IDENTIFICATION OF HIGH RISK EROSION AREAS WITHIN THE ITAIPU BASIN BY WATERSHED MODELING THROUGH RUSLE.

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Introduction

The Itaipu hydroelectric facility is the largest producer of electricity in the world, providing Brazil and Paraguay with clean and economical energy. The dam is located between Brazil and Paraguay on the Parana river and its basin has a contributing area of approximately 150,000 km^2 as shown in Figure 1. This area includes some of Brazils most productive lands with soils of basaltic origin in the state of Parana used for intense agriculture; sandy soils in the State of Mato Grosso do Sul mostly used for grazing; and some very productive land in Paraguay. As this land is further developed, there is a continuous threat of increasing soil loss that could lead to significant silting of the reservoir. This could in turn affect hydroelectric power production, aquatic life in the reservoir, naval transport, and tourism in the area. Determining what areas are most prone to erosion is therefore very important and modeling is the ideal way to do this in a cost effective manner. Modeling also permits us to simulate scenarios of improving conditions by changing management practices such as the implementation of no tillage agriculture, incrementing crop cover, terracing, and others.

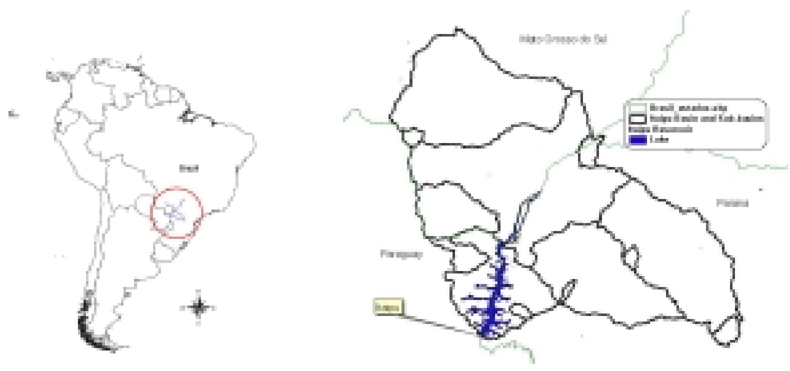

Figure 1. Location of the Itaipu and its basin.

Material and Methods

The Revised Universal Soil Loss Equation (RUSLE, Renard et al., 1998) together with geographic information systems (GIS) are being used to identify the regions with greater risk of erosion. RUSLE is an improvement of the original Universal Soil Loss Equation (Wischmeier and Smith, 1978), but still maintains the following format: A (Soil loss) = K (soil erodibility) R (rainfall erosivity) LS (length and slope) C (vegetation cover) and P (conservation practices). Due to the large size of the Itaipu basin, adaptations to the application of RUSLE had to be made using available data at large scales. These adaptations limit the prediction of erosion, but can be used to identify areas of potentially high erosion risk and can be used to compare potential erosion between areas.

The crop cover factor (C) was derived from the interpretation of the CBERS's (China Brazil Earth Resources Satellite) Wide Field Imager (WFI) instrument data with a resolution of 250m. A classification of the satellite imagery was done to identify different types of land use and vegetation cover in the basin, which were then assigned C values. Topographic data for the LS factor was obtained through the United States Geographical Service (USGS) world digital elevation model. Since this data comes in a resolution of approximately 900m, slope values were used to calculate the S factor, however, the length was fixed at a constant 100 meters for all simulations. The soil erodibility factor (K) was derived from the SOTER-LAC database as well as the Brazilian soils maps. The rainfall erosivity factor (R) was determined from actual meteorological data from as many as 300 stations in the watershed. Conservation practices for the P factor where initially obtained from the Instituto Brasileiro de Geografia e Estatistica (IBGE) agricultural census data. Future improvements to the quality of the modeling will include the following:

1) Use of LandSat images to determine C factors as well as field observations

2) Significant improvement of the LS topographic factor using recently acquired topographical data at a resolution of 20-50 meters.

3) Calculation of the soil erodibility factor (K) using state soils maps at a scale of 1:250,000

4) Continuous simulation of the R factor using meteorological data.

5) Determining actual current conservation practices for the P factor and C factor (no-tillage agriculture) using local census data and field verification.

Additionally, monitoring of sediment entering and leaving the reservoir and in key rivers is being done by turbidity sensors and water sampling in a series of monitoring points. These monitoring sites will also help in future validation of modeling results.

Results

Current modeling results show areas of high erosion risk within the Itaipu basin for cells of approximately 900 meters. For example, for the areas around the reservoir, modeling results are shown for regions of potential erosion with values higher than 5 tons/hectare/year in Figure 2. This simulation was run with all the available data for the LS, K, R, P, and for C factors assuming a case scenario where all agriculture was under conventional tillage. Results have been overlaid on top of the CBERS-WFI satellite imagery and it can be readily observed that large regions of this area are subject to high erosion potential under conventional tillage. In contrast, however, a simulation of the same area with no-tillage management practices is shown in Figure 3. Here we can observe a significant reduction in potential soil loss. Improvement of the modeling will enable us to simulate a wide variety of scenarios that can help define priorities for the application of conservation programs in the region.

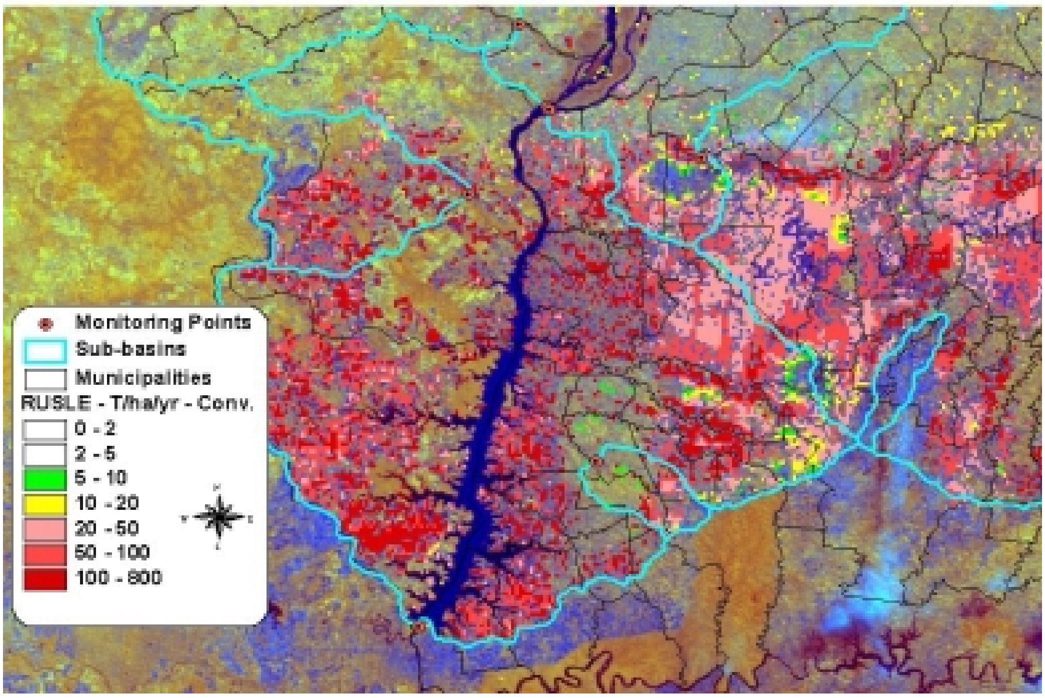

Figure 2. Erosion potential simulation for conventional tillage agriculture around the Itaipu reservoir.

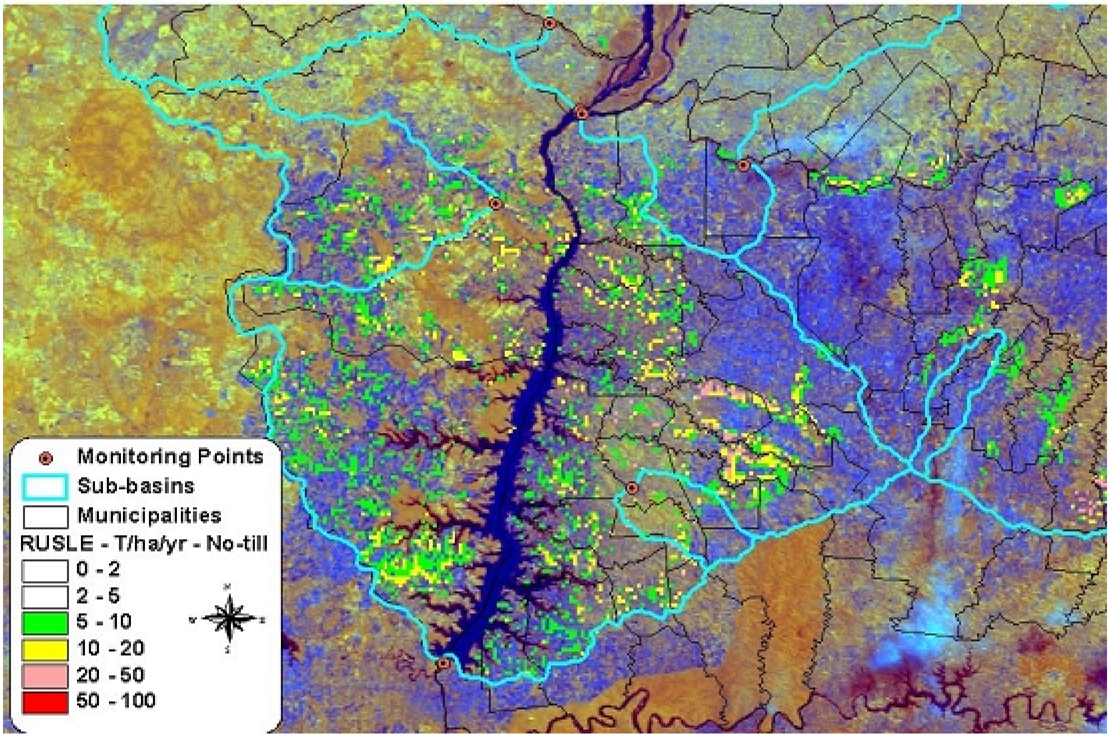

Figure 3. Erosion potential simulation for no-tillage agriculture around the Itaipu reservoir.

Summary and Conclusions

Modeling using GIS and RUSLE enables the identification of high-risk erosion areas within the Itaipu basin. Identification of these areas is very important because it enables action to be taken in specific locations where improvements can make a significant difference in reducing soil loss. Using modeling simulations, such as those presented in Figures 2 and 3, actions can be taken to help reduce the contribution of sediment to the reservoir at three major levels, (1) the watershed level, the (2) municipality level and (3) the individual farm property level. Further improvement of the modeling with more detailed data sets will enable better results and simulations. These results can then be used to prioritize the implementation of conservation programs throughout the region to reduce erosion and diminish the silting of the reservoir.

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