



13th World Water Congress, Montpellier, France
Domaine de Lavalette - 859 rue Jean-François Breton - 34093
Montpellier CEDEX 5 - France

POTENTIAL OF THE RAINWATER IN THE AREAS OF NORTHEAST CLIMATE SEMI-ARID OF BRAZIL

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ABSTRACT

The access to water is historical in Brazil, but the problem is more emblematic in the Semi-arid states. In general the populations that do not have access to water, is higher in the North (23.3%) and Northeast (56%) of the country. The Brazilian Northeast Region shows great climatic variability. In the Semi-Arid region of Brazil, approximately, 18 million people live in an area of about 870 thousand square kilometers and that includes the north of the States of Espírito Santo and Minas Gerais, the sertões of Alagoas, Bahia, Ceará, Paraíba, Pernambuco, Piauí, Rio Grande do Norte, Sergipe and southeastern part of Maranhão. The State of the Maranhão is located in the Northeast Region of Brazil, between the coordinates 01°01' 10°21' lat. S and 41°48' 48°40' long. W. It includes an area of 329,555. 8 km², delimited in the north by the Atlantic Ocean, the east by Piauí, in the south and southwest by Tocantins and the northwest by Pará.

This State is located in a humid transition area in the semi-arid climate of the interior of the northeast, the equatorial areas of the Amazo are reflected by the vegetal transition covering of the Savannah (Open pasture) in the south, to the Forests You may camp in the center and the eastern part and in the northwest, Ombrófila Forest.

(The main goal of this study is: evaluate the viability of captation of rainwater in the Southeastern part (Semi-arid) of the State of Maranhão.

It used to be divided in periods of: dry, normal and humid years; and analyses of probability of the total annual precipitation. Of these, the expected values of occurrence is inferred for the years whose precipitations are considered normal (around the average) or droughts (below the average). The expected values were estimated using normal distribution of probability, by means of Quantiles.

The criterion of choice for the normal distribution is based on the secular precipitation series. It shows a good tack to this model, it denotes similar occurrences, probabilistic of humid years (above of the normal climatology) or dry (below of the normal climatology).

Usually, the frequencies to delimit humid or dry years are placed in the quantiles of 75 and 25%, respectively, of probability and non excedence (Prob (Prec < p); being changeable Prec= "annual average Precipitation", and p = given value of annual total precipitation). Results show, that exactly in dry years, most critical areas of the State need only 35 m² of area of roof capitation.

It is necessary to try to solve the water problem so that it does not affect all the segments of the society in the semi-barren areas in the same way.

Key words: rainwater, semi-arid, Brazil.

INTRODUCTION

Water, the primary source of life for the human being, each year, becomes more scarce. The problem of access to water is historic in Brazil, and in the Semi-arid states the problem is more emblematic. According to IBGE data, 2000, 42.12% of the children and adolescents who live in the Brazilian semi-arid, have no access to the usual water networks, wells or springs at home or nearby. The national index is that 17.3% of children and adolescents have no access to water. The populations in general that do not access to water is greater in the North (23.3%) and Northeast of the country (56.0%). These indices increased in the interval from 1989 to 2000, when the North had 21.7% and the Northeast 50%. This verification, is in the National Research on Basic Sanitation, elaborated by the IBGE.

Regarding climatic conditions, the Brazilian Semi-arid is characterized by having a negative hydraulic register, whose mean annual pluviometric precipitations are equal or inferior to 800mm, evaporation 2,500mm per year and mean annual temperatures of 23° to 27°, with occurrences of periodical droughts, all of which determine the favorable outcome of the agriculture and cattle breeding and principally, the survival of the families (Moura,et al, 2007a and 2007b).

In Maranhão there are 45 municipalities in an approximate area of 96,000 km², with a population of 1,150,000 inhabitants. These municipalities have the worst indices and are among the poorest cities of the state.

From the hydraulic point of view, only a small part of the Semi-arid region is known to have a mean annual pluviometric precipitation inferior to 400mm. In all the Semi-arid, this average increases to 750mm per year. However, there is still a poor distribution of the rain in time and space. To the contrary of what has been thought in past years, it is not only droughts that are responsible for the disparity in the distribution of water, but also the lack of public policies and utilization of hydraulic resources. However, it is social mobilization in the Semi-arid states that has contributed to changing this situation.

In 2000, the Convivial Program was implemented and is being carried out in the Semi-arid-CPSA, which intervenes in the realities of the families by using diverse actions: hydraulic resources, appropriate production, contextualized education, management of naturally degraded areas, feeding safety etc. One of the principal programs is the PIMC- Program for a Million Cisterns, developed by the Articulation of the Semi-arid (ASA Brazil) in the communities.

From what has been disclosed, the objective of this study is to evaluate the capitation of rain water in the State of Maranhão in accordance with the mean annual precipitation and the frequency of drought occurrence.

MATERIAL AND METHODS

Region under study

The State of Maranhão, localized on the north coast of Brazil, is bound in the North by the Atlantic Ocean, it has a coastal extension of 640km in the East and a boundary with the State of Piauí in the South and in the Southeast with

the State of Tocantins and in the West it borders with the State of Pará, the predominant climate in the State is tropical.

Its relief presents two distinct regions, that include a coastal plain and tabular high plain. The coastal plain is formed by shallow lakes, tabular and extensive beaches. The great sand dune extensions and sculpturally carved out stretches of coastline, are highlighted, especially where they form the São Marcos and São José bays. The rest of the region is composed of high plains that form flat topped ridges that are called mountain ranges. In the Northwest part of the State, there is the so called Maranhão Amazon, which is characterized by forestry vegetation and equatorial climate. The rivers that bathe the State of Maranhão, in the majority, belong to the North and Northeast basins that occupy an area of 981,661.6km². It is made up of the Parnaíba river which is the biggest river of those that bathe the State of Maranhão and the Gurupi and Grajaú rivers which are localized on the border with the State of Piauí. The Tocantins river flows to the South, and delimits a large part of the border of Maranhão with the State of Tocantins. The Mearim, Itapecuru, Pindaré and Turiaçu rivers still stand out as the most important rivers of the State

Material used

In this work, data of historical precipitation series and georeferenced data bases were used, that were obtained from organs such as the Development Company of the São Francisco Valley- Codevasf, National Agency for Electric Energy-ANEEL, the National Water Agency-ANA and the Federal University of Campina Grande-UFCG. The georeferenced municipality and state bases were obtained from the Brazilian Institute of Geography and Statistics-IBGE.

Figure 1 shows the points and the names of the pluviometric stations used in this study.

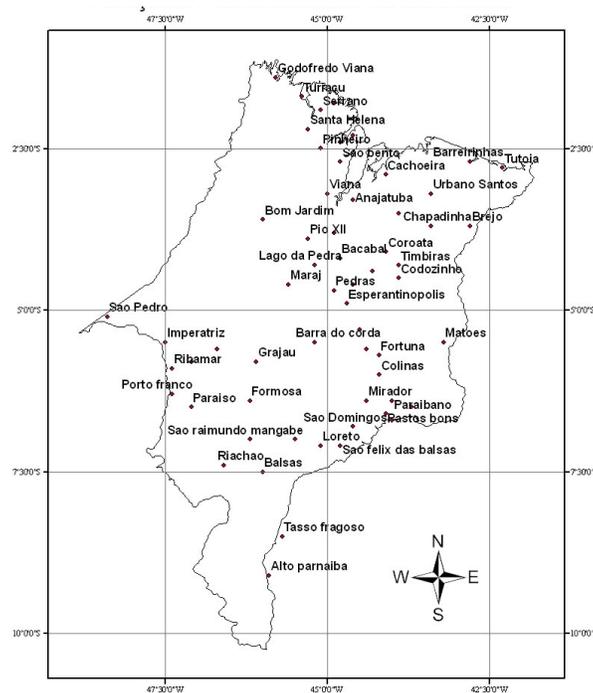


Figure 1- Spatial localization of the Pluviometric stations

Methods

The analyses of probability were realized by the annual totals of precipitation. From these, the expected values of occurrence were deduced of the years whose precipitations are considered normal (around the mean) or drier (below mean). The expected values were estimated using the normal probability of distribution, by means of Quantiles. The criterion for the choice of normal distribution worked well, due to the fact that the temporal series of precipitation shows a good adherence to this model, which denotes, probabilistically, similar occurrences, of humid years (above normal climatology) or dry (below normal climatology), as demonstrated in Galvncio et al,(2005;2006) and Moura et al. (2007).

The calculation of the captation area was carried out as proposed by Silva et al. (1998), in accordance with the model presented below:

$$Ac = \frac{VT}{C \times Pm} (m^2) \quad (1)$$

In which: VT is the total volume of water stored in cistern, equal to 16m³, according to the PIMC, in m³; C is the superficial drain off coefficient, estimated at an 0.70 dimension; P is the mean annual precipitation (mm), of the dry years.

RESULTS AND DISCUSSION

Figure 2 shows the annual mean precipitation (AMP) in the environment of the State of Maranhão. It is to be noted that the AMP decreases from 2400 to 700mm. The area with less precipitation is around the municipalities of Presidente Dutra, São Domingues do Maranhão, Fortuna, Colinas, Mirador and São Félix das balsas, this precipitation is approximately 1000mm, as can be seen in Figures 1 and 2.

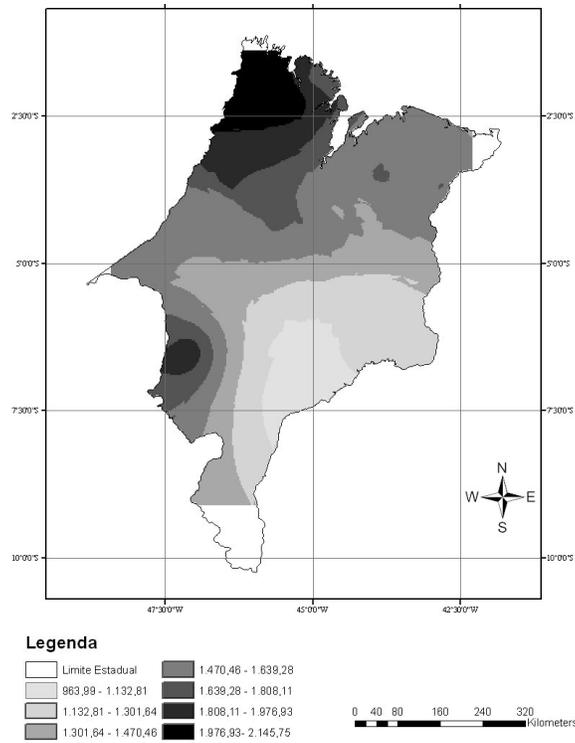


Figure 2 – Annual mean rainfall

Annual rains: Maximum/Medium/Droughts

The analyses of probability are in the annual totals of precipitation. These totals are inferred for the expected values of humid, normal and drier years of occurrence. The temporal series show a good adherence to the Normal Distribution, which probabilistically denotes similar occurrences in humid years (above normal climatology) or dry years (below normal climatology).

Figure 3 shows the annual mean totals of dry years. It is to be noted that in normal years the AMP in the environment of the State of Maranhão varies between 600 and 1900mm.

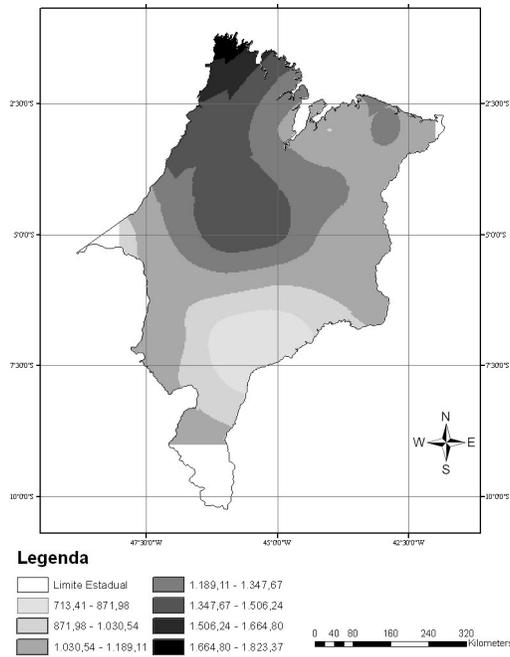


Figure 3 – Mean precipitation in dry years

Figure 4 shows the total annual averages of normal years. It is to be noted that in normal years the AMP in the environment of the State of Maranhão varies between 950 and 2200mm

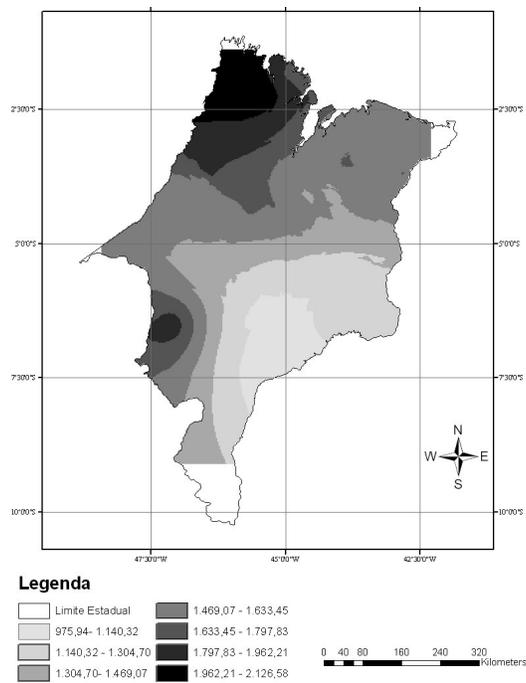


Figure 4 – Mean annual precipitation in normal years

Figure 5 shows the total annual averages of humid years. It is to be noted that in humid years the AMP in the environment of the State of Maranhão varies between 1200 and 2600mm.

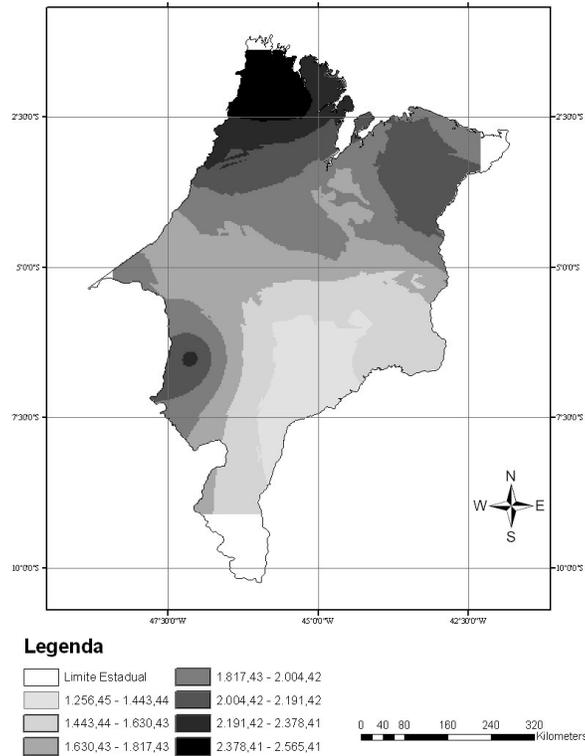


Figure 5 - Annual mean precipitation in normal years

Figure 6 shows the area of captation that is necessary for filling a 16m³ cistern in the environment of the State of Maranhão, in dry, normal and humid years. It is to be noted that in dry years, areas of captation of around 30m² are necessary and in normal years areas of 20m² and in humid years, areas of around 15m² are necessary.

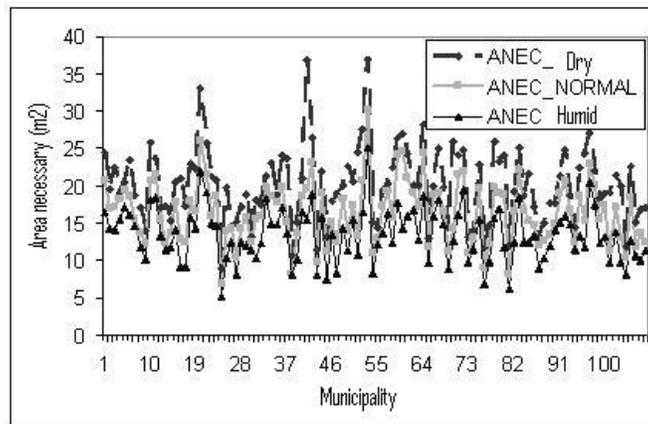


Figure 6 – Areas of captation necessary for the State of Maranhão, in dry, normal and humid years

Risk of drought in the State of Maranhão

Figure 7 shows the frequency of droughts in the State of Maranhão. It is to be noted that the area belongs to the polygon of droughts and besides presenting lower AMP it has areas that present greater frequencies of droughts in around 28% of the years. So, this area presents a greater risk of droughts.

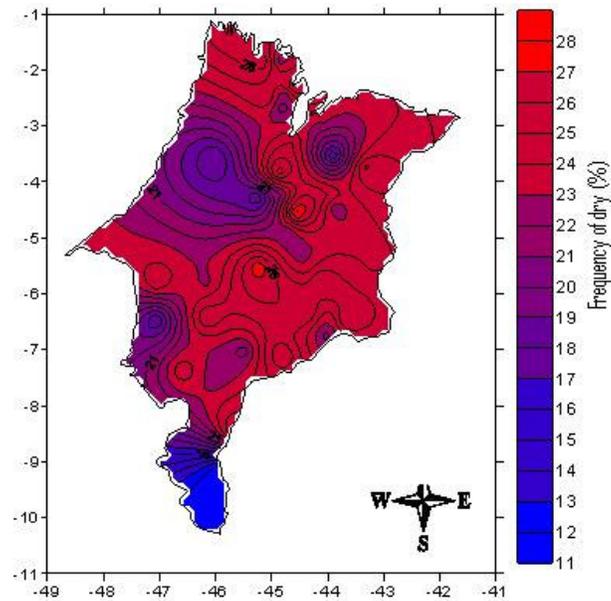


Figure 7 – Frequencies of drought in the State of Maranhão

Figure 8 shows the areas of captation that are necessary for filling a 16m^3 in the State of Maranhão. It is to be noted that in the polygon drought area a captation area of around 30m^2 is necessary.

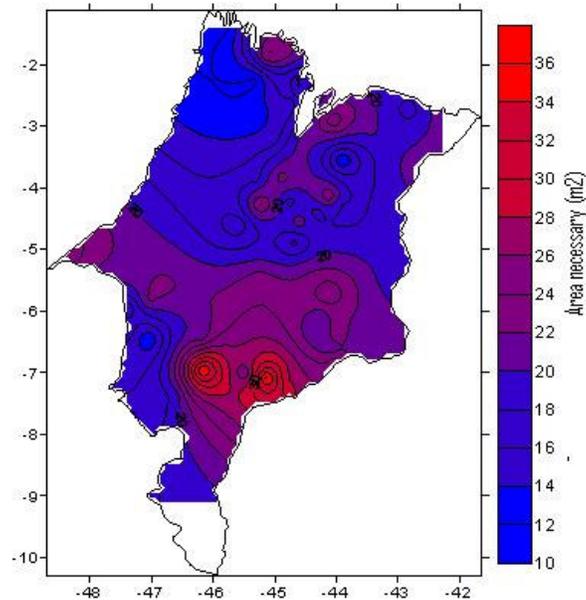


Figure 8 – Areas of captation necessary for the State of Maranhão

CONCLUSION

Precisely in dry years, the most critical areas of the State only need a 35m² of roof captation. It is necessary to try to solve the problem so that water scarcity does not affect all the segments of society, that means, of course, the inhabitants who live in semi-barren regions.

REFERENCES

Articulação no Semi-Árido Brasileiro - ASA. **Programa de formação e mobilização social para a convivência com o semi-árido: um milhão de cisternas**. Disponível em <<http://www.asabrasil.org.br/p1mc.htm>> Acesso em 10 abr. 2006.

BRASIL,. Ministério da Integração Nacional. Ministério do Meio Ambiente e Ministério da Ciência e Tecnologia. **Portaria Interministerial N^o.1**, de 09 de março de 2005. Diário Oficial, Brasília, 11 de março de 2005.

Brasil. Ministério da Saúde. Portaria N^o. 518, de 25 de março de 2004. **Diário Oficial**, Brasília, 26 de março de 2004. Seção 1, p. 266.

Galvêncio, J. D.; Souza, F. A. S.; Moura, M. S. B. **Aspectos climáticos da captação de água de chuva no estado de Pernambuco**. Revista de Geografia. DCG/UFPE, Recife, v. 22, n. 2, p. 15-35, 2006.

Galvêncio, J. D.; Ribeiro, J. G. Precipitação Média Anual e a Captação de Água de Chuva no Estado da Paraíba. Simpósio Brasileiro de Captação e Manejo de Água de Chuva, 5. **Anais...** Teresina: ABCMAC. 2005. CD-room.

IBGE. **Malha Municipal Digital do Brasil**. Rio de Janeiro – RJ. 19p. CD-room. 2000.

Moura, M. S. B. de.; Galvinctio, J. D.; Brito, L. T. de L.; Silva, A. de S. Sá, I. I. de; Leite, W. de M. **Influência Da Precipitação Pluviométrica Nas Das Áreas De Captação De Água De Chuva Na Bahia**. 6^o. *Simpósio Brasileiro de Captação e Manejo de Água de Chuva Belo Horizonte, MG, 09-12 de julho de 2007a*. Cd-ROM.

Moura, M. S. B.; Galvinctio, J. D.; Brito, L. T. de L. **Clima e a água de chuva no Semi-Árido**. In: Potencialidades de água de Chuva no Semi-Árido brasileiro/org. Luiza Teixeira de Lima Brito/Magna Soelma B. de Moura – Petrolina, PE: Embrapa Semi-Árido. 2007b, vol. 01, p. 37-59.

Rebouças, A. da C.; Marinho, M.E. **Hidrologia das secas – Nordeste do Brasil**. Recife, PE. SUDENE/DRN, 1972. 126 p. (Brasil. Sudene. Série Hidrogeológica, 40).

Silva. A. de S.; Brito, L. T. de L; Rocha, H.M. **Captação e conservação de água de chuva no semi-árido brasileiro: cisternas rurais II; água para consumo humano**. Petrolina, PE: EMBRAPA-CPATSA, 1988. (EMBRAPA-CPATSA. Circular técnica, 16).