

Spatial dynamics of rainfall erosivity in the Taperoá river basin, semiarid region of Paraíba

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Abstract

The rainfall by rainfall erosivity is the natural element that participates more actively in soil erosion because the rain is the main factor that causes the landscape modeling and must be studied to obtain information about the intensification of the process erosion. In general, if all other factors are held constant the only variable in time and space scales are the rains making the loss of soil proportional to rainfall erosivity. Before it was necessary to evaluate the potential of rainfall erosivity in the Taperoá River basin (SBHRT), describing the spatial and temporal, which is the main objective of this work. 22 posts rainfall data were used, obtained from the DCA / UFCG site, and from them we determined the erosivity factor. Through geoprocessing tools have been created maps that showed the spatial and temporal variability of rainfall and its erosivity. All analyzes were worked through Qgis 2.14 software, and through interpolation techniques were generated maps that show the erosive potential of the basin. The results show that the SBHRT an irregular seasonal distribution of rainfall erosivity with a peak in March and April; generally the sub-basin has a high and medium erosive potential and consequently high potential for soil loss by erosion, especially in the western sector where the erosive potential is considered very high and high.

Keywords: Erosivity, rainfall, semiarid.

1. Introduction

The erosive processes are phenomenon a that occur naturally in the earth's surface. The various natural elements interact with each other in order to increase or significantly soften the intensity and spread of the occurrence of soil erosion. For this, among other reasons, the individual study of each natural factor responsible for the erosion is highly necessary.

For river basins have been postulated several indicators of erosion and soil loss, among which the best known and used is the universal

equation of soil loss (USLE) developed by Wischmeier and Smith in 1978, estimating the loss of soil and also allow simulation scenarios indicating usability of each of a watershed industry.

The USLE is determined from the integration of natural factors, among them the rainfall erosivity (R), soil erodibility (K), the ramp length factor and the slope (LS) and man as the use and soil management (C) and conservation practices (P).

From these natural elements, rainfall by rainfall erosivity, is the most actively participates

in the soil erosion, because the rain is the main factor that causes the landscape modeling and must be studied to obtain information on the intensification of the erosion process because, in general, if all other factors are held constant the only highly variable factor in the temporal and spatial scales are the rains making the loss of proportional soil erosivity.

The definition of rainfall erosivity is simply stated by Hudson which would be the ability of rain to cause erosion (Guerra, 1998). According to Pereira (2000) with the onset of precipitation, part of the precipitate volume is somehow intercepted by vegetation or surface structures as part directly reaches the ground, moistening the aggregates and reducing its cohesion, depending on the rain duration the aggregates They disintegrate and give off later being dragged by runoff.

Rainfall is the most important factor in soil erosion and the intensity is one of its most active features. The precipitate volume and speed of the drops are directly related to the intensity and duration of rainfall (Bertoni and Lombardi Neto, 1990). Yet as important parameters for understanding the erosivity Guerra (1998) includes the timing and kinetic energy.

In this paper the study area is the sub-basin of the river Taperoá (SBHRT), an important watershed in the state of Paraíba because of its strategic position in it.

The sub-basin of the river Taperoá, with an area of about 5,900 km² is located in a region considered drier Brazil, regionally known as Cariri Paraibano, with annual rainfall between 400 and 600 mm (Lacerda, 2003; Xavier et al., 2012). Due to water scarcity and the existence of incipient soil, the basin has a low population density, and the extensive cattle the main economic activity of the region.

According to Seabra et.al. (2014), Rio Taperoá, main tributary of the Paraíba River basin is considered one of the most important and strategic position for the management of water resources in the state of Paraíba. Exactly at the confluence of the Taperoá River and the Rio Paraíba it was built a large dam forming the weir Pessoa, or simply Açude Boqueirão, due to its location in the municipality of the same name. This dam is responsible for supplying the largest

metropolitan area in the Northeast, the region of Campina Grande with nearly 600 thousand inhabitants.

Accordingly, the present work is general to evaluate the potential of rainfall erosivity in SBHRT, describing the spatially and temporally.

2. Material and methods

Study area

The sub-basins of the Taperoá River (SBHRT) is situated in the central part of the state of Paraíba, being located between the geographic coordinates 06 ° 51 '31' ' and 07 ° 34' 21 ' south latitude and 36 ° 00 '55' ' and 37 ° 13' 09 " west longitude (Figure 1).

The delimitation of the basin area was performed by SRTM image taken from the site of EMBRAPA (Brazilian Agricultural Research Corporation) in GIS environment with Qgis 2.6 software lines were created following the watershed of the basin, to thus be created the perimeter the same, so it was poligonizado the basin area in shapefile format, and through the tool "Geoprocessar" >> "Cruzar" was crossed to the area obtained from the bowl with a database of the municipalities of the IBGE (Instituto Brasileiro de Geografia e estatística) (Figure 1) to measure the area that each municipality is the drainage basin (Table 1).

The basin has about 5,900 km² and drains partially or totally the territory of 28 municipalities (Table 1), and covers seven Paraíba micro (Serra do Teixeira, Western Cariri Cariri Oriental, Campina Grande, Western Curimataú, Eastern Seridó Paraíba, Serido West Paraíba). These micro-regions are divided into three meso (Hinterland, Borborema and Agreste).

Rain characterization

For the characterization of rain basin were used monthly average data of 14 rainfall stations (Table 2), spatially distributed within the basin. For better characterization of it, all the data have an uninterrupted series of at least 20 years and have been achieved through the official of the Department of Atmospheric Sciences at the Federal University of Campina Grande site (DCA-UFCG).

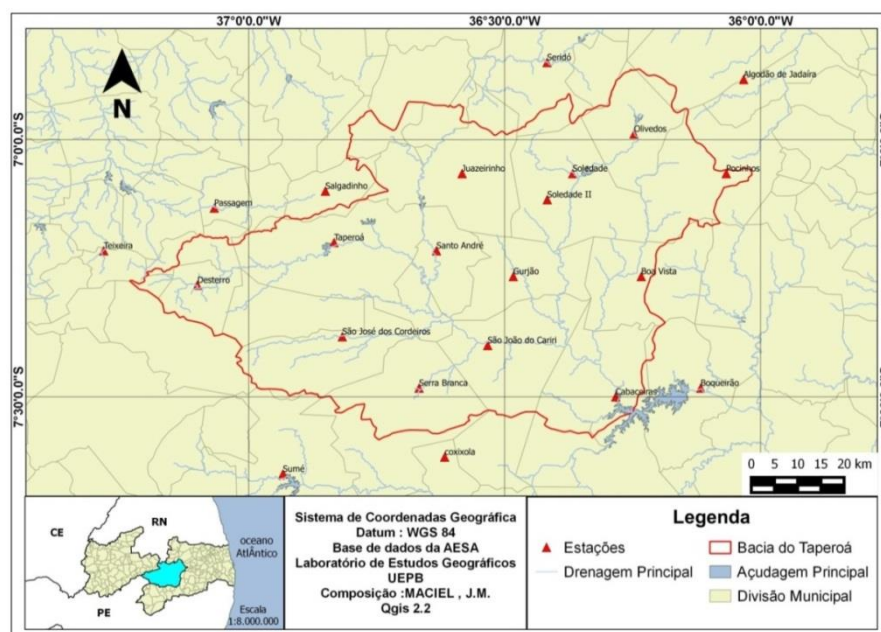


Figure 1- Delimitation of SBT in the state of Paraíba and location of rainfall stations used in this study. Source: Maciel (2014).

Table 1- Municipalities of the Taperoá River basin with their respective areas.

NOME	Total area (km ²)	Area in the basin (km ²)	% the basin
Assunção	126,49	118,26	2,01
Barra de Santa Rosa	825,95	24,05	0,41
Boa Vista	475,75	270,18	4,59
Boqueirão	424,60	11,32	0,19
Cabaceiras	401,38	360,70	6,12
Cacimbas	143,67	76,38	1,30
Campina Grande	621,95	1,30	0,02
Cubati	137,46	1,00	0,02
Desterro	178,31	177,16	3,01
Gurjão	342,85	342,85	5,82
Juazeirinho	468,86	395,40	6,71
Junco do Seridó	169,54	95,68	1,62
Livramento	284,59	284,21	4,83
Olivedos	319,43	312,77	5,31
Parari	128,00	128,00	2,17
Pocinhos	631,44	313,42	5,32
Salgadinho	184,42	30,05	0,51
Santo André	226,03	226,03	3,84
São Domingos do Cariri	222,43	57,78	0,98
São João do Cariri	702,66	496,85	8,44
São José dos Cordeiros	417,75	406,34	6,90
Seridó	275,26	52,58	0,89
Serra Branca	738,29	416,24	7,07
Soledade	561,20	560,94	9,52
Sumé	837,62	0,47	0,01
Taperoá	639,07	623,06	10,58
Teixeira	161,21	24,48	0,42
Tenório	105,28	82,32	1,40
Total	10.751,47	5.889,82	100,00

Source: IBGE

The monthly data were grouped chronologically and from measures of central tendency and dispersion (standard deviation) were prepared histograms for the definition of the rainy season and more "dry" period within the basin. The rainy season was regarded as the period of at least three months which concentrate a significant percentage (> 50%) of the total precipitated during the year.

For the creation of maps of spatial distribution of rainfall were added to this initial

serial data of eight other stations (Table 3) located in the same compartment geomorphologic (Borborema) above the bowl, but which nevertheless are not located within the same.

For the variable geomorphology not interfere with the space-time configuration of precipitation within the basin were despised the data from stations outside of geomorphological compartment Borborema.

Table 2- Monthly Average rainfall (mm) of the municipalities covering the river basin Taperoá.

Município	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez	T. anos
Boa Vista	26,0	35,3	82,3	69,4	58,7	53,0	46,0	19,3	5,5	6,6	4,4	9,5	20
Cabaceiras	15,4	36,6	49,3	63,0	38,9	37,4	35,4	12,2	3,4	3,0	3,1	6,9	72
Desterro	34,3	86,1	143,6	118,0	44,3	13,1	8,3	0,5	0,4	2,5	5,5	14,4	23
Gurjão	23,1	72,7	101,9	129,9	41,9	31,9	35,5	9,8	3,1	5,3	4,8	10,5	22
Juazeirinho	33,8	78,0	115,6	131,4	37,5	19,6	39,3	8,6	2,7	6,6	3,8	20,7	24
Olivedos	27,8	55,2	94,1	102,2	57,5	49,7	37,1	15,8	7,1	5,0	5,6	12,1	53
Pocinhos	20,0	35,2	64,3	68,9	51,5	51,4	48,7	18,7	9,8	5,2	3,5	8,1	63
Santo André	38,1	88,9	109,6	131,6	40,7	30,0	32,6	11,3	2,4	13,0	3,2	27,2	23
São João do Cariri	25,9	54,1	90,4	81,3	48,1	31,0	22,9	6,3	1,8	5,3	6,3	12,1	52
São J. dos Cordeiros	23,1	80,4	151,8	152,9	38,8	31,3	33,5	10,8	2,9	1,7	3,8	14,0	22
Serra Branca	32,4	80,8	118,2	136,0	39,9	29,5	24,4	10,1	5,3	4,9	5,8	30,6	21
Soledade	23,1	54,6	99,7	88,0	38,3	32,9	28,5	8,4	2,8	5,4	3,3	10,8	77
Soledade II	28,5	51,5	107,6	121,4	36,7	32,9	37,8	11,9	5,8	5,0	2,0	12,6	30
Taperoá	34,1	83,1	134,9	109,7	50,5	28,2	20,1	7,5	2,4	4,7	10,6	26,1	64

Source: Department of Atmospheric Sciences / UFCG

Table 3- Mean rainfall data (mm) of additional stations surrounding the basin.

Município	Jan	Fev	Mar	Abr	Mai	Jun	Jul	Ago	Set	Out	Nov	Dez	T. anos
Algodão de Jandaíra	19,6	42,7	67,9	86,6	39,5	34,6	38,6	13,7	11,6	4,8	4,2	9,3	25
Boqueirão	31,1	55,4	82,3	106,9	54,1	59,9	55,7	21,5	13,2	6,0	6,6	16,0	65
Coxixola	34,9	63,3	113,2	125,9	39,9	37,0	32,4	8,5	3,3	4,5	3,3	20,8	26
Passagem	60,6	139,5	177,6	173,6	40,6	19,8	11,7	1,9	0,7	1,1	8,1	17,7	25
Salgadinho	35,3	68,2	115,8	110,0	48,7	22,7	18,4	7,7	2,1	1,9	6,6	13,0	55
Seridó	25,0	93,9	93,1	120,0	41,5	22,8	22,1	5,1	2,4	1,5	3,9	8,4	28
Sumé	43,8	77,5	132,9	130,3	58,7	42,4	23,5	9,3	5,1	6,4	11,9	18,2	26
Teixeira	66,1	139,9	212,1	165,4	59,3	25	12,2	3,8	2,7	4,8	11,6	34,5	43

Source: Department of Atmospheric Sciences / UFCG

The summation of these data is important because of the rain be a continuous phenomenon in space and if it were carried interpolation only with data of Stations within the bowl, it could be

characterized erroneously, showing a nonexistent reality.

From the tool "interpolation complement"

the Qgis 2:14 geoprocessing software, the monthly rainfall data to the stations were interpolated using IDW method (Inverse power distance), it was demonstrated the spatio-temporal distribution of rainfall in bowl. With the same software were made by isohyets tool "extraction" >> "outline" for demarcating the same lines rainfall in the basin.

Erosivity rainfall

There are several methods that can be used to estimate the rainfall erosivity; The problem is to choose the most appropriate, since each event environment and are unique in spatial and temporal scales and hence erosion varies in different manners.

For Wischmeier and Smith, when all factors, except for rain, are held constant, the loss of soil by any exposed soil with unit area is directly proportional to the product of two rainfall characteristics energy kinetic (E) by its maximum intensity within 30 minutes (I_{30}) (Borges, 2009).

Several authors consider that the best method because it is noteworthy erosive characteristic of rain each 30 min event (Bertoni and lombardi Neto, 1990), however in many areas of use for is infeasible this method because of the failure and / or short collection coming from pluviographs data, and such data required to obtain the I_{30} . For this reason many authors attempted to correlate the factor erosivity (R) with characteristics of rainfall more easily measured and do not necessarily require intensity record, which came the following equation (1), proposed by Bertoni and Lombardi Neto (1990) used for erosivity calculations of this work.

$$(1) R = \sum \left[67,355 \left(\frac{p^2}{P} \right)^{0,85} \right]$$

Being:

“R”: rain erosivity (MJ mm ha⁻¹ ano⁻¹),

“p”: average monthly rainfall (mm)

“P” : average annual rainfall (mm).

The use of this method occurred because of that there was no satisfactory data pluviographs in SBHRT. Being a method to some simplistic point, due to the variables it

uses, the method proposed by Bertoni and Lombardi Neto is subject to various criticism from some authors, because according to them it is restricted.

However, Silva and Dias (2003) to correlate the two methods showed that the difference is statistically insignificant and that, according to them, the choice of most simplistic method does not invalidate the search and therefore there is no indication that limit their use, particularly in semi-arid areas.

The average monthly data used came from 14 rain gauge stations, spatially distributed within the basin. For better characterization of it, all the data have an uninterrupted series of at least 20 years and have been achieved through the official website of the Department of Atmospheric, Federal University of Campina Grande Sciences (DCA-UFCG).

For the creation of maps of spatial distribution of erosivity were added to this initial serial data of other stations 8 located on the same geomorphological compartment (Borborema) above the bowl, but which nevertheless are not located within the same.

3. Results and discussion

Rain characterization of SBHRT

Figure 2 shows the average of the monthly averages and standard deviation of rainfall, from 14 stations found within the river basin Taperoá.

It is observed that the rains are concentrated in a rainy season of three months (February, March and April) which represents more than 60% of the total precipitates during the year. In general, the SBHRT through criteria Gaussen and Bagnouls (Nimer, 1979a) all other months of the year were considered "dry" because the average temperature of the basin is around 24 °C, with minimum values of 21 °C in from July / August and maximum of 28 °C between November / December.

In this period considered "dry" it appears that there is in the basin a very pronounced dry period of three months (September, October, November) where precipitated total do not exceed 10 mm / month.

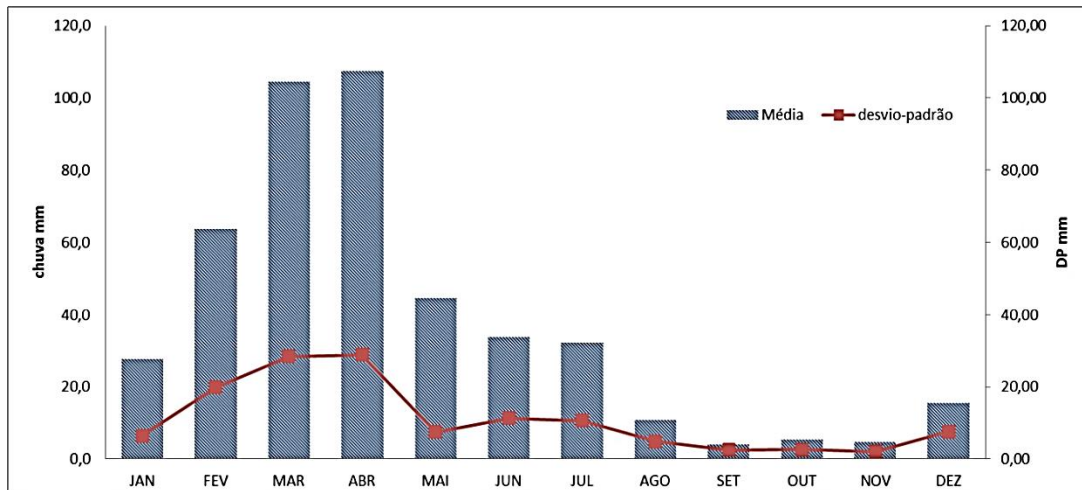


Figure 2- Average monthly rainfall regime for the basin of Taperoá.

The basin has two very pronounced cycles and rain that marked the environmental characteristics of the area. The first half of the year is more rainfall, while the second half of the year precipitated values decay, giving a small increase only in the last month of the year, which characterizes the beginning of the rainy pre-season next year with the month of subsequent January.

The largest standard deviations occur in the rainy season (February, March and April), showing that there is high variability of rainfall even in the rainy season. You know that historically the rain average will fluctuate naturally, so on the figures presented it can be seen that even in the rainy season may occur during the dry season, this is due to high variability of inducing rains that act not only in SBHRT but throughout Paraíba.

According to Araújo (2006) this characteristic spatial and temporal variability is due to atmospheric circulation systems that alternates from now areas / times with high rainfall sometimes areas / times with drought, as rainfall trainers mechanisms themselves throughout the area are irregular both in its spatial participation and on a time scale which causes this variability characteristic not only in the basin of river Taperoá but throughout northeastern Brazil.

According to Nimer (1979a) this variability and alternation of rain inducers in this region occur mainly by the fact that this area is the performance limit, especially the easterly waves and the ITCZ, causing heavy rains during

the period of their performances and dry when not there the effect of the same.

In work carried out in the regions of Paraíba backlands, Santos (2012) found rainy and dry seasons with approximately the same duration of that found in SBHRT, however the average total annual values of precipitation per station, found in the backlands of Paraíba are relatively larger than those found in SBHRT, showing that the action of rain-inducing these areas act with greater forces than in SBHRT, confirming the assertion Nimer (1979b)

From the map to the interpolated average values, prepared with the help of surrounding stations, shown in Figure 5, it is clear also that there is a greater amplitude rushed values within the basin, while the nearby city of Cabaceiras, Pocinhos and São João do Cariri annual totals are less than 400 mm and in the area corresponding to Teixeira municipalities and Cacimbas annual totals are greater than 600 mm, the western end of the basin with total close to 650 mm.

Even the greatest rainfall values found in the basin are still relatively lower than the values found, for example, by Santos (2012) in Paraíba backlands, showing that contrary to what is commonly / popularly known as the areas raining less in Northeast Brazilian. The Paraíba backlands breaks this rule at the state level, because it is easily found higher annual total to 800 mm unlike paraibano cariri where the annual totals are around 400 mm, reconfirming its status of being one of the "dry" areas Brazil.

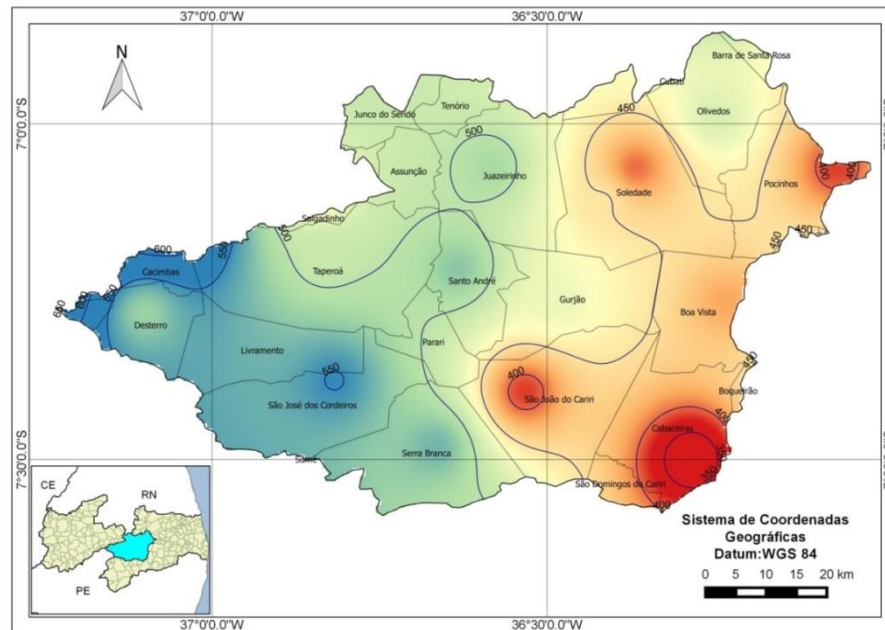


Figure 3- Spatial variability of the average total annual rainfall in SBHRT

The amplitude recorded in the total annual precipitation of the Municipalities que make up the basin is due to the atmospheric movements Numerous que focus on Paraíba and cause this spatial and temporal variability. Despite being fully inserted into the semi-arid region, was Observed significant spatial variation of the total annual rainfall, where the Cabaceiras to Desterro, about 100 km straight line, will isohyet 350-650 mm respectively (Figure 5). In studies in the basin of the Paraíba River, which the basin of the Taperoá River is the main tributary, Araújo (2006) reports that several weather systems are influencers of rain on the region, with greater or lesser intensity during certain times of the year, fact which is proven in the highly irregular temporal distribution in the basin.

Erosivity rainfall

For SBHRT, the average annual rainfall varies from 304.6 to 650 mm, therefore, the test results of rainfall erosivity in the Taperoá River basin showed that the annual mean value for the basin was 3230.54 MJ . mm / ha year. Through the interpolated data found a variation of 2690 MJ mm / ha year ranging from 2010.3 MJ. mm / ha year to near 4700 MJ. mm / ha.year.

The figure 4 shows the monthly average for erosivity SBHRT from the series used for the

precipitation calculation. Assessing intraannual variation of erosivity indexes and correlating these values with the precipitation, we observe high coefficients of variation, the monthly average erosion rate was higher in the high rainfall period, which covers the months of March and April and lower in the months of lowest rainfall in September, October, November.

Second Frota (2012) is characteristic of variation of erosion rates are typical of the Brazilian northeastern semi-arid region, according to the same, the rains are characterized by short duration and high intensity, thereby generating high erosivity in this short period and increased breakdown and transport stream this calcined material.

This feature is caused by the fact that the erosivity is closely linked to the precipitated total. This behavior is expected because the erosion calculations are based on monthly and annual rainfall averages, so the greatest ability to cause erosion is the rainy season, while the lowest erosivity will be in the months of drought (Boin, 2000; Santana, 2007), which in semiarid areas can easily be null due to fact that in some years the season "dry" records null values storm or does not have significant values in order to generate erosion.

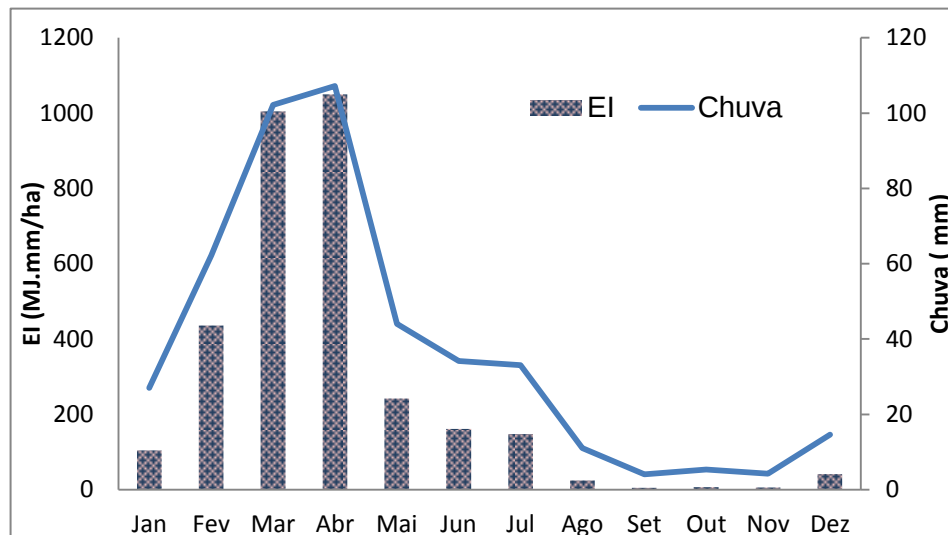


Figure 4- Average Graph Erosivity Monthly rainfall in SBHRT.

Figure 5 demonstrates the values of R factor for some locations in SBHRT with direct data of rainfall stations, showing the spatial variability of erosivity. It can be seen that the difference between the places that suffer from lower and higher erosive potential of rainfall are respectively Cabaceiras and São José dos

Cordeiros, and its difference increases even more after being observed values found by interpolating the data as can be observed in figure 6, where the difference between sites that have extreme potential consistent with the overall site smaller potential annual rainfall erosivity.

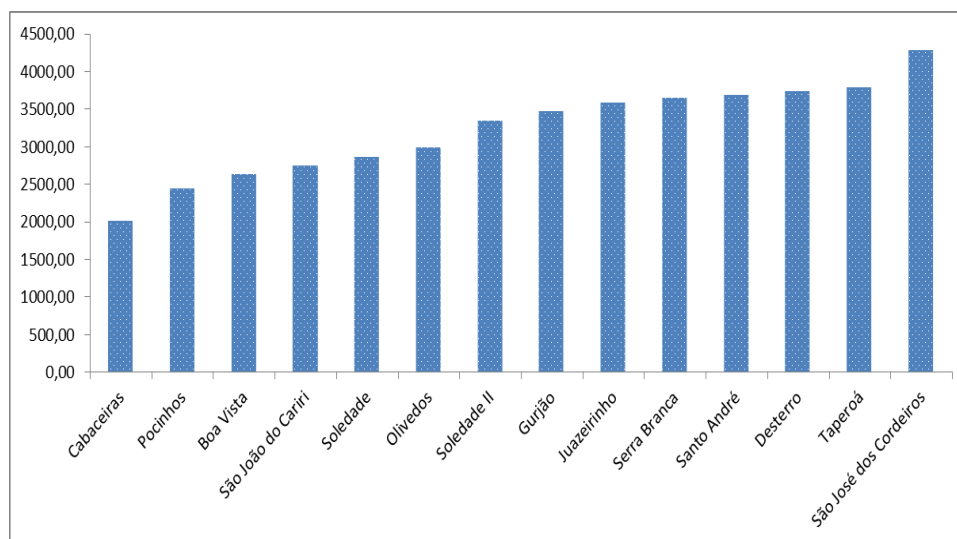


Figure 5- Factor R for some locations in SBHRT.

This variability of the erosive potential can also be observed in periods of the year regarded as the rainy and the dry months, showing the high variability of this factor even in the period of the same season.

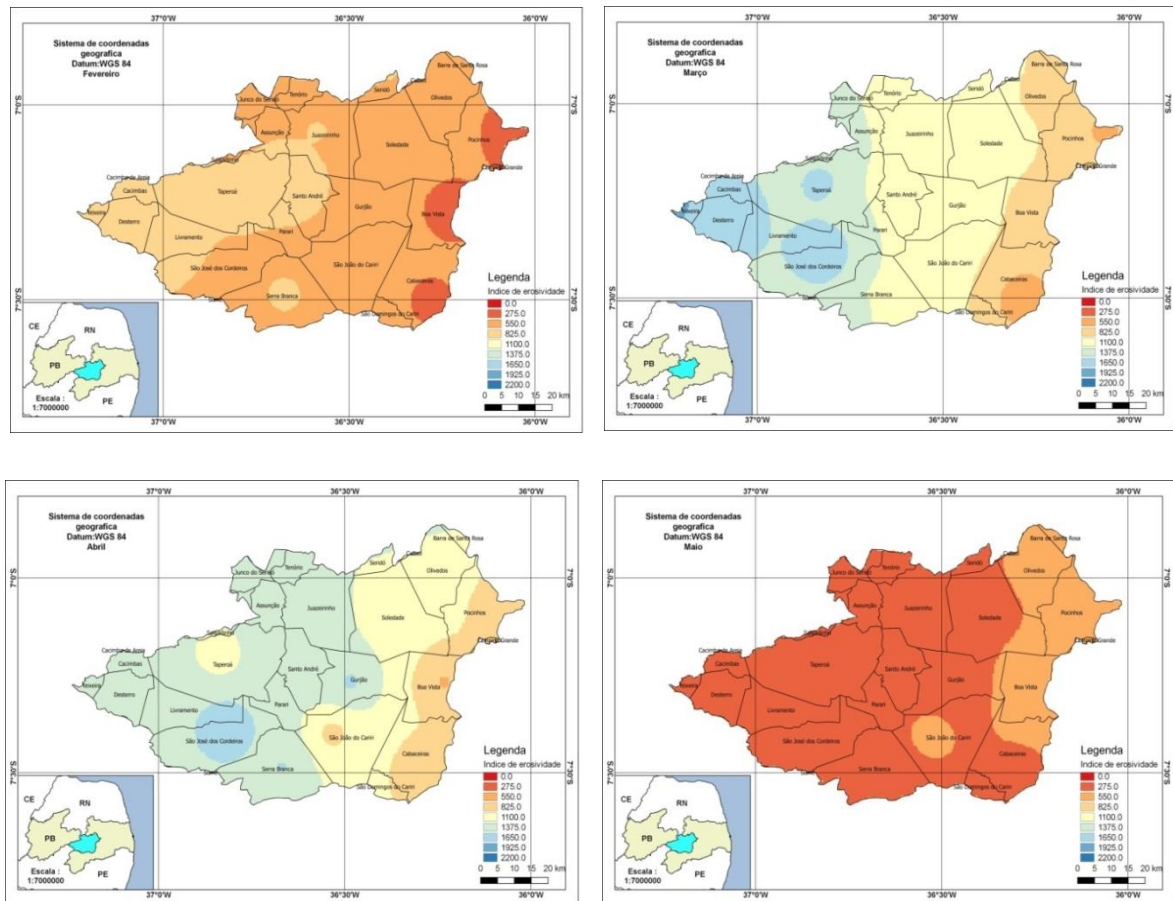
Frame 1 can be seen the erosive potential of rainfall in the months that have higher rainfall during the year, there is a clear transition from

erosivity index (Ei) westbound-east where in all demonstrated months, the center west sector sub-basin is more erosive potential in the remaining area potential remained always lower with the exception of May marks the end of the rainy season in its basin, this month the potential values are reversed and the central sector - potential erosion, worth mentioning that even so eastern subbasin passes present the greatest the

potential value of this sector are lower than those recorded in the rest of SBHRT in other months of the rainy season.

During the rainiest months the average erosivity values are around 716.2 MJ. mm/

ha.month, wherein the April presents the greatest potential to 1060.3 MJ. mm / ha.month and May has the potential to lower 253,8716,2 MJ. mm / ha.month.



Frame 1- Months with greater erosive potential in SBHRT

Frame 2 is shown the spatial distribution of rainfall erosivity in the months where the total precipitates are smaller, as can be seen due to such low values, the erosive potential is zero or very low values compared to other times of the year.

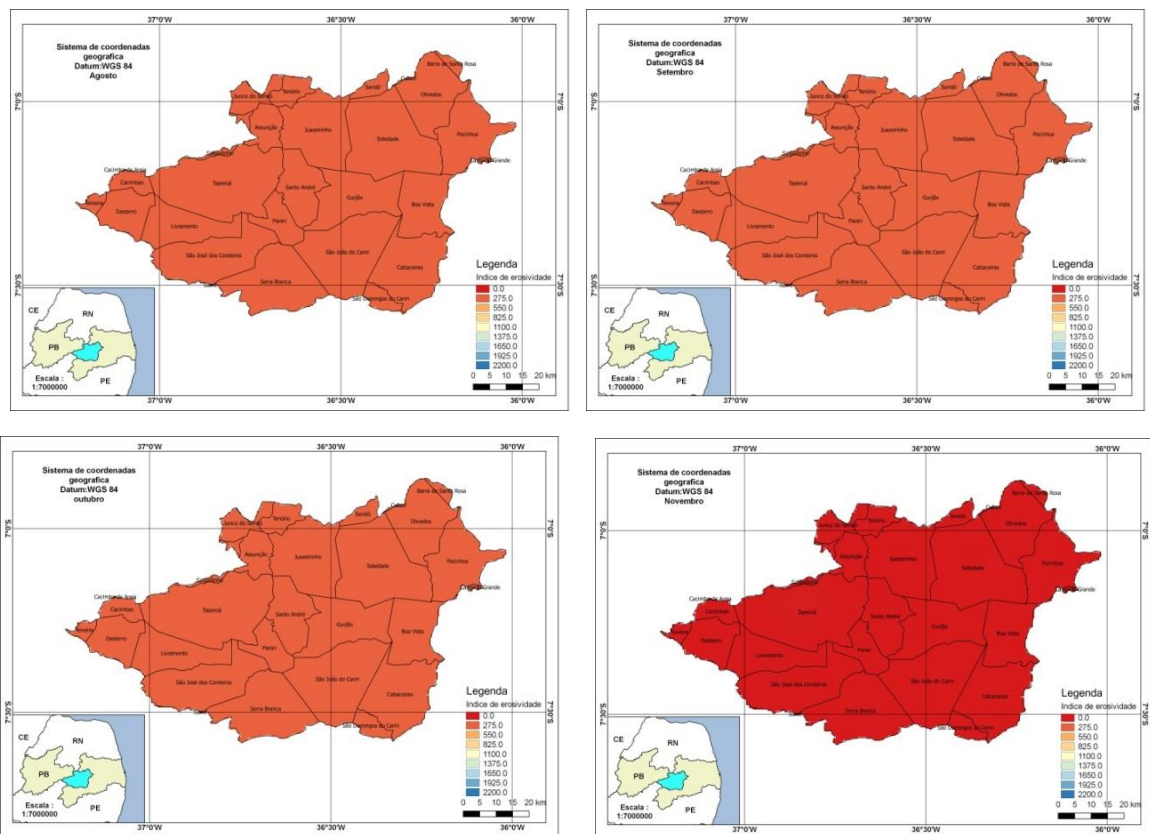
In the months where rainfall is less than the average erosive potential is 9.9 MJ. mm / ha.month ranging between 4.6 and 21.6 MJ. mm / ha.month in August and November respectively worth mentioning that beyond these amounts are very small in many areas in recent months this potential is null due to lack of rainfall.

Another fact that corroborates the high spatial variability of rainfall erosivity in semi-arid areas in general, and specifically SBHRT in the municipality of Soledad found data to two

rainfall seasons, but which nevertheless have between them a difference of 483.2 MJ . mm / ha year, it is noteworthy that these stations are far apart in about 8 km.

According to Figure 6 can be seen that there is downward trend of erosivity values in the west-east direction, the highest values are found in the municipality of Cacimbas with erosivity values close to 4700 MJ. mm / ha year in the same way, the municipality of Cabaceiras has the lowest erosivity values SBHRT.

Being a semi-arid region, one can see that the erosivity values (factor R) are low, showing that the rain variable in semi-arid areas compared to more humid regions, has lower potential erode soils.



Frame 2- erosive potential of rainfall for the less rainy months of the year.

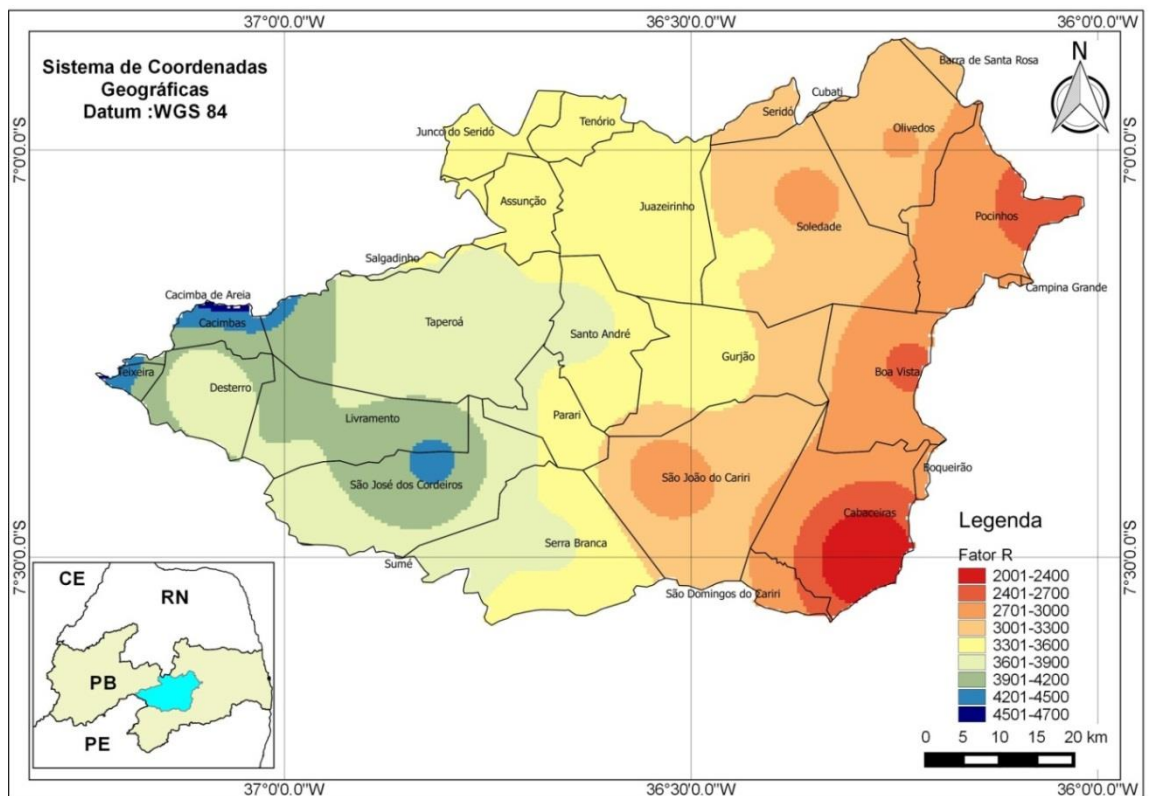


Figure 6- erosivity map of Taperoá Basin.

Other studies in the Brazilian semiarid region also showed this spatiotemporal variability of erosivity values, Aquino et al. (2006) found erosivity values of rainfall in the dry lands of the state of Piauí ranging 3316-6877 (MJ mm / ha. year) and Frota (2012) found in the state of Ceará values ranging 5137-6695 (MJ.

mm / ha year), thus validating the data in SBHRT.

Table 4 shows the monthly average erosion index (EI) and the R factor for each rainfall station used, and the overall monthly mean value, standard deviation, maximum and minimum values.

Table 4- rainfall stations with EI values and the factor.

EI / Fator R														
Estação	Código	Janeiro	Fevereiro	Março	Abril	Maio	Junho	Julho	Agosto	Setembro	Outubro	Novembro	Dezembro	Fator_R
Algodão de Jandaíra*	3837796	66,86	251,23	552,74	835,84	220,07	175,70	211,61	36,37	27,41	6,12	4,87	18,83	2407,65
Boa Vista	3847555	101,19	170,17	717,54	537,01	403,97	339,58	266,90	60,97	7,22	9,84	4,94	18,27	2637,59
Boqueirão*	3847979	111,60	297,80	583,64	910,39	286,02	340,09	300,55	59,58	26,00	6,80	8,00	36,06	2966,52
Cabaceiras	3857044	52,69	229,54	380,87	577,85	254,60	238,13	216,89	35,46	4,04	3,27	3,45	13,46	2010,26
Coxixola*	3856278	141,8	390,2	1048,2	1255,9	178,1	156,6	125,0	12,9	2,6	4,4	2,6	58,8	3376,86
Desterro	3845583	136,12	650,75	1552,65	1112,01	210,28	26,50	12,20	0,10	0,07	1,59	6,06	31,13	3739,46
Gurjão	3847505	74,52	523,27	929,00	1403,63	205,06	128,99	154,71	17,35	2,45	6,10	5,15	19,50	3469,73
Juazeirinho	3846185	133,60	553,62	1080,63	1343,57	159,41	52,90	172,63	13,04	1,82	8,32	3,25	58,05	3580,84
Olivedos	3837953	100,03	321,04	795,00	914,81	344,11	268,58	163,38	38,28	9,83	5,41	6,56	24,32	2991,36
Passagem*	3845289	286,68	1182,97	1783,41	1715,67	145,11	42,81	17,50	0,80	0,15	0,31	9,37	35,38	5220,17
Pocinhos	3847188	69,43	181,51	505,51	568,52	346,61	345,47	315,19	61,93	20,65	7,03	3,59	14,93	2440,37
Salgadinho*	3846231	159,52	488,68	1201,96	1101,42	275,67	75,31	52,70	11,98	1,32	1,11	9,22	29,19	3408,08
Santo André	3846475	160,90	679,40	969,77	1323,50	180,01	107,18	123,44	20,38	1,46	25,86	2,39	90,73	3685,03
São João do Cariri	3846894	108,03	377,88	904,50	755,23	309,44	146,64	87,63	9,77	1,16	7,28	9,77	29,63	2746,94
São José dos Cordeiros	3846739	65,47	545,58	1607,27	1627,12	158,10	109,74	123,17	17,98	1,92	0,78	3,04	27,95	4288,11
Seridó*	3837717	87,56	830,55	818,55	1260,20	207,26	74,87	71,01	5,87	1,63	0,73	3,72	13,71	3375,67
Serra Branca	3846969	120,47	569,57	1087,42	1380,27	171,63	102,72	74,39	16,61	5,55	4,86	6,47	109,31	3649,26
Soledade	3847128	85,89	370,70	1031,75	834,47	202,88	156,68	122,75	15,38	2,38	7,26	3,14	23,58	2856,87
Soledade II	3847218	111,0	303,5	1062,3	1304,2	170,6	141,7	179,4	25,2	7,4	5,8	1,2	27,7	3340,03
Sumé*	3856314	187,65	495,06	1238,34	1197,44	308,70	177,57	65,11	13,47	4,85	7,13	20,48	42,17	3757,97
Taperoá	3846434	139,56	634,45	1445,77	1017,26	272,07	101,04	56,82	10,63	1,53	4,80	19,15	88,59	3791,68
Teixeira*	3845448	290,26	1038,32	2106,49	1380,23	241,34	55,58	16,42	2,26	1,26	3,36	15,07	96,10	5246,68
Média		126,86	503,90	1063,78	1107,11	238,68	152,93	133,15	22,10	6,03	5,82	6,89	41,25	3408,51
Mediana		111,31	491,87	1039,96	1154,73	215,17	135,35	123,31	16,00	2,41	5,59	5,05	29,41	3392,47
Desvio-Padrão		62,9	262,7	431,6	332,7	71,5	97,2	88,8	18,9	8,1	5,2	5,3	29,3	804,4
Máximo		290,26	1182,97	2106,49	1715,67	403,97	345,47	315,19	61,93	27,41	25,86	20,48	109,31	5246,68
Mínimo		52,69	170,17	380,87	537,01	145,11	26,50	12,20	0,10	0,07	0,31	1,21	13,46	2010,26

When comparing the values found in SBHRT of "erosivity indices" (IE) and R factor for other areas of the semi-arid northeast it is noticed that the SBHRT has low values of erosivity, incontrovertible reflections of the total

annual low rainfall found in area.

To then be able to sort and compare the erosivity values with any other area, Carvalho (1994) describes reference classes for the values of R factor, as demonstrates the Table 5.

Table 5- universal erosivity classes.

Intervalo (MJ mm /ha ano)	Classe de erosividade
R<2452,5	Fraca
2452,5 <R<4905	Média
4905<R<7357,5	Média a forte
7357,5<R<9810	Forte
R>9810	Muito forte

Source: Carvalho (1994) adapted by Maciel (2014).

It is noteworthy that Carvalho (1994) Used as reference unit the metric system of erosive measures (tm.mm/ha.ano), soon to convert the metric system unit of standardized

universal system (MJ. Mm / ha .year), multiply the value by 9.81 consequently to convert unit of the international system to the metric system divides the value found by 9.81.

Thus, according to the reference values postulated by Carvalho (1994) in SBHRT erosion falls as weak average with predominance of the middle class, the erosivity is considered

weak in the municipalities of Cabaceiras and Pocinhos and average in all other municipalities SBHRT. As can be seen in Table 6.

Table 6: erosivity class for the 14 stations inside the SBHRT

Município	Fator R	Classe de erosividade
Boa Vista	2637,59	Média
Cabaceiras	2010,26	Baixa
Desterro	3739,46	Média
Gurjão	3469,73	Média
Juazeirinho	3580,84	Média
Olivedos	2991,36	Média
Pocinhos	2440,37	Baixa
Santo André	3685,03	Média
São João do Cariri	2746,94	Média
São J. dos Cordeiros	4288,11	Média
Serra Branca	3649,26	Média
Soledade	2856,87	Média
Soledade II	3340,03	Média
Taperoá	3791,68	Média

Because it is universal reference values they tend to homogenize areas in a single class, not demonstrating the local intensity compared to regional erosivity values.

To this was followed by a weighting criterion similar to that found in Frota (2012) and Aquino et. al. (2006), the SBHRT was

subdivided into five erosive potential classes for each class were calculated respective areas and percentages so as to identify which areas the erosion processes are more intense, this method takes into account the values found inside in the basin, so it is a uniquely made relative ranking for the same, demonstrates as Table 7.

Table 7: R factor Intervals for SBRT with their classes erosivity

CLASSES DE POTENCIAL EROSIVO	FATOR R (MJ. mm/ha.ano).	ÁREA	
		(km ²)	(%)
Muito Baixa	2000-2533	175,18	3,0
Baixa	2534-3055	1494,4	25,0
Média	3056-3575	2205,5	38,0
Alta	3576-4100	1846,5	31,0
Muito Alta	4101-4700	168,24	3,0

Table 7: R factor Intervals for SBRT with their classes erosivity

When analyzing Table 7 and Figure 7, we realize that the extremes (very low and very high) occur in smaller percentage of the basin (3%). The intensities considered too low are found in the municipalities of Cabaceiras and

Pocinhos which confirms the results found using the class erosivity.

Similarly the classes considered too high are concentrated in the western sector of the basin, with a "spot" in the municipalities of São

José dos Cordeiros and Livramento, caused by precipitates largest total in these two places compared to the surrounding areas. To suffer more with the erosivity problem of rains these areas must have consistent plans for environmental protection, especially of the savanna area, especially areas close to rivers, because of that vegetation is one of the natural elements that can soften the effects of erosivity (Guerra, 1998).

The vegetation acts in different ways in order to prevent the maximum action of rainfall erosivity how to avoid the direct impact of drops in the soil preventing the breakdown of particles; prevents soil compaction; increases the soil infiltration capacity and subsidize biological structures (animal and plant) that increase the permeability and porosity of the soil (Crepani, 2001). A The need for riparian forest protection in these areas are considered very high intensity, is the fact that this structure of vegetation prevents the delaminated particles of soil

Durantes rainfall events from reaching the rivers, with the loss of this kills the total sediment increases to cause serious problems, particularly the dams, as well as the river itself that ends up being silted up by these sediments thus reducing its volume and capacity (Guerra, 1998).

Although the erosive intensity percentage considered "very high" is very significant in the basin, the classes "High" and "Medium" are very significant, with 31 and 38% respectively, showing that the basin naturally tends to soil loss processes water erosion reaffirming the need for management and planning in order to promote conservation practices mainly of soil management.

In the semi-arid regions, soil degradation by water erosion is a serious problem and it has been studied in recent decades by agencies and researchers who care about the issues and the socio-economic and physical relationships of the semiarid region (Santos et. al. 2007).

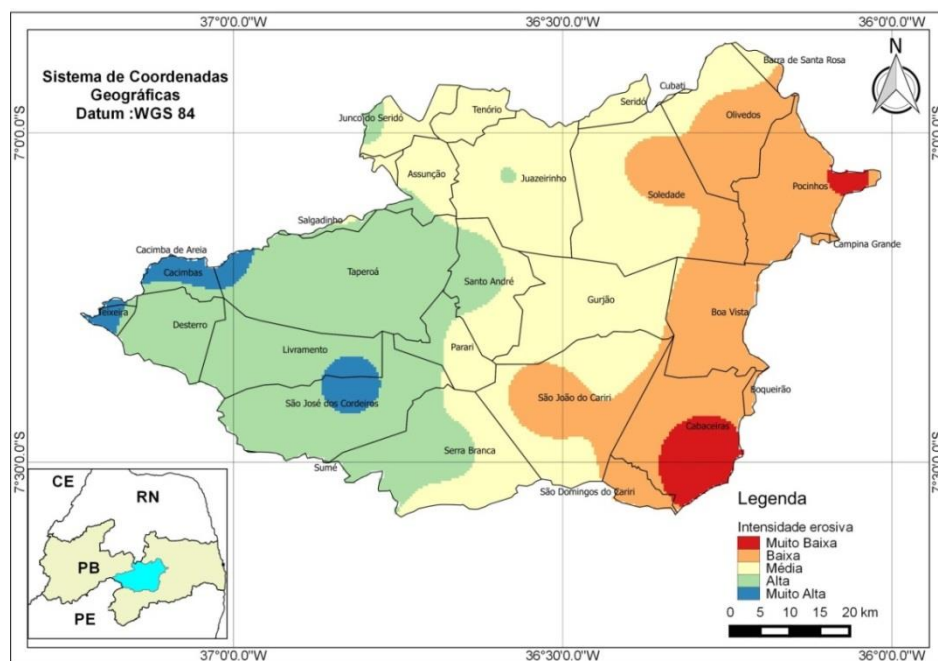


Figure 7: Map classes potential for erosion SBHRT.

4. Conclusions

According to resultdos found, it was concluded that the sub-basin of the river Taperoá has a short rainy season of three months (February, March and April) which account for nearly 60% of the expected volume for the year.

The largest standard deviations occur in the rainy season, showing that there is high variability of rainfall even in this period. The dry season is long and remarkable in the basin, where most of the municipalities in the basin have nine months dry during the year. The rainfall data compared with other areas of

Paraíba show the region as the area with the lowest rainfall in the state.

The average erosivity found was 3230.54 MJ. mm / ha year. The monthly average erosion rate was higher in the high rainfall period, which covers the months of March and April and lower in the months of lowest rainfall in September, October, November. The municipality with less erosive potential, the rain is Cabaceiras and most Cacimbas.

Comparing the erosivity values of rainfall found in SBHRT with other semi-arid areas it is clear that SBHRT has low values of erosivity, incontrovertible reflections of the total annual low rainfall found in the area. The erosivity falls as weak average predominantly middle class. Spatially, the erosivity decreases in the west to east, with the municipalities of Cacimbas Teixeira and the greatest potential for rainfall erosivity

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