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MORPHOMETRIC COMPARTMENTATION OF THE COCO RIVER BASIN AS SUBSIDY TO ANALYSIS OF ENVIRONMENTAL FRAGILITY

compartimentação morfométrica da bacia do Rio do Coco como subsídio a análise de fragilidade ambiental

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Resumo

O presente estudo teve como objetivo realizar a compartimentação morfométrica da Bacia Hidrográfica do Rio Coco. Para tanto, foi realizada a digitalização manual da hidrografia na escala 1:5.000 no ArcGis 10.1 a partir de imagens do satélite RapidEye, sendo utilizada a metodologia proposta por Strahler (1952) para a hierarquização da rede de drenagem. A compartimentação da bacia foi realizada no ArcGis 10.1 com base em análises da drenagem na paisagem (hidrografia e relevo). Foram definidos 05 compartimentos (sub-bacias), sendo: Sub-bacia do Ribeirão Prata, Sub-bacia do Ribeirão Piedade, Sub-bacia do Ribeirão Surubim, Sub--bacia do Alto Rio Coco e Sub-bacia do Baixo Rio Coco, para os quais foram aplicados parâmetros morfométricos, conforme as metodologias descritas por Horton (1945), Christofoletti (1969) e Strahler (1952). A partir da análise realizada pode-se observar que as sub-bacias do Alto Rio Coco e Ribeirão Piedade foram os compartimentos que apresentaram maiores fragilidades naturais em relação aos demais compartimentos, haja vista os resultados verificados na análise morfométrica realizada, sugerindo uma atenção especial às mesmas em relação ao uso e ocupação do solo.

Palavras-chave: Compartimentação morfométrica; Fragilidade ambiental; Bacia do Rio Coco.

Abstract

This study had as its object realizes the morphometric compartmentation of the Coco River basin. For this, it was performed the manual digitization of the drainage at scale 1:5,000 from RapidEye satellite images using ArcGIS 10.1, being used the methodology proposed by Strahler (1952) for the hierarchy of the drainage. The compartmentalization the basin it was performed in ArcGis 10.1 based on drainage analysis in the landscape (hydrograph and relief). Were defined 05 compartments (sub-basins), being: Sub-basin the Ribeirão Prata, Sub-basin the Ribeirão Piedade, Sub-basin the Ribeirão Surubim, Sub-basin the High Coco River and Sub--basin the Low Coco River, in which were applied morphometric parameters, according the methodologies described by Horton (1945), Christofoletti (1969) and Strahler (1952). From the analysis performed can be observed that the sub-basins the High Coco River and Ribeirão Piedade were the compartments that showed largest natural fragility in relation the other compartments, considering the results obtained in the morphometric analysis, suggesting a special attention to them in relation the use and occupation of soil.

Key words: Morphometric compartmentation; Environmental fragility; Coco River Basin.

Resumen

El presente estudio tuvo como objetivo realizar la compartimentación morfométrica de la Cuenca Hidrográfica del Rio Coco. Para esto, fue realizada la digitalización manual de la red hidrográfica en escala 1:5.000 en ArcGis 10.1 a partir de imágenes do satélite RapidEye, siendo utilizada la metodología propuesta por Strahler (1952) para la jerarquización de la red de drenaje. La compartimentación de la cuenca fue realizada en el programa ArcGis 10.1 con base en el análisis del drenaje y el paisaje (hidrografía e relieve). Fueron definidos 05 compartimientos (sub-cuencas), siendo: Sub-cuenca del Ribeirão Prata, Sub-cuenca del Ribeirão Piedade, Sub-cuenca del Ribeirão Surubim, Sub-cuenca del Alto Rio Coco y Sub-cuenca del Bajo Rio Coco, para los cuales fueron aplicados parámetros morfométricos, conforme las metodologías descriptas en los trabajos de Horton (1945), Christofoletti (1969) y Strahler (1952). A partir del análisis realizado se puede observar que las sub-cuencas del Alto Rio Coco y del Ribeirão Piedade fueron los compartimientos que presentaron mayores fragilidades naturales en relación a las demás sub-cuencas, situación verificada con los resultados del análisis morfométrico realizado, requiriendo por tanto una atención especial en relación al uso y ocupación del suelo.

Palabras claves: Compartimentación morfométrica; Fragilidad ambiental; Cuenca hidrográfica del Río Coco.

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INTRODUCTION

The morphometry of hydrographic basins is understood as a quantitative analysis of the resulting elements of modeled relief (expression and spatial configuration) (SALLES, 2010, p. 05). For Soares and Souza (2012, p. 20), this type of analysis enables the identification of important general characteristics in a basin, especially when considering the relationship of the geomorphological characteristics associated with relief and drainage network.

The researches in hydrographic basins facilitate the monitoring of natural changes or introduced by man (RODRIGUES, PISSARRA e CAMPUS, 2008, p. 311), and its delimitation one of the first and most common procedures performed in hydrological or environmental analysis (ARAÚJO, TELES e LAGO, 2009, p. 4631). Thus, morphometric analysis plays an important role in studies involving basin, as it enables a systematic evaluation of the physical aspects of a basin and a better understanding of the dynamic of resources (FREIRE, LAGE e CHRISTÓFARO, 2013, p. 5443).

According to Nunes, Ribeiro and Fiori (2006, p. 01), the morphometric study of hydrographic basins is defined as the quantitative analysis of the relationship between the physical geography of the basin and its hydrological dynamics. Barbosa and Ferreira (2012, p. 112) discuss that the morphological and morphometric characterization of an area allow to know the natural potential existing in it, facilitating the identification of occupancy risk areas, fragile environments, environmental impacts, human interference and the dynamics of the natural evolution of the landscape.

The morphometric analysis has a close relationship with geography, since it allows understanding, through a set of morphometric parameters that relate to a list of geographic features, the dynamics of the basin as a whole, including its different compartments and consequently its natural fragility.

Identify the environmental fragility of a basin means assessing, first through isolated analysis of indicators of relevant physical aspects of the environment under study, and later crosses of these, the intensity with which this environment can be exploited without harming its dynamics and its balance, taking into consideration the limitations imposed on him by the natural and anthropogenic components (GHEZZI, 2003, p. 02).

It is important to note that this assessment becomes important, since it allows to assess the natural vulnerability of a basin, which according to Souza (2005, p. 52) corresponds to the degree of probability that the natural attributes have in conditioning, induce or accelerate the occurrence of a particular hazard. The author evaluates the morphometric susceptibility of drainage basins as the parcel of responsibility of the geometric behavior of the basins in triggering of problems, such as floods, erosion, landslides, among others.

Ghezzi (2003, p. 08) points out that through the study of the fragility can be identified the vulnerability of an environment to some kind of use or occupation, either by result of their exploitation by either own natural factors. His study aims to observe how an environment, which of course can present degrees of fragility, behaves or may behave with the advent of human interference.

Therefore, the morphometric characterization of a hydrographic basin is one of the first and most common procedures performed in hydrological or environmental analysis, and aims to elucidate the various issues related to the understanding of local and regional environmental dynamics (TEODORO et al., 2007, p. 137).

In this sense, the present study aimed the analysis and morphometric compartmentalization of Coco River Basin as an aid to analysis of environmental fragility, in search of a more embracing understanding of how natural processes can be influenced by the uses and occupations imposed in the study area.

STUDY AREA

This study was developed at the Coco River Basin. This is located on the right bank of the Araguaia River Basin, in the state of Tocantins. The area of the basin is approximately 6,670 Km², divided between the municipalities of Caseara, Marianópolis do Tocantins, Divinópolis do Tocantins, Monte Santo, Paraíso do Tocantins, Chapada de Areia, Pium and Barrolândia. The main watercourse of this basin is the Coco River, this has its sources in the Serra do Estrondo, having an approximate length of 356 km.

MATERIAL AND METHODS

METHODOLOGICAL PROCEDURES

The work was divided into three stages, namely: obtaining topographical and water data; lifting morphometric parameters; morphometric analysis and compartmentalization of the Coco River Basin.

- **Step 01**: Topographic data collection and water

The acquisition of relief attributes was held from Topodata project data, this offers data from the Digital Model Elevation (DME), prepared from SRTM (Shuttle Radar Topography Mission).

The drainage network was obtained by manual scanning in the scale 1: 5.000 using the ArcGIS 10.1, for which RapidEye Satellite images were used (resolution 5 m), dated September 2011. It is important to mention that were considered as drainage channels all those noticeable in RapidEye images that allow the linear flow of water including the intermittent course.

The methodology used for ranking the drainage network was proposed by Strahler (1952), where no tributaries channels are considered to be of first order, two first order channels form a second order channel, two second-order channels form a third row, and so on.

From the attributes of relief and drainage network, were performed the calculations of area, perimeter, length of the basin, the main river length, length of watercourses and number of channels in ArcGIS 10.1.

- **Step 02**: Survey of morphometric parameters

The morphometric parameters used in this study were: altimetry amplitude, the main river slope, slope of the basin, drainage density (Dd), river density (Rd), compactness index (Kc), conformation index or form factor (F), tortuosity index (Ti), roughness index (Ri), roundness index of the basin, concentration time (Ct), maintenance coefficient (M), channels gradient (Cg), bifurcation ratio (Rb) and the ratio between the medium length of channels (Rl). Such parameters followed the methods described by Horton (1945), Christofoletti (1969) Strahler (1952).

- **Step 03**: Analysis and morphometric compartmentalization of the Coco River Basin

In this step the morphometric analysis of the Coco River Basin was carried out as a whole, aiming at the understanding of the morphometry of this unit, especially the understanding of the basin's dynamic, since it can provide shapes, processes and development, differentiated, from heterogeneous compartments.

The identification and definition of the morphometric compartments existing in the basin was performed based on analysis of the drainage network configuration in the landscape (hydrography and relief). From this assessment 05 compartments were defined (sub-basins), as follows: Sub-basin of Ribeirão Prata, Sub-basin of Ribeirão Piedade, Sub-basin of Ribeirão Surubim, Sub-basin of the Upper Coco River and Sub-basin of the Lower Coco River.

It is noteworthy that the region surrounding the plain of the basin (termed as coco_lakes) were excluded from the analysis because it is a very heterogeneous environment, which do not fit the analysis of morphometric parameters defined in this study.

In order to identify the behavior of each morphometric compartment in relation to its environmental fragility analyses were performed for each compartment from morphometric parameters defined in step 02.

RESULTS AND DISCUSSION

MORPHOMETRY OF THE COCO RIVER BASIN

Table 1 describes the morphometric results obtained for the Coco River Basin.

Table 1 - Results of morphometric parameters of the Coco River Basin

Morphometric parameters	Results
Drainage area	6258.07 Km^2
Perimeter	613.96 km
Length of the Main River	355.3 Km
Length of water courses	7533.31Km
Basin Length	164.99 Km
Drainage pattern	Dendritic
Order of the basin (Strahler)	7th
Minimum altitude	142.96 m
Medium altitude	233.54 m
Maximum altitude	697.18 m
Altimetry amplitude	554.22 m
Steepness of the Main River	0.97 m/Km
Slope of the Basin	3.35 m/Km
Maximum slope of the basin	73.91%
Medium slope of the basin	3.80%
Drainage density (Dd)	1.203 Km/Km^2
River density (Rd)	2.637 $channels/Km^2$
Compactness index (Kc)	2.17
Conformation index or form factor (F)	0.229
Tortuosity index (Ti)	2.37
Roughness Index (Ri)	666.72
Roundness index of the basin	0.208
Concentration time (Ct)	42 H
Maintenance coefficient (M)	831.255 m/m^2

The basin of the Coco River is classified as 7th order, according to Strahler classification (1952). This has an area of 6,670 Km^2, but the considered area for analysis was 6258.07 Km^2, since the area that make up the seasonally flooded plains (lakes region) was not considered for analysis.

The observed drainage density was 1.203 Km / Km^2, indicating that the basin has a medium drainage capacity. Regarding the drainage density, the value found was 2,637 channels / Km^2, i.e., each square kilometer there are 2,637 channels, however, it is noted that the basin has a variable density of the drainage network, being made up of the richest regions in the number of channels in relation to others, justifying the need for partitioning the study area.

The observed values of the compactness index (2.17), form factor (0.229) and roundness index (0.208) indicate that the Coco River Basin doesn't have a circular shape, corresponding, therefore, to an elongated basin feature, being, little susceptible to flooding under normal precipitation conditions. Besides these characteristics, the concentration time found was considered high (42 hours), increasing the low probability of flooding.

The sinuosity observed to the Coco River was 2.37, according to Stipp et al. (2010, p. 122), above 2.0 sinuosity values is characteristic of a sinuous drainage network, with possible accumulation of sediments along the channel, which can be aggravated by human action.

The average slope of the basin was 3.8%, indicating the predominance of a flat relief to gently undulating and a maximum of 73.91% (Figure 1), near Estrondo Ridge (basin hydrographic basin), strongly wavy relief, as the EMBRAPA classification (1979). It should be mentioned that the Coco River Basin is very extensive, which has a heterogeneous relief in all its extension, which reinforces the importance of compartmentalization of it, in order to further analysis.

A minimum altitude of 142.96 m and a maximum of 697.18 m (Figure 1) was observed, resulting in an altimetry amplitude of 554.22 m. This has a direct relationship with the roughness of the basin, which was considered strong (Ri = 666.72).

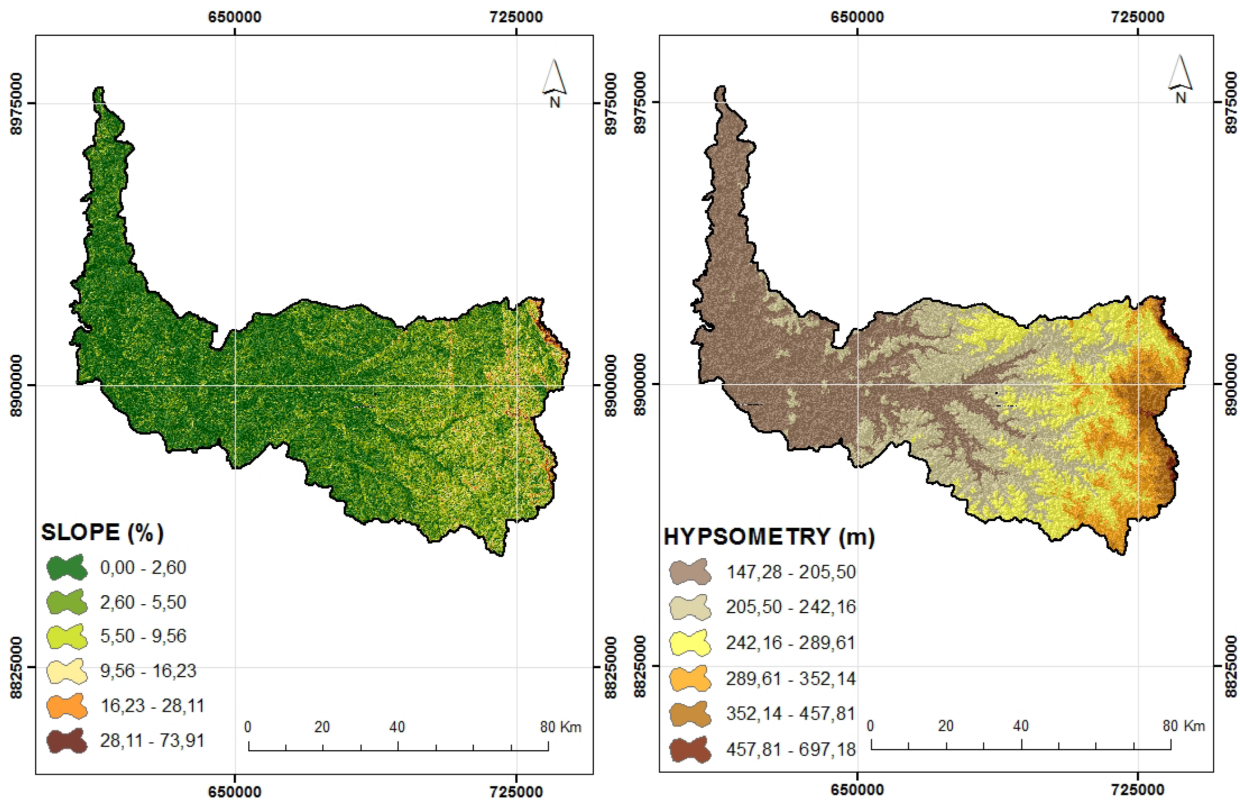

Figure 1 - Hypsometry and slope of the Coco River Basin.

MORPHOMETRIC COMPARTMENTALIZATION OF THE COCO RIVER BASIN

The Coco River Basin was divided into 5 compartments, as follows: Sub-basin of Ribeirão Prata, Sub-basin of Ribeirão Piedade, Sub-basin of Ribeirão Surubim, Sub-basin of the Upper Coco River and Sub-basin of the Lower Coco River, as shown in Figure 2.

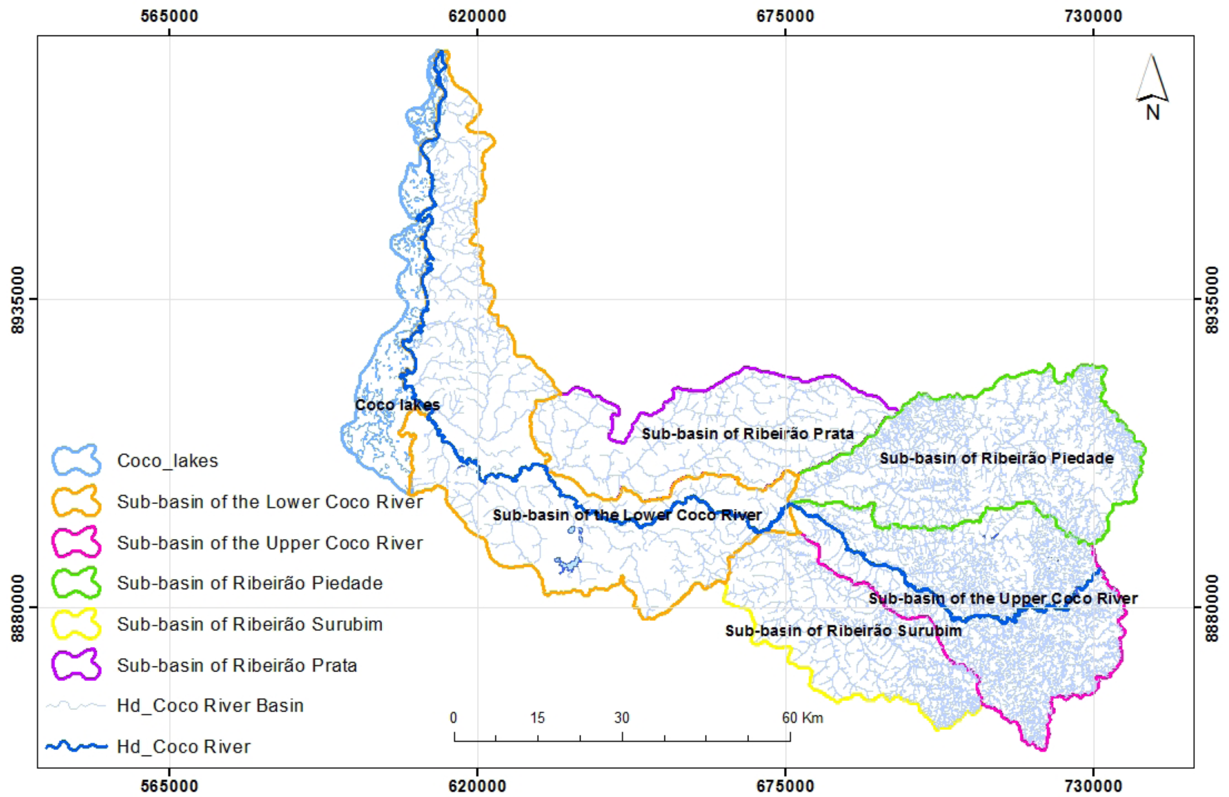

Figure 2 - Morphometric compartmentalization of the Coco River Basin.

The morphometric compartmentalization of the Coco River Basin enabled the identification of distinctive features throughout the basin. Table 2 shows the results obtained for morphometric parameters assessed in the compartments.

The evaluated sub-basins have a drain dendrite pattern with diversified drainage density values. According to Villela and Mattos (1975, p. 245), the drainage density (Dd) may vary from 0.5 km / km² for basins with little drainage to values above 3.5 km / km² for exceptionally well-drained basins. In this context, evaluated sub-basins can be grouped, as its drainage, in the following way: a) well-drained - sub-basin of the Upper Coco River (2.104 km / km²); b) average drainage - sub--basins of Ribeirão Piedade (1.55 km / km²) and Ribeirão Surubim (1.321 km / km²) and c) poor drainage - Ribeirao Prata sub-basins (0.62 km / km²) and Lower Coco River (0.636 km / km²).

The water density relates the number of channels with the total area of the basin (Almeida et al., 2013, p. 139), or indicates the number of channels to each square kilometer. As can be seen in Table 02the values vary considerably between the analyzed compartments, deserving highlight the sub-basin of the Upper Coco River with 6.725 channels / km ², and the Lower Coco River sub--basins with 0.411 channels / km² and Ribeirão Prata with 0.49 channels / km², indicating that the sub-basin of the Upper Coco River has a greater capacity to generate new channels in relation to the other evaluated sub-basins which may be related to their pedologic, geological and climatic characteristics. These results agree with the values obtained for the drainage density, by pointing high infiltration to the sub-basins of the Lower Coco River and Ribeirão Prata and high surface runoff for sub-basin of the Upper Coco River.

Regarding the shape of the sub-basins, all they exhibited elongated shape and can be proven by the values obtained for the indexes of compactness, roundness and form factor, indicating little susceptibility to floods in regular conditions of precipitation, deserving highlight the sub-basin of the Lower Rio Coco, which presented the smallest form factor (0.174) and circularity index (0.157) and consequently the highest value for the compactness index (2.50), confirming that this compartment is more elongated than the other, which can be shown in Figure 2 above. According to Cardoso et al. (2006, p. 244), in the basins with circular shape there are greater possibilities of heavy rains occur simultaneously in all its extension, concentrating large volume of water in the main tributary.

Table 2 - Results of morphometric parameters of the compartments of the Coco River Basin

Morphometric characteristics	Unit	Rib. Prata Basin	Rib. Piedade Basin	Rib. Surubim Basin	Upper Coco River Basin	Lower Coco River Basin
Drainage area	Km²	951.64	1203.05	777.97	1315.07	2010.32
Perimeter	Km	181.53	193.01	145.62	201.02	400.65
Length of the Main River	Km	90.30	130.18	68.79	118.47	236.81
Length of water courses	Km	592.15	1865.76	1028.34	2767.98	1279.66
Basin Length	Km	63.91	64.27	50.08	65.55	107.30
Drainage pattern	-	Dendritic	Dendritic	Dendritic	Dendritic	Dendritic
Order of the basin (Strahler)		5th	6th	6th	6th	7th
Minimum altitude	M	168.27	185.89	182.47	186.47	142.96
Medium altitude	M	212.3	275.12	232.53	282.11	187.61
Maximum altitude	M	288.3	697.18	361.60	679.19	247.22
Altimetry amplitude	M	120.03	511.29	179.13	492.72	104.26
Steepness of the Main River	m/Km	1.131	1.141	2.18	2.75	0.128
Slope of the Basin	m/Km	1.878	7.95	3.57	7.516	0.97
Maximum slope of the basin	%	21.56	73.91	32.88	70.03	39.30
Medium slope of the basin	%	2.64	5.66	3.53	5.95	2.31
Drainage density (Dd)	Km/Km²	0.62	155	1.321	2.104	0.636
River density (Rd)	channels/Km²	0.49	3.47	2.795	6.725	0.411
Compactness index (Kc)	-	1.647	1.558	1.461	1.552	2.50
Conformation index or form factor (F)	-	0.232	0.291	0.31	0.306	0.174
Tortuosity index (Ti)	-	1.42	2.251	1.457	2.095	2.323
Roughness Index (Ri)	-	74.4	792.49	236.63	1036.6	66.3
Roundness index of the basin	-	0.363	0.404	0.461	0.408	0.157
Concentration time (Ct)	H	3.9	8.6	6.4	13.7	10.2
Maintenance coefficient (M)	m/m²	1612.9	645.16	757.002	475.285	1572.32
Channels gradient (Cg)	%	0.113	0.114	0.218	0.27	0.012

As regards to the concentration time, i.e., the time required for all the fallen precipitation at any point of the basin reaches its end point, was observed for Upper and Lower Coco River sub-basin the highest values, being 13.7 for the first and 10.2 to the second. The sub-basin that presented a shorter concentration was Ribeirão Prata sub-basin (3.9) and the Ribeirão Piedade sub-basins a value of 8.6 and Ribeirão Surubim 6.4.

The sinuosity of the main channels of the sub-basins analyzed indicated that the Ribeirão Piedade, the Upper Coco River and Lower Coco River are crooked, they presented, respectively, sinuosity indices of 2.251, 2,095 and 2.329. In sinuous channels there may be a higher accumulation of sediment, which may be exacerbated by human activities. Already the values observed for Ribeirões Prata (1.42) and Surubim (1.457) suggest mildly tortuous or transitional channels. According to Lana et al. (2001, p. 07) and Stipp et al. (2010, p. 122), values for the sinuosity index near 1.0 indicates that the channel tends to be rectilinear. Already values higher than 2.0 suggest tortuous channels and intermediate values indicate transitional, regular and irregular shapes. It is interesting to note that for sub-basin of the Upper Coco River (Ri = 1036.6) and the sub-basin of Ribeirão Piedade (Ri = 792.49) roughness was considered strong, agreeing with the drainage density and altimetry amplitude recorded for such compartments, while for the sub-basins of Ribeirão Prata and lower Coco River, the roughness presented was weak, getting 74.4 and 66.3, respectively.

Sousa and Rodrigues (2012, p. 142) points out that high roughness values indicate severe runoff and also erosive events.

In terms of medium slope, the values range from 2.31% to 5.95% representing a flat relief to gently undulating, as the EMBRAPA classification (1979), however, it is noteworthy that the presence of a strongly wavy relief was also identified, with maximum slope of up to 73.91%, deserving highlight the sub-basins of the Upper Coco River and Ribeirão Piedade, which showed the highest values for both the medium slopes as to the maximum. For these sub-basins, there is a tendency of increased runoff compared to the others, under the same conditions of vegetation cover, soil type and precipitation, suggesting a higher natural fragility and hence more prone to degradation.

For the medium slope of the main channel and gradient channels, stood out the sub-basins of the Upper Coco River and Ribeirão Surubim, observing respective slope values of 2.75 m/m and 2.18 m/km. Tonello et al. (2006, p. 855) report that the channel slope interfere in the flow velocity of the water on the course, thus, high values indicate greater runoffs and shorter time of permanence of water, being convenient a more intensive soil and water management.

According to Santos and Morais (2012, p. 626), the maintenance factor is an index that aims to calculate the minimum area which the basin must provide for the maintenance of a fluvial channel meter, being its result indicated in m/m². In the analysis were highlighted the sub-basins of Ribeirao Prata and Lower Coco River with the highest values for this coefficient, being found 1612.9 m/m² for the first and 1572.32 m/m² for the second. As can be seen the mentioned sub-basins require a considerable area for maintenance (recharge area) and evolution of drainage. These results can be corroborated by the drainage density and hydrographic, which it was the lowest recorded, suggesting that the sub-basins have difficulties in renewing and training of new channels. This reality can be understood when it is found that the sub-basins presented low medium declivity, being considered its relief flat to gently undulating, as the EMBRAPA classification (1979), and low roughness indexes, very important factors in the river flow and formation of new channels. Table 3 shows the results obtained for the Horton's laws (1945).

The medium value for the bifurcation rate (Rb) for the analyzed sub-basins was similar, having the Upper Coco River sub-basin a greater observed value (5.55). Vestena et al. (2011, p. 99) studying the morphometry of the Caeté River Basin they found a medium value for the bifurcation rate close to that found for the Coco River sub-basins (4.0). The value 2.00 is normally found, however, if the channels produce certain slope, it can vary (HORTON, 1945, p. 291). According to Castro and Carvalho (2009, p. 04), the bifurcation ratio (Rb) indicates the degree of dissection of the river basin, the higher the value of the bifurcation index, greater the degree of dissection, values generally under 2 indicate hilly relief, therefore, the results suggest the presence of a relief dissected for the analyzed sub-basins.

It is mentioned that the values of bifurcation ratio (Rb) for the segments of the evaluated sub--basins do not have a specific pattern. You can see that the Ribeirão Prata sub-basin showed a higher Rb between the channels of first and second order (5.36), indicating for this compartment that the lower the hierarchical order, the greater the bifurcation ratio. In the case of sub-basins of Ribeirões Piedade and Surubim the largest verified bifurcation ratios were between the channels of fourth and fifth order, having the channels of first to third orders similar bifurcation behaviors. As for the sub-basins of the Upper Coco River and Lower Coco River the most representative bifurcation rate was for fifth-order channels, having the Upper Coco River a greater number of channels of lower orders (1st and 2nd). Was also found that the said sub-basin has forming channels of inner basins (microbasins), considering the number of identified channels of superior orders (4th and 5th orders).

For the ratio between the medium lengths of the channels (Rl), stood out the sub-basin of the Lower Coco River with a medium value of 6.74 and the sub-basin of Ribeirão Piedade with 3.90. Already Ribeirao Prata sub-basins, Ribeirão Surubim and Upper Coco River showed similar medium values, as follows: 2.60, 2.65 and 3.50, respectively.

Table 3 - Application results of Horton laws to the compartments of the Coco River Basin

CompartmentS	Order (w)	Nw	Lw	Log 10 Nw	Rb	Medium Lw	Log 10 Lw	Rl
Ribeirão Prata	1	238	249803	2.37	4.03	1049.59	3.02	2.39
	2	59	148147	1.77	5.36	2510.96	3.39	3.10
	3	11	85879	1.04	3.66	7807.18	3.89	2.63
	4	3	61635	0.47	3.00	20545.00	4.31	2.27
	5	1	46686	0.00		46686.00	4.66	
	Average				**4.01**			**2,60**
Ribeirão Piedade	1	2.115	812574	3.32	4.16	384.19	2.58	2.24
	2	508	438658	2.70	4.13	863.50	2.93	2.26
	3	123	240351	2.08	4.24	1954.07	3.29	3.35
	4	29	189853,83	1.46	4.83	6546.68	3.81	1.77
	5	6	69689	0.77	6.00	11614.83	4.06	9.86
	6	1	114638	0.00		114638.00	5.05	
	Average				**4.67**			**3.90**
Ribeirão Surubim	1	1.073	462052	3.03	3.94	430.61	2.63	2.12
	2	272	248456	2.43	4,00	913.44	2.96	2.32
	3	68	144628	1.83	4.00	2126.88	3.32	2.60
	4	17	94306	1.23	8.50	5547.41	3.74	2.45
	5	2	27260	0.30	2.00	13630.00	4.13	3.78
	6	1	51551	0.00		51551.00	4.71	
	Average				**4.48**			**2.65**
Upper Coco River	1	4.496	1211232	3.65	4.32	269.40	2.43	2.33
	2	1.039	652748	3.01	4.31	628.24	279	2.74
	3	241	415412	2.38	4.63	1723.70	3.23	2.63
	4	52	236054	1.71	6.50	4539.50	3.65	4.03
	5	8	146536	0.90	8.00	18317.00	4.26	5.76
	6	1	105597	0.00		105597.00	5.02	
	Average				**5.55**			**3.50**
Lower Coco River	1	396	491312	2.59	3.66	1240.68	3.09	2.28
	2	108	306350	2.03	4.32	2836.57	3.45	2.62
	3	25	186152	1.39	5.00	7446.08	3.87	1.55
	4	5	57732,58	0.69	5.00	11546.51	4.06	20.50
	7	1	236811	0.00		236811.00	5.37	
	Average				**4.50**			**6.74**

NOTE: Nw is the number of channels; Rb is the bifurcation rate; Lw is the medium length; Rl is the rate of length.

The results of morphometric analysis in the different compartments of the Coco River Basin indicated that the sub-basins of the Upper Coco River and Ribeirão Piedade are the compartments that have higher natural fragilities. Therefore, these compartments deserve special attention as regards the activities of use and occupation of the soil, which, if not performed with caution may potentiate the effects of natural processes, such as the intensification of soil losses by erosion and consequent siltation and decrease in water quality.

FINAL CONSIDERATIONS

From the results obtained for morphometric compartmentalization of the Hydrographic Basin of Coco River can be concluded that:

- The analysis of compactness indices, roundness and form factor indicated that all evaluated compartments exhibited elongated shape, signaling little susceptibility to floods in regular rainfall conditions;
- The sub-basins of Ribeirão Prata and Lower Coco River are compartments that showed the highest maintenance coefficients, 1612.9 m/m² and 1572.32 m/m² respectively, indicating a considerable area for maintenance (recharge area) and evolution of drainage;
- The sub-basin of the Upper Coco River presented a greater number of lower orders channels (1st and 2nd), and indicate high ability to articulate forming channels of inner basins (micro-basins), given the number of identified channels of superior orders (4th and 5th orders);
- The more representative density and hydrographical drainage was for the sub-basin of the Upper Coco River with 2.104 Km/Km² and 6.725 channels/Km², respectively, indicating greater ability to generate new channels in relation to the other evaluated sub-basins which can be related to their soil, geological and climatic characteristics;
- Roughness presented to the sub-basin of the Upper Coco River (Ri = 1036.60) and the sub-basin of Ribeirão Piedade (Ri = 792.49) suggest severe runoff and also the erosive occurrences for these compartments, implying conservation soil practices.

Therefore, the set of analyzed morphometric parameters indicated that the sub-basins of the Upper Coco River and Ribeirão Piedade are the compartments that have higher natural fragilities, requiring greater management of the activities of use and occupation of the soil, to minimize the potential effects of natural processes occurring in these compartments.

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