SUSCEPTIBILITY AND RISKS TO WATER EROSION IN THE UPPER OF ARAGUAIA RIVER BASIN (GO/MT), BRAZIL

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INTRODUCTION

The soil is a very important natural resource to life in general, especially to human life, because it is the base of its activities. However, in some parts of the word it is not exposed to adequate conservational practices, which result in degradation of the quality and negative impacts on the ecosystems and biodiversity. One of this impacts concerns the water erosion, the most important cause of the accelerated loss of properties on agricultural lands by reduction of fertility, desertification and increase of recent sedimentation in the hydrical channels. The laminar erosion is a common form but no evident signs are visible, except when the roots appear on the cultures and pastures. It is caused by runoff, mainly in the tropics. Some soils have high susceptibility and risks to this form of erosion, frequently the fine sandy soils after deforestation of their original cover and replacement by intensive agricultural an pasturage activities without conservational practices.

This article presents the results of the laminar erosion in the Upper Araguaia River Basin situated in the Central Plateau of Brazil, an important area of recharge level of large rivers, in part situated under states of Goiás and Mato Grosso and covered by the savannah named Cerrado in Brazil. This area is suffering an intensive and indiscriminate deforestation of the original dominant savannah (83%) in the landscape in the last 40 years, resulting in rapid substitution by soy and cotton cultures and pasturages, near 45% of total of area in 1999. This process are is propagated from the high plateau where the clayey soils and smooth relief are predominant corresponding to a high land use capacity, to the lowered dissected zones that contour it, covered by fine sandy soils, non-cohesive, with fine porosity, lower fertility and organic matter too (Quartzarenic Sandy Sols in Brazilian Soil Taxonomy) (equivalent Inceptsols in the USA Soil Taxonomy) without conservational practices. In addition, the tropical climate have an annual precipitation concentrated in the summer, about

80% of the total rain by year, with highly intensive rains sometimes above the infiltration capacity of the soil, promoting the increase of runoff and, by consequence, the erosion when the soil is not sufficiently protected by vegetation cover.

The aim of this work is to elaborate the susceptibility and risk maps to laminar erosion related to the actual land use to obtain a comprehensive study about the factors and to subside the correct management to the environmental planning.

THE STUDY AREA

The Araguaia river basin, which occupies an area of 777,308Km2, is drained by one of Brazil's largest river. This basin still contains important phytophysionomic features of Amazon Rain Forest (low basin) and original Brazilian Savannah's fragments (middle and upper basin), named Cerrado, one of the planet's biodiversity hotspots. The Upper Araguaia River Basin is located in the Brazilian Center West Region with a total area with 4, 496Km2. Its sources are located in the extreme southwest and southeast of the states of Goiás and Mato Grosso, respectively. This basin, principally the South of Upper Basin, is suffering intense morphogenetic processes by accelerated hydrical pluvial incision erosion, mostly by gullies, since the middle of the past century, related to the last pioneer Cerrado's occupation. This process has promoted indiscriminate and intense deforestation that changed more than 50% of the original savannah's area by strong mechanized agriculture, mostly soy beans, cotton and pastures, without any general soil conservation practices and no respect to the environmental laws concerning the obligatory preservation areas (sources, gallery forest and escarpment cover).

The study area is situated in the south of the high basin (Figure 1). It presents four main geomorphic surfaces of which two main ones are evident in the landscape: (1) a high and tabular surface known as plateau (named Serra de Caiapó), generally < 3% of the inclination, the regional aquifer recharge, with rates higher than 875m and covered by clayey Red and Red Yellow Latosols with high porosity related to the micro aggregate structure, no erosion susceptibility and high land use capacity with predominance of soy bean and cotton cultures; (2) a lower surface which involves the first one, with large and smooth interfluves with average medium rates of about 600 -700m of altitude, counting with soft and moderated convex forms, mainly thick sandy soils, Quartzarenic Neosols, with high erosion susceptibility related to the straight or soft slopes with low inclinations, generally ≅ 8%, featuring big hollow areas and small ones in the foothills, with very low land use capacity,

dominance of pastures and many big or medium gullies installed; (3) an escarped erosive sinuous form with a 50m average fault also large and moderate inclinations normally deforested with mass movement and ravine forms installed; (4) the small alluvial plains restrict (Barbalho, 2002;Castro et al, 2004).

The lower zone is largely dominant in the landscape and the density of drainage is lower with a lithostructural control, rectangular and dendritically patterns, this one in the source area.

The geological substratum corresponding to the Botucatu Formation (Jurotriassic) dominant in mostly all of the area, mainly in the lower zone and related to the fine under-developed sandy soils, named Quartzarenic Neosols (equivalent to Inceptsols) and Hidromorphic Neosols in the bottom of valleys, both with dominant pastures and some discontinuous forest galleries. This formation may be intercalated by toleitic basalts from Serra Geral Formation (Eo-cretaceous) visible in the escarped zone, side by side with the Cambisols and Lithosols. The Sedimentary Tertiary-Quaternary clayey ferruginous sediments dominate the high plateau related to the Red and Red Yellow Latosols (equivalent Oxisols) intensively cultivated by soy and cotton.

MATERIALS AND METHODS

The preliminary morphopedological compartments studies are focused on environmental thematic characteristics: geology, geomorphology (including topographic hypsometric and declivities), pedology, land use by photo and satellite images interpretation and field observation.

The susceptibility study is based on the USLE model adaptive by Salomão (1999), it concerns the erosivity, erodibility, length of slopes, LS factor (crossed length of slopes and declivity) and K factor (erodibility) maps which are elaborated by matrix crossing of LS and K factors by SPRING program in the LEGAL function to calculi (Figure 2).

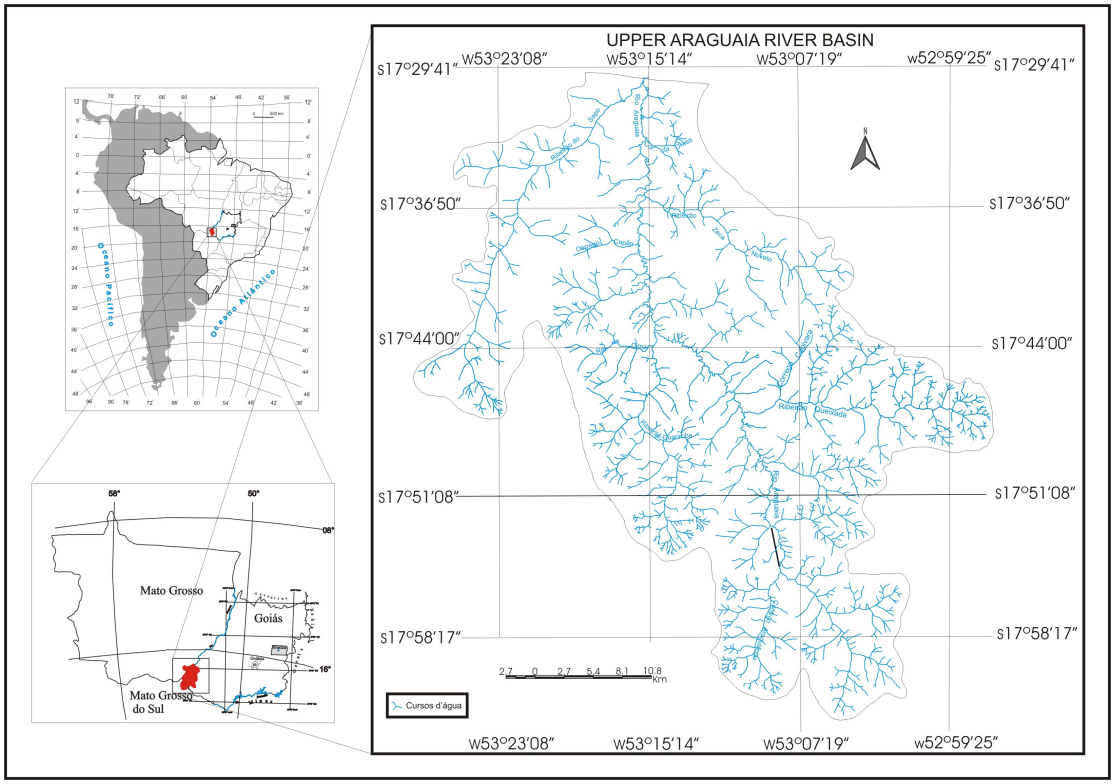

Figure 1: Localization map – South region from Upper Araguaia River Basin

Study area soils*		Factor LS			
		I (51-70)	II (34-51)	III (17-34)	IV (0-17)
Erodibility Factor K	1- PVA	**I**	**I**	**II**	**II**
	2- RQ, RQg	**I**	**II**	**II**	**III**
	3**	-	-	-	-
	4- LV; LVA; RL;C	**III**	**IV**	**IV**	**V**
	5**	-	-	-	-

* PVA – RED YELLOW ARGIC SOIL; RQ –QUARTZARENIC NEOSOL; RQg – HYDROMORPHIC QUARTZARENIC NEOSOL; LV – RED LATOSOL; LVA –RED YELLOW LATOSOL; RL – NEOSSOLO LITHÓSOL; C - CAMBISOL
** In the study area it's none of this class of soils.

Figure 2: Susceptibility class to laminar erosion, by erodibility X LS factor, to the different soils in the area. From: adap. SALOMÃO (1999)

This susceptibility class is related to the potential land use class (LEPSCH et al 1993) identified by Barbalho (2002) and given the class:

Class I – Extreme susceptibility corresponding to the VI e VIII classes of land use capacity;

Class II – Very susceptible corresponding to the VI class of land use capacity;

Class III – Moderate susceptibility corresponding to the IV class of land use capacity;

Class IV – Low susceptibility corresponding to the III class of land use capacity;

Class V – Lower or no susceptible corresponding to the I, II and V classes of land use capacity.

The real land use affects directly the potential to laminar erosion (SALOMÃO, 1999), the risk map concerns the crossing between the susceptibility and land use maps. The matrix-crossing table gives the risk map from Barbalho (2002) (Figure 3):

		Land use				
		Agriculture	**Pastures**	**No dense Savannah**	**Dense Savannah**	**Humid Grassland and gallery forest**
Class of susceptibility	**1**	I	I	I	II	--
	2	I	II	II	III	--
	3	II	II	II	III	--
	4	II	III	III	III	--
	5	III	III	III	III	III

Figure 3: Table to laminar erosion risk class. From: adaptated from IPT (1990) apud SALOMÃO (1999).

The class description is:

- **Class I: high potential** – land use without any respect to the laminar erosion susceptibility class;
- **Class II: moderated potential** – land use without respect to the laminar erosion susceptibility class but controlled with conservational practices;
- **Class III: low potential** – land use adequate with susceptibility class

RESULTS AND DISCUSSIONS

Susceptibility to the laminar erosion process

The susceptibility to laminar erosion process map (Figure 4) shows the natural conditions and it represents the different degrees of susceptibility to the phenomena related to the relief forms, declivity averages and kind of soils, which was expected due to the results from the crossing of the maps.

Most part of area (46%) containing class III (moderated susceptibility) corresponds to the IV land use capacity class, which fields present complex problems and need intensive conservational practices. It is related to the fine sandy soils (RQ) and indicates the pastures and/or forest, eventually annual cultures if the conservational practices are induced. This class is situated in the central part of the South Upper Basin low dissected zone characteristic by smooth and convex topography, moderated erodibility and low declivities (still 6%).

Anyway, this zone presents some little dispersed areas of susceptibility class II (very susceptible) about 22% of total of area, corresponding to declivities between 6 and 12% and related to the fine sandy soils associated with residual tabular features of high surface with smoothed and escarped zones. They correspond to the class VI of land use capacity that presents intensive conversational practices. They are appropriated to the reforestation practices and pastures, partially given by their low agricultural aptitude and moderated declivity (SALOMÃO, 1999).

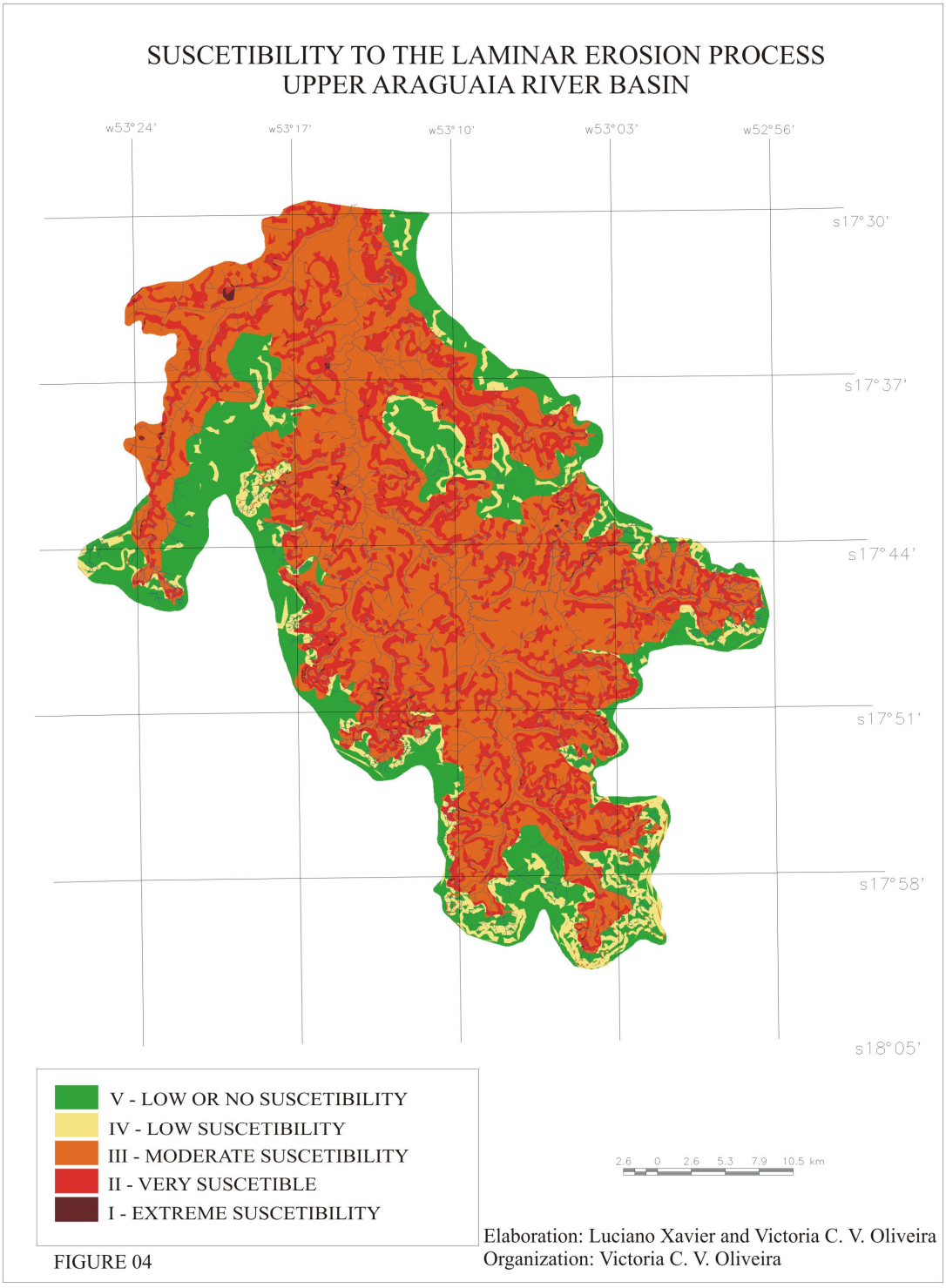

FIGURE 04

The V (low or no susceptibility) and IV classes (low susceptibility) both extending about 28% of the total of the area related to the lower declivity, between 0 to 6%, located in the top of the tabular high plateau that presents minor susceptibility related to the clayey Red and Red Yellow Latosols witch have lower erodibility. The same happens with the

Cambisols and Lithosols. The V class corresponds to the Class I and II of land use capacity, where I does not need of conservational practices, but II needs simple erosional control.

The IV class corresponds to which shows the class III of land use capacity needs strong conservational practices by consequence of the fine sandy soils. The class I (extremely susceptible), which occupies <1 % of the total area is situated in the escarped zone which declivity (20 to 45%), contour the tabular high surface. They correspond to classes VII e VIII of land use capaticity and are indicated to the preservation biodiversity or reforestation according to the requirements of the environmental laws.

Concluding, about half of the total area presents moderated susceptibility, and in addition to the extremely susceptible area it approximates nearly 70%, given the intensive use without conservational practices and no preservation zones proposed in the environmental laws (Barbalho, 2002)**.**

Risks to the laminar erosion process

Crossing the susceptibility map with the land use map resulting the risk map that concern the effective possibility of development of the phenomena. This map presents three class: high, moderated and lower (Figure 5).

Two classes are dominant: class III (lower potential of risks) (49%) and II (moderated potential) with 45%, both near 95% of the total of the area. Class III corresponds to the high plateau and the alluvial plains covered by gallery forest or dense savannah cover, where the potential of land use and the effective use is compatible (northeastern and southeastern of the area) and needs simple conservational practices to a preventive control the erosion development. Class II (moderated potential of risks) corresponds essentially to the lower dissected compartment occupied by pastures and agriculture. However, their land use capacity and use presents high no compatible forms because they contain fine sandy soils associated to the big length of slopes, that induces high energy of the runoff. Its must be recommended to natural preservation related to the dominant class VIII (biodiversity preservation) land use capacity and protected by environmental law with.

Class I, high potential of risks, represents only about 5% of the total of area distributed in a sort of longed amoeboid islands isolated and dispersed in the lower compartment, normally near of escarped zone. They concern the most critical risks in the region and compounding 4 groups. The first one situate near the source area of Araguaia river

corresponds to class VIII of the land use capacity indicated to the preservation of biodiversity but it is used by agricultural activity, without adequate conservational practices, so highly no compatible management. The second is situated in the margins of Gabiroba Brook (on left of Araguaia river), and like the first one, is indicated to the preservation of biodiversity but it is occupied by agricultural activities without conservational practices too. In this case the incompatibility is extreme. Both of them receive the convergent flux coming from the escaped zone. The third critic group is situated at northeastern of the area, near of Sapo Brook, the most important tributary of Araguaia River in the south upper basin.

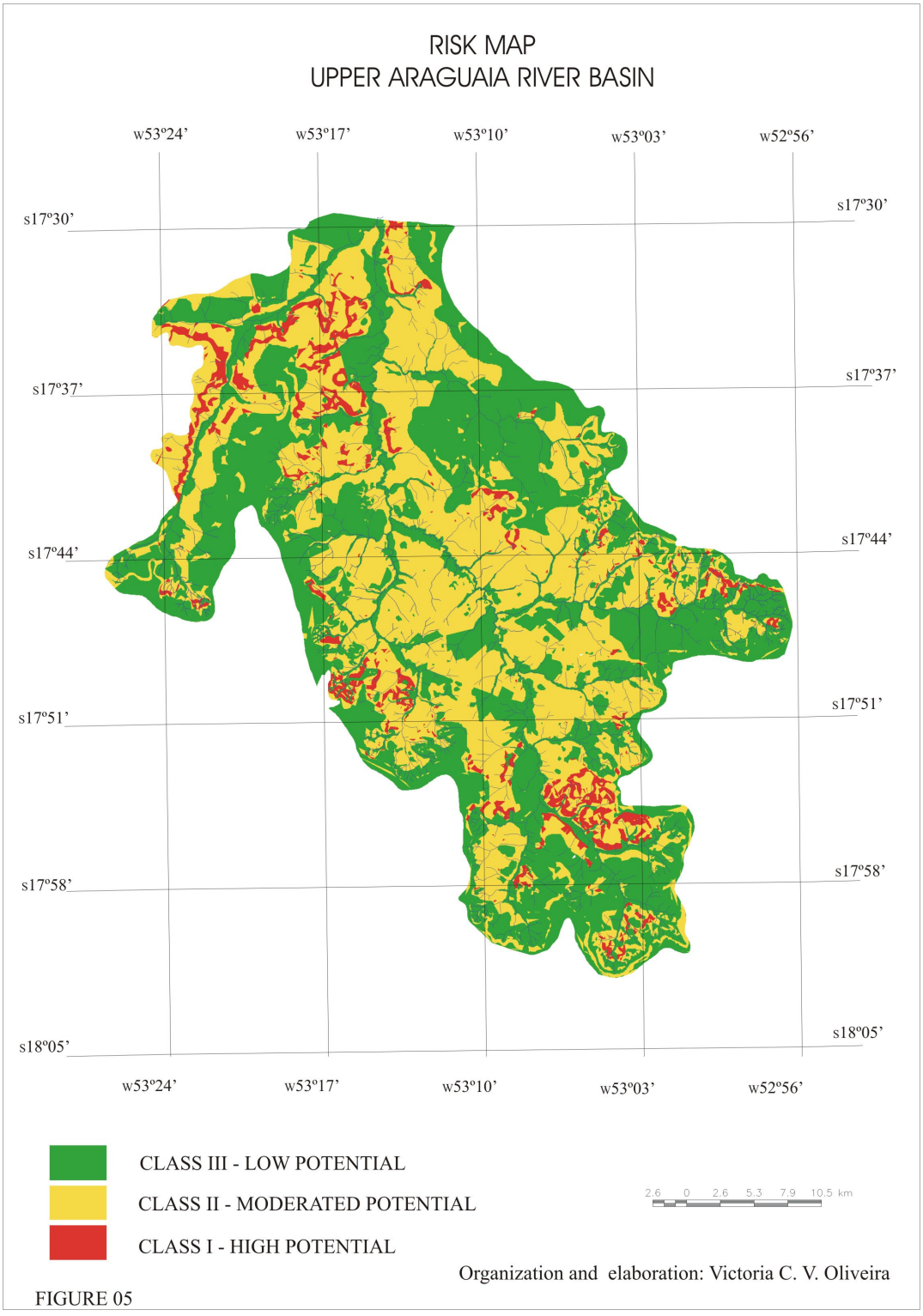

FIGURE 05

Like these ones, but longer, presents extremely no compatible use because it is occupied by agricultural activities. It is grouped like one archipelago with several long and continuous islands contouring the bottom of the valley in both margins at east of interfluves

which separates the Araguaia River from Sapo Brook. In this case it needs maximal attention because the high erosivity induces the most critical risks to the region. The forth and last sector grouped is the minor part of them grouped in little islands around the residual tabular features in the center of the region near the source area of Queixada Brook, not far from the escarped zone.

In conclusion, we can see one evident correlation between the high potential of risks and the land use activities maximum or highly no compatibility, when considering their topographical position, the forms of relief and fine sandy soils. In fact, the position near the source area or the escarped zone or the Araguaia channel, potentials the probability of the increase of runoff energy, by consequence, the beginning of the erosion process, also the intensive agricultural activities without adequate conservational practices. In the pasture areas the risk is moderated when the management is adequate, because the properties of grass protect more than the agricultural activities. It's the case of mostly part of the South of Upper Araguaia Basin. There we can observe the absence of adequate conservational practices.

CONCLUSIONS

The results show that the most part of the area is of moderate susceptibility to laminar erosion process by consequence of the characteristic of rocks, relief and soils. However, if considering the high and extremely susceptible zones and critic sectors for South Araguaia River Basin, it is coming to 70% of susceptibility, since moderate to highly and streamly susceptibility. Only the high tabular plateau presents a lower or none susceptibility.

The risks map, the most important to the planning, shows that a half of the area presents lower class of risk potential corresponding to the high tabular surface. But, the other part presents moderated risks class by consequence of the fine sandy soils without adequate management of pastures to protect the soils. All the little most critic sectors corresponding to the preservation areas are protected by environmental laws but have not been accomplished because they are submitted to agricultural activities and a maximal discordance with land use capacity.

These results contribute to an environmental diagnostic of the South Upper Araguaia River Basin concerning the susceptibility and risk maps to laminar erosional process, by coincidence the mostly critic ones on the concentrated gully's focus area too. The method based in mapping of three of the USLE prediction factors - erosivity, erodibility and

LS – allows one to have a satisfactory evaluation and interpretation to subside the planning, mainly to these areas. In conclusion, the lower compartment needs special attention as well.

REFERENCES

BARBALHO, M.G.S. Morfopedologia aplicada ao estudo de erosão linear na alta bacia do rio Araguaia (GO/MT). Dissertação de Mestrado.IESA/UFG, 2002.

CASTRO, S.S. et al. Condicionantes geológicos, geomorfológicos, pedológicos e de uso e manejo dos solos na circulação hídrica e processo de voçorocamento na alta bacia do rio Araguaia (GO/MT). *In* Os (des)caminhos do uso da água na agricultura brasileira - COUTO, E..& BUENO, J.F. (ORG.). SBCS; XIV RBMCSA, Cuiabá (2004).

INSTITUTO DE PESQUISAS TECNOLÓGICAS DO ESTADO DE SÃO PAULO (IPT). Controle de erosão. Secretaria de Energia e Saneamento, Departamento de Águas e Energia Elétrica/SP. 2ª ed. 1990.

LEPSCH, I. F., BELLINAZZI, J., BERTOLINI, D., ESPINDOLA, C. R. (1983). Manual para levantamento utilitário do meio físico e classificação de terras no sistema de capacidade de uso. Campinas: Sociedade Brasileira de Ciência do Solo.

SALOMÃO, F.X.T. Controle e Prevenção dos Processos Erosivos Cap. 7 In Erosão e Conservação dos Solos: Conceitos, Temas e Aplicações. Rio de Janeiro: Bertrand Brasil, p. 229-263.1999.