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ALTERNATIVE OF LIVING IN THE GEOGRAPHICAL OUTLINE OF CARIRI PARAIBANO, BRAZIL

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ABSTRACT

Drought is a natural phenomenon that affects the environment and socioeconomic activities. In this context, the main objective of this work was to analyze the main characteristics of the drought from 2012 to 2017 and to establish the alternative of coexistence in the geographical section of the Cariri in Paraiba, Brazil. The work was carried out in the territorial section of Sumé, intermediate geographical region of Campina Grande, Paraiba, Brazil. With the annual rainfall data, the rainfall regime was established and with the rain anomaly criterion, the drought categories. The main results showed that drought is not a new phenomenon and reflects on the environment and socioeconomic activities. The rainfall regime in that geographic section is asymmetrical and irregular. The criterion of the rain anomaly and the respective index allows quantifying the magnitude and type of drought, evidenced by the drastic reductions in the water level of the Sumé reservoir and in livestock activities. The catchment of rainwater, even in drought years, proves to be an efficient alternative to increase the supply of water for the purposes of consumption and family production, conditions necessary for local coexistence.

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INTRODUCTION

Water is an indispensable element in life and its scarcity is one of the biggest social problems in the world. In the semi-arid region of northeastern Brazil, this scarcity is greater in rural areas, where water is lacking for human consumption (Almeida and Farias, 2015). The difficulty of regular access to water is still a situation present in the social reality of the Brazilian semiarid, mainly for the population living in the rural area. It also highlights the importance of rainwater catchment technology for these conditions, when associating social technologies with public policies that influence the citizens' life Water scarcity is undoubtedly the main factor impeding development in the northeastern semi-arid region, because if there is a lack of water, even for human consumption and animal desendentation, there is no way to live together. What little is planted is usually lost. The main income generating activity is small cattle and goat breeding (Hauschild and Döll, 2000). The rainfall is the main source of water and the weather of the element with higher spatial and temporal variability, especially, in semi-arid Paraiba, where rain is characterized by irregularity in quantity and distribution. Even in the short rainy station, which lasts for about two to four months, the totals of rains are extremely irregular in amount and in distribution, when comparing one location to another (Almeida, Freitas and Silva, 2013). Drought is a phenomenon of the climate that drastically affects a region, for causing severe damages that affect economic and social activities, described, a priori, when the total rainfall is below a reference value that should not be confused with aridity because it is a permanent feature of the climate (Almeida, 2017). However, the effect of a drought depends on the location, because the weather conditions that result in scarcity and/or irregular distribution of rain in the semiarid region can differ considerably from one location to another (Almeida, 2012). The drought of Northeast Brazil represents a particular "target of opportunity" because they are unusually well defined in terms of the large-scale circulation setting and possess an extraordinary economic and social impact (Hastenrath, 1990). The drought is a normal part of climate, rather than a departure from normal climate (Glantz, 2003), although it is a natural catastrophe has very different from the other types of disasters. The catchments of rain water and its subsequent storage in cisterns is one of the alternatives being used increasingly to reduce the number of people without access to water for human consumption. For UNEP (2009) and others, this social water technology (SWT), is a

public policy directed to the Northeastern semi-arid, through the programs of One million cisterns (P1MC) and training and social mobilization to live with the semi-arid (P1+2). The paradigm of coexistence with drought or with the Northeastern semi-arid began to be guided from the mid-1990s, when science realized that this expression no longer made sense, due to the nature of the phenomenon and the social and environmental effects (Alves, 1982). It is noteworthy, however, that this important SWT needs to be adopted and expanded for this region, as it allows increasing the water supply, with the same rainfall regime, a condition that makes it possible to fix the man in the field and, consequently, the coexistence in the semiarid (Almeida and Farias 2015). In this context, the main objective of this work was to analyze the main characteristics of the drought from 2012 to 2017 and to establish the alternative of coexistence in the geographical section of the cariri in Paraiba, Brazil.

MATERIALS AND METHODS

The work was carried out in the geographical section of the municipality of Sumé (07º40'18 "S, 36º52'48" W and altitude of 532 m), located in the intermediate geographical region of Campina Grande and immediate of Sumé, in the State of Paraiba (PB), Brazil, composed of eight municipalities, with a population of about 53 thousand inhabitants. The yearly rainfall data for the city of Sumé, PB, were extracted directly from the website of the Executive Agency for Water Management of the State of Paraiba (AESA), Campina Grande, PB, from 01/01/1931 to 12/31/2017. With the annual data, the rainfall regime was established, adopting the methodology of Almeida and Farias (2015). To characterize the drought period from 2012 to 2017, in that location, the annual rain anomaly (RA) criterion was adopted, in mm, which consists of calculating the difference between the observed rain value in each of that year, minus the annual median of expected rain (from the series), according to expression:

$$RA(mm) = \text{total observed rain (mm) - expected annual median (mm)}$$

To establish the category of drought, from that period, the Rain Anomaly Index (RAI) was used, whose methodological procedure is found in the article by Rooy (1965), rearranging the calculations after the positive chronological ordering of the anomalies and negative (RA), using the respective expressions:

$$RAI = 3 \times \left[\frac{(N - \overline{N}}{(\overline{M} - \overline{N})} \right], \text{ for positive anomalies of (RA);}$$

$$RAI = -3 \times \left[\frac{(N - \overline{N}}{(\overline{X} - \overline{N})} \right], \text{ for negative anomalies of (RA)}$$

Being:

N= observed rainfall (mm) (mm)

$\overline{N}$ = average rainfall (mm);

$\overline{M}$ = average of the ten highest values of rainfall (mm);

$\overline{X}$ = average of the ten lowest precipitation values (mm).

In possession of the RAI values, the types of droughts described by Araújo *et al*. (2009) were adopted, with some modifications, as follows: a) in possession of the RAI values, the types of droughts described by Araújo *et al*. (2009) were adopted, with some modifications, as follows: extremely dry (RAI <- 4,0), very dry (-4,0 =< RAI <-2,0) and damp (0,0 =< RAI < 2,0). To estimate the volumes of rainwater catchment (VPCAC) and required water (VNEC), for residential catchment area of 100 m^2 and for families with two, three and four people, were calculated according to the equation and procedures recommended by (Almeida and Farias, 2015). To prove the main effects of the drought from 2012 to 2017, in the territorial section of Sumé, PB, Brazil, the percentages of water stored in the Sumé reservoir (http://www.aesa.pb.gov.br/monitoramento) and the livestock sector (https://www.ibge.gov.br/ cidades-e-estados). Calculations, statistical analysis and making of tables, tables and graphs were made using the Excel spreadsheet.

RESULTS AND DISCUSSION

Main characteristics of the rainfall regime and droughts in northeastern Brazil: Knowledge of the main characteristics of the local rainfall regime is necessary for water and environmental planning and the basis for the management of water resources, with their respective applications, from electricity generation to water supply, for potable and non-potable purposes and agricultural production. In the annual rainfall distribution model, it appears that the mean value differs from the median, that is, that there is no asymmetry. This condition recommends the use of the median, which agrees with the indications made by (Almeida and Cabral Júnior, 2014). Drought in northeastern Brazil is not a new phenomenon, dating from the 16th century, in the first records made by the Portuguese Jesuit priest Fernão Cardim, around 1587, when he collected three of his texts, between 1548? - 1625 (Cardim, 1925). With the evolution of scientific knowledge, drought can be classified into at least four types: agricultural, meteorological, hydrological and socioeconomic, whose monitoring requires indexes in time and space scales. It is agreed with the report by Wilhite (1985) that the meteorological drought, for example, results from a deficit of rainfall, that is, when the amount of rain accumulated in a period is below the climatologically expected value. However, scientific studies on the problem of drought began in the second half of the 19th century, when the occurrence of prolonged droughts put population and economic activities at risk. These studies corroborate Silva (2008), when trying to discover and explain the natural causes of the drought phenomenon in the Northeast, although he had a partial vision for fragmented solutions to combat drought and its effects. It is agreed with Carvalho (1988), that the implementation of "public drought policies" only started after the recognition by governments that the majority of public policies practiced in Northeast Brazil, in the last century, were formulated in the scope of combating droughts and not about living with it.

There is no doubt that droughts affect society and environmental conditions in the semi-arid region, not only agricultural and economic activities, but also because of the lack of water, both for water supply and for human consumption and animal consumption, in urban and rural areas.

Rainfall indicators for the 2012/17 drought in the territorial area of Sumé, PB: For this temporal fraction (2012/17), Figure 1 shows the indicators of annual anomaly of the rain observed year by year in relation to the expected (median of the series) and their respective drought categories.

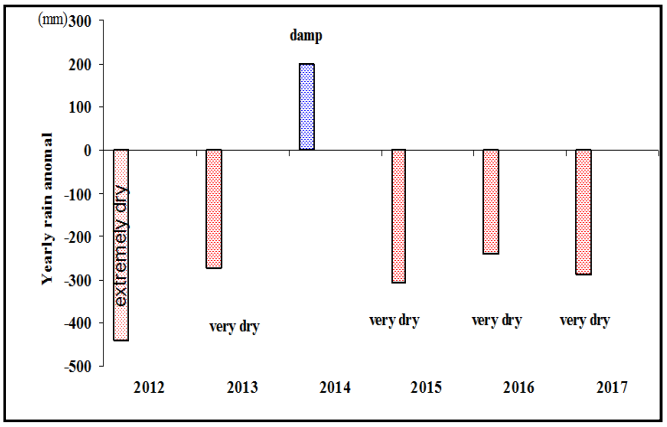

Figure 1. Yearly rain anomaly and the respective drought categories, in Sumé, PB, Brazil

Of the seven years analyzed, which constitutes the last drought period, in the aforementioned geographic cut, it is visible that most of the rain deviations were negative, that is, it rained less than expected, except in 2014, whose type of drought was damp. The time elapsed between 2012 and 2017, it is observed that the largest rainfall deficit occurred in 2012, with 439.0 mm, that is, 439 liters of water were not allowed to enter each m^2 of area. That year, the most severe drought category was recorded. It is noteworthy, however, that in the seven analyzed dwarfs, the categories of droughts predominated, classified as severe drought (very dry) and only in 2014, it presented a small surplus, being considered by a light drought (dump). The accumulated RA indicators allowed us to state that there had been a rainfall deficit in the order of 1300 liters per m^2, a value equivalent to two and a half times the expected median.

Evidence of the effects of the 2012/2017 drought: One of the biggest problems facing the Northeast region of Brazil is that of droughts and/or droughts. These two conditions directly influence water supply and the main agricultural activities, which generate jobs and income. The Sumé public weir (Figure 2) is the main reservoir to supply water to the city and the immediate geographical region of Sumé.

Figure 2. Spatial view of the Sumé federal public weir, Paraiba, Brazil

To prove the effects of drought, Figure 3 shows the percentages of water volume stored in the Sumé weir, during the drought period from 2012 to 2017, counted year by year for the first month (January) and last (December) of the years analyzed. The graphical representation of said Figure 3 shows a continuous decrease in the volume (percentage) of water in the reservoir over these seven years, reaching a minimum level, in January 2017, below the recommended technical volume.

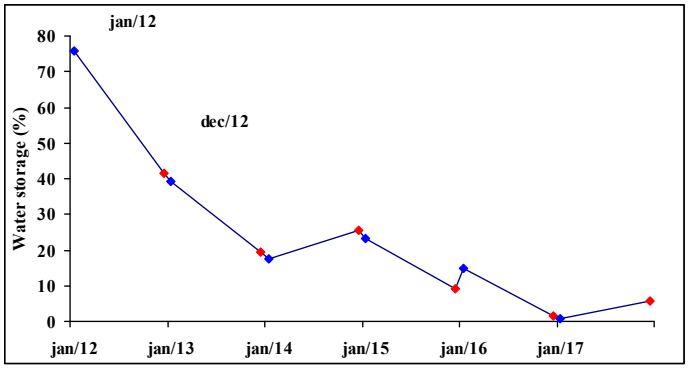

Figure 3. Percentage of volumes of water stored in the Sumé reservoir, PB, Brazil

As can be seen (Figure 3), the Sumé Weir had a volume in excess of 34 million m^3 in January 2012, corresponding to 76.0% of the maximum volume (44.8 million m^3). Excluding some small rainfall, from January 2012 to December 2013, the percentage of storage was 19.5% and the rate of decrease was 28.25% per year, that is, it lost 33.1 million m^3. If the Sumé dam is the main reservoir, with this drought the continued decrease in the level of stored water, the spring did not have water to supply the population of the Immediate Geographic Region of Sumé. Therefore, there is a need for alternatives to increase the supply of water for drinking purposes and other domestic activities, especially for those who live in the countryside, using social water technologies. With the advent of drought, the situation has worsened, considering that dairy farming is the main generator of employment and income. Figure 4 shows the effect of drought on the reduction in the numbers of the herd (cattle, goats and sheep) in that municipality.

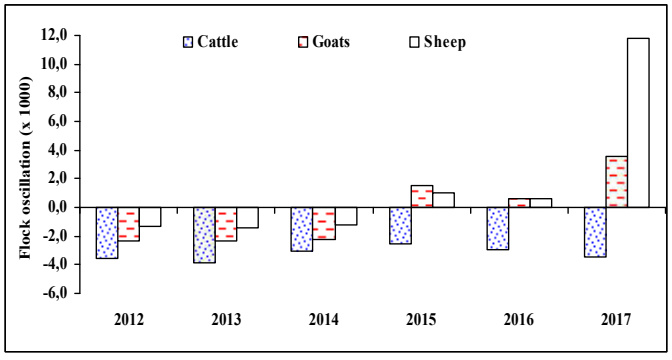

Figure 4. Oscillation of cattle, goats and sheep in the municipality of Sumé, PB, Brazil

It is observed (Figure 4), in the 2012 drought, for example, there was a reduction in the herd of more than seven thousand heads, equivalent to 3.6 cattle, 2.3 goats and 1.6 sheep. Without resources to maintain the herd, as of 2015, the producer opted for small port animals (goats and sheep), with an average increase of 1900 and 4500 heads and an average decrease in the number of cattle, in the order of 3200 animals. The results presented here show the effects of drought only in the activity related to the livestock sector, as these are the main responsible for the fixation of the man in the field, for the

generation of employment and income of the Sumé territorial area. These extreme environmental conditions reflect, in all social and economic aspects of the population. In this context, it is proven that in order to continue living in this environment, social water technologies are needed, especially those for capturing rainwater, as this is the main or only technological alternative that makes it possible to increase water availability, with the same rain regime.

The alternative of catchment rainwater: The premise of country life has been much romanticized for millennia, especially in the West. However, living in the rural area has always offered less opportunity for development, especially in the Northeastern Semi-arid region, as there is difficulty in water even for human consumption and animal desendentation. In most rural dwellers, rainwater harvesting is the main or the only alternative to increase water supply, not only for drinking purposes, but for use in small family production. The use of rainwater, as it is one of the simple and inexpensive solutions, can help in the preservation of drinking water, also bringing the benefit of reducing runoff and minimizing problems with floods. Figure 5 shows the potential volume of rainwater catchment (VPCAC), for three catchment areas (60, 80 and 100 m^2) and annual rainfall totals observed in the years 2012 to 2017, in Sumé, PB, Brazil.

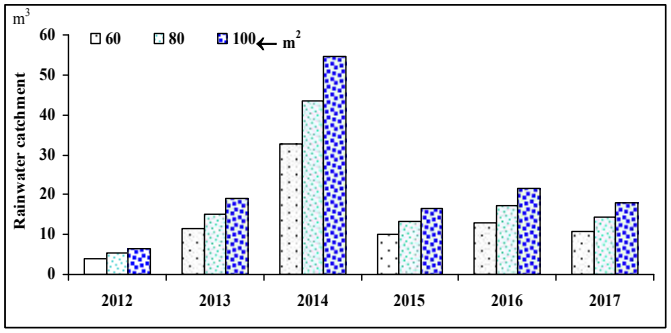

Figure 5. Potential volume of rainwater catchment (VPCAC), for three catchment areas, and total rainfall observed in the years 2012 to 2017

The graphical visualization shows very clearly that for the same amount of rain, the VPCAC is directly proportional to the catchment area, which shows that precipitation is the most important variable. Even during a long drought period (2012 to 2017), a catchment area of 100 m^2 (Figure 5), which may or may not be the residential roof surface, it is observed that the potential volumes of rainwater catchment were, most of them, above 17 thousand liters. In the hypothesis of a reservoir (cistern) with a capacity to store 54 thousand liters, for example, it would avoid losses of water captured in the rainiest years. It is observed that in 2014 (Figure 5), the catchment areas of 60, 80 and 100 m^2, captured rainwater volumes equivalent to 33, 44 and 54 thousand liters, that is, at least, twice the maximum capacity to store in standardized cisterns (16 thousand liters), obviously, underestimation in the volume of the reservoir provides a great loss of water, as there is no way to store. It is noteworthy, however, that the main objective of the One Million Cisterns Program (P1MC) is to improve the lives of families living in the Northeastern Semiarid, guaranteeing access to quality water, that is, water for human consumption. This program is similar to that of China, whose priority was also for human consumption. The annual volumetric relationships between the potential volumes of rainwater catchment (VPCAC) and the necessary ones (VNEC), for a family with three people and a catchment area of 100 m^2, applicable to the rain regimes of 2012/2017, are shown in Figure 6.

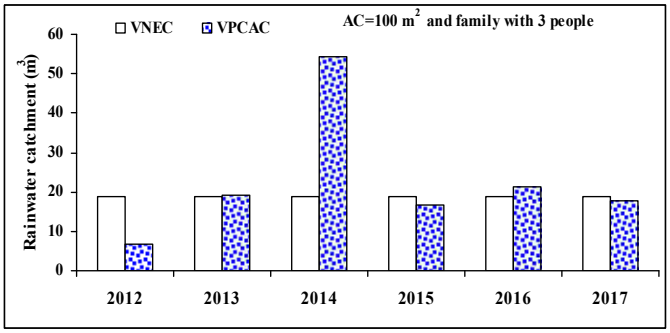

Figure 6. Relationship between the volumes of water required (VNEC) and of rainwater catchment (VPCAC), for families with three people and a catchment area of 100 m^2. Sumé, PB, Brazil

In general, VPCACs have always been higher than VNECs, for families with two people, in all years, except in 2012. These conditions show that rainwater harvesting is a viable alternative to offer water, even in the droughts. Maintaining the same conditions, but increasing a consumer (Figure 6), it appears that the VPCAC was greater than or equal to the VNEC in 2013, 2014 and 2016, although in the other years, the volumes captured were lower than necessary (VPCAC <VNEC). These results corroborate with the statements made by Almeida and Farias (2015), that the cisterns distributed by the Federal Government and other Institutions, were not adequately dimensioned in order to meet the needs of families, whether in urban or rural areas. If the cistern is a guarantee of family supply, obviously, its volume must meet the need for water for the purposes of human consumption and animal desendentation and for small production, which corroborates the reports of Brito *et al*., (2007).

Conclusions

Drought in northeastern Brazil is not a new phenomenon; it affects the environment, water supply and socioeconomic activities. The rainfall regime in the geographical section of Sumé, Paraiba, Brazil, is asymmetrical, irregular and the use of the median is recommended. The rain anomaly criterion and the respective index allow quantifying the magnitude and type of drought and its effects on the drastic reductions in the water level of the Sumé reservoir and in livestock activities. The efficiency of rainwater catchment is proven, even in the drought years, given that the volumes captured are sufficient to supply a family with at least two people. There is a need to adapt the size of the cistern to the local rainfall regime and the volume of water needed for family consumption and production, conditions that are necessary for local living together.

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