II Pedometrics
Nov, 24th to 27th, 2021
Brazil

Use of variables derived from the Digital Elevation Model for the sustainable planning of soils in Bom Jardim – RJ

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Thematic Session: Legacy Data: How Turn It Useful?

Abstract

The research goal is to analyze terrain attributes obtained from a digital elevation model (DEM) to represent soil forming factors used in digital soil mapping at Bom Jardim county, Rio de Janeiro state, and also to delimit arable areas. The DEM was generated to represent the altimetry of the study area, and subsequently, the basic attributes of the terrain were extracted: slope, slope height, aspect, valley depth index, topographic moisture index and factor - LS. Soil properties were correlated with terrain attributes through a Spearman correlation method. It is concluded that, the terrain covariates derived from the digital elevation model can represent the soil forming factors and be used at the digital soil mapping of the area, as well as be used to establish agricultural suitability areas in mountainous areas, such as Bom Jardim – RJ.

Keywords: digital soil mapping, topographic parameters, hillslope area, soil conservation and security.

Introduction

Advances in remote sensing have occurred quickly, especially regarding spatial and spectral resolutions, both of great interest for digital soil mapping (DSM) (TEN CATEN, et al., 2011). Thus, factors and processes of soil formation can be modeled from variables measured by remote sensing and geoprocessing techniques. Therefore, it is essential to create a database with environmental variables that most influence the variability of soils in order to further develop digital soil mapping of soil attributes and classes in a interest area (CALDERANO FILHO et al., 2009).

Orbital remote sensing data and terrain attributes derived from a digital elevation models (DEM), have been used to understand the spatial and temporal relationships between soil classes, properties and different environmental variables (SANCHEZ et al., 2009). These attributes are commonly used as auxiliary variables in the spatial prediction of soil-landscape patterns and contribute to the improvement of the mapping of soil classes and properties, such as horizon thickness, elements in the soil solution, texture, color, moisture, among others (Gessler et al., 2000).

The objective of this work is to analyze terrain attributes derived from a digital elevation model (DEM), in Bom Jardim county, in order to select covariates that represent soil forming factors and also to delimit arable areas based.

Methodology

The study area corresponds to Bom Jardim county, Rio de Janeiro state, between the coordinates 22º 06' and 22º 18' S and 42º 12' and 42º 30' W. The total area have 385.04 km^2, with strong-wavy relief, altitudes ranging between 405 to 1,630m, and average slope of 38%. According to Calderano Filho et al. (2009), three main soil classes (Oxisols, Epodossolo and Argisol) occurs in the area. To compose the soil database, 209 soil profiles were used, collected and described according to SiBCS (SANTOS et al., 2005), in a total of 603 soil samples. From the entire dataset the following soil properties were selected to use in the present analysis: coarse sand, fine sand, clay, clay dispersed in water and organic carbon.

A digital elevation model (DEM) was generated to represent the altimetry of the study area, from the official digital cartographic base of the state of Rio de Janeiro - scale 1:25,000. The topographic database in vector format, contour lines with 10 meters of equidistance, quoted points and a hydrography were interpolated using the "TopotoRaster" tool to obtain a 20m resolution DEM. At the end of this procedure, the spurious depressions were corrected by using the "FillSink" tool, in order to make it hydrologically consistent.

Later, the DEM was imported into the System for Automated Geoscientific Analyzes (SAGA-GIS, 2020) program, the Terrain Analysis function was used to extract basic terrain attributes: slope, aspect, valley depth index, topographic wetness index, and factor - LS. the terrain attributes were associated with soil samples database, and the free software QGIS 3.10.4 was used to edit the maps and produce the legends.

Results and discussion

Analyzing the image (Figure 1A) it can be seen that the areas of the municipality present considerable variation in relief. Bom Jardim is a municipality of mountainous areas and fragile ecosystems.

Slope is one of the most important terrain attributes associated with pedogenetic processes, as it directly affects surface and subsurface water flow velocity and, consequently, soil water content, erosion/deposition potential and many other important exogenic processes. According to the map presented in Figure 1B the average declivity varies around 20.51 to 41.02º, characteristic of a heavily undulating to mountainous relief.

The Figure 1C present the LS factor where with higher LS Factor represent a region where there is loss of kinetic energy and the deposition of eroded material from higher

parts of the terrain takes place. The topographic moisture index (Figure 1D) describes a region's tendency to water storage. According to the parameters of Lin et al. (2006) the soils of Bom Jardim are well drained, but only in the highest parts of the landscape. These moisture conditions expressed in the map can also be associated with soil thickness, structure, density and permeability.

In Figure 1E we have the aspect map, this attribute has an influence on insolation, evapotranspiration, and the distribution and abundance of flora and fauna. On the map Figure 1F is represented the valley depth index, which describes how flat the bottom of a valley is. For mountainous regions these areas have great importance, since this particular region has a high susceptibility to erosion (CARVALHO JÚNIOR, et al., 2014), and a relevant role to agricutural production. This areas can be indicated both for silvopastoral activities in drier areas, and agroforestry activities at the humid areas.

The correlation matrix between soil properties and terrain attributes is presented in Figure 2. Coarse sand content and water-dispersed clay did not correlate with any terrain attribute, while fine sand content was correlated with topographic moisture index and DEM. The clay content was corrected with the valley depth index. In relation to organic carbon, only and correlated with DEM.

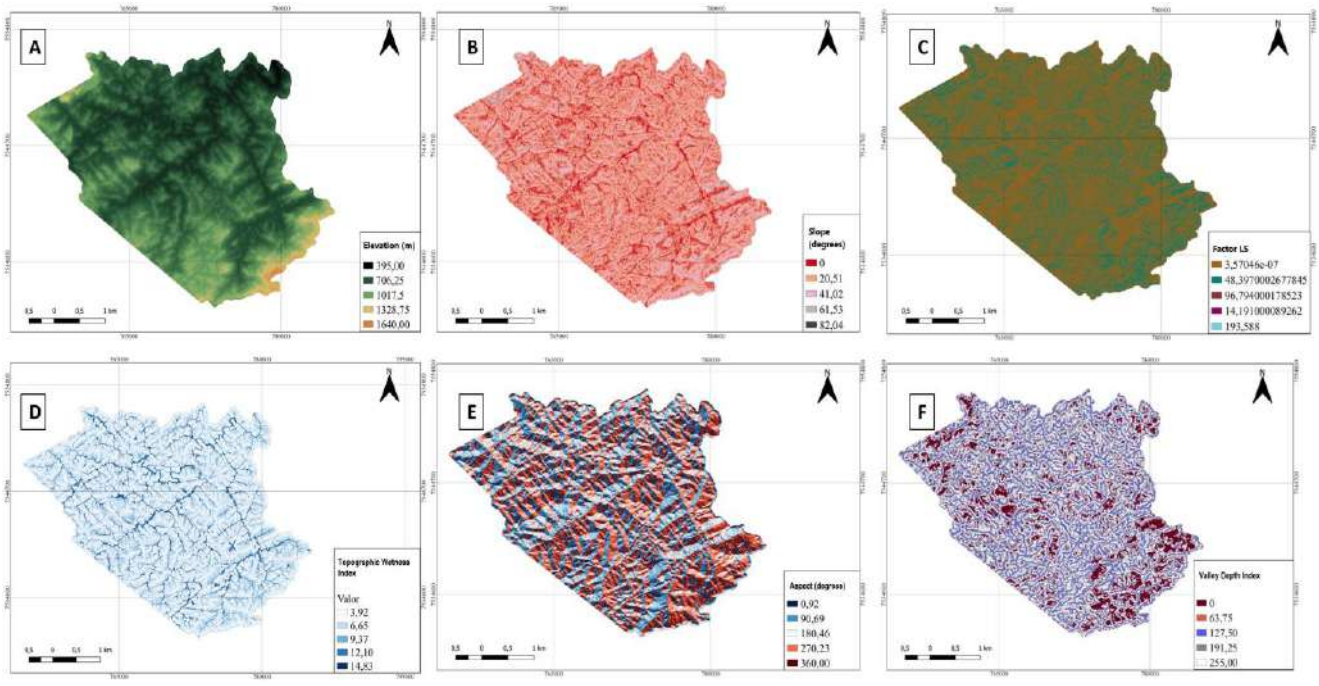

Figure 1. (A) Digital elevation model - DEM and digital model of environmental covariates, with a spatial resolution of 20 m, for the municipality of Bom Jardim – RJ. B (Slope); C (LS Factor); D (typographic moisture index); E (Aspect) and F (Valley depth index)

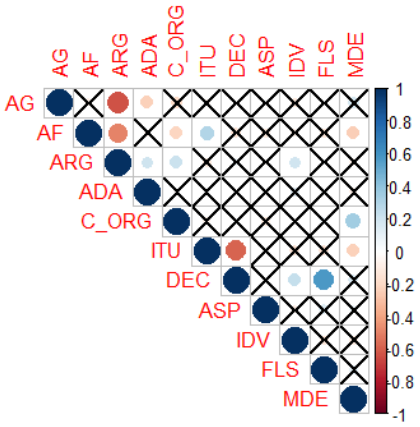

Figure 2. Correlation matrix between the properties of the soil surface layer with the environmental co-variables and terrain attributes. (AG = coarse sand; AF = fine sand; AGR = clay; ADA = clay dispersed in water; C_ORG = organic carbon; ITU = topographic wetness index; DEC = slope; ASP = aspect; IDV = valley depth index; MDE = digital elevation model.

Conclusions

The environmental covariates derived from the digital elevation model can be used to represent soil forming factors, such as slope, LS factor and topographic wetness index. As well as the covariates aspect, topographic wetness index and valley depth can be used to establish agricultural suitability areas in mountainous areas, such as Bom Jardim county, in Rio de Janeiro state.

References

CALDERANO FILHO, B. et al. Caracterização dos solos do município de Bom Jardim-RJ. **Anais**...Proceedings of XXXII Congresso Brasileiro de Ciências do Solo (Fortaleza SBCS CE). 2009.

CARVALHO JUNIOR, W. el al. A regional-scale assessment of digital mapping of soil attributes in a tropical hillslope environment. **Geoderma**, v. 232-234, p. 479–486, 2014

COMISSÃO DE FERTILIDADE DO SOLO DO ESTADO DE MINAS GERAIS. **Recomendações para o uso de corretivos e fertilizantes em Minas Gerais** – *5ª Aproximação.* Viçosa, MG, 1999. 359 p.

GESSLER, C. et al. Comparação de métodos para mapeamento digital de solos com utilização de sistema de informação geográfica. **Ciência Rural**, v. 40; p.2099-2106, 2001.

LIN,S. et al. Atmospheric correction of Landsat ETM+ land surface imagery. I. Methods. **IEEE Transactions on geoscience and remote sensing**, v. 39, n. 11, p. 2490-2498, 2006.

SANCHEZ, P.A. et al. Digital soil map of the world. **Science**, v.325, p.680-681, 2009.

TEM CATEN, A. et al. Componentes principais como preditores no mapeamento digital de classes de solos. **Ciência Rural**, v.41, n.7, p.1170-1176, 2011.