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USE OF REMOTE SENSING AND ANALYSIS OF THE GEOPROCESSING SOIL ERODIBILITY: A STUDY OF BASIN CAMARÁ - PB

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Abstract

The basin of the dam Camará - PB presents great diversity of landscapes, especially in relation to landform, soil. Its importance lies in concerns about the conservation of the environment and the socio-economic development and preservation of natural resources in the area in search of integrated and sustainable development. This study aimed to contribute to developing a map of Camará erodibility of the basin for future research and projects that improve environmental conservation. Thus, there were collection and analysis of the soil, drawing up a map of slope, for more accurate results. Was used in this study an image of CBERS, for 2004 and geoprocessing techniques using the program SPRING, descriptive basis for the work field, where it was collected GPS control points for observation. From the information of soil and topography, we described the areas susceptible to erosion. The results obtained in the watershed data showed that in his 19 geoenvironmental units present most of the strong wavy relief and soils Regosols, deep and well drained.

Keywords: SPRING, susceptibility to erosion, geotecnologic.

1. Introduction

A watershed is a unit of territorial management of water resources and has an integrative character of the dynamics that occur in environmental units, revealing excellent study areas for planning (Hidalgo, 1992). It is represented by different ecological units, which define its natural characteristics, socioeconomic and political.

A good environmental planning passes directly through water management, because it is a public good whose management should be decentralized and participatory (Hidalgo, 1992).

The study watersheds stems from an overview of the combination of the physical and social environment present in these environments, is, not fragmented interpretation

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of the relationship between humans and nature and natural resources among themselves (soil - water - vegetation - wildlife - climate), regardless of the location of the fences dividing farms or municipal lines dried currency (Antunes, 2003).

Aiming to supply the communities part of Brejo was built from 2000 to 2001, Camará dam, through an agreement of the State Government and the Ministry of National Integration. The catchment area of this dam covers an area of approximately 104 km^2, covering the cities of the land of Esperança, São Sebastião de Lagoa de Roça and Remígio, belonging to the wasteland micro Borborema, Alagoa Nova and Areia, located in the micro Brejo (Silva, 2006). The dam had a capacity to store about 27 million m3 of water, only 65% capacity, on June 17, 2004, occurred the rupture of its wall, causing serious material damage and human (Nieble, 2004).

The catchment area of the dam Camará presents a great diversity of landscapes, especially in relation to landforms, soils and production systems, and a high population density which makes it more vulnerable to the erosive action and environmental degradation (Silva, 2006).

The risk of environmental degradation is also related to soil erosion, loss of biodiversity, siltation, contamination of soil resource - water, which can result in loss of biodiversity, unproductive land and compromise the quality and quantity of water resources (Alvares and Pepper, 1998).

Regarding erosion, these are determined by physical, chemical and morphological properties of the soil, the vegetation, the greater or lesser protection of soil, the slopes and lengths of slopes, conservation practices and soil management and crop (Alvares and Pimenta, 1998). The problem of erosion is due not only to the existence of soils susceptible to erosion processes related to periods of high rainfall, but also to a disorderly occupation without basic criteria of environmental planning (Paiva, 2003).

In studies environmental diagnostics, identification and characterization of the attributes of physiographic and human actions on the environment can be made by systematic evaluation of data on determinants of erosion. These are embodied in Equation Universal Soil Loss - USLE was developed to estimate the average annual soil loss by water erosion from agricultural areas (Wischmeier and Smith, 1965; Wischmeier and Mannering, 1969; Renard et al., 1997; Bryan, 2000).

With the integrity of the site concerned, especially the importance of this watershed, which covers a large population and demand for the integrity of your physical space, it has become of paramount importance diagnosis of isolated elements that compose it, to determine its contribution in environmental susceptibility. Thus, within conservation design can know which areas can still be used and what practices should be adopted for sustainable development.

This study aimed to improve the diagnosis of soil erodibility of watershed Camará, through the use of geotechnology, through remote sensing and GIS.

2. Material and Methods

2.1 Study area

The catchment area of the dam Camará has an area of 104 km^2, and is contained in the upper quadrangle whose geographical coordinates are 60 58'20" 45'40" South and 350 West, and less than 70 04'40" south and 350 53'40" west. The basin covers parts of the counties of Alagoa Nova, with an area of 37.4 km2; São Sebastião de Lagoa de Roça, with 7.9 km2; Esperança, with 33.9 km2; Remígio, with 16.0 km2 and Areia with 8.4 Km2, as can be seen in Figure 1.

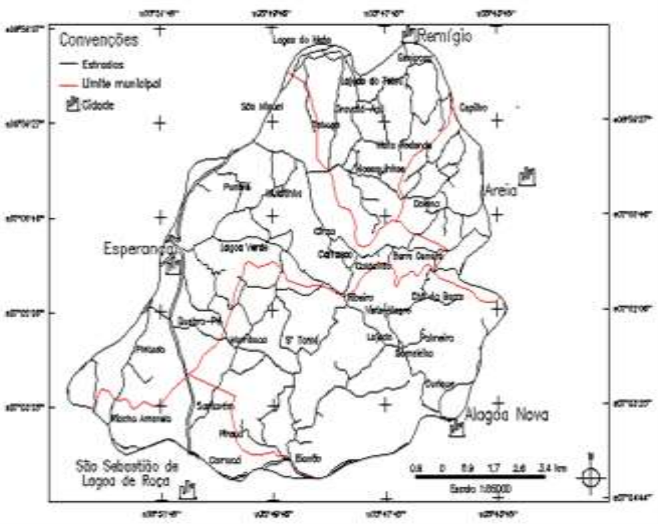


Figure 1. Political and road map of the catchment area of the dam Camará-PB (Silva, 2006).

The basin is located on the Camará Borborema Plateau, and covers part of the physiographic regions of Brejo and Agreste Borborema, State of Paraiba. The Brejo characterized by the occurrence of clay soils with a strong corrugated undulated (Figure 2), whereas the soils presents Agreste relief soft wavy to wavy.

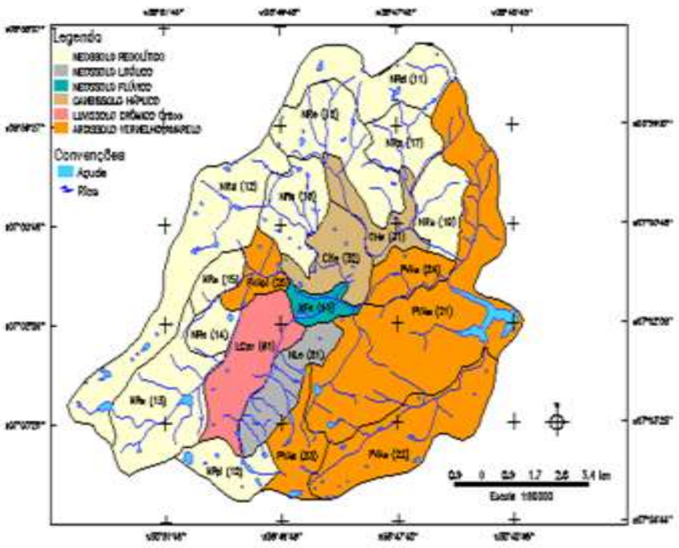


Figure 2. Soil map of the basin weir Camará-PB (Silva, 2006).

Considering the attributes related to natural components, soil and topography, and the socio-economic, related to land use, Silva (2006) separated nineteen geoenvironmental units in the basin Camará, shown in Figure 3, coded by numbers and colors. It is observed that the units that make up the region of Brejo in the watershed are represented by the colors: red, orange and mustard, geoenvironmental units comprising of: (1) Cepilho, (2) Sítios das Banana, (3) Pastagens de Alagoa Nova, (4) Caldeirão- Camará, (5) Caiana, (6) Pastagens de São Tomé, and (7) Sao Tome The other units match the Agreste region to Borborema, which can be subdivided into: a) units of the central area drier - to (8) Pastagens Riacho do Boi and (9) Encosta de Sao Tome, dark brown in color, the (10) Mumbuca, light brown in color, and (11) Riachão, in blue b) units in an intermediate position of the landscape - the (12) Vertentes de Remígio, (13) Mulatinha, (14) Lagoa Verde (15) Quebra - pé (16) Riacho Amarelo in dark gray, and c) in units top position - (17) Remígio, (18) and Esperança (19) Camucá / Santarém, in light gray.

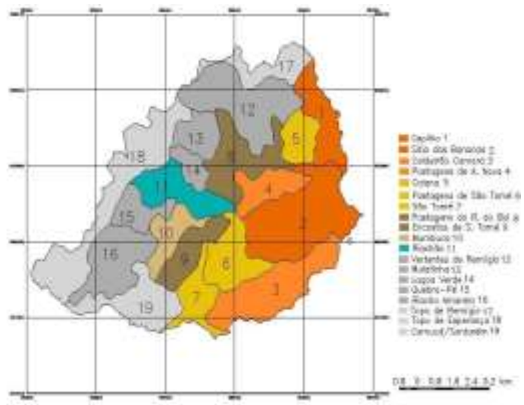


Figure 3: Geoenvironmental units watershed of Camará - PB (SILVA, 2006).

2.2 - Materials

The research in question used as the base topographic IBGE, leaves Campina Grande (SB-25-YCI) and Solânea (SB-25-YA-IV) and municipal maps IBGE, all in scale 1: 100,000 and soil map and population density of Camará basin, according to the database of Silva (2006).

We used the image provided by INPE (National Institute for Space Research), the satellite CBERS CCD sensor, orbit-point 147-108, with passage of 22 July 2004 (bands 2, 3 and 4).

The computer programs used were: SPRING (Processing System Georeferenced Images) version 4.3.3, and its extensions: the IMPIMA (view image), the SCARTA (editing letters) and IPLOT (printing) to produce the maps and classification of the image; beyond ARCVIEW (to upgrade the drainage network and the boundary of the basin). The program was used as AUTOCAD drawing tool, assisting in the representation of various geographical aspects (digital design), with the combined use with GIS SPRING.

For activities in the field we used a GPS navigation device, the model Etrex Summit / Garmin to georeference the positioning of targets. Later, transfer the file to the GPS program was used Track Maker the same company.

Photographs to record the landscape points were obtained with the use of a digital camera with a resolution of 6.0 megapixels. For analysis of factor erodibility 45 representative samples were collected from soil classes occurring in the bowl chamber.

2.3 - Methods

2.3.1 - Database and cropping area

To develop the study we used the electronic database of the watershed Camará, adapted from Silva (2006). From this we obtained the basic information necessary to work such as trimming the watershed and thematic maps of geoenvironmental units, soil and population density of the study area.

2.3.2 - Georeferencing image

Georeferencing image were used topographic SUDENE (1:100,000 scale) in digital media, which were imported in DXF files of type-R12. We used the SAD69 datum and projection UTM (Universal Transverse Mercator) through georeferencing on screen.

2.3.3 - Preparation of the statement of Soil Erodibility

Was used as the base soil map prepared by Silva (2006), according to Figure 4:

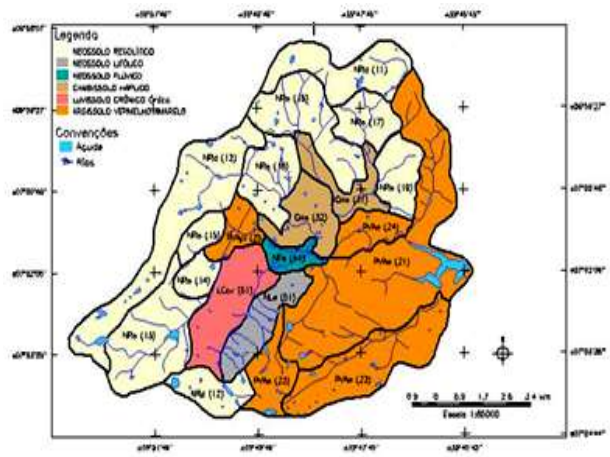


Figure 4: Soil watershed weir Camará - PB.

We tried to collect samples of the main soil classes, which were still little explored by Silva (2006) and there were no accurate data, reaching a total of 45 samples for the representation of areas. With which they carried out in the Laboratory of Physics of Soil DSER / CCA / UFPB, the particle size analysis. The samples were fractionated according to the classification of textural American System - USDA, which separates the sand fraction in five classes: very coarse sand, coarse sand, medium sand, fine sand and very fine sand, silt and clay beyond.

With the result of textural analysis was carried out calculations for determining the erodibility factor (M) based on the formula proposed by Wischmeier et al, 1971:

$$(M\ x = NS\ (NS + NA))$$

That is, the M factor is determined by multiplying the percent of new silt fraction (NS) times the sum of new silt fractions newest sand (NA). The fraction called "new silt - NS" is composed of the sum of silt and very fine sand.

While the fraction called "new sand - NA" represents the fraction subtraction of sand with very fine sand fraction.

Table 1: Classes of soil erodibility, proposed by Wischmeier et al. (1971).

Classes Erodibility	Limit Classes (Factor M)	Symbol	Index erodibility
Very Low	0-500	MB	1
Low	500-1000	B	2
Average	1000-1500	M	4
High	1500-2000	A	8
Very High	2000-2500	MA	16

Based on the occurrence of soil classes in each mapping unit, and considering the crossing done electronically this work, the soil map with the slope map was drawn to the erodibility of each soil map unit (Soil Association) associating each soil class or classes of slope, characteristics of their occurrence in the landscape (Table 2). In, for ease of location and retention of soil units are linked to unit's geoenvironmental.

alternating between classes very low and low slope, which is to say, based on the Classification of Land Use Capability (LEPSCH et al. 1991), which depend on the slope, over two-thirds of the basin area, can be used in agriculture.

Table 2: Soil Association.

Solos Unit	Unit Geoenvironmental	Classes Slope (%)				
		0 - 6	6 – 12	12 - 20	20 - 40	> 40
PVAe 21	Cepilho	VL	L	M	H	VH
NRe 19	Caiana	A	H	H	VH	VH
NRd 11	Topo de Remígio	A	H	H	VH	VH
NRe 17/18	Vertentes de Remígio	A	H	H	VH	VH
CHe 31/32	Pastagem do Riacho do Boi	A	H	VH	VH	VH
NRe 10	Mulatinha	A	H	VH	VH	VH
NRe 10/CHe	Lagoa Verde	A	H	H	VH	VH
NRd 12	Topo de Esperança	A	H	H	VH	VH
PVApl 25	Riachão	A	H	H	VH	VH
PVAe 24	Caldeirão-Camará	L	A	H	H	VH
PVAe 21	Sítios das Bananeiras	VL	L	M	H	VH
PVAe 22	Pastagens de Alagoa Nova	L	A	H	H	VH
PVAe21/23	Pastagens de São Tomé	L	A	H	VH	VH
PVAe23	São Tomé	A	A	H	VH	VH
NLe 51	Encostas de São Tomé	A	A	H	VH	VH
LCOv 61	Mumbuca	L	A	A	VH	VH
NRe 14	Quebra Pé	A	A	H	VH	VH
CHe 32	Riacho Amarelo	A	H	H	VH	VH
NFe 41	Camucá Santarém	A	H	H	VH	VH

3. Results and Discussion

The results are presented and discussed for each of the factors considered here, determining the erodibility of watershed dam Camará, namely: relief (slope) and soil.

3.1 - Relief Index – IRE

At the study occur 7189.8 ha with slopes equal to less than 12% (Table 3), corresponding to 70.8% of the total area of the bowl chamber, which is 10,190 hectares. This

For according Lepsch (1991) the limit is up to 12% slope area, according to the classification of land use capability. In large part, the occurrence of areas less sloping soils is associated Entisols, which are predominantly distributed in the northwestern half of the basin (Figure 5), comprising most of the municipalities of Remígio, Esperança and São Sebastião de Lagoa de Roça.

Also in this same area, the occurrence of more pronounced slope, middle and upper classes (Figure 5), are associated with the strong dissections Vertentes Riacho do Boi in the town of Remígio, north, and west, in the headwaters of Riacho Amarelo , in São Sebastião de Lagoa de Roça. These areas are common sloping soils the presence of shallow, poorly developed and occurrence of rock outcrops. This is the case of the mapped area in the vicinity of the town of Esperança, represented by the rock wall that separates the plateau town of Esperança slopes of the creek Quebra-pé.

More often, the more hilly areas occur in the southeastern half of the basin, comprising soils Ultisols and Inceptisols, with horizon prominent and strongly undulated relief, with humid, typical landscape of the region Brejo. This area comprises the lands of Alagoa Nova municipalities comprising the district of São Tomé and Serra da Gameleira and Areia, the district Cepilho.

In total 2230 hectares occur, which corresponds to 21.9% of the basin area with slopes between 12% to 20%; 740 hectares with slopes between 20% to 40% (7.3% of the area) and only 20 hectares with a slope equal to or greater than 40%. These areas of greatest vulnerability correspond to 30% of the area of study.

According to Silva (2006), the steep slopes favor the erosion process, and affect soil management, and agriculture contribute to a low income due to loss of nutrients dragged by surface erosion. Figure 6 illustrates the Unit of Environmental Field of Bananas and Cepilho with strong relief and wavy sites with horticulture and agricultural areas.

Table 3: Classes of slope and relief index for the lands of the watershed dam Camará - PB

Classes Slope	Limits %	Area ha	Area %	Index Relief
Very Low	0-6	3.710	36,4	1
Low	6-12	3.490	34,2	2
Average	12-20	2.230	21,9	4
High	20-40	740	7,3	8
Very High	>40	20	0,2	16

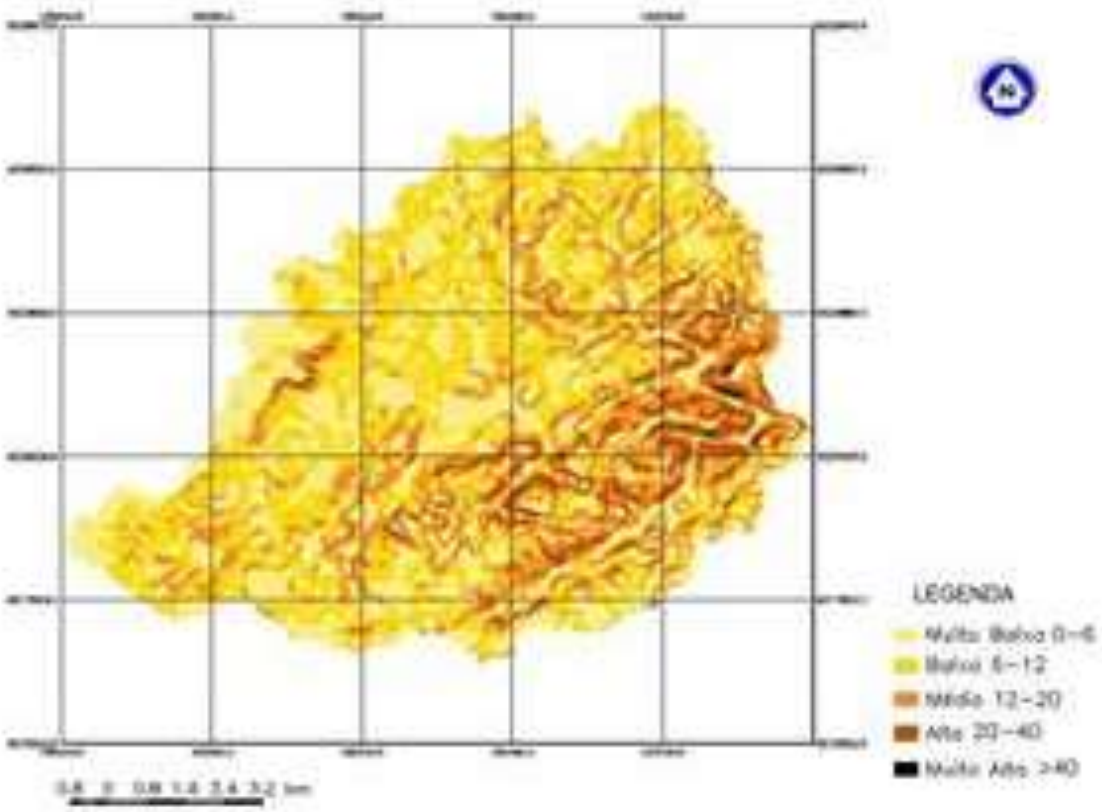


Figure 5: Watershed slope of Camará – PB.

Figure 6: Field of the Bananas, Alagoa Nova-PB.

3.2 - Soil erodibility index – ISO

By granulometric factor "M" was calculated erodibility for each soil class (Table 5), based on the results of particle size analysis of 45 soil samples (Table 6). Susceptibility to soil erosion is directly related to the content of silt and very fine sand (WISCHEMEIER, 1971), and we can thus relate this factor soil characteristics identified in the basin.

Soils with very high erodibility (VH) in the watershed, Table 5, are associated with Aridsol Entisols Orthent Santarém and Inceptisols Udept of Caiana / Mata Redonda young soils that are rich in silt, and often shallow ; beyond Mollisols Udoll with sandy loam texture of Gameleira, where the percentage of very fine sand and thin, provide the most erodibility.

Table 5. Erodibility major classes of soil watershed weir Camará, from the M factor (size), proposed by Wischmeier et al. (1971).

Number Samples	**Classes of soil**	**Location**	**Classes Erodibility**
1	Aridsol /Entisols Orthent	Santarém	VH(*)
2	Aridsol	Santarém	A
1	Ultisols Udult	Gameleira-Sítios Banana .	VL
6	Ultisols Udult	Marionaldo-Cepilho/ Sítio Banana-Gameleira	L
4	Ultisols Udult	Alagoa Nova - Campina	A
3	Mollisols Ustoll	Bianão/ São Tomé	A
9	Mollisols Ustoll	Eng.Cipó/Pastagens SãoTomé	H
1	Mollisols Ustoll	Gameleira p/ Bianão	VH
1	Inceptisols Udept	Caiana/Mata Redonda	VH
5	Inceptisols Ustept	Caiana - Bonfim and Lagoa Verde	H
8	Inceptisols Ustept	São Tomé and Gameleira	A
1	Ultisols Ustult	São Tomé	L
1	Ultisols Ustult	São Tomé	VL
6	Entisol	Mulatinha – Esperança - Mata Redonda - Caiana de Baixo	H
1	Entisol	Lagoa Verde	A

The low percentage of area occupied by class erodibility VH, 0.9%, is due to the methodology used in the soil mapping units are crossed with the slope classes. In this case, much of their occurrence in class must be mapped to high erodibility (H). In turn, the high class erodibildide, which occupies 36.5% of the watershed is represented largely by Regolithic Neosols occupying approximately 40% of the catchment area, as can be seen in Figure 7 in the region of north and west are intensively cultivated.

Table 6. Particle size analysis of soil watershed Camará – PB.

SAMPLES	SVT	ST	SA	SF	SVF	ST	SILT	CLAY	CLASSIFICATION
4810	191	229	174	151	55	800	101	99	*SAND FRANCE*
4811	124	124	175	134	46	603	252	145	*FRANCE SAND*
4812	123	248	168	178	38	755	75	170	*FRANCE SAND*
4815	48	150	170	153	88	609	104	287	*FRANCE CLAY SAND*
4816	65	143	150	143	58	559	110	331	*FRANCE CLAY SAND*
4818	114	189	174	157	58	692	140	168	*FRANCE SAND*
4819	154	179	179	215	50	777	149	74	*SAND FRANCE*
4820	192	253	177	154	51	827	76	97	*SAND FRANCE*
4821	233	294	142	104	36	809	109	82	*SAND FRANCE*
4822	160	356	198	130	41	885	69	46	*SAND*
4823	143	283	207	143	54	830	94	76	*SAND FRANCE*
4824	54	172	151	156	64	597	125	278	*FRANCE CLAY SAND*
4825	49	146	123	141	67	526	171	303	*FRANCE CLAY SAND*
4826	117	167	134	134	43	655	106	239	*FRANCE CLAY SAND*
4827	165	173	193	122	48	701	85	214	*FRANCE CLAY SAND*
4828	99	158	145	122	33	557	83	360	*CLAY SAND*
4829	127	150	116	103	31	527	81	392	*CLAY SAND*
4830	164	123	75	86	29	477	53	470	*CLAY SAND*
4831	129	126	71	58	21	405	108	487	*CLAY*
4832	159	112	81	68	23	443	133	424	*CLAY*
4835	166	186	163	146	55	716	194	90	*FRANCE SAND*
4836	238	180	133	138	60	746	171	80	*FRANCE SAND*
4837	251	161	116	151	48	727	124	149	*FRANCE SAND*
4843	81	146	107	109	31	474	102	424	*CLAY SAND*
4844	104	211	183	140	46	684	145	171	*FRANCE SAND*
4845	63	128	224	264	90	769	162	69	*SAND FRANCE*
4846	90	225	263	200	58	836	139	25	*SAND FRANCE*
4847	101	241	190	142	51	725	137	138	*FRANCE SAND*
4848	145	178	142	147	56	668	166	166	*FRANCE SAND*
4849	135	137	132	147	58	609	169	222	*FRANCE CLAY SAND*
4850	108	168	175	185	43	679	175	146	*FRANCE SAND*
4851	60	195	273	231	80	869	109	22	*SAND*
4852	82	228	246	193	68	818	130	52	*SAND FRANCE*
4853	201	206	175	153	50	785	143	72	*SAND FRANCE*
4854	209	211	173	133	45	771	127	102	*FRANCE SAND*
4855	98	189	172	157	56	672	150	178	*FRANCE SAND*
4856	136	169	154	159	61	679	148	173	*FRANCE SAND*
4857	105	167	113	77	26	488	108	404	*CLAY SAND*
4858	131	121	108	98	34	492	107	401	*CLAY SAND*
4865	106	157	192	217	76	748	139	113	*FRANCE SAND*
4866	73	147	289	248	58	815	93	92	*SAND FRANCE*
4867	93	220	336	212	51	912	88	0	*SAND*
4868	71	152	318	245	59	845	103	52	*SAND FRANCE*
4869	76	161	285	264	79	865	113	22	*SAND*
4870	136	209	264	209	53	871	105	24	*SAND*

The Regolithic Neosols occur in larger extents in northeastern Brazil, on flat terrain and soft wavy therefore very suitable for agriculture, these soils are intensively used as cotton, pineapple, sisal and several subsistence crops (Oliveira, 2005). His sandy texture impart a high erodibility, Class A, are the most representative soils of the watershed municipalities that belong to Agreste Borborema (Figure 7).

Figure 7: Area of soil Entisol.

The Ultisols are the second predominant soil type in the basin of Camará. In general, the region's rugged and wetter, the Brejo associated geoenvironmental units of São Tomé, and Gameleira, Cepilho with more loamy texture, prominent horizon (rich in organic matter and well structured) were more resistant to erosion therefore, with the lowest indices of erodibility VL and L (Table 7, Figure 8). However, in some points, as in the Alagoa Nova to Campina Grande, we verified the presence of Ultisols Red Yellow textural abrupt change, which second Oliveira (2005) is particularly more susceptible to erosion (Figures 9 and 10).

Table 7: Indices erodibility for slope classes

Indices	**Factor M**	**Classes**	**Área ha**	**Área %**
1	0 - 500	Very Low	390,1	3,8
2	500 - 1000	Low	1.033,9	10,2
4	1000-1500	Average	4.936,5	48,6
8	1500-2000	High	3.706,1	36,5
16	2000-2500	Very High	88,2	0,9

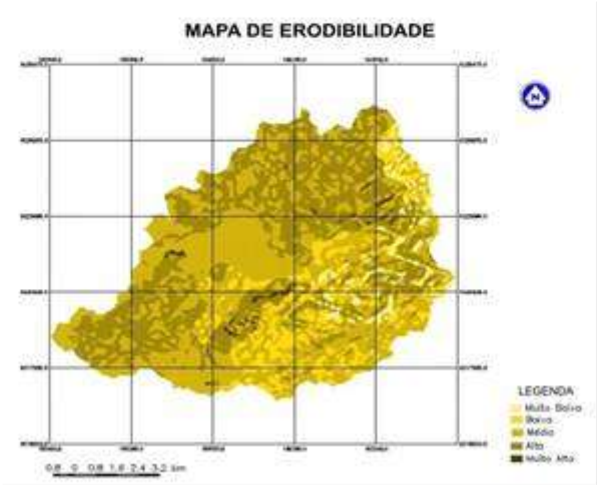
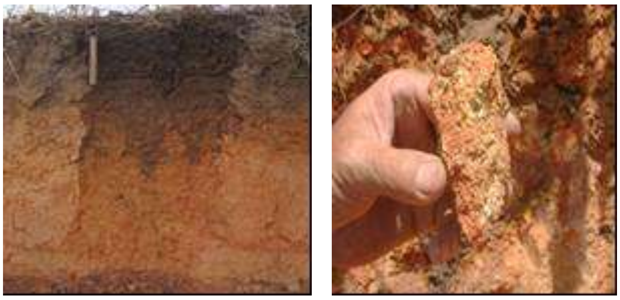


Figure 8: Erodibility Basin of Camará - PB.



Figures 9 and 10: Profile and soil sample Alfissol.

Thus, it was observed that according to Figure 8, is predominant in the field of catchment chamber, a level of erodibility medium to very high, the area covering 86% of the entire area.

This factor is noticeably intensified in areas of high population density where farming is most intense, as well as having less protected land, the constant activity makes you more susceptible to erosion.

4. Conclusions

The total area of the catchment area of the dam is 101.9 km2 Camará, with almost half of their land (47.7%), presents an average erodibility. The second class of slope that appeared most in the study area is high, which greatly favored process erodibility. This class predominates mainly in areas relating to the municipalities of Remígio and São Sebastião de Lagoa de Roça.

Areas with clay soils despite the low erodibility showed high levels of vulnerability, mainly due to the factors: population density and soil slope.

Diffusely, the agricultural areas of sandy soils and / or clay, with sharper slopes, have a high level of erodibility due to inappropriate use and management of land.

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