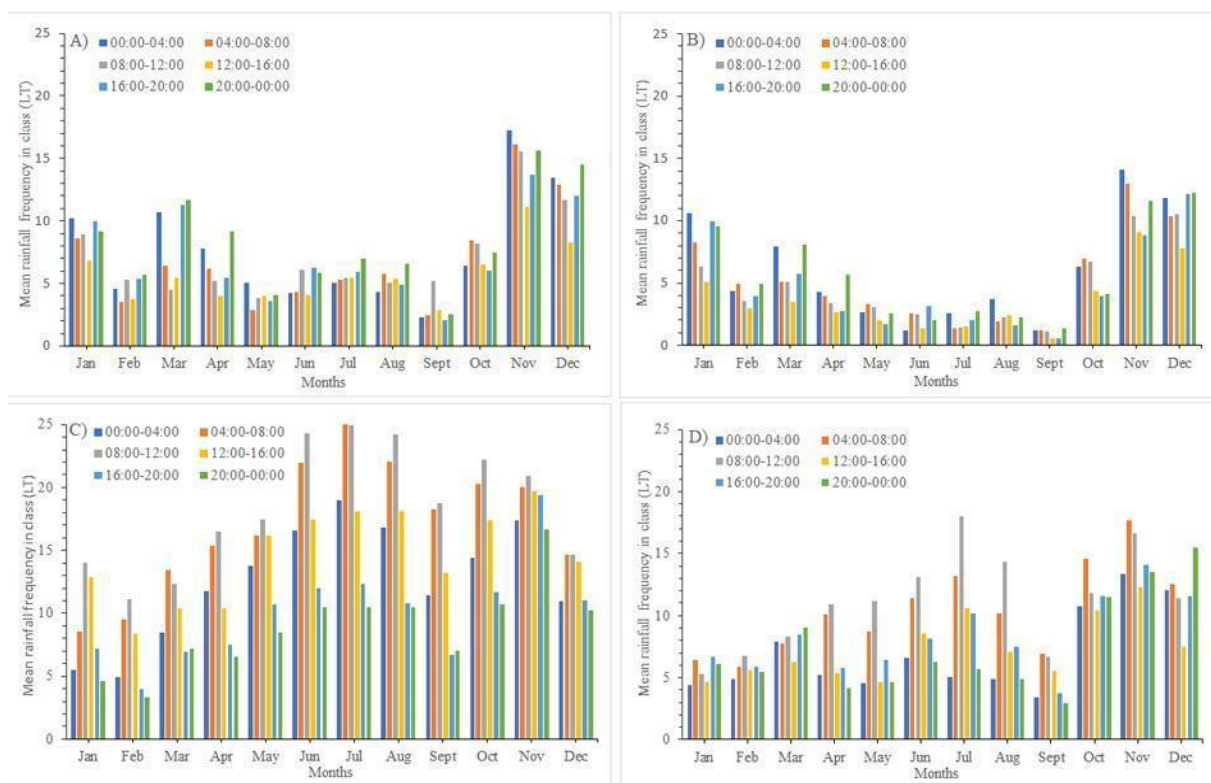


Figure 6: Mean monthly rainfall frequency in classes (LT) for the municipalities of (A) Almenara; (B) Itaobim; (C) Porto Seguro; (D) Serra dos Aimorés.

Conclusions

The understanding of precipitation, both locally and regionally, is extremely important for various purposes, whether for the management of water resources and socioeconomic activities in the region; furthermore, understanding its daily cycle is essential. Therefore, taking into consideration the objectives that were proposed in this article, and the discussions about the results presented, the following conclusions are exposed:

1. No statistically significant temporal trends were found for the municipalities with respect to precipitation in the time series studied.
2. Porto Seguro and Serra dos Aimorés have their maximum rainfall in the month of November, in Almenara and Itaobim, in the month of December.
3. The lowest rainfall values in each region occurred in the following

periods: in Serra dos Aimorés and Almenara, the lowest rainfall rates occurred between May and September, in the municipality of Itaobim, between April and September, and in Porto Seguro, its minimum rainfall occurs in February.

4. The highest rainfall rates in each region occur in the following periods: in the municipalities of Almenara, Itaobim and Serra dos Aimorés, in the months of November and December. In Porto Seguro, in addition to presenting higher rainfall in this period, it records monthly maximums of more than 110 mm between the months of March and August.
5. The analysis of average monthly rainfall, represented in LT classes, revealed distinct patterns in each municipality studied. In Porto Seguro, the highest precipitation volumes occurred in the daytime period, in the 04:00-08:00, 08:00-12:00 and 12:00-16:00 sections. In Serra dos Aimorés, the highest volumes were observed in the sections 16:00-20:00, 20:00-00:00

and 00:00-04:00. In Almenara and Itaobim, the highest volumes occurred in sections 20:00-00:00 and 00:00-04:00.

6. The distribution of the highest frequencies of rainfall in the LT classes showed distinct patterns among the regions studied. In Porto Seguro and Serra dos Aimorés, the highest frequencies occurred in the daytime period, in the intervals 04:00-08:00 and 08:00-12:00. On the other hand, in the municipalities of Almenara and Itaobim, the highest frequencies were recorded at night, in the intervals of 20:00-00:00 and 00:00-04:00.

In summary, this study plays a relevant role, contributing to the knowledge of precipitation in the southern region of Bahia, providing relevant information to improve the management of water resources, mitigate environmental risks and promote a more sustainable and resilient development to climatic conditions.

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