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Erosive Potential of Rainfalls in the Climate Change Scenarios in the Upper Taquari River Basin, MS, Brazil

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Introduction

Brazilian Central-Western Region has become a great producer of grain crops and meat along the last forty years. The typical climatic conditions of the *Cerrado* biome are responsible for the dry winter and wet summer with convective rains, which precipitates as storms with high kinetic energy drops. The vegetation is formed by “Cerrado”, composed by bushes and grasses, and “Cerradão”, which has higher density of tree species. Soil studies in the region have pointed predominantly nutrient poor soils, iron- and aluminum-rich, good physical properties. Around 90% of the area of Upper Taquari Basin (UTB) is in the north region of Mato Grosso do Sul state, and the erosion effects are reflected downstream in the river, that is connected to the Pantanal Basin. These conditions, added to the management system used without conservationist practices and not obeying the environmental laws, brought drastic consequences to the region such as the water erosion process, especially severe in the Upper Taquari Basin-UTB (MARTORANO et al, 2002; LISBOA, 2008). Last four decades were marked by meaningful anthropogenic changes in the UTB; the erosion process is the more expressive environmental problem among those changes (GALDINO et al., 2003; GALDINO et al., 2006).

Some studies point out that the environmental changes in the basin have caused severe impacts on the Pantanal biome, such as the flooded area increment and the “sedimentation” of the rivers and springs. The Upper Taquari Basin is located in the La Plata River Basin, with an area of 3, 1 million km2 along five countries in the South America (Argentina, Bolivia, Brazil, Paraguay and Uruguay), the La Plata is the fifth largest basin of the world. In the Brazilian territory, in which the La Plata Basin is the second largest one, the main development axe in the Centre-Southern region is on this basin. The negative impacts of the UTB anthropogenic changes may damage the ecosystem services that are essential to life quality of inhabitant peoples.

The erosion process in the UTB becomes more severe due to some environmental factors such as: soil fragility, agricultural machinery traffic during the rainy season, the high temperatures and the high intensity rainfalls, topographic conditions and inadequate soil management. The high intensity of the rainfall precipitation speed up the erosion in the areas characterized by the lack of vegetation cover and the occurrence of compacted soils due to the machinery traffic, the excessive animal grazing on degraded pastures or the sandy texture. Considering the rainfall as one of the erosion factors, and the fact that long historical series of rainfall intensity and duration are not available, this study aimed in the estimates of the rainfall erosive potential based on the climate data. Within the *Universal Soil Loss Equation*-USLE, proposed by WISCHMEIER & SMITH (1958) and validated by the same authors (WISCHMEIER & SMITH, 1978), the erosivity factor (“R”) is able to point out the most vulnerable areas to the occurrence of ravines and gullies and also to contribute to the evaluation of the rainfall-runoff relations, sediment transfer models and the main hydrological flow processes in the watersheds (FERREIRA & FRANCISCO, 2009). This study aims to evaluate the spatial distribution of the rainfall erosivity factor

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within the UTB, and the impact of the climate change scenarios on this index, which can be used to identify sustainability thresholds.

Material and Methods

The Upper Taquari Basin is located between the coordinates 17°06’ and 19°48’ South and 53°06’ and 55°06’ West, in the Middle-Western region of Brasil. Its area is approximately 28,000 km^2, of which 86,5% are in the state of Mato Grosso do Sul (MS), and 13,5% in the state of Mato Grosso (MT). The municipalities within the basin are Alcinopolis, Camapua, Costa Rica, Coxim, Pedro Gomes, Rio Verde de Mato Grosso e Sao Gabriel d’Oeste, in the MS state, while in the MT state the municipalities are Alto Araguaia e Alto Taquari. The river basin is divided in four sub-basins (Figure 1). From the 90 m resolution data available in the *Shuttle Radar Topography Mission* (SRTM) images (http://seamless.usgs.gov), the slope map was extracted by applying the software ENVI (v 4.5) and classified by the use of ArcGIS 9.3, in order to evaluate the effects of the topography in the erosive process (Figure 2). The classes of slope was based on the assumptions proposed by Ramalho & Beek (1995), i.e., flat (0 to 3%); gently wavy (3 to 8%); moderately wavy (8 to 13%); wavy (13 to 20%); heavily wavy (20 to 45%) and hilly (>45%).

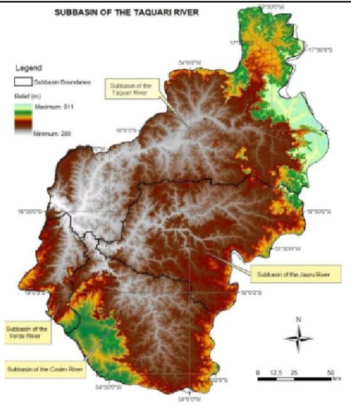

Figure 1. Sub-basins of the Upper Taquari Basin (UTB), Mato Grosso do Sul, Brazil.

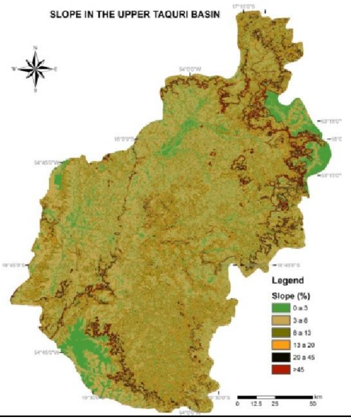

Figure 2. The slope classification ranges of the Upper Taquari Basin (UTB), Mato Grosso do Sul, Brazil.

The climate data were obtained from http://www.iwmi.org, and the thermo-hydrical conditions were evaluated in the UTB. The monthly and annual rainfall precipitation, p and P, respectively, were used to estimate the erosivity in the study area, using the following equation (BERTONI & LOMBARDI NETO, 1999) :

$$R = \sum EI = \sum(67{,}355 * (\frac{p^2}{p})^{\wedge}0{,}85)$$

where R is the annual average erosivity ($MJ.mm.\ ha^{-1}.h^{-1}.year^{-1}$); EI is the monthly erosivity ($MJ.mm.\ ha^{-1}.h^{-1}.month^{-1}$); p is the monthly average rainfall precipitation (mm); P is the annual average rainfall precipitation (mm). The values were estimated in software worksheets and exported to the ArcGIS 9.3, within which the erosivity map of the UTB was generated.

Results and Discussion

The relief classes in the Upper Taquari Basin area have the following percentages: 16% of total area are flat; 48% in the gently wavy range of slope; 21% are moderately wavy; 8% wavy; 5% heavily wavy and only 1% is considered hilly (>45%). In summary, 77% are within the range from gently wavy to wavy.
The annual mean pluvial precipitation in the area varies from 1,434 to 1,614 mm. The total rainfall values are higher in the municipalities of Alcinopolis, when compared to other municipalities such as Coxim, Camapua, Rio Verde e Sao Gabriel do Oeste (Figure 3a). The mean air temperature are higher in the sub-basin “Taquari”, with values around 25.5 and 25.8°C, whilst the lower temperatures occur in the North of UTB, and their range is between 22.1 and 22.5°C, reflecting the topothermic effects in the study area (Figure 3 b).

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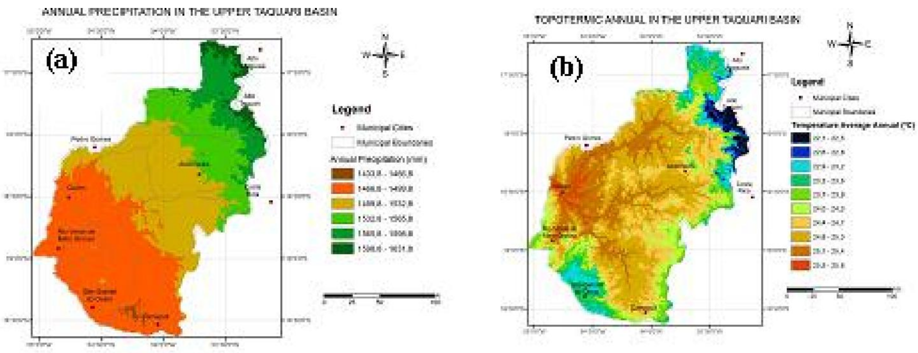
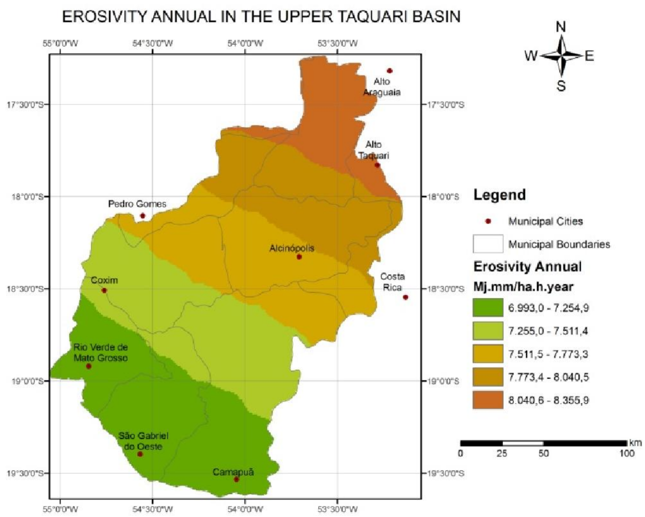


Figure 3. Pluvial precipitation and annual topotermic conditions in the Upper Taquari Basin.

Estimated rain erosivity in the UTB varies between 6.993,0 and 8.355,9 MJ mm.ha^{-1} h^{-1} year^{-1}, and the highest values are in the north region of UTB, in the areas of the municipalities Alto Taquari and Alcinopolis and partially, the areas of Alto Araguaia and Costa Rica. In the municipalities Rio Verde de Mato Grosso, Camapua and Sao Gabriel d' Oeste, the erosivity is lower than 7.254,9 MJ mm.ha^{-1} h^{-1} year^{-1}. These results agreed with those from Galdino et al. (2003), who observed that the average annual precipitation erosivity in the UTB was 7.914,3 MJ mm ha^{-1} h^{-1}year^{-1}.




Erosion processes in Camapua, Alcinopolis, Sao Gabriel d'Oeste and sediment transfer evidences in the Upper Taquari Basin, MS, Brazil.

Figure 4. Erosivity annual conditions in the Upper Taquari Basin, MS, Brazil.

Galdino et al (2003) found out that the municipality Camapua presents the largest area of sandy soils classified as Quartzous Sand, with 13% of the UTB area and 51% of Camapua municipality. This type of soil occurs also in the municipalities of Coxim, Alcinopolis, Alto Araguaia, Sao Gabriel d'Oeste, Rio Verde and Pedro Gomes, and the sub-basins Taquari and Jauru present the largest areas covered with Quartz Sands within UTB. The authors concluded that almost 80% of the area presents high soil erodibility and estimated the average soil loss in 1994 as 70.4 t ha^{-1}ano^{-1}, value classified as high degree of erosion. These data demonstrate the importance of the conservationist practices adoption, such as the No-tillage cropping and the integration of cropping-grazing-forestry system in the Cerrado biome.
Taking into account that soil losses depend directly on the rainfall erosivity factor, this study analyzed the climate change scenarios from IPCC (2007) forecasts concerning total precipitation to 50 and 100 years in two different proposed situations to the region: reduction of 15% and increment in 15% within the next century. In rainfall reduction scenarios, the average annual rainfall should reach the range from 1,300 to 1,447 mm within 50 years and from 1,235 and 1,335 mm within 100 years. In rainfall increase scenarios, the mean annual rainfall should vary from 1,566 to 1,730 mm within 50 years and from 1,663 and 1,863 mm within 100 years (see figure 5). These values show the importance of mitigation actions to reduce the erosive process in the UTB, which is hard in the current climate conditions, and may become even worse if subjected to more intense and longer rainfall events in a possible future climate situation.

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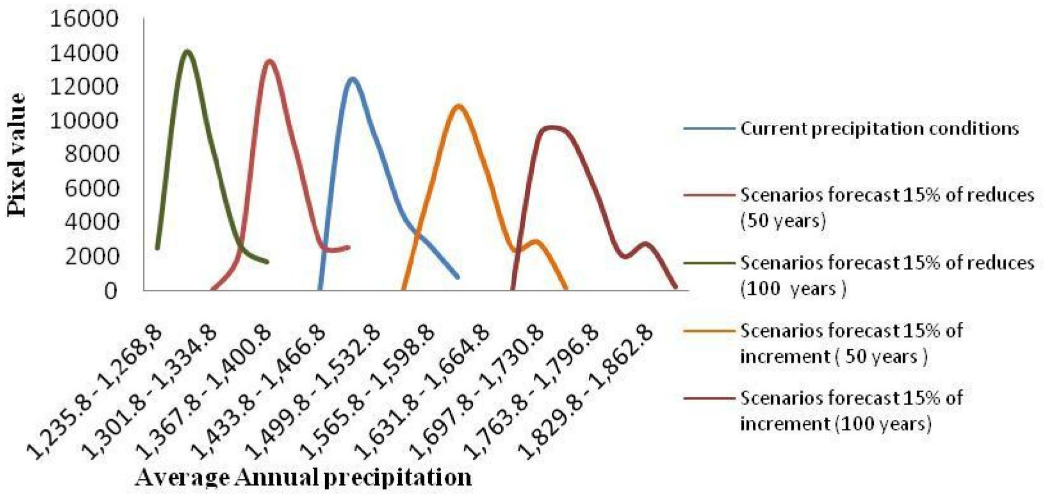

Figure 5. Current precipitations and scenarios of the Change Climatic

Conclusions and Outlook

The erosivity values increase severely in incremental annual pluvial precipitation scenarios, showing that in the North part of UTB the process will be worst in 2100 if the adoption of conservationist management systems do not occur. The recommended practices include the No-tillage cropping associated to the environmental laws application, such as the maintenance of vegetation in the riparian zone and in the areas with slopes higher than 45 degrees, considered by law as Permanent Preservation Areas.

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