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Water Balance Comparison Between 2000-2016 and 2016 and Its Influence of Water Storage in Soil in The Semiarid of Pernambuco State, Brazil

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ABSTRACT

Water planning is the basis for any form of integrated management of water resources. The balance on the water deficit or increase can reduce production and/or product quality, while excess irrigation, in addition to losses of water and energy, can contribute to the leaching of nutrients and agrochemicals into the layers from the ground or even reaching the water table. The objective of this study was to perform and analyze the calculation of the water balance by the Thornthwaite and Mather method (1948, 1955) between the period 2000-2016, and its comparison with the year 2016, to verify the water deficit and the influence of storage of soil water, in the municipality of Serra Talhada, in the state of Pernambuco, Brazil. The average monthly precipitation data was provided by the Agência Estadual de Águas e Clima de Pernambuco - APAC. The software was used in electronic spreadsheets to extract monthly and annual averages, plotting their respective graphs and trends. The temperature data were estimated by the software Estima_T. The meteorological elements studied here and discussed show that abrupt changes occurred and that inhabitants should change tactics in the future to plantings, water storage, and survival conditions. Even more specific future studies should be taken into account to better visualize how transient systems and local effects will affect rainfall variability and ETP and EVR. The tendency of temperature increase and evaporative indices may cause extreme events of short time and high-intensity precipitation.

INTRODUCTION

The seriousness of preparing the Water Balance (WB) for a given region is related, for example, to the economic viability of planting grain and controlling sowing times, constituting a strategy for planning and the development of programs, mainly with a focus on sustainability.

The WB makes it possible to establish the wettest period and quarter, in which farmers will plan to take advantage of the rains and plant their dry land, thus helping to reduce the use of water from the water table and reservoirs.

In arid and semiarid regions, the inadequate use of irrigation can also lead to soil salinization. On the other hand, through proper planning and management, can be determined the amount of water in a crop, which implies studies of soil surveys, climate, and cultural factors.

Water planning is the basis for dimensioning any form of integrated management of water resources, thus, the water balance allows knowledge of the need and availability of water in the soil over time. The water balance as a management unit allows classifying the climate of a region, carrying out the agroclimatic and environmental zoning and the period of availability and water need in the soil, in addition to favoring the integrated management of water resources (LIMA, 2009).

A study by Medeiros et al. (2012) for the municipality of Picuí, Paraíba state of Brazil, indicates that rainfall rates will not be sufficient for various types of crops, which makes rainfed cultivation unfeasible if the pessimistic scenarios are confirmed. The author also warns that, given a pessimistic scenario, the condition for storing rainwater for human consumption and the animal will suffer significant impacts, requiring, therefore, planning to cope with the drought through the construction of cisterns and other similar, which enable the storage of water and minimize the impacts of lack of rain.

Medeiros (2016) performed the calculation of the monthly WB for the municipality of Matinhas, Paraíba state of Brazil, with a view to citriculture planning. The WB resulted in eight months (August to March) of water deficit with a cumulative total of 354.5 mm, with a water surplus in June and July, evapotranspiration 32% above the rainfall, and with the annual real evaporation in the order of 906.7 mm.

The objective of the present work is to perform and analyze the computation of the Water Balance by the method of Thornthwaite and Mather (1948, 1955) in the period 2000-2016, and its comparison with the year 2016, to verify the water deficit and the influence of the water storage in the soil in the municipality of Serra Talhada, Pernambuco state of Brazil.

MATERIAL AND METHODS

The study area comprises the municipality of Serra Talhada (Figure 1), located in the semiarid region of Pernambuco state, Brazil. It is in the territory of Pajeú, Sertão mesoregion of the state. It is located at the geographic coordinates of latitude 07° 59' South and longitude 38° 17’ West, with an average altitude of 429 m.

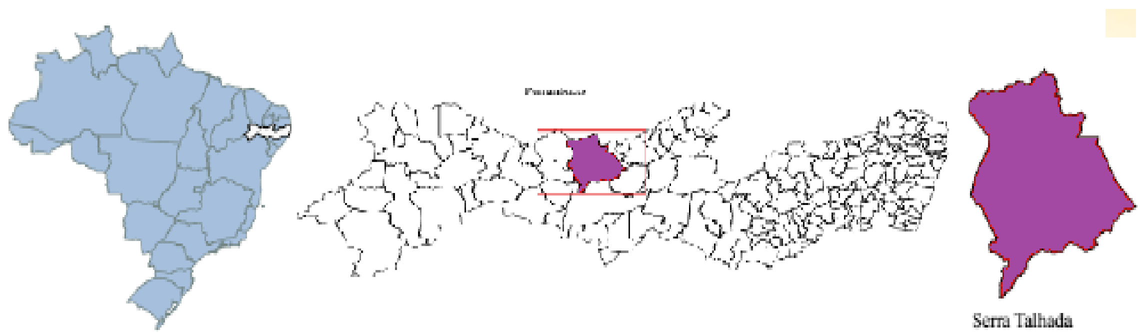

Figure 1. Location of Serra Talhada municipality, in the Pernambuco state of Brazil.

Source: Medeiros (2022).

The rainy season starts in February with pre-season rains (rainfalls that occur before the rainy season) and ends at the end of August and may last until the first half of September. The rainy quarter focuses on April, May, and June and its dry months occur between October, November, and December. The factors causing rainfall in the municipal area are the contributions of the Intertropical Convergence Zone (ITCZ); formation of high-level cyclonic vortices (VCAS); contribution of northeast trade winds, in the transport of steam and moisture which condense and form clouds, causing moderate to heavy rains; formation of lines of instability; orography; heat Exchange; and their local and regional contributions (MEDEIROS, 2016).

According to the climate classification by Köppen (1928), Serra Talhada has the AS Tropical Rainy climate, with dry summer. This classification is by Alvares et al. (2014). Regarding the soils, in the gently undulating relief, there are Planosols, poorly drained, medium natural fertility and with salt problems; tops and high strands, predominate Non-calcic Bruno soils, being shallow and high natural fertility; tops and high slopes of the undulating relief predominate Podzolic, drained and medium natural fertility; and in residual elevations are the Litholics, shallow, stony soils and medium natural fertility.

The interstitial domain is composed of sedimentary rocks from the Alluvial Deposits, Colluvium-eluvial Deposits, Tacaratu Formation and Mauriti Formation. The Fissural Domain is composed of crystalline basement rocks that encompass the metamorphic rocks subdomain consisting of the Serra do Olho D'água Formation, Riacho da Barreira Complex, Recanto-Riacho do Forno Suite, Salgueiro-Riacho Gravatá Complex, São Caetano Complex and Complex Serra de Jabitacá; and the igneous rocks subdomain of the Calcialkaline Suite Itaporanga, Suite Meruoca, Suite Prata, Suite Salgueiro-Terra Nova, Suite Triunfo, Suite Conceição Suite Xingó and Granitoides.

The vegetation is composed of Hyperxerophilic Caatinga with stretches of Deciduous Forest.

The monthly average precipitation data were grouped, characterizing a period of climatological normal for the period 2000-2016, where the software was used in electronic spreadsheets, to extract the values of monthly and annual averages, plotting their respective graphs and trends. These data were provided by the Agência Estadual de Águas e Clima de Pernambuco (APAC, 2018).

The temperature data were estimated by the Estima_T software (Cavalcanti et al., 1994; Cavalcanti et al., 2006) and is available on the website of the Unidade Acadêmica de Ciências Atmosféricas da Universidade Federal de Campina Grande (UFCG) http://www. dca.ufcg.edu.br/download/estimat.htm.

The method of Thornthwaite (1948) and Thornthwaite et al. (1955) was used to calculate the climatological water balance on a monthly scale for the study area, that is, the cyclical water balance (WB), elaborated from the climatological normals of temperature and precipitation average. This technique is the most used to work with global water balance data, from a climatological point of view, through accounting for the natural supply of water to the soil, through rainfall (P), and atmospheric demand, through potential evapotranspiration (ETP), considering a maximum possible level of storage. The water balance provides estimates of actual evapotranspiration (EVR), water deficit (DEF), water surplus (EXC), and effective soil water storage (ARM), which can be elaborated from the daily to the monthly scale, according to Camargo (1971).

The available water capacity (CAD) representative of the soils found in the study region was used in the WB calculations. The CAD's worked in the study were 100 mm to verify irrigation with monitored water deficit and the influence of water storage on the ground. For the WB calculations, electronic spreadsheets developed by Medeiros (2017) were used.

RESULTS AND DISCUSSIONS

Table 1 shows the evaporative variability followed by its water deficiencies and surpluses for the period 2000-2016 and its comparison with the year 2016.

The evapotranspiration of the decade was higher than that of 2016 throughout the period, with an annual total of 1501.8 mm, while in 2016 the total was 912.9 mm. The decadal evaporation flowed above the year 2016 throughout the period, except for June and September, with an annual total of 601.9 mm in the decade, and 404.4 mm in 2016.

There was no water surplus in the decade, while in 2016 there was a surplus of 13.1 mm in March. Water deficiencies were registered between March to January in the 2000-2017 decade, while in 2016 there was no deficiency in January and March.

Table 1. Data from the decade 2000-2016 and the year 2016 for the municipality of Serra Talhada, in Pernambuco state of Brazil.

Period								
	2000-2016				2016			
Months	ETP	EVR	DEF	EXC	ETP	EVR	DEF	EXC
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
January	149,2	93,7	55,6	0,0	87,2	87,2	0,0	0,0
February	126,4	126,4	0,0	0,0	77,9	47,6	30,3	0,0
March	130,4	129,4	1,0	0,0	84,1	84,1	0,0	13,1
April	119,4	80,6	38,8	0,0	78,2	63,4	14,8	0,0
May	108,8	59,1	49,7	0,0	73,8	48,3	25,5	0,0
June	92,5	19,9	72,6	0,0	63,6	20,6	43,0	0,0
July	91,6	18,4	73,2	0,0	60,5	11,9	48,5	0,0
August	102,9	5,4	97,5	0,0	61,9	5,1	56,8	0,0
September	121,5	1,9	119,6	0,0	69,4	11,1	58,3	0,0
October	148,0	10,8	137,3	0,0	80,9	1,8	79,1	0,0
November	151,6	19,8	131,8	0,0	84,5	0,8	83,7	0,0
December	159,4	36,6	122,9	0,0	91,0	22,5	68,5	0,0
Yearly	1501,8	601,9	899,9	0,0	912,9	404,4	508,5	13,1

Abbreviation meanings: ETP - potential evapotranspiration; EVR – actual evapotranspiration; DEF - water deficit; EXC - water surplus.

Source: Medeiros (2022).

The meteorological elements studied and discussed here show that sudden changes have occurred and that the inhabitants will have to change their tactics in the future to planting, water storage, and survival conditions.

Ufoegbune et al. (2011) presented estimates of the water balance in Lake Oyan in northwestern Nigeria with the specific objectives of obtaining the monthly average rainfall, seasonal rainfall patterns, estimation of evaporation, potential, and actual evapotranspiration of the studied area.

They evaluated the amount of surplus water that is present easily available for infiltration and drainage, in addition to determining the amount of recharge available per area. Their work supports the study in this paper.

In Figure 2 there is the variability of the water balance where water replacement is observed in January and March. The water deficiencies occurred between April to December and February. Removal of water in the soil occurs between April to September and February. In March there is a small water surplus. The year 2016 was not good for water storage and the agricultural sector was in deficit.

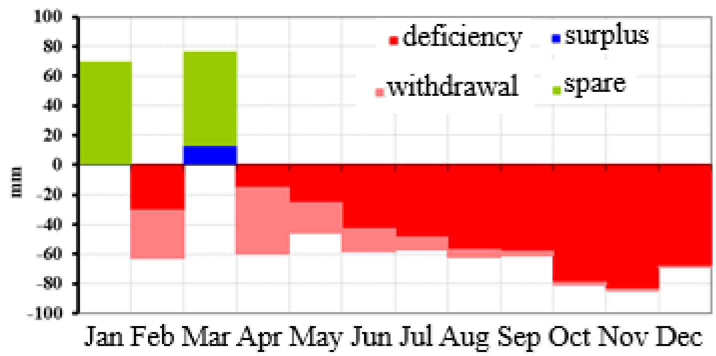

Figure 2 – Water balance graph for the year 2016 for the municipality of Serra Talhada, in Pernambuco state of Brazil.

Fonte: Medeiros (2022).

In Figure 3 there is water replacement in February, and in the other months, water deficiency predominated, with a greater deficiency in the months from August to December. Therefore, the period 2000-2016 can be characterized as a period of high water deficits.

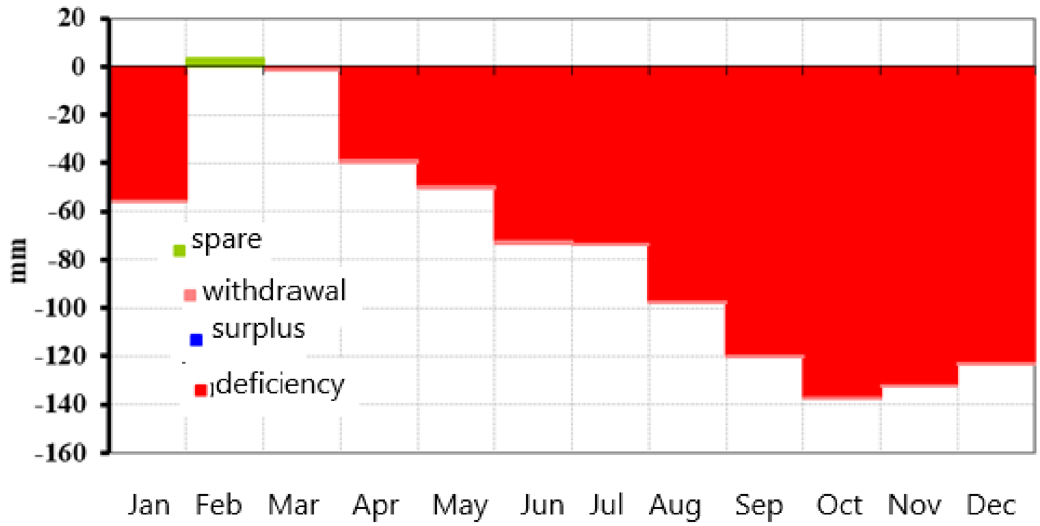

Figure 3 – Water balance graph for the period 2000-2016 for the municipality of Serra Talhada, in Pernambuco state of Brazil.

Source: Medeiros (2022).

Several authors in studies in the semiarid region of Brazil have shown that in the period 2000-2016 occurred water shortages, this study confirms these assertions.

CONCLUSION

The water balance is an important tool in the climate classification of a given region and for the presentation of the excess and water deficiencies of the soil for the capture of rainwater, pointing out its similarities with atmospheric conditions.

The meteorological elements studied and discussed here show that sudden changes have occurred and that the inhabitants will have to change their tactics in the future to planting, water storage, and survival conditions.

Even more specific future studies should be considered to better visualize how transient systems and local effects will affect rainfall variability and ETP and EVR.

The trend of temperature increase and evaporative indexes may cause events extremes of short-term and high-intensity rainfall.

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