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IMPACTOS DAS MUDANÇAS CLIMÁTICAS NO BALANÇO HÍDRICO CLIMATOLÓGICO PARA O MUNICÍPIO DE IGUATU-CEARÁ

EUGENIO PACELI DE MIRANDA[1]; JHON LENNON BEZERRA DA SILVA[2]; EVERTON KAUAN ELIAS BATISTA[3] E VICTOR LIMA ARAÚJO[4]

[1] Departamento de Engenharia Agrícola, Instituto Federal de Educação, Ciência e Tecnologia do Ceará – IFCE Campus Iguatu, Brasil, e-mail: paceli.miranda@gmail.com; ORCID (https://orcid.org/ 0000-0002-1390-1639)
[2] Pós-Graduação em Irrigação no Cerrado, Instituto Federal Goiano – Campus Ceres, GO-154, km 218 – Zona Rural, 76300-000, Ceres, Goiás, Brasil, e-mail: jhon.silva@ifgoiano.edu.br; ORCID (https://orcid.org/ 0000-0002-2611-4036)
[3]Graduando em Engenharia Agrícola, Instituto Federal de Educação, Ciência e Tecnologia do Ceará – IFCE Campus Iguatu, Brasil, e-mail: everton.kauan08@aluno.ifce.edu.br ORCID (https://orcid.org/ 0009-0002-7151-8379)
[4]Graduando em Engenharia Agrícola, Instituto Federal de Educação, Ciência e Tecnologia do Ceará – IFCE Campus Iguatu, Brasil, e-mail: lima.victor07@aluno.ifce.edu.br ORCID (https://orcid.org/ 0009-0007-9796-5675)

1 RESUMO

Objetivou-se mensurar os impactos de alterações climáticas no Balanço Hídrico Climatológico (BHC) para o município de Iguatu/Ceará. O BHC foi feito pelo método proposto por Thornthwaite e Mather (1955) para o cenário atual e mais seis cenários de mudanças climáticas propostos pelo Painel Brasileiro de Mudanças Climáticas (2012). O BHC do cenário atual apresentou excedente hídrico apenas em março e abril. Já os demais cenários (C1–C6) obtiveram aumento significativos na temperatura além da redução da precipitação, ambos apresentando déficit hídrico acentuado ao longo da normal climatológica, inviabilizando a agricultura de sequeiro. A mudança climática local influenciou diretamente o BHC em Iguatu-Ce.

Palavras-chave: semiárido brasileiro, agricultura de sequeiro, deficiência hídrica.

MIRANDA, E. P.; SILVA, J. L. B.; BATISTA, E. K. E.; ARAÚJO, V. L.
IMPACTS OF CLIMATE CHANGE ON THE CLIMATOLOGICAL WATER BALANCE FOR THE MUNICIPALITY OF IGUATU-CEARÁ

2 ABSTRACT

This study aimed to estimate the impacts of climate change on climatological water balance (BHC) in the city of Iguatu/Ceará. The BHC was created via the method proposed by Thornthwaite and Mather (1955) for the current scenario and six other climate change scenarios proposed by the Brazilian Panel on Climate Change (2012). The BHCs in the current scenario presented a water surplus only in March and April. The other scenarios (C1–C6) had significant increases in temperature in addition to a reduction in precipitation, both presenting a marked water deficit throughout the climatological normal, making rainfed agriculture unfeasible. Local climate change directly influenced the BHC in Iguatu-Ce.

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Keywords: brazilian semiarid, rainfed agriculture, water deficiency.

3 INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) in its Sixth Assessment Report (AR6) noted a 1.1 °C increase in global temperature in recent years (IPCC, 2022). The IPCC warns of more severe climate changes, with projections of a global temperature increase that could reach or exceed 1.5 °C by 2040. Analyzing these current and future scenarios for the Northeast Region and the semiarid region of Brazil under conditions of semiaridity, aridity and drought, the study by Marengo and Bernasconi (2015) projected a temperature increase of 2 °C between 2041 and 2070.

In an update of climate projections for Northeast Brazil, the study by Marengo *et al.* (2020) warned of conditions of reduced rainfall, which has influenced the increase in water deficit in more than half of the region, with a probability of warming of 4 °C by 2100. In this context, these regions face increases in the frequency, intensity and duration of extreme events, such as severe drought, in the short, medium and long term (Barbosa, 2023; Barbosa, 2024).

Improving water resource management is essential because of the growing demand for actions aimed at ensuring water security in the context of climate change, with an emphasis on adaptation measures that consider the worsening of chronic problems, such as the greater occurrence and severity of drought periods (Dias, 2020). This problem highlights the urgent need to improve the way available water is managed. With constant climate change around the world, global temperature variation has been credited, consequently affecting water availability, which is the factor that is most influenced by the increase in temperature. The climatological water balance is obtained from monthly precipitation and evapotranspiration data to measure the amount of water available for a region throughout the year.

It is necessary to understand the impacts caused by climate change scenarios, where this concept has already surpassed the abstract idea and has become fateful. According to Souza and Cruz (2024), water is an indispensable resource for human survival and is linked to complex issues that involve society, and the growing demand for water, which is related to scarcity in regions and the degradation of water resources, increases the risk of conflicts of interest. Climate change intensifies problems such as droughts, desertification, floods, and storms related to water scarcity; this point is not limited only to quantity but also to quality, sometimes making water unfit for human consumption and use for other activities (Dias, 2020).

This study aims to measure the impacts of climate change on the climatological water balance in the municipality of Iguatu, CE.

4 MATERIALS AND METHODS

The municipality of Iguatu, belonging to the state of Ceará, is located at latitude 06°27'48" S e 39°24'42" W, whose Köppen climate classification is type BSw'h', climatically characterized as hot and dry (Alvares *et al.*, 2013).

The climatological water balance (BHC) was prepared for the municipality of Iguatu/CE for the current scenario on the basis of data series from 1961-2020 obtained from the portal of the National Institute of Meteorology and for six climate change scenarios (Table 1) proposed by the Brazilian Panel on Climate Change (2012).

Table 1. Scenarios of changes in reference evapotranspiration (ETo) and precipitation (P) proposed by the BPCC.

Scenario	T (° C)	P (mm/year)
++Current	28.1 [1]	951.7 [2]
C1	+0.5	-10%
C2	+1.0	-20%
C3	+1.5	-25%
C4	+2.5	-35%
C5	+3.5	-40%
C6	+4.5	-50%

Source: [1] Average annual temperature, [2] Annual precipitation, adapted from the Brazilian Climate Change Panel (2012).

The BHC was determined via the method proposed by Thornthwaite and Mather in 1955 (Pinheiro *et al*., 2013) from monthly values of reference evapotranspiration (ETo) and precipitation, considering a soil water capacity (SWC) of 100 mm. Reference evapotranspiration values were obtained via the Thornthwaite method (Equation (1)).

$$ETo = F.16\left(10.\frac{Ti}{I}\right)^{a} \qquad (01)$$

Where: ETo is the reference evapotranspiration (mm/month); F is the correction factor (tabulated); Ti is the average monthly air temperature (° C); I is the thermal index; and a is the coefficient.

5 RESULTS AND DISCUSSION

Only the current BHC, with climatological normals from 1961-2020 (Figure 1), shows that there is a surplus only in the months of March and April and that a rainfed crop is recommended only in these two months.

Figure 1. Climatological water balance (BCH) of Iguatu/CE for the current scenario (climatological normals from 1961-2020).

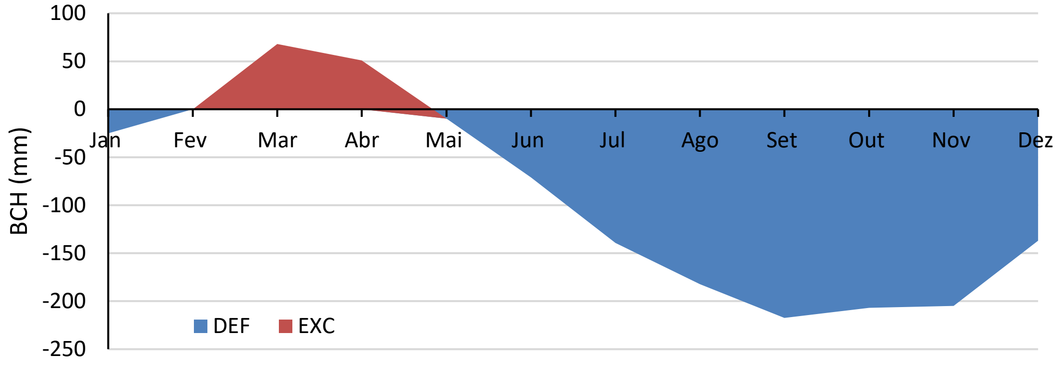


Table 2 highlights all the scenarios with their respective levels of annual water deficiencies and surpluses. In scenario 1 (C1), an increase of 0.5 ° C in air temperature and a 10% reduction in precipitation were observed. Therefore, there is no longer a water surplus. Deficiencies increase as temperatures increase and precipitation decreases in the other scenarios (C2–C6), which indicates that for an increase of only 0.5 ° C in air temperature and a 10% reduction in precipitation, agriculture in the region is dependent on irrigation.

Table 2. Annual water deficiency and surplus levels of BHCs in the municipality of Iguatu/Ceará according to all scenarios.

Scenario	Deficit	Surplus
Current	954.9	100.62
C1	1258.5	0.00
C2	1419.1	0.00
C3	1620.7	0.00
C4	2045.5	0.00
C5	2453.3	0.00
C6	2944.8	0.00

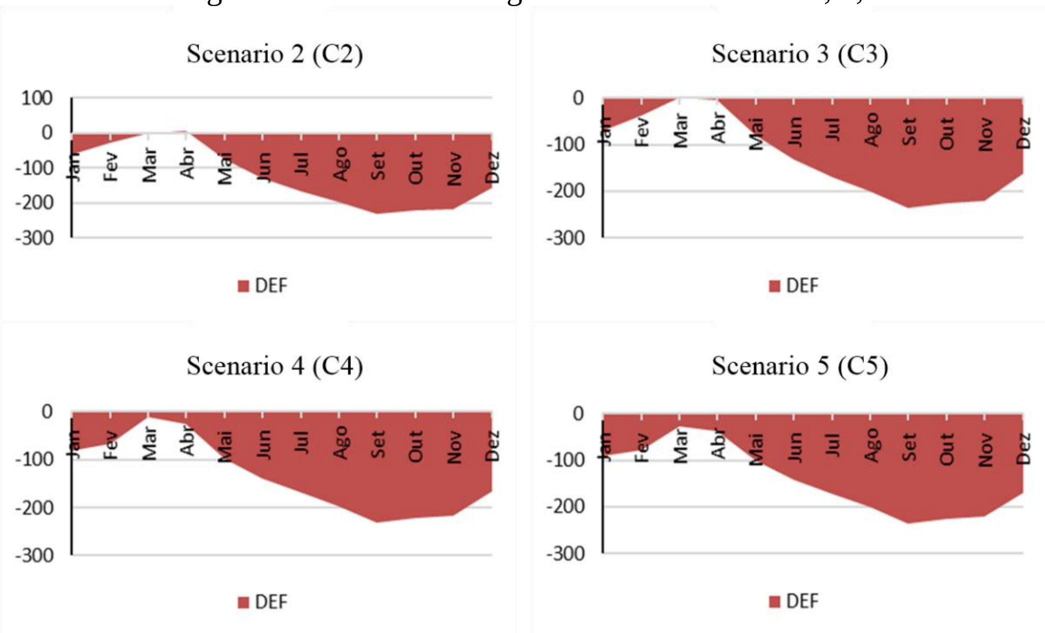
Table 3 shows the monthly deficits and surpluses for the current scenarios, C1, C2, C3 and C4. As seen, only the current scenario presents a water surplus in the months of March and April, and from C1 onward, all months of the year presented a deficit. Comparing the current scenario and C1, the 0.5 ° C increase in air temperature and a 10% reduction in precipitation resulted in an increase in the annual water deficit of approximately 32%.

Table 3. Climatological water balance for Iguatu-CE, according to all the scenarios.

	Current		**C1**		**C2**		**C3**		**C4**	
	DEF	EXC	DEF	EXC	DEF	EXC	DEF	EXC	DEF	EXC
	(mm)		(mm)		(mm)		(mm)		(mm)	
Jan	45.9	0	85.6	0	99.6	0	121.1	0	166.3	0
Fev	0.0	0	12.9	0	22.4	0	41.1	0	85.1	0
Mar	0.0	49.4	0.0	0	2.3	0	22.6	0	72.1	0
Abr	0.0	51.2	0.0	0	0.0	0	26.1	0	72.6	0
Mai	0.4	0	37.1	0	60.0	0	79.9	0	120.4	0
Jun	0.4	0	87.9	0	109.3	0	124.6	0	154.0	0
Jul	88.0	0	115.7	0	130.9	0	144.3	0	171.7	0
Ago	130.4	0	150.3	0	164.2	0	178.3	0	208.2	0
Set	162.3	0	178.4	0	192.5	0	207.3	0	239.3	0
Out	183.9	0	203.0	0	218.7	0	236.1	0	273.7	0
Nov	194.0	0	211.4	0	227.2	0	244.3	0	281.2	0
Dez	149.5	0	176.1	0	192.0	0	194.9	0	200.6	0
Total	954.9	100.6	1258.5	0	1419.1	0	1620.7	0	2045.5	0

Figure 2 highlights the increase in deficits in scenarios C2, C3, C4 and C5, which basically portray the severe effects of drought and high climate variability. The water surplus was significantly affected by the increase in temperature and consequent reduction in precipitation over time. Therefore, the graphs show that water deficiency predominated over time, with a significant increase in all months of the year.

Figure 2. Climatological water balance of Iguatu/CE for scenarios 2, 3, 4 and 5.



6 CONCLUSIONS

Climate change scenarios had a significant influence on BHCs for the municipality of Iguatu/Ceará , where only the current scenario showed the possibility of implementing short-cycle rainfed agriculture in two months.

In the other scenarios (C1–C2), all months of the year presented water deficits, which made dryland agriculture unviable, resulting in social and economic impacts of great magnitude, especially for small farmers.

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