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Climate variables on the hydrographic basin of Uruçuí Preto River – Piauí, Brazil subsidies for the management of water and agricultural resources

Variáveis climáticas sobre a bacia hidrográfica do rio Uruçuí Preto – Piauí, Brasil subsídios para gestão de recursos hídricos e agropecuários

Variables climáticas sobre la cuenca hidrográfica del río Uruçuí Preto - Piauí, Brasil subsidios para la gestión de recursos hídricos y agrícolas

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Abstract
The knowledge of the climatic characteristics of the hydrographic basins, especially regarding the temporal and spatial distribution of rainfall, the relative humidity of the air and the maximum, minimum and average temperatures of the air, which offer important subsidies to the management of water resources and agriculture. The irregular distribution of rainfall indicates instability in the entry of water into the hydrological system, exercising control over water availability

in time and space, the relative humidity of the air influences animal and plant behaviors and the amount of water available in the atmosphere. The temperature, on the other hand, influences the evapotranspiration rates, indicating the energy availability of the environment and, consequently, the environmental water demand. The work presents characteristics of the hydrographic basin of the Uruçuí Preto River (BHRUP), in terms of rainfall, relative humidity, temperature, climatological water balance and climatic regimes. The graphs of annual behavior and seasonal regimes elaborated for 25 pluviometric stations distributed in the interior and around the basin, most of them in operation since the 1960s, followed by the elaboration of average isoietas charts and the one of the rainiest semester, relative humidity of the air, isotherms of the maximum, minimum and average temperatures, and of the letters of potential evapotranspiration, real evaporation and water deficit. The climatic types were appreciated due to the influence of the habitual behavior of the atmosphere on the potential and real environmental demand for water and also on the anthropic demand. The Thornthwaite (1948, 1953) climate system was used, based on the comparison between potential evapotranspiration and rainfall.
Keywords: Climatic regimes; Relative humidity; Air temperature; Water balance.

Resumo
O conhecimento das características climáticas das bacias hidrográficas, especialmente quanto à distribuição temporal e espacial da pluviosidade, da umidade relativa do ar e das temperaturas máximas, mínimas e médias do ar, os quais oferecem importantes subsídios à gestão dos recursos hídricos e a agropecuária. A distribuição irregular da pluviosidade indica instabilidade na entrada de água no sistema hidrológico, exercendo controle sobre a disponibilidade hídrica no tempo e no espaço, a umidade relativa do ar influência nos comportamentos animal e vegetal e na quantidade da água disponível na atmosfera. Já a temperatura exerce influência sobre as taxas de evapotranspiração, indicando a disponibilidade energética do ambiente e, consequentemente, a demanda hídrica ambiental. O trabalho apresenta características da bacia hidrográfica do rio Uruçuí Preto (BHRUP), quanto à pluviosidade, umidade relativa do ar, temperatura, balanço hídrico climatológico e regimes climáticos. Os gráficos de comportamento anual e regimes sazonais elaborados para 25 postos pluviométricos distribuídos no interior e no entorno da bacia, a maioria deles em operação desde a década de 1960, seguidos da elaboração de cartas de isoietas médias e a do semestre mais chuvoso, umidade relativa do ar, isotermas das temperaturas máximas, mínimas e médias, e das cartas de evapotranspiração potencial, evaporação real e déficit hídrico. Os tipos climáticos foram apreciados devido à influência do comportamento habitual da atmosfera na demanda ambiental potencial e real de água e também na demanda antrópica. Foi utilizado o sistema climático de Thornthwaite (1948, 1953), baseado na comparação entre evapotranspiração potencial e pluviosidade.
Palavras-chave: Regimes climáticos; Umidade relativa do ar; Temperatura do ar; Balanço hídrico.

Resumen
El conocimiento de las características climáticas de las cuencas hidrográficas, especialmente en cuanto a la distribución temporal y espacial de las precipitaciones, la humedad relativa del aire y las temperaturas máximas, mínimas y medias del aire, que ofrecen importantes subsidios al manejo de los recursos hídricos y la agricultura. La distribución irregular de las lluvias indica inestabilidad en la entrada de agua al sistema hidrológico, ejerciendo control sobre la disponibilidad de agua en el tiempo y el espacio, la humedad relativa del aire influye en el comportamiento de animales y plantas y en la cantidad de agua disponible en la atmósfera. La temperatura, en cambio, influye en las tasas de evapotranspiración, indicando la disponibilidad energética del medio ambiente y, en consecuencia, la demanda ambiental de agua. El trabajo presenta características de la cuenca hidrográfica del río Uruçuí Preto (BHRUP), en términos de precipitaciones, humedad relativa, temperatura, balance climatológico hídrico y regímenes climáticos. Los cuadros de comportamiento anual y regímenes estacionales elaborados para 25 estaciones pluviométricas distribuidas en el interior y alrededor de la cuenca, la mayoría en funcionamiento desde la década de 1960, seguido de la elaboración de cuadros de isoietas medias y el del semestre más lluvioso, la humedad relativa de la cuenca. aire, isotermas de las temperaturas máxima, mínima y media, y de las letras de evapotranspiración potencial, evaporación real y déficit hídrico. Los tipos climáticos fueron apreciados por la influencia del comportamiento habitual de la atmósfera sobre la demanda ambiental potencial y real de agua y también sobre la demanda antrópica. Se utilizó el sistema climático de Thornthwaite (1948, 1953), basado en la comparación entre la evapotranspiración potencial y la lluvia.
Palabras clave: Regímenes climáticos; Humedad relativa; Temperatura del aire; Equilibrio hídrico.

1. Introduction

Climatic variations intervene in the availability and dependence of water, conditioning the event of critical situations for society and for the environment. There is a strong analogy of the volume, frequency and intensity of rainfall with the availability of surface, underground water and agriculture, since rain represents the most important phase of the hydrological cycle, being the primary source of most of the terrestrial fresh water. There is an almost direct proportionality between the intensity of the rain and infiltration. When the rains are evenly distributed, they may allow greater infiltration, as the speed of penetration into the soil follows the precipitated index. Torrential rains favor direct runoff, as the infiltration rate may be lower than the large volume of precipitated water in a short period of time. It is therefore important to assess the temporal dispersion of rainfall, which is normally very high in the tropical region.

The hydrological cycle is a closed sequence of natural phenomena that can be divided into two parts: the aerial branch, normally studied in the field of meteorology and the terrestrial branch, the object of hydrology.The boundary surface of the phenomena pertinent to each of these branches is the globe-atmosphere interface. It is considered that the aerial branch of the hydrological cycle begins when the water is transferred to the atmosphere, in the state of vapor, ending when it is returned to the Earth's surface, in liquid or solid state. The water vapor that appears at the globe-atmosphere interface mixes with the air by turbulent diffusion, being quickly transported by the air currents. Afterwards, finding favorable conditions, it returns to the solid or liquid state inside the atmosphere itself, or in some other point on the surface, in general, very distant from the place where it originated. For all these reasons, the concentration of water vapor in the air is quite variable, both in space and in time. This variation is, in general, all the greater the closer to the source surface the layer is considered. From a purely meteorological point of view, the variation in the concentration of water vapor in the air has no profound implications, as it significantly influences the energy of the atmosphere (Peixoto, 1969).

Knowledge of the amount of water vapor in the air is essential in several other branches of human activity. It is known, for example, that ambient humidity is one of the factors that condition the development of many pathogenic microorganisms that attack cultivated plants and plant transpiration itself is closely related to the moisture content of the surrounding air. The influence of air humidity on longevity, fertility and the rate of development of many insect species is also known (Neto et al., 1976). On the other hand, one of the parameters used to define the degree of environmental comfort for people and animals is also the atmospheric humidity prevailing in the place in question. Finally, it is emphasized that the maintenance of the optimum range of air humidity constitutes an object of constant control during the storage of numerous products. It is recognized that this parameter is little explored in the current bibliography, which demonstrates the need to better understand its spatial and temporal variations for the area under study.

The temperature indicates the energy availability of the environment, playing an important role in the processes of photosynthesis, respiration and evapotranspiration. Temperature data are widely used to estimate evapotranspiration using simplified methods. Any climatic characterization on a regional scale must use temperature data, in view of the interactions of this element with other geoenvironmental variables.

The living beings that populate the planet live adapted to the energy of the environment. In addition to daily variation, the air temperature also varies throughout the year, depending on the layout of the relief and the latitude, which influences the distribution of solar radiation. Air temperature has a clear effect on the development of living beings, since temperature is one of the most important meteorological elements, as it reflects the energetic and dynamic states of the atmosphere and consequently reveals the atmospheric circulation, being able to facilitate and/or block atmospheric phenomena (Dantas et al., 2000).

Knowledge of the behavior of climatic variables is of paramount importance for the planning of agricultural activities. And the air temperature stands out in the conduct of studies concerning agricultural ordering, land use, ecological zoning and climatic aptitude, sowing time, estimate of the crop cycle, among others. (Oliveira Neto et al., 2002).

In addition to the spatialization of temperature data, it is important to characterize their variation in time. In mathematical models for quantifying growth and predicting the proper sowing time, the average daily temperature is an important parameter both in promoting (10 °C to 30 °C) and in inhibiting growth and crop development (Aspiazu, 1971; Sierra & Murphy, 1973).

In the present study, rainfall, relative humidity, maximum, minimum and average temperatures, evaporation and evapotranspiration and water balance were studied from the point of view of their spatial and temporal irregularity. Graphs of annual behavior, seasonal regimes and average isoietas and the one of the rainiest semester, relative humidity of the air, isotherms of the maximum, minimum and average temperatures, and of the letters of potential evapotranspiration, real evaporation and water deficit were elaborated. The climatic types of the region were also considered due to the influence of the usual integrated behavior of the atmosphere on the potential and real environmental demand for water and even on the anthropic demand, in addition to the meteorological factors causing or not rains in the studied region.

Small producers to develop subsistence activities used only riverside lands and narrow areas close to urban agglomerations. With the development and expansion of agriculture and livestock, large land areas are being used for the aforementioned purposes, and do not take into account some meteorological elements that can minimize the occurrences of damage from anomalous effects that may happen.

It is characterized by the high atmospheric moisture content, as a consequence of large flows of water vapor into the atmosphere, due to the high rates of evapotranspiration.

Knowledge of the wet season or wetter quarter is of fundamental importance for establishing the best planting time and growing season, particularly for the practice of rainfed agriculture. Studies of this nature have been developed for the Northeast of Brazil, based on temporal analysis of rainfall (Bastos & Azevedo, 1986).

Medeiros et al. (1989) defined the relative humidity regimes in the Northeast of Brazil (NEB), using 64 climatological stations with more than 10 years of observations covering the region, which allowed the delimitation of three regimes for the Northeast of Brazil (NEB). Medeiros et al. (1992) also studied the behavior of the relative humidity of the air for some stations in the State of Piauí.

The pluviometry represents the fundamental attribute in the analysis of tropical climates, reflecting the performance of the main currents of the atmospheric circulation. In the southern region of the state of Piauí, specifically, the rains determine the regime of perennial rivers, streams, streams, levels of lakes and ponds, the occupation of the soil, being essential to the planning of any activity the knowledge of its dynamics.

The factors that provoke rain in the studied area are the formation of lines of instability carried by the trade winds from the Southeast/Northeast, heat exchange, traces of cold fronts during their most active penetrations, formation of convective clusters, orography, training contributions cyclonic vortexes and local effects are factors that increase the transport of water vapor and humidity and consequently the cloud cover.

2. Methodology

2.1 Localization of the study area

The region is drained by the Uruçuí Preto River and by the affluent Ribeirão dos Paulos, Castros, Colheres and Morro da Água, and by the streams of Estiva and Corrente, both perennial. The Uruçuí Preto River basin is predominantly embedded in the Parnaíba River sedimentary basin, constituting one of the main tributaries on the right bank. It has a total area of approximately 15,777 km2, representing 5% of Piauí's territory and covers part of the southwest region, projecting from the south to the north in the form of a spear, according to Piauí Development Company (COMDEPI) (2002).

The total area of the basin is located between the geographic coordinates that determine the rectangle from 07°18'16" to 09°33'06" south latitude and 44°15'30" at 45°31'11" west longitude of Greenwich. In accordance with COMDEPI (2002), the hydrographic basin of the Uruçuí Preto River shows a unique set of forms of regional relief, dominated by the tabular-plateau and plateau forms, characteristic of the sub-horizontal sedimentary rocks.

Only the Plateau of the Parnaíba Sedimentary Basin is identified as a morphostructural unit in the region and, in addition to being located in the central-eastern portion of the Piauí-Maranhão Sedimentary Basin, it is constituted by a sequence of sandy-clay sediments, composing the various sedimentary formations.

According to Brazilian Agricultural Research Corporation (EMBRAPA) (1986), the three most frequent classes of soils identified in the Uruçuí Preto River basin are Yellow Oxisol (predominant in the basin), Entisol and Entisol Quartzipsammentunder and Hydromorphic.

For COMDEPI (2002), the supply of groundwater in the Uruçuí Preto river basin occurs through four aquifers, Serra Grande, Cabeças, Poti/Piauí and Pedra de Fogo Formation. The Serra Grande Formation is mainly composed of coarse and medium sandstones, conglomerates and conglomerates at various levels (beige to white), with flat cross stratification. In addition, although it is one of the most outstanding in the Northeast, it is also distributed throughout the Parnaíba Sedimentary Basin, it does not offer efficient exploration possibilities in the Uruçuí Preto River basin due to the great depths.

According to COMDEPI (2002), the identification and description of vegetation in the Uruçuí Preto river basin region are found:

- from the top of the plateaus, with the typical vegetable community of the savannas constituted by a discontinuous stratum composed of shrub and tree elements characterized by tortuous trunks, thick bark, leathery leaves and an almost asymmetrical canopy. Among the most frequent species are barbatimão, broad-leafed stick and simbaíba, and the soil surface is covered by a grassy stratum of wild grass;
- starting from the slopes between the top of the plateaus and the flat stretch through which the Uruçuí Preto River flows. In this aspect, the cerrado develops in a more closed way, composed of larger species, among which pau d´arco, Gonçalo Alves;
- the basin area is bypassed by 25 municipalities and 24 farms.

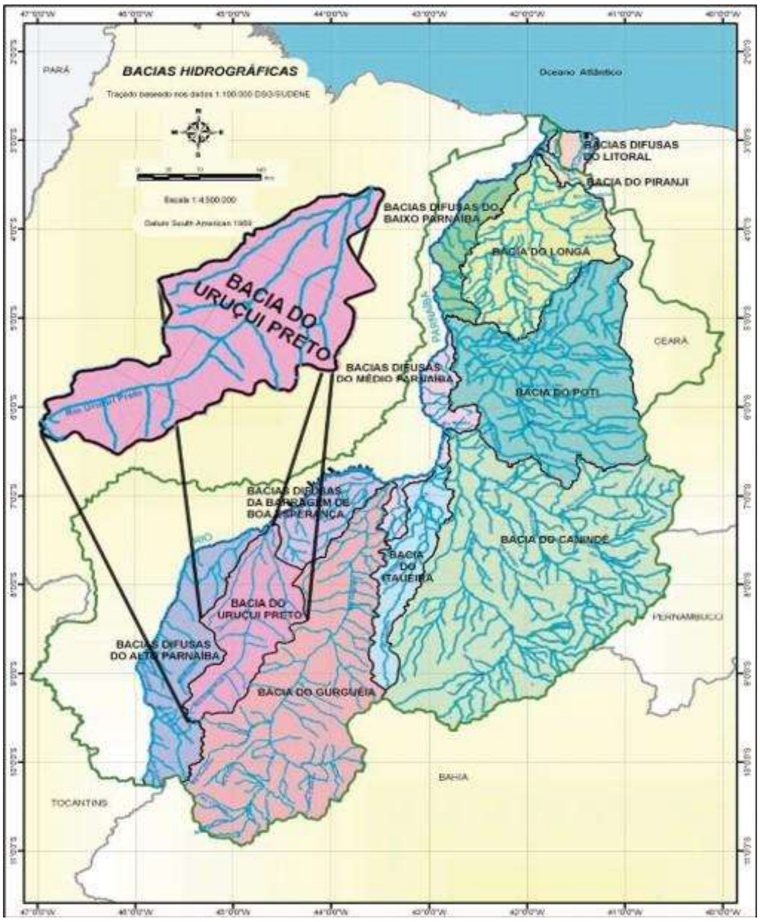
2.2 Obtained data for study

The area of interest of the study has a network of meteorological stations reduced and poorly distributed spatially, which makes it difficult to characterize the climatic conditions. Therefore, it was used interpolated data, estimated and generated by multiple linear regression lines, through the software estima_T (Cavalcanti et al., 2006).

For the analysis of the intermunicipal climatic behavior of the Uruçuí Preto river basin, precipitation data acquired through the Northeast Development Superintendence (SUDENE) and from the Piauí State Technical Assistance and Rural Extension Company (EMATERPI) were used for the 1960 to 1990, comprising 49 pluviometric stations located in the study area.

The climatic classification was used according to the Köppen systems, in which two climatic types are distinguished in the Uruçui Preto river basin - PI, Aw, hot and humid tropical, with rain in summer and drought in winter, and Bsh , hot semiarid, with summer rains and dry winter, Medeiros (2013).

Figure 1. Location of the hydrographic basin of the Uruçuí Preto River – PI.



Source: Adapted according to Medeiros (2013).

The precipitation regime that comprises the study area begins with the pre-season rains, starting in the second half of October. The characterization of the rainy season begins in the first days of the month of November and continues until the month of March, with the months of December, January and February as the rainiest quarter.

The factors causing rain that are predominantly present in the hydrographic basin of the Uruçuí Preto River are the formation of lines of instability carried by the trade winds from the Southeast / Northeast, heat exchanges, traces of cold fronts, when their penetrations are more active, formations of convective clusters, orography, contributions of formation of cyclonic vortices, conveyor belt, orography and local effects. These are factors that increase the transport of water vapor and humidity and, consequently, the cloud cover.

Normally the rains have moderate intensity (from regular weather and around seven to eight hours of daily discontinuous rains), followed by irregularity due to the failures of the active meteorological systems. It should be noted that the occurrence of summer periods (occurrences of several consecutive days without rain during the rainy season) in the four-month period (December, January, February, March) is expected. Its magnitude is varied depending on the season and the deactivated meteorological factors. There have been occurrences with summer periods greater than nineteen monthly days in the interval of time that occurred within the four-month period, Medeiros (2013).

The study of the spatial temporal behavior of rainfall relied on data provided by the Northeast Development Superintendence (SUDENE) and the Institute of Technical Assistance and Rural Extension of the State of Piauí (EMATERPI); these data were collected in 25 stations. Table 1 shows the municipalities with their pluviometric posts and their geographic coordinates.

Table 1. List of municipal rainfall stations and their respective geographic coordinates for the hydrographic basin of the Uruçuí Preto River.

MUNICIPALITIES/COORDINATES	LAT ° '	LONG ° '	ALT meters
Alvorada Gurguéia	08 25	43 46	281.0
Alto Parnaíba - MA	09 07	45 56	220.0
Avelino Lopes	10 08	43 57	400.0
Barreira do Piauí	09 55	45 28	500.0
Bom Jesus	09 04	44 21	220.0
Colônia do Gurguéia	08 10	43 48	200.0
Corrente	12 26	45 09	434.0
Cristalândia	10 39	45 11	600.0
Cristino Castro	08 48	44 13	240.0
Curimatá	10 02	44 17	350.0
Currais	09 00	44 24	320.0
Elizeu Martins	08 12	43 23	210.0
Gilbués	09 49	45 21	500.0
Julio Borges	10 19	44 14	389.0
Manoel Emídio	07 59	43 51	200.0
Monte Alegre	09 45	45 17	454.0
Morro Cabeça no Tempo	09 43	43 54	479.0
Palmeira do Piauí	08 48	44 18	268.0
Parnaguá	10 13	44 38	316.0
Redenção Gurguéia	09 30	44 36	365.0
Riacho Frio	10 07	44 57	400.0
São Gonçalo do Gurguéia	10 01	45 18	440.0
Santa Filomena	09 05	46 51	380.0
Santa Luz	08 55	44 03	340.0
Sebastião Barros	10 49	44 50	360.0

Source: SUDENE/EMATERPI (2013).

The data of precipitation, relative humidity of the air and the maximum, average and minimum air temperatures were worked on electronic spreadsheets and analyzed in order to identify patterns of temporal and spatial distribution. For climatic characterization, the climatic water balance of Thornthwaite (1948, 1955) was used, which is based on the comparison between potential evapotranspiration and rainfall. Based on these variables, the humidity and thermal efficiency indexes are calculated.

The first generates a scale that goes from dry to very humid. The second generates another scale, the megathermal the cold. The climatic types for the hydrographic basin of the Uruçuí Preto River were identified considering only the spatial variations of the annual humidity, aridity and water index. The climatic classification was used by the Köppen method according to Table 2.

Table 2. List of municipalities and their respective humidity indexes (IU), aridity indexes (IA), water indexes (IH) and climatic classification according to Köppen for the hydrographic basin of the Uruçuí Preto River.

MUNICIPALITIES/COORDINATES	LAT ° ‘	LONG ° ‘	ALT meters	Köppen
Alvorada Gurguéia	0.46	48.32	-47.86	Bsh
Alto Parnaíba - MA	0.00	57.45	-57.45	AW
Avelino Lopes	0.00	47.35	-47.35	Bsh
Barreira do Piauí	14.02	40.27	-26.25	AW
Bom Jesus	3.91	43.11	-39.20	Bsh
Colônia do Gurguéia	0.11	60.62	-60.51	Bsh
Corrente	18.69	37.86	-19.17	AW
Cristalândia	15.79	38.24	-22.45	AW
Cristino Castro	3.02	46.41	-43.38	Bsh
Curimatá	1.77	43.44	-41.67	Bsh
Currais	4.44	44.47	-40.03	Bsh
Elizeu Martins	0.00	49.82	-49.82	Bsh
Gilbués	13.67	39.78	-26.12	AW
Julio Borges	14.83	40.09	-25.26	AW
Manoel Emídio	0.00	49.37	-49.37	Bsh
Monte Alegre	11.31	38.51	-27.20	AW
Morro Cabeça no Tempo	4.15	39.39	-35.24	Bsh
Palmeira do Piauí	0.07	49.77	-49.71	Bsh
Parnaguá	10.33	39.62	-29.29	AW
Redenção Gurguéia	1.78	46.51	-44.73	Bsh
Riacho Frio	9.51	37.76	-28.25	AW
São Gonçalo do Gurguéia	12.28	40.89	-28.61	AW
Santa Filomena	39.18	38.15	1.02	AW
Santa Luz	3.65	46.18	-42.53	Bsh
Sebastião Barros	16.28	37.64	-21.37	AW

Source: SUDENE/EMATERPI (2013).

3. Results and Discussion

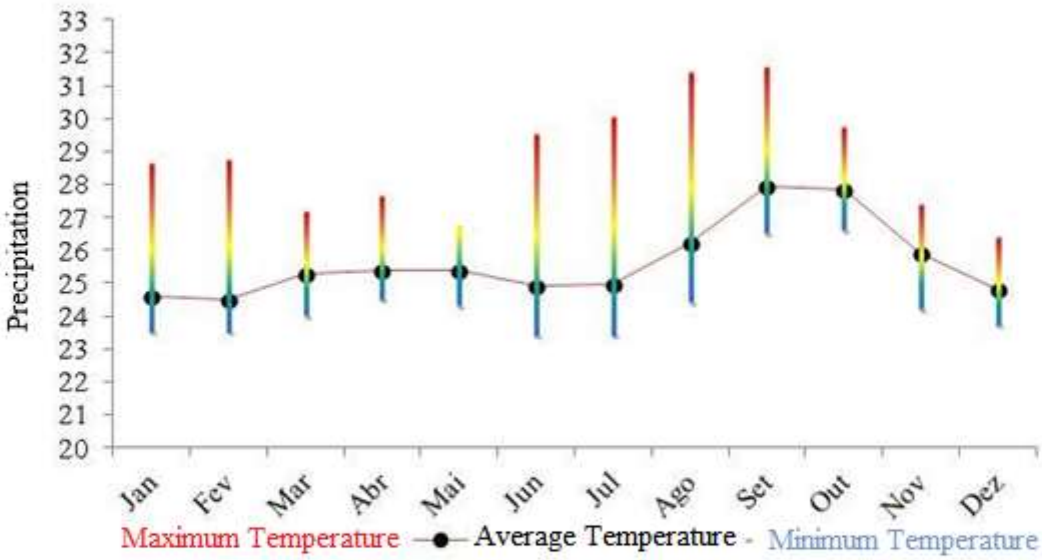
3.1 Rainfall

The precipitation regime that comprises the area of the hydrographic basin of the Uruçui Preto River (BHRUP), located in the southern region of the state's precipitation regime, falls within the range of the isoeites from 478.7 to 1,413.3 mm, with a precipitation annual average around 916 mm.

Normally, the rains have moderate intensity (of regular weather and around six to nine hours of daily discontinuous rains), followed by irregularity due to the failures of the active meteorological systems. It should be noted that the occurrence of summer periods (occurrences of several consecutive days without rain during the rainy season) in the four-month period (December, January, February, March) is expected. Its magnitude is varied depending on the season and the deactivated meteorological factors. There have been occurrences with summer periods exceeding eighteen days per month in the time interval that occurred within the four-month period.

The analysis of rainfall in the dry and rainy seasons allows us to perceive the variability in the spatial and temporal distribution of rainfall, due to a topographic barrier that significantly interferes with the passage of humid air from the traces of the cold fronts (Figure 2). In the rainy season, which runs from October to April, the average total rainfall in the study area ranges from 53.8 to 180.8 mm. In the dry period, which extends from May to September, this area remains with total rainfall fluctuating between 0.8 to 22.0 mm. The variability of rainfall indexes between the twenty-five stations fluctuates from 478.7 to 1.413.3 mm, these sudden fluctuations are due to the topographic barrier and the number of years of rain collections, that is, some municipalities such as Alvitrados do Gurguéia Avelino Lopes, Colônia do Gurguéia and Manoel Emidio have a 17-year rainfall series. The predominant vegetation is the park and, to a lesser extent, patches of cerrado and caatinga arboreal, which proves the occurrence of a relatively more humid climate.

Figure 2. Graph of the spatial distribution of maximum, average and minimum annual rainfall for the hydrographic basin of the Uruçuí Preto River.



Source: Authors.

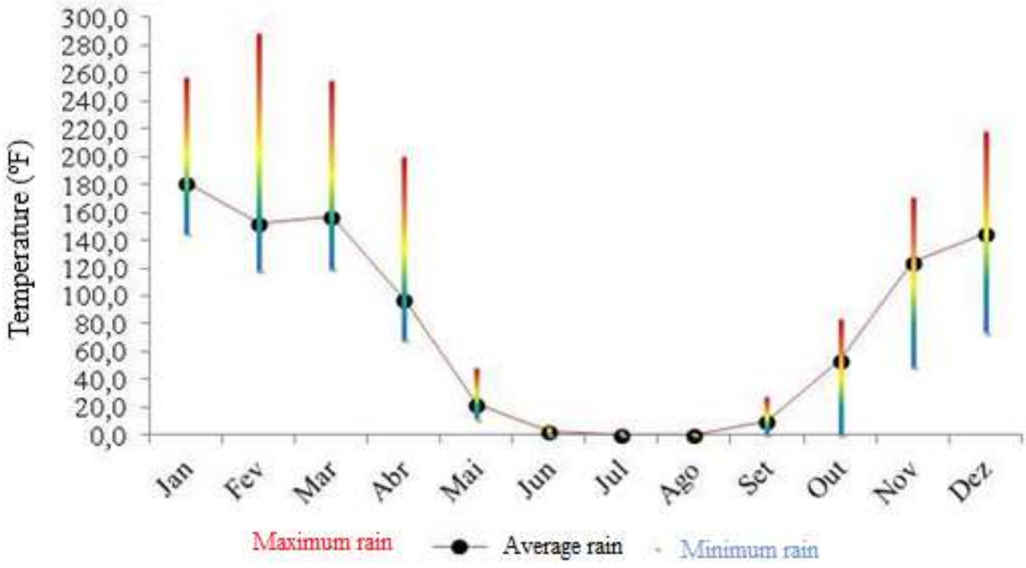
It is good to remember that the pluviometric indexes and their seasonal distribution are due to the combination between the dynamic mechanisms of the atmosphere, which have regional influence, therefore extrapolating the limits of the basin, and the static factors, of local influence. The configuration of the relief and the entrance traces of the cold fronts with greater activities are decisive factors for the spatial and temporal distribution of the rains and determinants for the thermodynamic processes in the entire study area.

In any case, considering that rainfall tends to increase from low to high altitudes, it is possible that on the tops of plateaus in the central area of the basin the rates are slightly higher compared to the valleys. The absence of data does not allow to confirm this possibility. This would not indicate greater water availability due to the high combination of soils as described, Soils with Latosol B horizon, present in the association LVd10; poorly developed soils occur in the R8 association; Quartz sandy soils, constituting the association AQd2; and tropical concretionary soils, forming part of the SCT5 association.

3.2 Temperatures

The temperature analysis, carried out for the twenty-five municipalities that make up the hydrographic basin of the Uruçuí Preto River, highlighted its maximum and minimum values followed by the average annual value. Although it aggregates water characteristics from the cerrado with variations from AW (hot and humid climate) to Bsh (semi-arid climate), the spatial fluctuations of maximum temperatures range from 28.5 ºC to 39.0 ºC, with an annual average of 32.2 ºC. Fluctuations in average temperatures range from 23.4 ºC to 31.6 ºC, with an annual average of 25.7 ºC, minimum temperatures vary and 16.9 ºC to 24.2 ºC, with an annual rate of 19.9 ºC, Medeiros (2013). Naturally, in the valley bottoms, the values are higher and in the mountain regions they are lower. The major problem related to the study of the thermal behavior of the basin is the lack of meteorological and fluviometric stations. Figure 3 represents the variations of the maximum, average and minimum annual temperatures estimated by the method of multiple regression lines, Cavalcanti (1994).

Figure 3. Graph of the spatial distribution of maximum, average and minimum annual temperatures for the hydrographic basin of the Uruçuí Preto River.

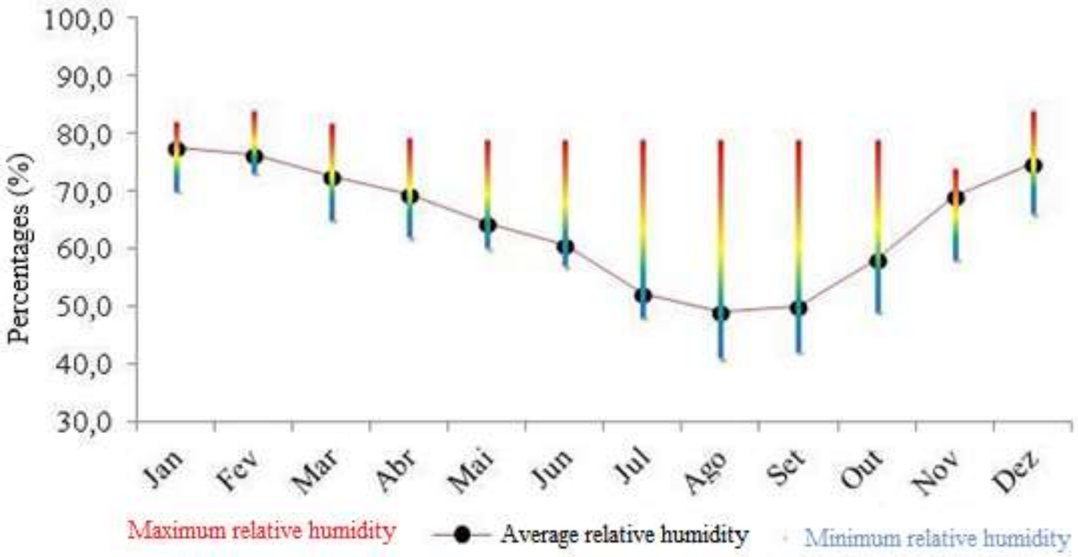


Source: Authors.

3.3 Relative humidity of the air

The temporal and spatial fluctuations of the maximum relative air humidity wavered between 74.0% and 84.0%, while the fluctuations in the average relative humidity of the air vary between 49.1 and 77.7% and the minimum relative humidity of the air ranged from 41.0 to 73.0%. Analyze of the relative humidity of the air in the study and maximum, average and minimum annual variations in relative humidity are represented in Figure 4.

Figure 4. Graph of the spatial distribution of relative maximum, average and minimum annual air humidity for the hydrographic basin of the Uruçuí Preto River.



Source: Authors.

3.4 Climate water balance

The most widely used technique for working with global water balance data from a climatological point of view is the water balance of Thornthwaite and Mather (1948, 1955). By 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 (CAD), the water balance provides estimates of actual evapotranspiration (ETR), water deficiency (DEF), water surplus (EXC) and effective water storage in the soil (ARM), which can be elaborated from the daily to the monthly scale (Camargo, 1971; Pereira et al., 1997).

In Table 3, the climatological water balance is most often presented on a monthly scale and for an average year, that is, a cyclical water balance drawn from the average climatological conditions of average temperature and rain. According to Camargo and Camargo (1993), it is a useful and practical instrument to characterize the humidity factor of the climate, being its indispensable use in the climatic characterization (Vianello & Alves, 1991; Pedro Júnior et al., 1994), as well as in the definition of the agricultural aptitude of the regions (Ortolani et al., 1970; Camargo et al., 1974).

Table 3. Regional water balance of Thornthwaite and Mather (1955) for the hydrographic basin of the Uruçuí Preto River.

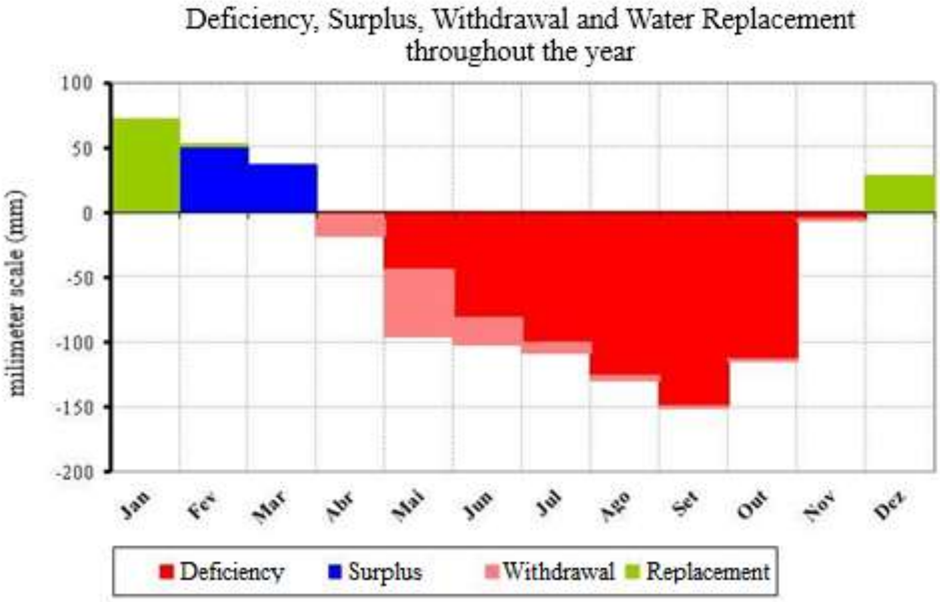
Months	T °C	P mm	ETP m	EVR mm	DEF mm	EXC mm
Jan	24.6	180.8	109.7	109.7	0.0	0.0
Feb	24.5	152.4	100.1	100.1	0.0	51.2
Mar	25.3	157.2	121.1	121.1	0.0	36.1
Apr	25.4	97.9	115.7	114.2	1.5	0.0
May	25.4	22.0	117.5	73.4	44.1	0.0
Jun	24.9	2.8	104.8	23.4	81.4	0.0
Jul	25.0	0.8	109.1	8.5	100.6	0.0
Aug	26.2	0.8	130.1	3.6	126.5	0.0
Sep	27.9	10.4	160.3	11.2	149.1	0.0
Oct	27.8	53.4	167.3	53.6	113.7	0.0
Nov	25.9	123.8	128.8	123.8	5.1	0.0
Dec	24.8	144.4	116.7	116.7	0.0	0.0
AVERAGE	25.7	78.9	123.4	71.6	51.8	7.3

Source: Medeiros (2007).

Figure 5 presents the regional water balance of Thornthwaite and Mather (1955) for the hydrographic basin of the Uruçuí Preto River. It is observed that there is a water surplus only in the months of February and March; from April to November the situation is handicapped. In the months of April, May, June, July, August, September, October and November the environmental water demand (evapotranspiration) is higher than the supply (rainfall). The storage is maximum in the months of February and March, that is, the soil remains with 100 mm of stored water. In fact, out of a total of 916 mm of precipitation per year (on average), only 87.3 mm is available to percolate or run off superficially and this occurs in the months of February and March.

The graph below represents the cycle of deficiency, surplus, withdrawal and water replacement throughout the year for the hydrographic basin of the Uruçuí Preto River.

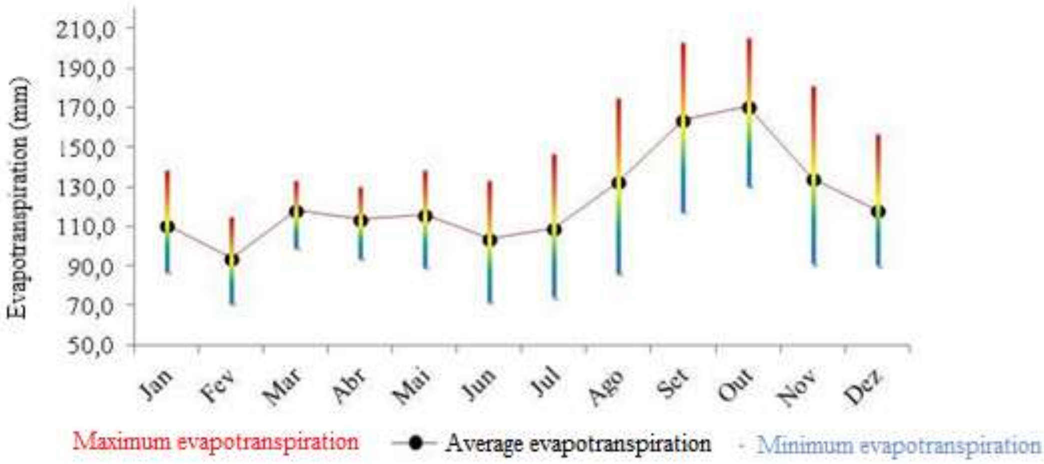
Figure 5. Graph of the water balance for the hydrographic basin of the Uruçuí Preto River.



Source: Authors.

Figure 6 represents the spatial variations of potential evapotranspiration (ETP) for the hydrographic basin of the Uruçuí Preto River. The maximum fluctuations of monthly ETP occur between 114.5 and 205.7 mm, whereas in the average ETP the fluctuations are between 93.8 and 170.8 mm, and the minimum fluctuations in ETP occur between 70.7 and 130, 2 mm. The average ETP of the study area is 1,483.9 mm.

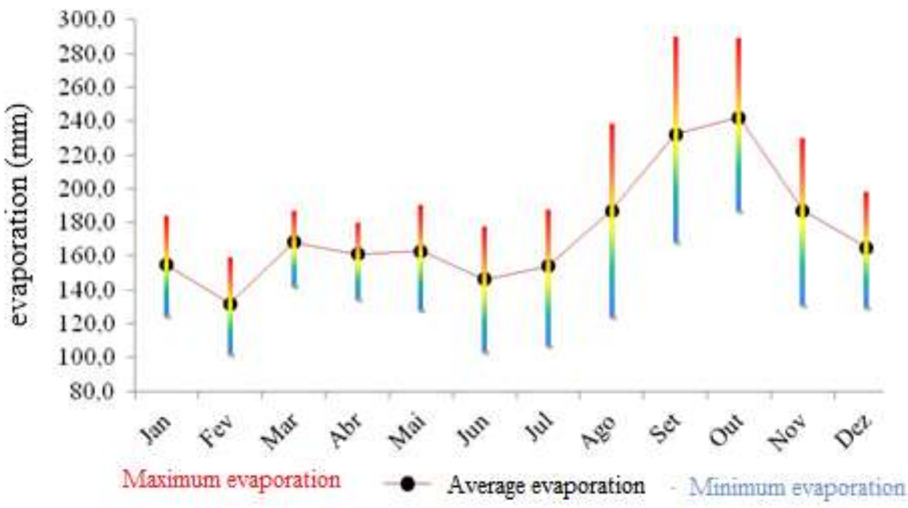
Figure 6. Graph of the spatial distribution of maximum, average and minimum annual potential evapotranspiration for the hydrographic basin of the Uruçuí Preto River.



Source: Authors.

Figure 7 represents the spatial variations of the actual evaporation (EVR) for the hydrographic basin of the Uruçuí Preto River. The maximum fluctuations of monthly EVR occur between 159.0 and 289.7 mm, whereas in the average EVR the fluctuations are between 131.7 and 242.0 mm, and the minimum EVR fluctuations occur between 101.1 and 186, 0 mm. The average EVR of the study area is 2,092.0 mm.

Figure 7. Graph of the spatial distribution of maximum, average and minimum annual Evaporation for the hydrographic basin of the Uruçuí Preto River.



Source: Authors.

4. Final Considerations

For future work we recommend studies following the methodology described with recommending humid regimes important for studies of weather forecast and mainly for agricultural planning, contributing to information to the rural man when preparing the land for planting. In this way, preventing it from planting at inappropriate times, avoid waste and losses, and still have the right conditions for profitability and agricultural yields, in addition to the control of diseases and pests of cultivated plants. In urban planning, it aims at extreme events of floods, flooding, floods, overflowing of lakes and lagoons.

Such delimitations of the wetter quarters and information on the periods of lower relative humidity of the air serve as a warning to federal, state and municipal authorities, in addition to decision makers, for better planning.

The pluviometric scenarios more adequately incorporate the spatial and temporal variability of the rains and are more compatible with the physical reality, allowing to make the classification and climatic regionalization dynamic and adjusted to the models of climatic forecast in use in Brazil.

The climatic classification criterion of Thornthwaite and Mather (1955) is less restrictive than that of Thornthwaite (1948), since it recommends scales of aridity and semiaridity with greater amplitude.

The hydrographic basin of the Uruçuí Preto River presents significant climatic heterogeneity, which creates varied scenarios in relation to water availability and demand. The climate factor acts dynamically along with other attributes of the physical and biotic environment and is decisive as to the occurrence of significant geoenvironmental distinctions within the basin, including ecological differences and even influences on cultural patterns and ways of using natural resources.

The understanding of the behavior of the parameters rain, temperature and other variables related to the climatological water balance, especially regarding the temporal and spatial inconsistencies, can contribute to the understanding of the physical-natural dynamics of the hydrographic basin of the Uruçuí Preto river. In the present study, it was evidenced that the temperature variations (maximum, average and minimum) are relatively within the normal state standard; as for rainfall, the temporal and spatial dispersion of monthly and annual totals is very high. In this regard, the existence of patterns of spatial and temporal distribution of rainfall was indicated.

The climatological water balance of the hydrographic basin of the Uruçuí Preto River is favorable to various agricultural activities. In addition to the reduced amount of rain in the dry season, temperatures are high and the relative humidity of the air remains below the indication of OMM. For plants, the situation is greatly complicated during the dry period, as ETP remains high and the water supply depends on absorption from the deepest layers of the soil. In this case, it is good to remember that the soils in the region are not restricted, including with regard to groundwater capacity.

The results presented in the present work may contribute to an optimization of agricultural activities and other water uses that require identification of situations in which the climate is the limiting factor. New alternatives for territorial use and occupation, in tune with the physical and environmental reality of the Uruçuí Preto river basin, must be evaluated and suggested.

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