International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

Check for updates

Estimation of rain erosivity index in Caruaru-Pe

Raimundo Mainar de Medeiros [1,*], Manoel Vieira de França [1], Romildo Morant de Holanda [1], Luciano Marcelo Fallé Saboya [2], Moacyr Cunha Filho [1] and Wagner Rodolfo de Araújo [3]

[1] *Federal Rural University of Pernambuco, Brazil.*
[2] *Academic Unit of Agricultural Engineering Federal University of Campina Grande, Brazil.*
[3] *Geography Estacio de Sa University, Brazil.*

International Journal of Science and Research Archive, 2022, 05(02), 177–182

Publication history: Received on 02 March 2022; revised on 09 April 2022; accepted on 11 April 2022

Article DOI: https://doi.org/10.30574/ijsra.2022.5.2.0078

Abstract

The objective is to determine the erosive indexes of rainfall (R), subsidizing information to the agricultural, water and textile sectors so that they can carry out planning and projects with safety aiming at improvements in productivity. The historical rainfall values of 104 years were ceded by the Water and Climate Agency of the State of Pernambuco and by the Superintendency of Development of the Northeast. The data used correspond to the series of years from 1913 to 2016 where the monthly average of each year was calculated and with the values found, determined average values of monthly precipitation in the period of 104 years. There is a need for pre-planning of land for implantation of agricultural projects, so that land displacement does not occur, supported by a monitoring of the changes occurring in the soil, especially in hillside regions, taking into account the contours of the terrain levels, thereby avoiding The silting of rivers and reservoirs. Erosivity follows the rhythm of the rainy season where its maximum occurrence is centered in the months of May, June and July and the minimum occurrences are the months of October, November and December. Caruaru was classified with low annual erosive power.

Keywords: Climatic Fluctuations; Evaporative Indices; Erosive indexes; climatic factor

1. Introduction

Erosion is a process of displacement of land or rocks from a surface. It can occur by the action of phenomena of nature or by human action. As for the actions of nature, we can mention the rains as the main cause of erosion. Upon reaching the soil, in great quantity, it causes landslides, infiltrations and changes in soil consistency, causing soil displacement, the process is accentuated by the wind and the temperature change.

The climatic factor in regions susceptible to desertification (arid, semi-arid and dry regions), taking into account their spatial and temporal variations, is determinant in the degradation of natural resources (water, vegetation, soils, etc.), thus imposing limitations on the management and Productivity according to the statement of [6].

Of the consequences that may occur in the attributes of the current climate, the serious ones would be the increase in the indices of aridity and the desertification areas due to the increase of the water deficit, besides extreme events that would be associated, in the regions that are already arid or semi-arid, The Brazilian semi-arid region [10].

With regard to precipitation, forecasts indicate that a reduction should occur in the tropical and subtropical region and an increase in the average of the regions of higher latitudes. In the northeastern semi-arid region, droughts during the rainy season will become even more serious, compromising the rainy season quality of the region according to [10].

[Corresponding author: Raimundo Mainar de Medeiros
Pós-Doc Federal Rural University of Pernambuco, Brazil.

For [9] showed that rainfall erosivity indices in the area of the Uruçuí Preto - Piauí river basin are very high. They used monthly precipitation data for the period 1960 to 1990. The total erosive index of 28,429.1 MJ mm ha^{-1} h^{-1} $year^{-1}$ was determined using the equation of Wischmeier and Smith. It was observed that the highest rates of erosivity occurred in the months of November to April coinciding with rainy season. However, the field capacity presents maximum values in the months of May to October (drought period) coinciding with the lowest values of erosivity.

For [4] showed that the erosive process and its intensity depend mainly on the climatic conditions of the region, factors related to topography, soil cover and soil properties.

For [9] have shown that rainfall erosivity is due to the quantity, intensity and duration of rainfall. Rainfall erosivity was estimated in the city of Areia - PB, using monthly precipitation data from 1910 to 2010 through the equation determined by [12, 13], by means of the sum of the values found each month. The factor (R) found was 31,528.8 MJ mm $ha^{-1}h^{-1}year^{-1}$. The highest rates of erosivity were observed in the months of March to August, coinciding with the rainy season and the maximum field capacity, with crop residues, and for the months of September, the first fortnight of February occurred. Lower erosivity indexes corresponding to the dry period and the beginning of the pre-season rains.

For [12] and [13] developed mathematical expressions for the purpose of evaluating the factors causing water erosion and estimating annual soil losses known as the Universal Soil Loss Equation and considered to be a good instrument for predicting losses Of soil, requiring relatively small numbers of information when compared to the more complex models and being well known and studied in Brazil. However, for its use, it is necessary the survey of several factors, among them the Erosivity of Rains (R), that allows the evaluation of the erosive potential of the precipitations of a certain place.

The objective is to determine the erosive indexes of rainfall (R), subsidizing information to the agricultural, water and textile sectors so that they can carry out planning and projects with safety aiming at improvements in productivity.

2. Material and methods

The municipality of Caruaru is located in the Agreste mesoregion and in the Ipojuca Valley Microregion in the State of Pernambuco, bordering Toritama, Vertentes, Frei Miguel and Taquatinga do Norte, to the south with Altinho and Agrestina, to the east with Calves and Riacho das Almas, and to the west with Brejo da Madre de Deus and São Caitano. The municipal area occupies 928.1 km^2 and represents 0.94% of the State of Pernambuco, with 16.6 km^2 being in urban perimeter and the remaining 903.9 km^2 forming the rural area. The seat of the municipality has an altitude of 554 meters and geographical coordinates of 08 ° 17'S latitude and 35 ° 58'W of longitude, distant 140.7 km from the capital. Figure 1 shows the location of the municipality of Caruaru.

Source: Medeiros [2022]

Figure 1 Location of the municipality of Caruaru **–** PE

The municipality of Caruaru is inserted in the geoenvironmental unit of the Borborema Plateau, formed by massive and high hills, with altitude varying between 650 and 1,000 meters. It occupies an area of arch that extends of the south of Alagoas until Rio Grande do Norte. The relief is generally bustling, with deep valleys and narrow dissected. With respect to the fertility of the soils, it is quite varied, with a certain predominance from average to high. The municipality is cut by perennial rivers, but of small flow and the groundwater potential is low.

The vegetation is formed by subsurface and deciduous forests, typical of wilderness areas. It has the caatinga as dominant vegetation of the municipality, with its typical trees, such as: juazeiro, baraúna, mulungú, algaroba and imburana, bushes of the type velameiro, quinceiro and nettle, bromeliaceas of the type such as caroá, macambira, gravatá and cactáceas of the type Xique-Xique, Mandacarú, Crown-of-Friar and Candlestick. It also has humid and

arboreal vegetation (tropical forest) to the south, as it has a border with the Pernambuco brejo in the southern end of the municipality.

The Caruaru climate according to the [3] classification is semi-arid (BSh), with warm and dry summers and mild and rainy winters in accordance with [1]. The rainy season begins in February with pre-season rains (rainfall occurring before the rainy season) with its end occurring at the end of August and may extend until the first half of September. The rainy trimester focuses on the months of May, June and July and its dry months occur between October, November and December. The factors that cause rainfall in the municipality are the contribution of the Intertropical Convergence Zone (ZCIT), the formation of high level cyclonic vortices (VCAS), the contribution of northeastern trade winds in the transport of steam and humidity to which they condense and form clouds causing rainfall Moderate to strong, formations of instability lines, orography and their local and regional contributions forming clouds and provoking moderate to strong rains according to [7].

Due to its location in the lands of Borborema, the soil has smooth surfaces that are undulating and undulating. The Planosols are moderately deep, strongly drained, acidic to moderately acidic and medium natural fertility, and Podzolics, which are deep, clayey texture and average natural fertility the high. In the elevations occur Litolics, shallow soils, clayey texture and average natural fertility. In the valleys of rivers and streams, Planosols occur, moderately deep, imperfectly drained, medium / clayey texture, moderately acidic, high natural fertility and salt problems. There are also Rock outcrops.

The rainfall data were acquired from the Northeast Development Superintendency (SUDENE), the Pernambuco Water and Climate Agency [2] from 1913 to 2016, using statistically simplified calculations to define historical average.

The current limitation of water resources is an important constraint to economic and social development, since it can lead to numerous challenges in the planning and management of this resource, according to [10]. The data failures occurred between the 90's can be explained by the change of responsibility in the collection of rainfall records from the old [11] to the current [2], in this period of transition the stations went through maintenance and others were implemented in some cities between 1989 and 1992 .Fulling of faults, homogenization and consistency in these data were accomplished to be able to work and provide reliable information to the public in general.

In order to determine the erosivity factor, the equation proposed by [12] and [12, 13] was defined as:

$$EI_{30} = 67{,}355\left(\frac{r^2}{P}\right)e^{0{,}85}$$

2.1. Being

- EI_{30} the monthly average of the rainfall erosivity index [MJ.mm ha^{-1}.h^{-1}];
- R the mean monthly precipitation [mm]; and
- P the mean annual precipitation [mm].

The R factor (erosivity of rainfall) allows the evaluation of the erosive potential of the precipitations of a certain place, being possible to know the capacity and the potential of the rain to cause erosion in the soil, so that an appropriate management and proper occupation of the ground can be done [9, 10]. The calculation of this factor is the sum of the monthly values of erosivity, according to the equation:

$$R = \sum_{1}^{12} EI_{30}$$

3. Results and discussion

Table 1 shows the variability of the historical precipitation and the distribution of rainfall erosion from the 1913-2016 period of the study area, it is observed that in the months of April, May and June rainfall causes erosion, in the other months Erosion caused by rainfall. The values of erosivity and R are shown in Table 1, in which it shows the variation of the monthly historical averages of precipitation and the evaluations of the EI30 index and the R factor.

The high rainfall indexes correspond to 44% of precipitated annual values in May, June and July. The reduced rates occur in October, November and December, corresponding to 6.5% of the total rainfall Occurred.

Table 1 Monthly and annual precipitation mean values with EI_{30} and R-factor

Monthly	Averages Monthly	EI_{30}	R
JAN	33.5	2597.5	
FEV	47.5	3152.4	
MAR	63.7	3339.4	
APR	73.4	3509.8	
MAY	80.1	3793.2	
JUN	92	4272.3	
JUL	80.5	4070.6	17142.2
AUG	42.3	2337.6	
SEP	23.7	1789.2	
OCT	8.9	842.8	
NOV	12.4	1267	
DEC	15.9	1417.7	
ANNUAL	573.4	17142.2	

Source: Medeiros, [2022].

The monthly irregularity in the rainfall indices is due to the meteorological factors that inhibit and / or activate rainfall systems in the area under study with local and regional contributions.

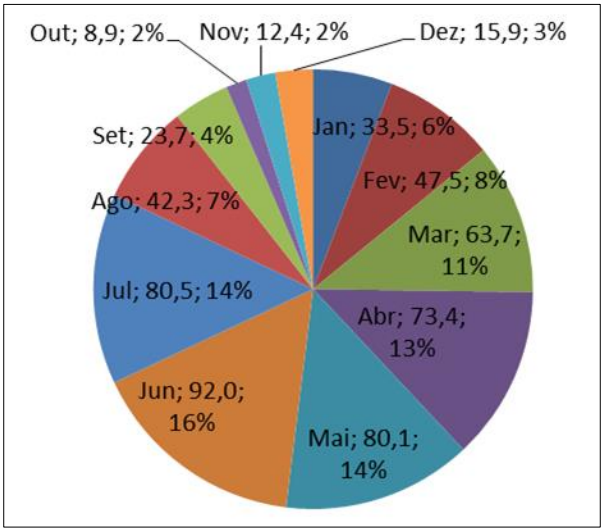


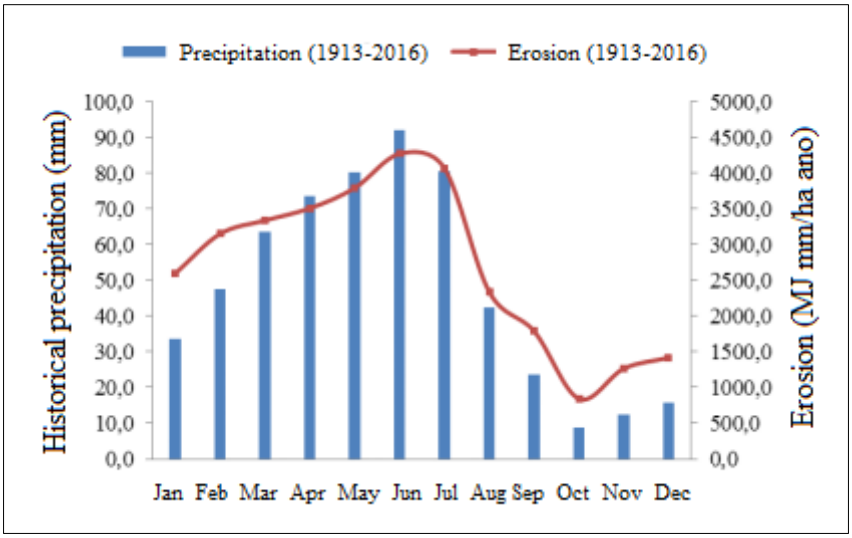
Figure 2 Monthly distribution of precipitation and its percentages for the municipality of Caruaru.

Source: Medeiros, [2022].

The municipality of Caruaru records a rainfall index of 573.4 mm $year^{-1}$. The months from March to July, where the highest incidence of rainfall occurs, contribute 68% of the annual index. Between August and February months where rainfall rates are, low has a contribution of 32% of the annual value (figure 2).

The distribution of historical mean precipitation and erosivity assessments is shown Figure 3.

The historical variability of precipitation can be highlighted in figure 3, in the months of October, November and December there are low rainfall indices, in the months of May, June and July we have the rainy quarter, besides highlighting incremental precipitation increases in the months From January to May.



Source: Medeiros (2022).

Figure 3 Average monthly rainfall and Erosivity in the period from 1913 to 2016.

The erosivity indices presented in Figure 2 follow the precipitation criterion with their values of high and low indices, thus proving what was proposed by [5].

Similar work developed by [7] showed that the results of erosive indices obtained in the city of Matinhas - PB, corroborates in this study of Caruaru.

4. Conclusion

Rainfall index fluctuations may be caused by large-scale factors, such as the Intertropical Convergence Zone and extreme climatic events such as convective movements, lines of instabilities that occurred during the periods studied; And by microscale factors, such as local effects and disordered urban growth, causing surface warming, and cloud formation in the study area.

There is a need for pre-planning of land for implantation of agricultural projects, so that land displacement does not occur, supported by a monitoring of the changes occurring in the soil, especially in hillside regions, taking into account the contours of the terrain levels, thereby avoiding The silting of rivers and reservoirs.

Erosivity follows the rhythm of the rainy season where its maximum occurrence is centered in the months of May, June and July and the minimum occurrences are the months of October, November and December, the deforestation of the native vegetation for the construction of neighborhoods, favelas and buildings The high levels of desertification, silting up of rivers, streams, streams, wells, reservoirs, lakes, ponds and the lowering of the water table, causing extreme fluctuations in the contribution of meteorological elements and Wellbeing of urban centers.

Caruaru was classified with low annual erosive power. The need to obtain a methodology capable of evaluating the factors causing water erosion and estimating annual soil losses resulted in the development of the Universal Soil Loss Equation estimated by [12] and [12, 13]. This equation is considered a good tool in predicting soil losses, requiring a relatively small number of information when compared to more models that are complex and being well known and studied in Brazil. However, for its use, it is necessary the survey of several factors, among them the Erosivity of Rains (R), that allows the evaluation of the erosive potential of the precipitations of a certain place.

Compliance with ethical standards

Disclosure of conflict of interest

All authors contributed to the formation, analysis and revision of the text.

References

[1] Alvares CA, Stape JL, Sentelhas PC, Gonçalves JLM, Sparovek G. Köppen's climate classification map for Brazil. Meteorologische Zeitschrift. 2014

[2] APAC - Water and Climate Agency of the State of Pernambuco. 2017.

[3] Köppen W, Geiger R. Klimate der Erde. Gotha: Verlag Justus Perthes. Wall-map 150 cm x 200 cm. 1928.

[4] Gonçalves JLM, Stape JL, Wichert MCP, Gava J. Plant waste management and soil preparation. Conservation and cultivation of soils for forest plantations. Institute of Research and Forest Studies [IPEF]. Chapter, Piracicaba, São Paulo. 2002; 3: 133 – 204.

[5] Lemos MSS, Bahia, VG. Erosivity of rain. Agricultural Report, Belo Horizonte. 1992; 16[176]: 25-31.

[6] Matos RM, Medeiros RM, Silva PF. Characterization and climatic aptitude of crops for the municipality of Alhandra - PB, Brazil. Revista Brasileira de Agricultura Irrigada. 2015; [9]: 183-192.

[7] Medeiros, RM. Studies of precipitation factors in the state of Pernambuco - Brazil. 2016.

[8] Medeiros RM, Matos RM, Silva PF, Saboya, LMF. Calculation of water balance and erosivity for the municipality of Cabaceiras-PB. Journal Encyclopaedia Biosfera. 2016; 11[21]: 2894.

[9] Medeiros RM, Oliveira RCS, Gomes, Filho MF, Costa Neto FA. Rain erosivity in the area of the Uruçuí Preto-PI river basin, Brazil, aiming at the development of soil management. 9th Congress of Higher Agricultural Education Area-PB - october 27 to 30 of 2014.

[10] Nobre P, Melo, ABC. Intra-seasonal climatic variability over the Northeast of Brazil in 1998 - 2000. Climanálise, CPTEC / INPE, São Paulo. V10, p.123-132. December. 2001.

[11] SUDENE - Northeast Development Superintendency Department of Natural Resources. Meteorological instruments used on surface. DRN: Recife. 1990.

[12] Wischmeier, WH, Johnson, CB, Cross, BV. A soil erodibility nomograph for farmaland and construction sites. Journal of Soil and Water Conservation, Ankeny. 1971; 26: 189-193.

[13] Wischmeier WH, Smith DD. Rainfall energy and its relationship to soil loss. Transactions of the American Geophysical Union, Washington. 1958; 39[2]: 285-291.