International Journal of Research in Geography (IJRG)
Volume 1, Issue 2, 2015, PP 32-37
ISSN 2454-8685 (Online)
www.arcjournals.org

Potential for Rainwater Catchment's as an Alternative for Human Consumption in Drier Micro-Region of the State of Paraiba, Brazil.

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Abstract: *Irregularities in rainfall distribution system in the semiarid Paraiba and the frequent droughts associated to the absence of appropriate public politics, hinder economic and social development, especially, of the micro-region more drought of the state of Paraíba, in northeastern Brazil. In view of this, it explains the need for rainwater catchment's as a way to increase the offer of water, being the estimate the main objective. For its realization, we used monthly rainfall series of the two driest locations of said micro region and based on the criterion of statistical climatology was established rainfall patterns and adopting six annual regime scenarios (median, the driest year and the rainier and levels of 25, 50 and 75 % probability). The statistical data analysis was done using frequency statistical distributions and measures of central tendency and dispersion. The main results showed that the rainfall regime is asymmetric, extremely variable and the short rainy season lasts about three to four months. Even so, there is a high potential of rainwater catchment's that makes possible to capture amounts of water that meet the demands of human consumption, animal consumption and small family farms.*

Keywords: *droughts, rainwater, water crises, rural cisterns*

1. INTRODUCTION

The water is an indispensable element to the life and, therefore, it constitutes of the largest social problems of the world, the availability of drinking water does not increase in proportion to population growth.

That still becomes worse more in the rural zone, where the lack of drinking water and food malnutrition are factors that most affect the population living in the countryside. Although those subjects are widely discussed for a long time, still do not have an alternative that allows increase offer of water that meets human consumption and small agricultural production.

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 [1].

That characteristic in the rain regime has been limiting the water supply, even for drinkable ends, and therefore for use in activities inherent in rural areas. This water insecurity prevents the expansion of family farming, man's survival in the field and raise levels of social inequality.

The difficulty of regular access the any source of drinking water is still a present situation in Brazilian social reality and, particularly, critic for the population that resides in the rural zone. It is pointed out, still, the importance of the technology of the reception of water of the rain, for referred those conditions, when associating the social technologies with the public politics that influence the citizens' life.

It is noteworthy; however, the importance of rainwater catchment's for diffuse ends, especially for people living in rural areas. Therefore, it is evident the need of investments, the search of the development, but hovering in water scarcity. However, to increase water availability, with the same amount of rains, can only be achieved using a catchment's area which enables collecting a volume of water needed to meet a demand for water that meets human consumption and animal, beyond the use on small family production [2].

During centuries the inadequacy of water or its scarcity at certain times, was identified as largely responsible for the socio-economic backwardness of the Northeast of Brazil, mainly, in its semi-arid portion. This situation caused the water to become a key resource and acquire an important status for the regional society.

These peculiarities require adoption of measures and alternatives of alternatives to maintain the man of the field in your habitat, without to degrade the atmosphere and to allow the harmonic coexistence to each other. Is tended in the potential of rainwater catchments the unique and/or the main alternative to living in this region.

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 [3].

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 [4]. The drought is a normal part of climate, rather than a departure from normal climate [5], although it is a natural catastrophe has very different from the other types of disasters.

In this context, the rain water catchment’s technique is an important alternative to leverage local development. Therefore, there was need to be considered the potential of reception of rainwater, as an alternative for human consumption in drier micro-region of the state of Paraiba, Brazil, being those determinations the objective principal of this work.

2. Materials And Methods

The work was carried out in the localities of Cabaceiras (7°29'20 "S, 36°17'14"W and altitude: 388 m) and Riacho de Santo Antônio (7°41'15" S, 36° 9'33' 'W and altitude: 440 m), located in the driest micro-region of the state of Paraíba, in northeastern Brazil.

It opted for an analytical and descriptive research. The analytical trends covered at work, refers to the implementation of rainwater catchments systems, as a civil society initiative aimed at coexistence with the semiarid region.

The rainfall data (monthly and year) were given up by the Executive Agency of Administration of the waters of State of Paraiba (AESA) for the period: 1962-2012. With based on these data it was applied descriptive statistical analysis.

The data of rains were analyzed using statistical climatologically criteria, frequency distributions and obeying will chronological sequence. Soon after, were determined the measures of central tendency (average and medium) and of dispersion (width and standard deviation).

The rainy season was considered one that presented in sequence the largest median values. Six sceneries were simulated with annual totals of rainfall equivalent to the driest year, the rainiest and the median period and at the levels 25, 50 and 75% probability and catchment’s areas (AC, in m^2) of 60 80, 100 m^2, for these sizes are the most frequently found in semiarid residences [6].

The potential volumes of rainwater catchment’s (VPRC, L) were determined for each condition and flow coefficient (Cf, dimensionless), by the expression 1:

$$VPRC\ (L) = \text{Rainfall patterns scenarios}\,(mm) \times AC\,(m^2) \times Cf \quad (1)$$

O required water volume (VWR) was determined according to the total number of people per family (NPF), catch daily consumption per person (CPD L) and the total number of days of use per year (NDU), calculated by equation 2:

$$VWR\ (L) = NPF \times CPD \times NDU \quad (2)$$

Rearranging the equations 1 and 2, there was obtained required catchment’s area (ACN, in m^2) using the equation 3

$$ACN\ (m^2) = \frac{VWR\ (L)}{rain\ (mm) \times Cf}$$

(3)The potential volume of reception of water necessary (VPN) was determined for each scenario rainfalls, using equation 4:

$$VPN\ (L) = \text{Rainfall patterns scenarios}\,(mm) \times AC\,N\,(m^2) \times Cf \quad (4)$$

The calculations, the statistical analyses, as well as, the making of the graphs, pictures and tables were made, being used a spreadsheet Excel.

3. Results and Discussions

The monthly averages of averages, medians and standard deviations of rain the places Cabaceiras and Riacho de Santo Antonio are irregularly distributed. The monthly averages August-September to January-February are below the respective standard deviations. When computed the year, these deviations are equivalent to about 50.0% of the arithmetic average.

Being compared the regime of distribution of rains of the referred places, it is verified that the monthly arithmetic averages of the series, besides they be different they are larger than the respective ones medium. It shows, however, that the "profile" of rainfall distribution is asymmetric and that the asymmetry coefficient is positive.

Same being the arithmetic mean, the measure of central tendency more used, it is not the most probable value to occur in this type of distribution. That indicates, therefore, the use of the median, instead of the mean, which agrees with the results found at other places in the semi-arid northeast by [7].

These results agree with those of [8] that in areas or places where the predominant climatic regions with a large interannual variation of precipitation, the statistical measure of normal is less meaningful than other measures, such as the range, median, or mode of the precipitation distribution.

With relationship to the rainy station, there is a sequence of months, with larger medium values, that begins in February-March and it finishes in April-May. Being quantified the percentile of rain in this period amounts to about 70.0% of the annual total. These results agree with found for other places of the state of Paraíba by [7] and a short rainy season in semi-arid northeast and droughts have severe human impact by [9].

The characterization of the monthly and annual rainfall patterns is the primary condition to estimate the potential volumes of rainwater catchment's (VPRC). The VPRC depends on the rainfall regime and the local catchment's area. Now, the required water volume (VWR) depends on the VPRC and total number of people per family, catch daily consumption per person and the total number of days of use per year.

In the rural areas, per capita consumption is also influenced by hygiene habit and the distance from source to the consumption place. In the ambit of that discussion, some authors mention about the need to establish a minimum value for the domestic supply of water, regarding the existence of differentiated values, varying between 14 and 50 L. $hab^{-1}.d^{-1}$.

The annual potential of rainwater harvesting, in $L.m^{-2}$, for five rain sceneries, to the places of Cabaceiras and Riacho de Santo Antonio are shown in Figure 1. Observed that referred annual potential is around 400 liters per m^2. The scenery with regime rainfall annual-minimum and maximum - it happens with a small a lot of probability of the order of 2%.

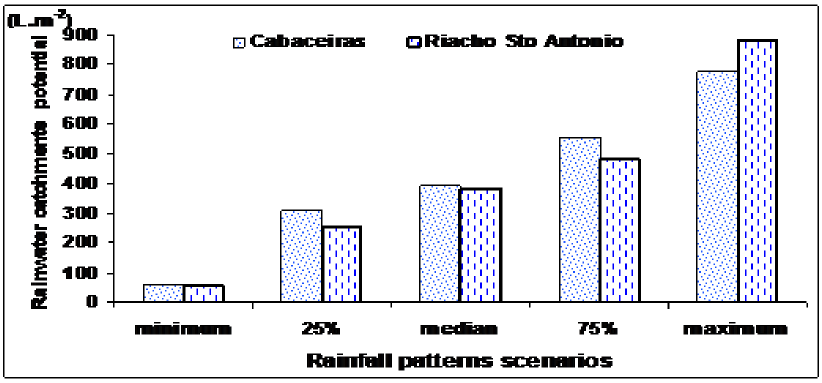

Figure1. *Annual potential of rainwater catchments, in $L.m^{-2}$, for five scenarios of rainfall patterns for the two driest locations of Paraíba, Brazil.*

The Figures 2 and 3 show, respectively, the potential volumes of rainwater catchment's, for five rainfalls scenarios and three catchments areas, to Cabaceiras and Riacho de Santo Antonio, located in one of the driest regions of the State of Paraiba, Brazil.

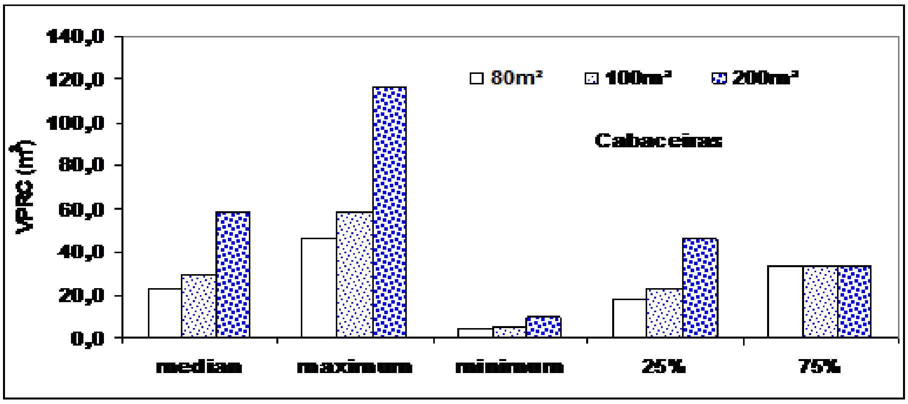

Figure2. *Potential volumes of rain water harvesting (VPRC), for five rainfall sceneries and three catchments areas for Cabaceiras, Paraíba, Brazil.*

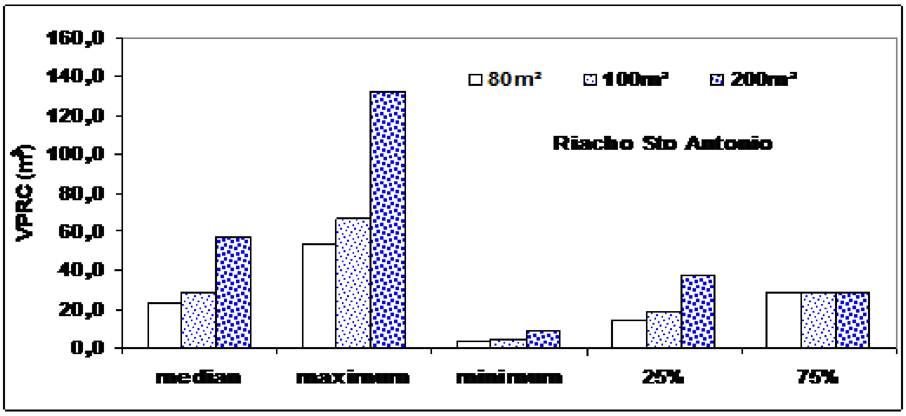

Figure3. *Potential volumes of rain water harvesting (VPRC), for five rainfall sceneries and three catchments areas for Riacho de Santo Antonio, Paraíba, Brazi.*

Being compared the first scenery of the pluvial regime (medium), to both places (Figures 2 and 3), it is observed that the potential volumes of reception (VPRC) they overcome 16 thousand liters, even, for the smallest reception area (80 m^2). THE volume of 16 m^3 is the value of reference of the Program One Million Cisterns (P1MC), considered to be enough to assist to the basic needs of a family with five people, for a period without rains of 240 days.

Comparing the first scenery of the rainfall regime (median) to both locations (Figures 2 and 3), it is observed that the potential volumes of capture (VPRC) exceed 16.000 liters, even for the smallest catchments area (80 m^2). This volume is the reference value adopted by the Brazilian government program, but is insufficient to meet the basic needs of a family with five people for a period of 240 days without rain.

The experience of rainwater harvesting for human consumption in Brazil, can be shared with that found in other countries such as South Africa [10], Australia [11] and India [12].

With relationship to the minimum condition, that it is equal to the scenery of the driest year of the series, the reception volumes are insufficient to supply with water a family with four people, to areas of lower receptions 200 m^2, in other words, it is smaller than 16 m^3. However, the chances of this minimum occurs is very small (less than 2%).

Being chosen the level of probability of 75%, that is equal to the chances of happening three years in a series of four, the VPRC range from 33.3 thousand liters in Cabaceiras against 29.1 thousand liters in Riacho de Santo Antonio. The different values of potential volumes of reception, for a same rainfall patterns, depend on the size of the reception area.Adopting a consumption captures diary of 30 liters of water per person, for the medium condition of rain, and for residences with 4, 6, and 10 people, the catchment's areas (ACN) and the volumes of water required (VWR), for Continuous

use of 240 days a year, are shown in Figure 4

It appears (Figure 4), the necessary volume of water increases exponentially in function of the user

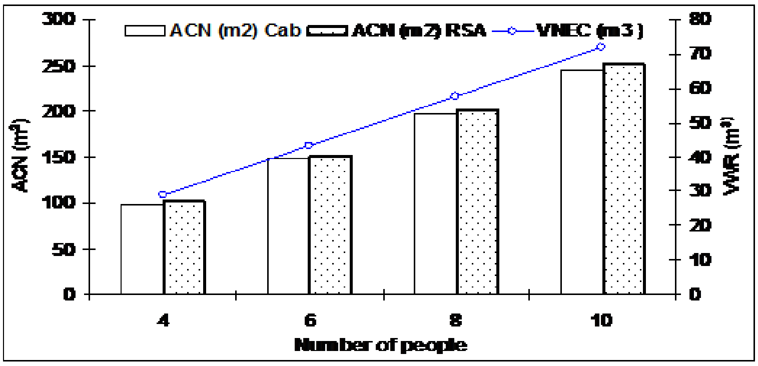

Figure4. *Relationship among the areas of catchments of rain water (ACN) and the water volumes necessary (VNEC), in function of the user number, for Cabaceiras (Cab) and Riacho de Santo Antonio (RSA), in the micro region more drought of Paraíba, Brazil.*

Therefore, to meet the demand for water in any rainfall patterns scenario, there is need to increase the area of catchments.

The Figure 5 summarizes the potential volumes of water required for the five scenarios of rainfall patterns, and family with four people.

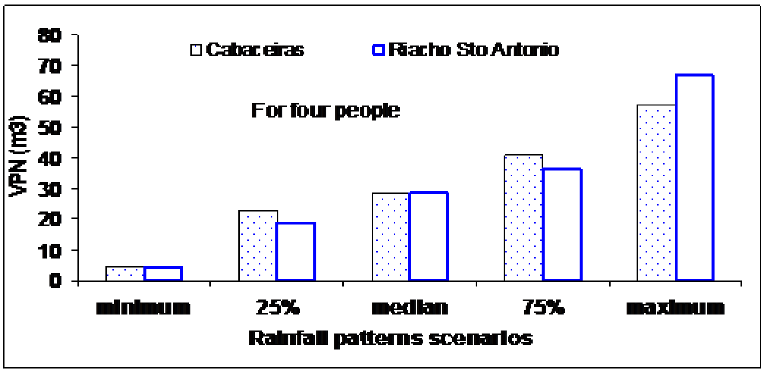

Figure5. *Potential volumes of water necessary for five sceneries of rainfall patterns, catchment's area of 80 m2 and use for 4 people, for the two places more drought in the state of Paraiba.*

In the scenery of happening an annual total of rain at the level of 25%, in other words, one year every four years, it is observed that the volume of water involved (VPN) is 23.000 liters to Cabaceiras and 19,000 liters to Riacho de Santo Antonio, values well above to the maximum volume of 16 thousand liters of the cisterns, standardized in the Program of a million Cisterns (PM1C), for the Brazilian government. Obviously, the median condition, that it is the most probable of happening, the volume of the cistern needs must be greater. Thus, there is need to scale a volume of the cistern in function of rainfall regime and the quantitative need for consumption and not to set a single volume.

4. Conclusions

The rainfall regime of the richest locations of Paraíba is extremely variable and asymmetric. The short rainy season lasts about three to four months. Still, there is a high potential for rainwater harvesting, which enables capture an amount of water needed to the demands of consumer and small family farms.

The plate's cisterns "standardized" by the Brazilian government, with a fixed volume of 16 thousand liters of water are under or over reservoirs sized for the volume of water abstracted depends on local rainfall patterns, the size of the catchment's area and the number of users and/or volume of water required.

The rural community understands that the cistern is an important social technology for the local development, besides being a social structure, politics and economical that should be associated to the public politics.

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