IDENTIFICATION OF AREAS PRONE TO SHALLOW LANDSLIDE IN PARQUE NACIONAL DA SERRA DOS ÓRGÃOS (BRAZIL) CONSIDERING SEASONAL RAINFALL

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1. INTRODUCTION

Mathematical modeling is being increasingly used to predict events occurring in nature. That tool enables developing models based on physical data which reproduce the dynamics of natural phenomena, giving means to greater control over them, and even spatial and temporal prediction of their occurrences. Mathematical modeling has been largely applied among the various existing phenomena in nature with the purpose of identifying zones which are prone to mass movement occurrences such as landslides.

Process-based models for shallow landslide hazard assessment based on coupling digital elevation models (DEMs) to hydrological and slope stability models allow delineation of areas at risk for shallow landsliding [1] [2] [3]. These models have been used to predict areas subject to shallow landsliding in both urban and rural settings in temperate regions of the western United States [2] [3] [4] [5] [6] [7] and in tropical Brazil [8] [9]. Within the diverse existing models, one which stands out is the SHALSTAB [3], which has been widely tested in many temperate climate areas, as well as in several regions in Brazil [8] [9], with steep slope.

In this paper we applied SHALSTAB model in order to identify, within the landscape, the spatial and temporal variability at places prone to shallow landslide in Serra dos Órgãos National Park (PARNASO) take account the average monthly pluviosity throughout the year.

2. STUDY AREA

The research was developed in the National Park of Serra dos Órgãos (PARNASO); part of the Serra do Mar complex inside the Atlantic Rainforest is located in southeastern Brazil in the central of Rio de Janeiro state (Figure 1). The region is well-known by its steep scarps that lead to the generation of landforms. The relief has elevations that can reach 2,263 m with a strong structural control [10]. The vegetation structures in landscape have high spatial variability because it correlates with environmental factors, such as microclimate, moisture, soil and geomorphological processes [11]. The climate is characterized by dry season in the winter and a wet season with strong rainfall especially in the summer.

3. METHODS

SHALSTAB model combines a hydrological model with the infinite slope stability model to calculate the ratio of the steady state rainfall to soil transmissivity needed to trigger slope failure based on drainage area, local slope, bulk density, friction angle and soil cohesion [2] [3] [4] [5] [6] [7].

The methodology is sectioned into the following stages: a) elaboration of the digital elevation model (DEM) and its derived maps, such as slope and contribution area, b) application of the SHALSTAB model, considering the various events of rainfall throughout the year, and c) quantification of areas prone to landslide for each rainfall event occurred.

The DEM was created using the TOPOGRID module from ARC-INFO software. This procedure employs an algorithm to create hydrologically sound DEMs by coupling a drainage enforcement algorithm that removes spurious sinks and pits, with a finite difference interpolation technique [12]. The interpolation algorithm was designed to have the computation efficiency of local methods (e.g., Inverse Distance Weighted) and the continuity in the interpolated surface generated by global methods (e.g., Kriging interpolator). The cell unit dimensions established for the DEM were 20m.

4. RESULTS

The figure 1 shows the landslide map based on different values of rainfall. The dark gray color represent areas with steep slope considered unconditional unstable. The beige areas are considered to flat to trigger landslide independent of rainfall quantity. The other colors represent the susceptible landslides area depending on rainfall quantity. Because of the seasonal rainfall the landslide we also run the model using the average monthly pluviosity value. Many differences can be observed between dry and wet seasons (Table 1). Thus, this approach is important to minimize risk to the visitors of the PARNASO.

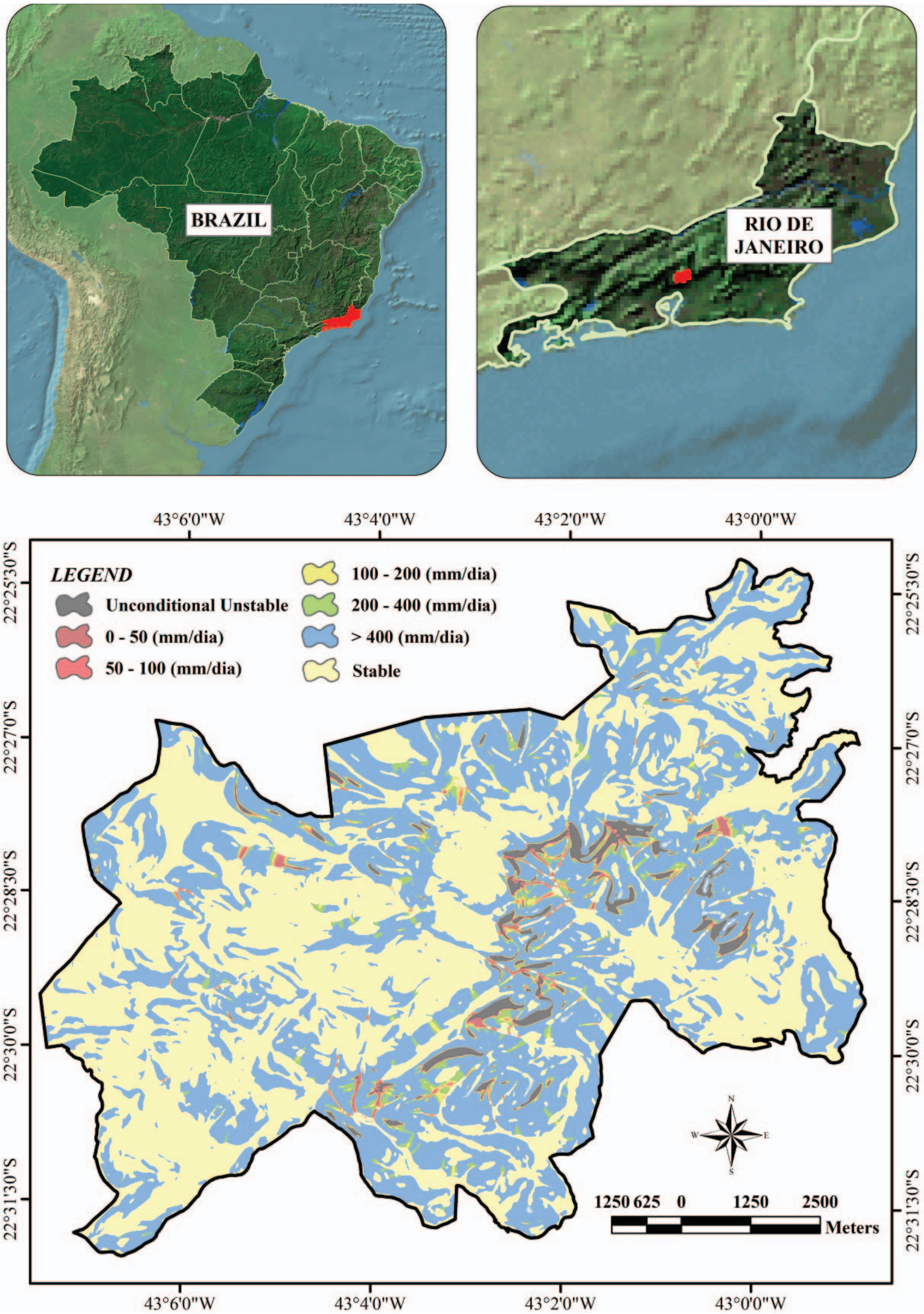

Figure 1 – Study location and susceptible landslides map.

Table 1 – Affected area by the average monthly pluviosity.

MONTH	AREA (m^2)	PERCENTE (%)
January	1,297,308	1.30
February	861,269	0.86
March	667,685	0.67
April	1,137,332	1.14
May	545,278	0.55
June	218,866	0.22
July	798,567	0.80
August	73,847	0.07
September	501,573	0.50
October	545,278	0.55
November	1,172,155	1.17
December	1,252,866	1.25

5. CONCLUSION

The model results indicate the dynamics of the locations which present instability due to the seasonality of rainfall intensity. The application of the model, taking into account the greatest monthly rainfall events, may be used as an instrument of control for park visitation because it allows identifying the months in which there is greater risk to visitors.

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