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Amparo De São Francisco – Sergipe - Brazil, and Its Climate, Urban and Rural Planning Through The Water Balance

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ABSTRACT

Soil water availability is of fundamental importance for sustainable agricultural development, with the aim of eradicating poverty and ensuring food security incites. The great concern evident in this article is the frightening and disorderly growth of the demand for a resource with lower supply in the face of sustainable development so proposed and necessary to societies now and in the future. Andwater balance is the tool used to estimate water dimensioning. The objective is to identify the periods of surplus and water deficit, using the agroclimatological water balance between 1963-2020 to assist agricultural planning, based on the sustainable management of water resources in the municipality of Amparo de São Francisco. The study was developed through monthly average rain agroclimatic data from 1963 to 2020. The average thermal air data were estimated by the software Estima_T, corresponding to the same rain period. The model used to determine the water balance was proposed by Thornthwaite (1948); Thornthwaite and Mather (1955)and affected its spreadsheet calculation structure. There is the occurrence of risk of losses in the production of woodland, planners should develop sustainable projects aiming at a better distribution of water use, primordial natural resources to a healthy quality of life, and maintenance of other cycles of nature. Water deficiencies were recorded from June to August. Water surpluses between September and March. It evaporated equal to the rainfall indices and evapotranspiration 64.1% of the total annual value pluviometric. Planning should be carried out followed by climate problems for better regional agricultural development.

INTRODUCTION

The disordered growth of urban sectors in recent decades has generated increasingly chaotic and inefficient cities, especially in developing countries, where obsolete models are in place without attention to socio-environmental and socioeconomic issues (SPINELLI et al., 2013). Cities are the places of residence of more than 50% of the world's population. Thus, thinking about suitable urban environments is essential. Human life would be virtually impossible without the natural resources provided by the Earth: sunlight, water, oxygen, plants, and pollution-free areas, an aspect evidenced in the following conclusion: "Humans evolved outdoors immersed in natural habitats with vegetation and exposed to sunlight, clean air, and water" (FARR, 2013).

This lack of contact is since consumer relations, where many have no idea of the serious damage their lifestyle causes to nature, is reflected in addition to the damage to the environment and society, where the scarcity of connection has been causing several psychological problems, such as Attention Deficit Hyperactivity Disorder (DHDA), in addition to increased stress to the human being (LOUV, 2016). Instead of trying to re-establish this contact through urban vegetation, the concern of green spaces in the city to practice physical activities is increasingly restricted to the permanence of the population, where living spaces are being neglected by urban managers, disregarding the various social, psychological, and environmental benefits of these spaces. It is human essence to desire contact with green (SOUSA, 2016) where natural disasters are increasingly intensifying in large and medium urban centers.

Natural disasters are hydroclimatic, geological, and biological phenomena that affect human-inhabited areas causing agitation in the order of a community, causing human and material losses, negative impacts on the economic and socio-environmental spheres in large proportions, the consequences of which exceed the capacity of self-recovery of the affected society (NOY, 2009; TOMINAGA et al.,2009; LONDE et al.,2014).

In this sense, the climatological water balance can help with additional information to decision-makers to avoid possible public calamities such as floods, floods, floods, floods, river overflow, lagoons, as well as domestic depletions and rain drainages that result in human losses and negative changes to socioeconomic aspects in urban centers.

The Brazilian semi-arid climate has as one of its characteristics the great rainfall irregularity, which integrated with the high interannual oscillations, causing direct impacts to agricultural activities. Oliveira et al.,(2017); Martins et al., (2018), stated that the information that was related to the monitoring of agricultural developments will adapt greater security to production systems, especially for the area of the Brazilian semi-arid region where there is a need for water resources.

The use of the agroclimatic water balance is a tool that assists producers and ranchers in the identification of regional climate fluctuations, in the consent, choosing or not to use irrigation systems for soil replacement in their enterprise (SANTOS et al.,2010). Therefore, information on water availability helps in agricultural planning, as well as in choosing the best planting times and, thus, making more efficient the use of environmental, financial, and human resources to increase production, maximizing profitability.

The planning of water resources helps in the correct decision-making process for better agricultural production, besides enabling and determining the appropriate period for planting and harvesting which provides the ideal amount of water to be applied by the irrigation system (ASCOLI et al., 2017; BARRETO et al., 2014; SILVA JUNIOR, 2018).

The use and disorderly occupation in areas of environmental risk are the most aggravating factors of the current population development scenario. Dias e Silva (2015) points out that soil degradation is a recurrent phenomenon in Brazil, because it presents dominant tropical climatic characteristics with predominantly susceptible soil throughout the territory, and soil erosion is one of the most recurrent types of degradation (ESTEVAM-ALVES et a*l.*,2016). Their understanding is better understood when analyzed in the hydrographic basin system, since the conditioning factors of the water balance (which include rainfall, surface, and underground flow), are the main influencing agents of the process in the amazon environment (MOQUET et al., 2016). Thus, water monitoring is necessary.

The water balance (BH) is an option where it allows monitoring and quantifying through climatological data (temperature, precipitation, and reference evapotranspiration) storage, surplus, deficiency, and soil water replacement (CARVALHO et al., 2011).

Albuquerque et al., (2018) ensure that in the Brazilian semiarid region, there are irregular rainfall fluctuations and water storage, and these storm fluctuations can differ significantly from one year to another, thus, adapted management is required to obtain higher efficiency of water use.

Santos et al., (2018) and Passos et al., (2017) ensure that the northeastern semiarid region has as its predominant characteristic the high evaporative, evapotranspiration, and insolation rates, with irregular spatial and temporal rain distribution.

Holanda et al., (2019); Matos et al., (2018), and Passos et al., (2016) showed that the water balance is obtained by computing water demand and availability through rainfall, evapotranspiration, evaporative, water storage, water deficit, and excess. Through information on the inlet (rain) and outlet (evaporation) of water in the soil, Water Balance (WB) demonstrates its periods of deficiency and water surplus, providing valuable information to farmers, researchers, and decision-makers, among many other applications in the area.

França et al., (2018) implemented the WB for São Bento do Una and Serra Talhada - PE and verified the influences of El Niño in the years 2012 and 2016 and in La Niñaseason for the year 2008 and 2011 in the rainfall distribution through the analysis of the balance sheet. They concluded that the El Niño episode influenced (with an increase or decrease) the rainfall indices of the studied municipalities. In the Episode of La Niña, the distribution of these indices was irregular, reflecting in WB surpluses and water deficiencies.

Carvalho et al., (2012) and Coutinho et al., (2015) discuss the importance of the study of rainfall in watersheds for regional water balance because the consequences of infiltration and surface runoff of rainwater are essential factors for the maintenance of water resources that are directly influenced by extreme climatic events, in which such stages of the hydrological cycle control the erosive processes influenced by hydroclimatic variations (BALBINOT et al., 2008; LICCO et al., 2015).

The changes that occur in the soil with the removal of native vegetation and the implementation of industry, commerce, buildings, and roads, have been causing serious socio-environmental risks (LACERDA et al., 2012). The lack of forest preservation is crucial because it provides the production and deposit of organic material that promotes advantages to the soil, such as greater resistance to erosive, hydrological processes and mitigates socio-environmental disasters caused by extreme events in urban centers.

The objective is to identify the periods of water deficit and excess, using the calculation of the agroclimatological, rural, and urban water balance between 1963-2020 aiming to assist in the planning and management projects of water resources for Amparo de São Francisco – Sergipe.

MATERIAL AND METHODS

Amparo de São Francisco is located in the Northeast sector of the Sergipe State and is limited to Telha city and the East and South, Canhoba city to the west, and the State of Alagoas to the north. With an area of 39.8^{km2} and altitude of 51 meters and with 10°08'04" south latitude and 36°55'46" west longitude. (Figure 1).

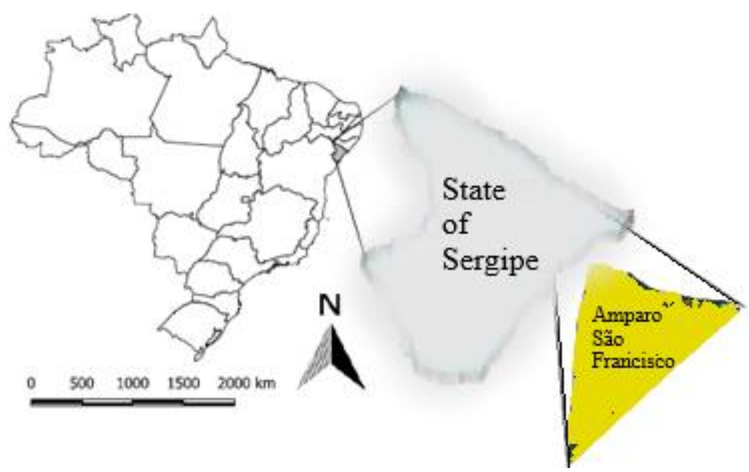

Figure 1. Location of Amparo de São Francisco within the state of Sergipe.

Source: França (2022).

With regard to the contribution of vegetation in the urban microclimate, it promotes a better balance between vegetation, climate, and soil. Reduces solar radiation in heat periods, alters the speed and direction of winds, slows noise pollution from the damping of noise, contributes to the reduction of air pollution through photosynthesis, alters the temperature and environmental humidity as a function of shading by reducing the thermal load received, thus preserving fertility, soil permeability and also influences the water balance, consequently in precipitation

(MASCARÓ et al., 2010), thus contributing to the improvement of the quality of life of the urban population.

The municipality is contained in a region characterized by two well-defined seasons, a rainy season, flowing from February to August, and the dry period, oscillating from September to January. The classification of Köppen (1928) and Köppen et al., (1931) recorded "As" climate (hot and humid tropical rainy). The studios with the authors: Medeiros, (2020); Alvares*et al.,*(2014)had the same climatic type in the studied area.

The study was developed through monthly and annual average rain agroclimatic data acquired from the Northeast Development Superintendence (SUDENE, 1990) and the Sergipe Agricultural Development Company (EMDAGRO-SE, 2020), for the corresponding period from 1963 to 2020.

The software Estima_T estimated the average thermal values of the air (CAVALCANTI et al., 1994; CAVALCANT et al., 2006), for the same rainy period (CAVALCANTI et al., 2006) given by:

$$T = C0+C1\lambda+C2Ø+ C3h+ C4\lambda2+C5Ø2+C6h2+C7\lambda Ø+C8\lambda h+C9Øh \qquad (1)$$

In which:

$C_0, C_1,..., C_9$are the constants;

$\lambda, \lambda_2, \lambda Ø, \lambda h$ longitude;

$Ø, Ø_2, \lambda Ø$ latitude;

$h, h_2, \lambda h, Ø h$ height.

Estimates of thermal series were added to the temperature anomaly of the Tropical Atlantic Ocean (Cavalcanti et al., 2006). The Climatological Water Balance (CWB) is used to calculate the water availability in the soil to establish the numerical values of the aridity indexes. It counts precipitation in the face of potential evapotranspiration, taking into account the water storage field capacity. The model used to determine WB was Thornthwaite (1948); Thornthwaite et al., (1955), carried out its calculation structure by electronic spreadsheets according to Medeiros (2016).

RESULTS AND DISCUSSIONS

Table 1 shows the oscillations of theWB for the studied area. The average annual temperature is 25.9 ºC and its monthly oscillations flow between 23.1 ºC (July) to 28 ºC (March). With annual rainfall indices of 994.8 mm and their monthly fluctuations occurring between 27.3 mm (November) to 191.3 mm in mayo. Evapotranspiration 1551.2 mm annual, thus evapopiru6.1% above the annual rainfall value, the monthly fluctuations of ETP flowed from 81.7 mm (July) to 172.4 mm (March). In the %P/ETP column, we have relative values of how the ETP behaved in relation to the storm indices. In the %P/EVR column, we observed the fluctuations of these indices where for most months the vaporizer indices exceeded the rainfall. They recorded water deficiencies from June to August totaling 135.8 mm. Water excess occurs from September to March totaling 556,6 mm, the largest water surpluses recorded between November and January and those of smaller surpluses from April to August.

Table 1. Demonstration of the water balance in Amparo de São Francisco between 1963-2020.

Months	T(ºC)	P(mm)	ETP(mm)	EVR(mm)	EXC(mm)	DEF(mm)	%P/ETP	%P/EVR
January	27,5	47,8	161,8	49,8	112,0	0,0	29,6	96,1
February	27,8	59,0	154,9	59,6	95,3	0,0	38,1	99,0
March	28,0	80,4	172,4	80,6	91,8	0,0	46,6	99,7
April	27,3	172,6	148,1	148,1	0,0	0,0	116,5	116,5
May	25,6	191,3	120,0	120,0	0,0	0,0	159,5	159,5
June	24,3	162,1	94,8	94,8	0,0	63,3	171,0	171,0
July	23,1	150,0	81,7	81,7	0,0	68,3	183,6	183,6
August	23,2	88,5	84,3	84,3	0,0	4,2	105,0	105,0
September	24,2	65,5	95,9	91,7	4,2	0,0	68,4	71,5
October	26,0	40,8	130,6	84,6	46,1	0,0	31,2	48,3
November	27,0	27,3	149,0	48,5	100,5	0,0	18,3	56,4
December	27,1	44,9	157,6	50,9	106,7	0,0	28,5	88,2
Annual	25,9	994,6	1551,2	994,6	556,6	135,8	64,1	100,0

Legend: Temperature=T(ºC); Precipitation =P(mm); Evapotranspiratiration = ETP (mm); evaporation = EVR (mm); surplus = EXC (mm); Deficiency = DEF (mm);

%Precipitation/Evapotranspiratiration = %P/ETP and %Precipitation/ evaporation = %P/EVR in Amparo de São Francisco between 1963-2020.

Source: França (2021).

Figure 2 shows the BH graphfor100 mm CAD. Water excesses were recorded between June and August, water replacement of April and June, water withdrawal in the soil between September and December, and water deficit of September and March. These results show similarities with the Studies of the IPCC (2014); Marengo et al. (2011); Araújo, et al. (2020); Medeiros (2019).

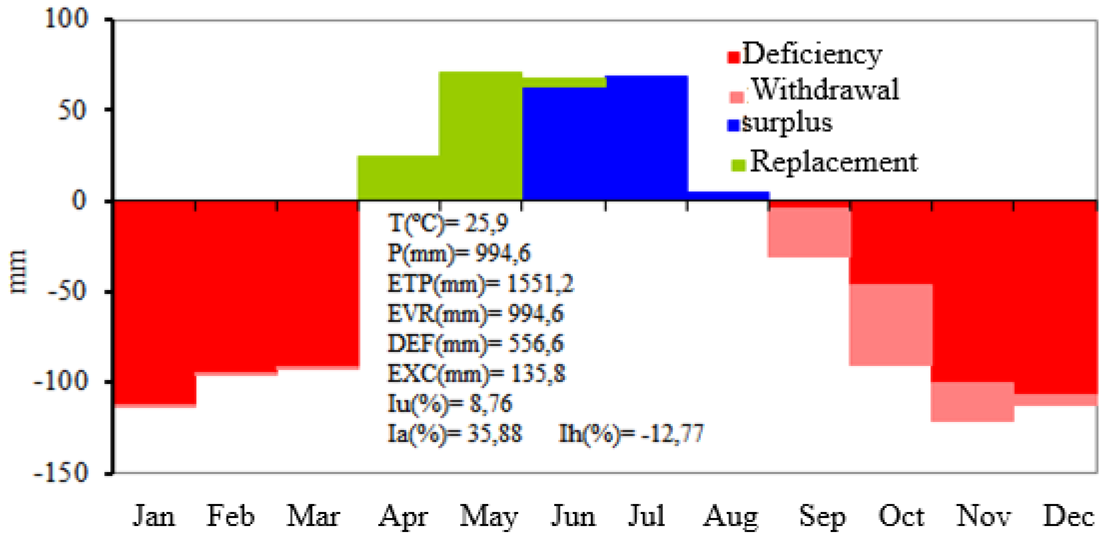

Figure 2. Graph of the water balance with field capacity (CAD) of 100 mm; Replacement; Surplus; Withdrawal and Disabilityin Amparo de São Francisco - Sergipe from 1963-2020.

Source: França (2022).

Water deficiency is one of the main agrometeorological elements responsible for the decrease in agricultural productivity, so the volume of water in the soil fluctuates according to the typology and depth of the root system of the cultures, assisting in the realization of better management for irrigation, in the socioeconomic and socio-environmental sectors (PEREIRA et al., 2002).

Evapotranspiration/rain percentages are observed in the negative indices for the years: 1965, 1966, 1967, 1971 to 1975 and 1978 with oscillations between -50% to 0.2%. Positive evapotranspiration indices (evapotranspiration above rainfall values) ranged from 0.1% to 220%.

These indices were caused by high wind intensity, low cloud coverage, results of studies by Marengo et al., (2011); IPCC (2014); Holanda et al., (2020) corroborate the results of this study.

It is of fundamental importance to highlight the relationship between urban afforestation and rainwater drainage. When there is vegetation located in permeable areas, especially the tree-sized ones, it can contribute to the infiltration and absorption of water and consequently to the supply of groundwater. However, it is necessary to carefully observe the type, dimension, and location of the vegetated area and permeable surface area, as well as the porosity of the soil, to ensure the stability of the vegetation without the risk of tipping. There is also a permeable free zone according to the need of vegetable, isolated group. Porosity should favor the process of water percolating (AZEREDO, 2017), which corroborates the results of the study.

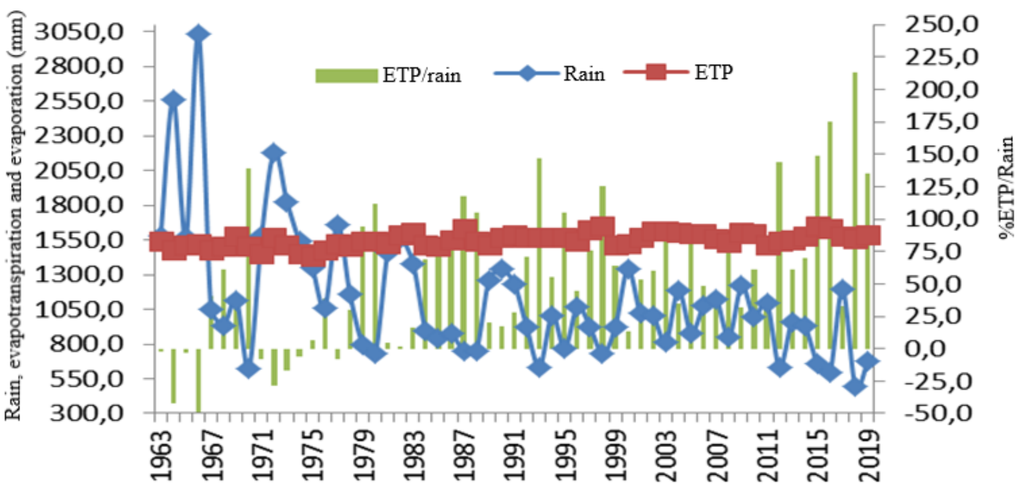

Figure 3. Graphic representation of the rainfall, annual evapotranspiration indexes, and their indexes percentage evapotranspiration/rain for Amparo de São Francisco – Sergipe between 1963-2020.

Source: França (2022).

Figure 3 shows the fluctuations of the elements, precipitation, annual evaporation, and its percentage evaporation/rain index. The percentage rates of evaporation/rain recorded evaporation values well below the rainfall indices, except for the year 1988, which presented a higher rate than the rainfall rate of 20%. Rainfall rates in 1964 and 1966 were the highest. EVR flowed below rainfall in most of the observed.

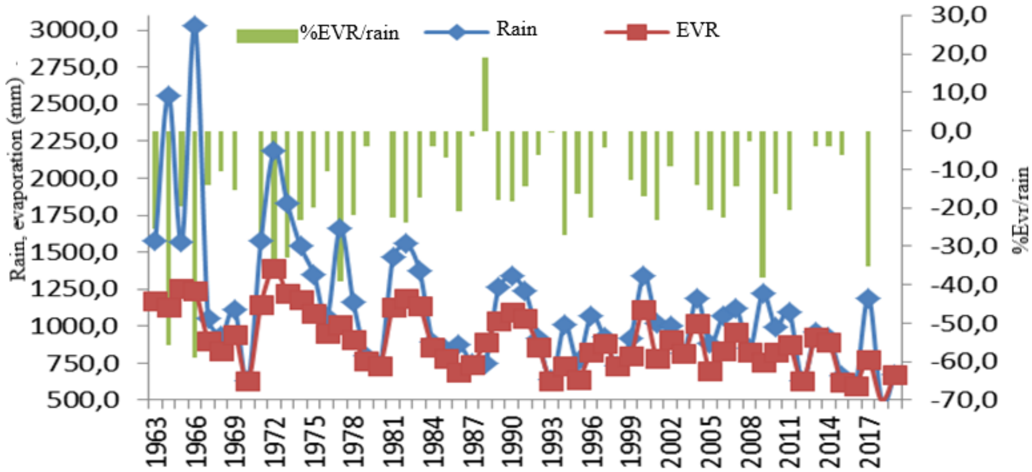

Figure 4. Graphic representation of precipitation, annual evaporation, and its percentage evaporation/rain index for Amparo de São Francisco - SE between 1963-2020.

Source: França (2022).

CONCLUSIONS

There is the occurrence of risk of losses in the production of land; planners should develop projects aimed at a better distribution of water use. Irrigation should be implemented in the agricultural area to ensure better productivity throughout the year. Water deficiencies were recorded from June to August. Water surpluses between September and March. It evaporated equal to the rainfall indices and evapotranspiration 64,1% of the total annual value pluviometric. A plan followed by climate skills to better air the region's agricultural development should be realizer.

The centralization of urban or rural centers by housing along water sheets and in a risk area, there must be some form of planning to avoid soil losses and other forms of degradation such as water pollution and outbreaks of water diseases. Monitoring deforestation and conservation practices, as well as proper soil management, are essential to reduce the chances of occurrence of these environmental risks, thus preventing in extreme years, not only socio-economic losses but also in some cases reducing the risk of social losses that the environment can entail.

The authors clarify that it is up to the government to be responsible for policies for the preservation, conservation, recovery, and expansion of tree specimens, from the afforestation plans that should be part of agricultural, rural, and urban planning, also trying to choose suitable species to avoid harm to society. The environmental bodies from the conception of an ecological awareness understand that each inhabitant has the perception of the benefits derived from afforestation and the value that regional native species possess for the preservation of culture and history.

REFERENCES

1. Albuquerque, F.S.; Silva, E.F.F.; Lopes, P.M.O.; Moura, G.B.A.; Silva, A.O. Water conditions and plant growth of important agricultural crops for indigenous communities in the Brazilian semi-arid. Ceres Magazine [online] 65. Recovered from http://dx.doi.org/10.1590/0034-737X201865020001.2018.

2.Alvares, C.; Stape, J.; SentelhaS, P.; Gonçalves, J.; Sparovek, G. Köppen's climate classification map for Brazil. Meteorologische Zeitschrift 22, 711–728. 2014.

3.Araújo,W. R.;Medeiros, R.M.; França, M. V. Spatialization of evapotranspiration in the ipojuca river basin -PE, Brazil. J. Biotec.Biodivers. v.8, p.205 - 218. 2020.

4.Ascoli, A.A.; Hernandez,F.B.T.; Sentelhas, P.C.; Teixeira, A.H.C.; Amendola, E.C.; Ascoli, R.T. Need for irrigation in sugarcane crop as a function of harvest time. In: Inovagri International Meeting, 4. (INOVAGRI), 2017, Fortaleza. Annals... Fortaleza: ABID. 2017.

5. Azeredo, J.F.F. The. Green I want you comfortable: The contribution of Urbana forestation to the term environmental comfort, at the level of the pedestrian user. Thesis (Ph.D. in Urban Development) - Center for Arts and Communication, Federal University of Pernambuco, Recife-RN.2017.

6.Balbinot,R. ; Oliveira, N.K.; Vanzetto,S.C.; Pedroso, K.; Valerio, A. F The role of the forest in the hydrological cycle in hydrographic basins. Ambiência Magazine, v. 04, n. 01, p. 131 – 149. 2008.

7.Barreto,H.B.F.; Pereira, G.M.; Barreto, F.P.; Freire, F.G.C.; Maia, P.M.E. Duration-frequency intensity ratio for extreme precipitation in Mossoró - RN. Global Science and Technology, v.7, n. 3, p. 103–109. 2014.

8.Carvalho, A.P.V.; Brumatti, D.V.; Days,H.C.T. Importance of river basin management and determination of hydrological processes. Revista Brasileira de Agropecuária Sustentável, v. 02, n. 02, p. 148-156. 2012.

9. Oak, H.P.; Dourado Neto, D.; Theor, R.E.F.; Melo, B. Climatological water balance, effective storage of water in soil and transpiration in the coffee crop. Biosci. J. J., v. 27, n. 2, p. 221-229. 2011.

10.Cavalcanti, E.P.; Silva, V.P.R.; Sousa, F.A.S. Computational program for the estimation of air temperature for the Northeast region of Brazil. Brazilian Journal of Agricultural and Environmental Engineering, 10 (1), 140-147. 2006

11.Cavalcanti, E.P.; Silva, E.D.V. Estimation of air temperature according to local coordinates. In: Brazilian Congress of Meteorology, 8, 1994. Belo Horizonte, Anais. Belo Horizonte: SBMET, 1,154-157. 1994

12.Coutinho, M.D.L.; Costa, M.S.; Silva, A.R.; Santos,T.S.; Gomes, A.C.S.; Moraes,M.D.C.; Santos, P.V. Monthly water balance for two municipalities in the state of Paraíba. Revista Ciência e Natura, v. 37, n. 04, p. 160-170. 2015.

13. EMATER-SE. Company Technical Assistance of the State of Sergipe. www.wmaterse.gov.br. 2020.

14.Estevam-Alves, R.; Souza, L.F.; Souza,V.M.; Ferreira-Queiroz, T.A.; Vieira-Lima, J. Soil degradation and fragility in southwestern Goiás: the case of the Ribeirão da Picada watershed. Central American Geographic Journal, n. 56, p. 235-258. 2016.

15. Farr, D. Sustainable urbanism: urban design with nature. Translation by Alexandre Salvaterra. Porto Alegre: Bookman. 2013.

16.França, M.V.; Ferraz, J.X.V.; Medeiros, R.M.; Holland, R.M. Rolim Neto, F.C. El Niño and La Niña and their contributions to the water availability of the municipalities of São Bento do Una and Serra Talhada - PE, Brazil. Brazilian Journal of Agrotechnology (Brazil) ISSN: 2317-3114. 8(1),15 – 21. 2018.

17.Holanda, R.M.; Medeiros, R.M. Climatic classification by köppen and thornthwaite method in Bom Jesus do Piauí, Brazil. Pantaneira Magazine, 16, 57 - 68.2019.
18. Intergovernmental Panel on Climate Change IPCC. Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Working Group II Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Available: GS. 2014.
19.Köppen, W. Grundriss der Klimakunde: Outline of climate science. Berlin: Walter de Gruyter, 388. 1931.
20.Köppen, W.; Geiger, R. Klimate der Erde. Gotha: Verlagconditioned. Justus Perthes. 1928.
21. Licco, E.A.; MacDowell, S.F.F. looding, floods, floods, and floods: Digress on its socio-economic impacts and governance. Journal of Scientific Initiation, Technological and Artistic, v. 05, n. 03.2015.
22.Londe, L. R.; Coutinho, M.P.; Gregory, L.T.; Santos, L.B.L.; Soriano, E. Water-related disasters in Brazil: Perspectives and recommendations. Revista Ambiente & Sociedade, v. 17, n. 4, p. 133-152, São Paulo. 2014.
23. Louv, R. The last child in nature: rescuing our children from nature-deficit disorder. Translation of Cláudia Belhassof. SanPaulo: Aquarian. 2016.
24. Marengo, J.A.; Noble, C.A.; Chou, S.C.; Mr. Tomasella. J.J.; Sampaio, G.; Alves, L.M; Obregon, G.O.; Soares, W.R.; Mr. Betts. That's a good one. ; Gillin, K. Risks of Climate Change in Brazil Joint Analysis of the Brazil-United Kingdom on the Impacts of Climate Change and Deforestation in the Amazon. 56p. 2011.
25.Martins, M.A.;Tomasella, J.; Rodriguez, D.A.; Alvalá, R.C.S.;Giarolla, A.; Garofolo, L. L.; Junior Siqueira, J.L.; Paolicchi,L. T.T.L.C.; Pinto, GLN. Improving drought management in the Brazilian semiarid through crop forecasting. AgriculturalSystems, v. 160, p. 21-30. 2018.
26.Mascaró, L.; Mascaró, J.J. Urban ambience. Porto Alegre: Masquatro Editora, 3rd Edition. 2009.
27. Matos, R.M.; Silva, P.F.; Borges, V.E.; Nephew, T.G.; Dantas Neto, J.; Saboya, L.M.F. Agroclimatic potential for the mango crop in the municipality of Barbalha - CE. Brazilian Journal of Irrigated Agriculture [online] 12. Recovered from 10.7127/RBAI. V12N100732. 2018.
28.Medeiros, R.M. Agrometeorological study for the State of Sergipe. p.138. avulas distribution. 2020th.
29.Medeiros, R.M; Holanda, R.M. Climatic classification and water balance by the Köppen and Thornthwaite method of barbalha, Ceará, Brazil. Revista Ecuador., v.8, p.19 – 43. 2019.
30.Moquet, J.S.; Guyot, J.L.; Crave, A.; Viers, J.; Filizola, N.; Martinez, J.M; Oliveira, T.C.;Sánchez, L.S.H.; Lagane, C.; Casimiro, W.S.L.; Noriega, L.; Pombosa, R. Amazon River dissolved load: temporal dynamics and annual budget from the Andes to the ocean. Environmental Science and Pollution Research, v. 23, n. 12, p. 11405-11429. 2016.
31. Noy, I. The macroeconomic consequences of disasters. Journal of Development Economics, v. 88, p. 221-231. 2009.
32. Oliveira, P.T.; Silva, C.M.S.; Lima, K.C. Climatology and trend analysis of extreme precipitation in sub-regions of Northeast Brazil. Theoretical and Applied Climatology, v. 130, n. 1-2, p. 77-90. 2017.
33. Steps, M.L.V.; Zambrzycki, G.C.; Pereira, R.S. Climatological water balance and climatic classification for the municipality of Balsas - MA. Scientia Agraria [online] 18. Recovered http://dx.doi.org/10.5380/ RSA. V 18i1.48584. 2017.
34.Steps, M.L.V.; Zambrzycki, G.C.; Pereira, R.S. Water balance and climate classification for a given region of Chapadinha - MA. Brazilian Journal of Irrigated Agriculture [online] 10. Retrieved from 10.7127/rbai. V 10n400402. 2016.
35.Pereira, A.R.; Angelocci,L. R.; Sentelhas, P.C. Agrometeorology: fundamentals and practical applications. Guaíba: Agriculture, 478p.2002.
36.Santos,G.O.; Hernandez,F.B.T.; Rossetti, J.C. Water balance as a tool for agricultural planning for the region of Marinópolis, northwest of the state of São Paulo.Revista Brasileira de Agricultura Irrigada,v. 4, p. 142-149.2010.
37.Santos, R.A., Martins, D.L., Santos, R.L. (2018). Water balance and climatic classification of Köppen and Thornthwaite in the municipality of Feira de Santana (BA). Geo UERJ [online] 33. Retrieved from 10.12957/geouerj. 2018.34159. 2018.

38. Silva Junior, J.F.; Hernandez, F.B.T.; Silva, I.P.F. Reis, L.S.; Texeira, A.H.C. Establishment of the most critical months for irrigated agriculture from the study of water balance. Brazilian Journal of Biosystem Engineering, v. 12, n. 2, p. 122-131. 2018.
39. Sousa, S.F.F. Therapeutic gardens in health units: application of a user-centered design methodology for populations with special needs – a case study of the Rehabilitation and Integration Center of Ouriense. 2016.
40. Dissertation (Master's degree in Landscape Architecture) - Instituto Superior de Agronomia, University of Lisbon, Lisbon, Spinelli, R.; Alves, A; Konrad, O. City, and buildings: the search for a new model. Academic Highlights. Slabado, v. 5, n. 4, p.173-186. 2013.
41. SUDENE. normally climatological of the SUDENE Area. Superintendence of Development of the Northeast. Agreement with the Weather Service, Recife. 1990.
42. Thornthwaite, C.W. An Approach Toward a Rational Classification of Climate. Geogr. Rev, 38, 55-94.1948.
43. Thornthwaite, C.W., Mather, J.R. The Water Balance. Publications In Climatology. New Jersey: Drexel Institute of Technology,104p.1955.
44. Tominaga, L.K.; Santoro, J.; Amaral, R. Natural disasters: know to prevent. Catalographic form prepared by the library of the Geological Institute. São Paulo, 2009.

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