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RESEARCH ARTICLE OPEN ACCESS

EXTREME PRECIPITATION EVENTS VERSUS MILK PRODUCTION: STATISTICAL VARIABILITY IN THE AGRESTE PERNAMBUCANO, BRAZIL

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ABSTRACT

The State of Pernambuco presents in its greatest extent with a semi-arid climate, which encompasses the Sertão and Agreste Mesoregions and is characterized by long droughts, high temperatures and low rainfall. Its economy is based on the cultivation of beans, corn and beef cattle, in addition to containing one of the largest dairy basins in the state. Thus, the objective of this work is to assess the severity of drought and floods through statistical variability. The studied area was in the Southern Agreste Region and the data collections comprised the period from 2010 to 2018 on milk production at IBGE and rainfall data, at APAC. For data analysis, the Shapiro-Wilk normality test was performed. Not finding normality, thus characterizing non-parametric data, Spearman's correlation was used. The data were submitted to the statistical software R at 5% probability ($P < 0.05$). During the studied period, there were peaks of rain in 2010, 2011 and 2017, which presented a greater number of months with high rainfall with months exceeding 500 mm monthly. On the other hand, drought in the region is a recurring phenomenon governed by climatic conditions and without human interference. In 2012, 2014 and 2016 were the ones with the highest number of months with rainfall below 300 mm monthly. It is concluded that by associating with technology and knowledge, a satisfactory milk production can be obtained in the Agreste region. On the other hand, drought in the region is a recurring phenomenon governed by climatic conditions and without human interference. In 2012, 2014 and 2016 were the ones with the highest number of months with rainfall below 300 mm monthly. It is concluded that by associating with technology and knowledge, a satisfactory milk production can be obtained in the Agreste region. On the other hand, drought in the region is a recurring phenomenon governed by climatic conditions and without human interference. In 2012, 2014 and 2016 were the ones with the highest number of months with rainfall below 300 mm monthly. It is concluded that by associating with technology and knowledge, a satisfactory milk production can be obtained in the Agreste region.

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INTRODUCTION

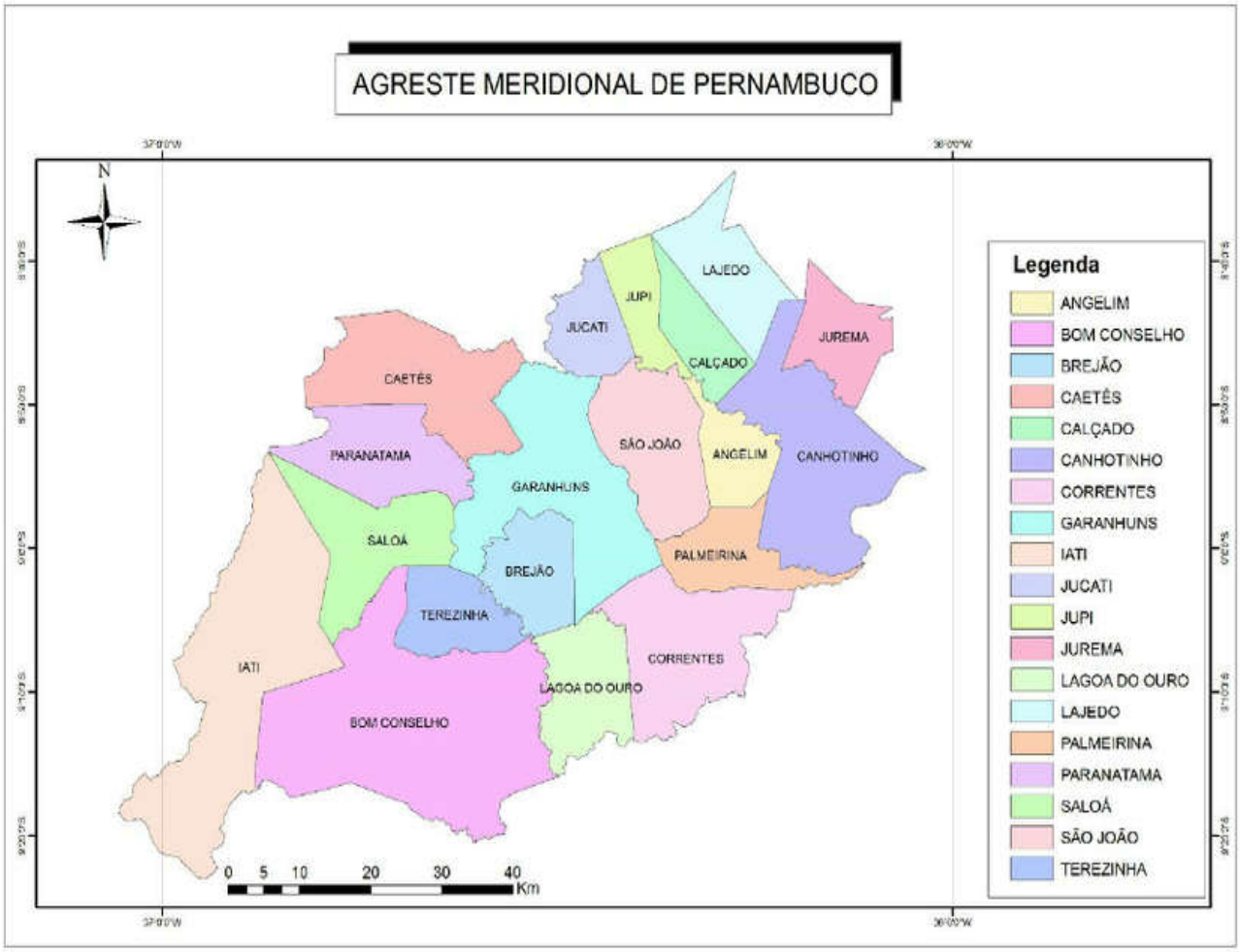
The Northeast region of Brazil is marked by climatic seasonality, with rainfall concentrated in short periods of time and high temperatures throughout the year, causing a rapid loss of water to the atmosphere. The interannual variability of rainfall, associated with low total annual rainfall over the Northeast region of Brazil, is one of the main factors for the occurrence of "drought" events. The State of Pernambuco presents an annual variation in water resources, in addition to

frequent droughts and floods (ALMEIDA *et al*., 2020). Andrade *et al*. (2018) consider drought to be an event that has a long period without rain and drastic consequences, such as animal death and threatens the survival of families through thirst and hunger, in addition to raising the cost of urban supply and generating electricity. According to the climatic classification proposed by Thornthwaite, the State of Pernambuco presents itself in its greatest extent with semi-arid climate and to a lesser extent with humid and sub-humid climate. The State has 70% of its territory located in the Northeastern Semi-arid, in the "Polígono das Secas" (BRITO *et al*., 2007). The area with a semi-arid climate encompasses the Sertão and Agreste Mesoregions and is characterized by long periods of drought, scarce rain distributed in a few months of the year, high temperatures and low rainfall, between 500 and 800 mm per year. The concentration of rainfall in the Mesoregion of Agreste is distributed between the months of February and June in the vicinity of the Sertão, while in the vicinity of the Forest, it occurs between March and July (ASFORA *et al*., 2017). The region's economy is quite diverse, with cultivation of beans, corn and beef cattle, in addition to being considered a state dairy basin (XIMENES *et al*., 2019). Over the years, the effects of climate variability and possibly climate change have caused disaster across the planet on a large scale, through changes in water resources and agriculture (PEREIRA *et al*., 2017). Precipitation is one of the factors used to assess the severity of drought, as it is one of the fundamental components in the hydrological cycle and is responsible for supplying water systems (MARUYAMA et a., 2005).

Its distribution on a temporal and spatial scale is influenced by the association of the components of the hydrological cycle with the influences arising from nature and anthropic action in the locality (ANDRADE *et al*., 2018). Several studies are carried out in Agreste and in other regions of the state correlating the variation of precipitation with some global systems, such as the El-Niño / South Oscillation and the Pacific Decadal Oscillation and others, being applied Climate Indexes producing more improved data (SILVA *et al*., 2018). For Silva *et al*. (2012) the study of precipitation over a period of time is essential to estimate the need for crop irrigation and domestic and industrial water supply. Given the socio-economic importance of the Agreste region of Pernambuco, the objective of this work is to evaluate the severity of drought and floods through statistical variability.

MATERIAL AND METHODS

Characterization of the study area: Located in the Agreste Pernambucano mesoregion, the Agreste Meridional Development Region has an area of 10,828 km² and is formed by 26 municipalities, where according to the 2010 IBGE Census, there is a population of 641,727 inhabitants, with 370,818 inhabitants in the urban area and 270,909 inhabitants in the countryside. The map with the distribution of the municipalities in the study region can be seen below. In relation to the rest of the state, the relief and climate of this region stand out, allowing, in addition to livestock activity, diversity of crops, such as floriculture. It also offers several options for tourism and dynamic economic activities that employ local labor.



Source: https://www.researchgate.net/figure/Localizacao-dos-municipios-do-Agreste-Meridional-de-Pernambuco-Fonte- Desenvolvidos_fig2_28604226

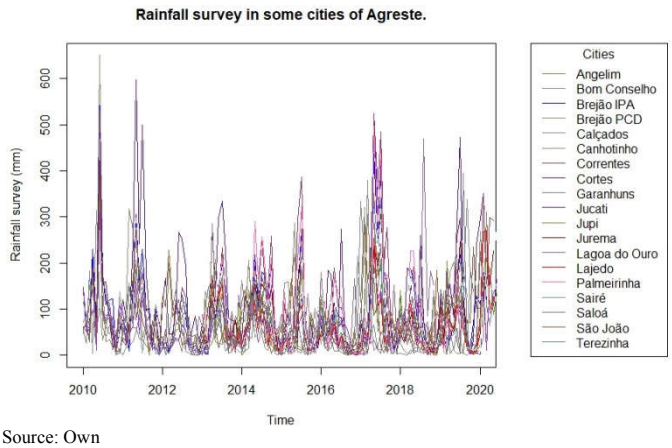
Figure 1. Geographic location of the study area

Data collection: Data on milk production in the municipalitiesios, located in Agreste de Pernambuco, were extracted from IBGE (Brazilian Institute of Geography and Statistics) in the period from 2010 to 2018. And the rainfall data, through the database made available by APAC (Agência Pernambucana de Águas e Clima). Where monthly data from January 2010 to June 2020 were considered, ordered by mesoregion of the harsh Pernambuco and the following posts: Angelim, Bom Conselho IPA, Bom Conselho PCD, Brejão IPA, Brejão PCD, Calçados, Canhotinho, Correntes, Caetés, Garanhuns , Garanhuns UAG / UFRPE, Iati, Jucati, Jupi, Jurema, Lagoa do ouro, Lajedo, Palmeirinha, Saloá, São João, Terezinha and the local Sairé post of the Guilherme Pontes Dam was added, breaking in June 2020.

Statistical analysis: The rainfall data were organized in Excel software, later the data was completed, with simple averages per period. For data analysis, the Shapiro-Wilk normality test was performed. It was found that there was no normality, thus characterizing non-parametric data, that is why Spearman's correlation was used in this study. The data were submitted to the statistical software R at 5% probability ($P < 0.05$).

RESULTS AND DISCUSSION

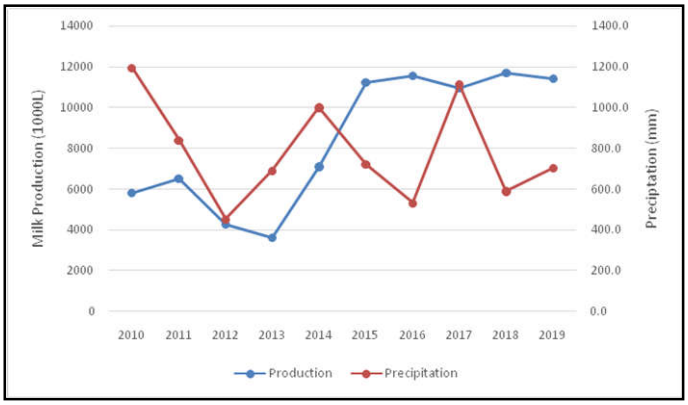
Analyzing the time series for the period from January 2010 to June 2020 in the cities of Agreste Pernambuco, it was found that the behavior of precipitation is divided into two moments, rainy and dry periods. The greatest expressiveness of rainfall is concentrated in the months from March to July and the other months of the year are characterized as months of drought, since the rainfall rate is very low or even non-existent. Thus evidencing an uneven distribution of rainfall throughout the year. Graph 1 shows the monthly rainfall indexes for 19 stations in the Agreste region of Pernambuco. It is possible to observe that the years 2010, 2011 and 2017 were the ones that presented the highest peaks of pluviometric indexes, with some months reaching indexes above 500 mm monthly. The year 2010 presented the highest index within the evaluated period, exceeding 600 mm monthly. The years 2012, 2014 and 2016 showed rainfall rates below 300 mm monthly. However, it was the year of 2016 that presented the largest number of stations with rainfall less than 200 mm monthly. Thus indicating periods of drought.



Source: Own

Graph 1. Monthly time series through precipitation, dry and rainy season from Angelim, Bom Conselho, Brejão IPA, Brejão PCD, Footwear, Canhotinho, Chains, Cortês, Granhuns, Jucati, Jupi, Jurema, Lagoa do Ouro, Lajedo, Palmeirinha , Sairé, Saloá, São João, Terezinha

Floods that occurred in the period of 2010 and 2011 in the hydrographic basins of Agreste and Mata do Estado made the drought process that took place in the Sertão unnoticed. However, even with poor rainfall distributed in late 2012 and in the first quarter of 2013, the drought still remained in the Agreste region (ASFORA *et al*., 2017). This fact corroborates with what Amador and Coutinho (2013) claim, who consider drought to be a recurring phenomenon governed by climatic conditions and not suffering interference from man in its causes or in its emergence, only to minimize its situation. It is of great relevance to highlight that, on June 15, 2020, the Guilherme Pontes dam broke, located in the rural area of the municipality of Sairé, Agreste Pernambucano. The structure of the dam lasted about 20 years and made the damming of the Sirinhaém River, cutting several places in the region, with the rupture, it also reached the municipality of Cortês. This extreme event was due to an increase in rainfall greater than expected in this period, with moderate to heavy rainfall. According to data obtained by APAC (Agência Pernambucana de Agua e Clima) -2020an accumulated volume of 112 mm was recorded in the municipality of Sairé in the interval of two days, this value was expected for the whole month of June. This being the main justification for the event that took place in Agreste Pernambucano. Knowing that the situation of drought and floods is repeated throughout all the years already seen, it is up to the producers to establish a plan, for decision making in order to take advantage of the short rainy season, through the insertion of technologies that make water storage feasible and consequently the continuity of its production. In addition, it is possible to cultivate drought-resistant plants, such as forage palm. Another strategy is to conserve food resources, such as hay and silage processes, which consist of harvesting the forage before the dry season and storing it during the dry season.



Source: Own

Graph 2. Temporal evolution regarding milk production in 1000 L and rainfall in mm in Agreste Pernambucano

Analyzing the graph 2 of the temporal evolution of milk production in 1000 liters and rainfall in millimeters in Agreste Pernambucano, it is possible to observe that from 2010 to mid-2014 these two quantities had similar behavior. However, in the following years there was a change in the behavior of the data analyzed. Even with the permanent changes in precipitation, the evolution of milk production remained constant. This can be explained by the evolution of dairy farming and the advancement of technology used in this market. According to Dos Reis Filho and Oliveira (2014), the rainfall average in 2012 in the Northeast region was well below the historical average, which generated great losses in the agricultural sector, thus compromising the production of

forage and the development of dairy farming, which directly depends of bulky food. But with the advancement of agriculture, improvement of animals and forages, insertion of technology in the field, and qualification of producers, there is an increase in milk production even in unfavorable climatic periods. The Pernambuco dairy basin is considered the second largest within the Northeast, second only to Bahia. Activity in the state is at its highest concentration in the Agreste region, due to historical, cultural, climatic and geographical factors (CORREIA, 2012). Judged as one of the pillars of the economy for the state, it is known that, historically, the Agreste Meridional has already presented superior production of the other micro-regions, and that its tendency of growth of production lately leads to a different representation in the sector at the regional level.

Spearman's correlation is considered a statistic that is based on rank and requires that variables X and Y be measured at least on an ordinal scale and do not require assumptions regarding the joint distribution of variables (SIEGEL, 1975). It's thep-value has the objective of affirming whether or not the two variables are statistically correlated or not. P-value values less than 0.05 are considered to state that the correlation between the variables worked is significant (PONTES, 2000). Analyzing Table 1, it can be seen that there is no correlation between the variables Milk Production and Rainfall Precipitation, considering that Spearman's Rho values are close to zero, and yet, the calculated p-values are all greater than 0 , 05, thus affirming the lack of correlation. Even though there is no significance in the calculated correlation, it is not appropriate to conclude that changes in one variable cause changes in the other variable or not. Controlled experiments would better express this relationship. For, it is known that climate change substantially affects agricultural production, both in the drought, in which there is a scarcity of water (essential for all production), and in floods, which devastate plantations and even animal husbandry. The different physical-natural characteristics of the Agreste region, which are generated by climatic variability, can cause problems, such as droughts and intense rains, promoting impacts on agriculture, water resources, health and the environment (SOUZA, 2011).

Table 1. Correlations between rainfall and milk production in Agreste Pernambuco in the period 2010-2019

County	Spearman correlation	p-value
Angelim	-0.2848	0.4274
Good advice	0.0909	0.8114
Brejão	-0.1272	0.7329
Caetés	-0.1190	0.793
Shoe	-0.3333	0.3488
Canhotinho	-0.0424	0.9186
Chains	0.6121	0.06647
Garanhuns	-0.3333	0.3488
Iati	-0.1151	0.7588
Jucati	-0.0061	1
Jupi	0.2606	0.4697
Jurema	-0.2121	0.5599
Gold Lagoon	-0.4424	0.2042
Lajedo	0.0424	0.9186
Palmeirinha	0.0181	0.9728
Paranatama	-0.0238	0.9768
Sairé	-0.0357	0.9635
Saloa	0.1757	0.632
Saint John	0.1878	0.1878788
Terezinha	0.0666	0.8648

Table 1: Spearman's correlation coefficient of precipitation with milk production in the municipalities. c = correlation; p-value = p-value.
Source: Own

Conclusion

The Agreste of Pernambuco, for having one of the largest and most important milk basins in the Northeast region, requires knowledge of the natural phenomena that regulate the climate in the region. With this, in the cities of Agreste it was observed that the rains in their greatest expression occur between the months of March and July and in the other months of the year they are characterized with drought, with low or no rainfall. The years 2010, 2011 and 2017 were those with the highest peaks in rainfall, with some months reaching rates above 500 mm monthly. With the year 2010 having the highest index within the evaluated period, exceeding 600 mm monthly. In relation to the drought period, the years 2012, 2014 and 2016 were the ones that presented the greatest number of months with rainfall indexes below 300 mm monthly. However, 2016 had the highest number of stations with rainfall below 200 mm monthly. Drought is a recurring phenomenon in the region and induces producers to carry out planning for decision making in order to take advantage of the short rainy season by applying technology and knowledge for continuous production.

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