Potential soil erosion assessment through the CORINE methodology in cattle districts of the Mayabeque province, Cuba

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A methodology included in the CORINE software (1992) was applied to evaluate soil erosion qualitatively. The application was performed in the cattle districts of Guayabal and Nazareno, located in the Mayabeque province. This methodology takes into account all the factors, included in thematic maps affecting objectively soil erosion. Each of the maps illustrates the space performance of the different erosion factors in the districts under view. Their summary, through the Geographical Information System (GIS) technology, permitted obtaining a potential erosion map, where the susceptibility to water erosion was represented per classes. The maps of the indices of erodibility and erosivity and the topographic were obtained, and, out of them, that of potential erosion. This latter was evaluated as of low category in the Guayabal cattle district, and as of moderate and high category, in the Nazareno cattle district. It was proved that, although the rain erosivity is the same in both districts, the landscape, rougher in the Nazareno district, controls the potential erosion.

Key words: *potential soil erosion, cartography of factors, geographic information system*

The soil is the basis of the feed production and the cattle development, thus, for fulfilling the growing need for feed and raw material is indispensable to work for its conservation. At present, soils are in serious degradation state, mainly due to water erosion. This process affects a large number of hectares, with modifications in the physical, chemical and biological properties, bringing about the reduction in feed production for men (Lobo *et al*. 2005) and in pastures for cattle.

The evaluation and cartography of the soil erosive processes have become a necessity, because they constitute a threat to sustainable cattle production (Le Bissonnais *et al*. 2002 and Stroosnijder 2005). The specialized literature has a wide scope of methodologies to study the erosion (Almorox *et al*. 1994, Gobin *et al*. 2003 and Vega and Febles 2005), among them, the thematic cartography of factors and the erosion models are noteworthy.

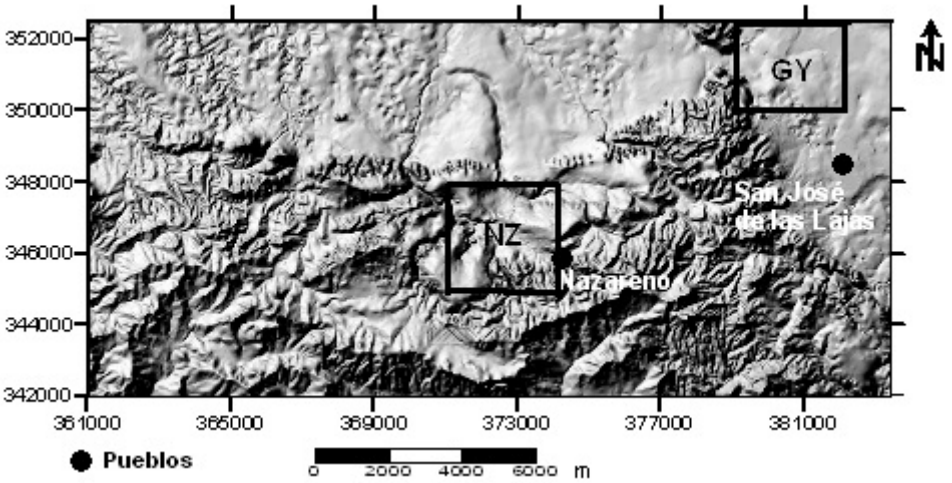
In Cuba, the geographic-comparative method has been the most used in erosion studies including typical profiles of each grouping, as patterns. Only in recent years the erosion models have been incorporated to researches, primarily USLE (Vallejo and Martínez 2000 and Reyes 2004), RUSLE (Ruiz *et al*. 2006 and Alonso and Díaz 2010) and MMF (Vega 2006, Febles 2007 and Febles *et al*. 2011), as well as the thematic cartography of factors in SIG environment (Cabrera 2002, Díaz *et al*. 2005, Vega 2006, Febles 2007 and Vargas 2010).

This work has as aim the qualitative evaluation of the potential erosion in the Nazareno and Guayabal cattle districts, in the Mayabeque province, in Cuba, through the application of the CORINE methodology. It is included in the CORINE program (1992), developed for the evaluation of the natural resources and the environmental problems in the southern regions of the European Community. The specialized literature also refers to the application of this methodology to assess soil erosion in localities different to the original region (Dengiz and Akgul 2005, Bayramin *et al*. 2006, Parlak 2007 and Abdurrahim and Baris 2010), because it considers all the factors affecting objectively the erosion processes in any territory (Kirby and Morgan 1984, Porta *et al*. 1999 and Blanco and Lal 2008). Additionally, it can be implemented with the use of the technology of the GISs, representing the most spread tool at present for the erosion assessment. This technology permits the modeling and analysis of the erosive process with a multidisciplinary approach, thereby its utility and spread is very useful for this type of researches (Shi *et al*. 2004, Jae Lim *et al*. 2005, Vega 2006, Febles 2007, Akay *et al*. 2008, Yuksel *et al*. 2008 and Morejón 2009).

Materials and Methods

The Guayabal cattle district, with more than 250 ha, is situated at 3 km from San José de las Lajas, specifically at the northwest, in the province of Mayabeque (figure 1). In this locality, the existence of a rock substrate, of carbonated composition, together with the climatic conditions, has favored the development and sequential evolution of the karst-erosive processes. These processes are perceptible in the convex flexures of the micro landscape devoted to grazing and other crops. Besides, they have contributed indirectly to accelerate the karst morphogenesis. As superficial expression of them, numerous dolines are identified in the landscape (Gounou and Febles 1997).

The Nazareno cattle district (figure 1) is located at the center of the Mayabeque province, next to the Nazareno



NZ: Nazareno cattle district, GY: Guayabal cattle district,
Black squares: limits of the districts

Figure 1. Location of the sectors under study.

town. It comprises 325 ha and it is identified as a region of highlands, with geomorphological contrasts and edaphic coverage of great complexity, examining the influence of the erosive processes, the lithostructural, geomorphological, morphometric differentiation and the conditions of use of the soils in the diverse altimetrical levels. In this unit a superior phase has not been developed in the erosive processes, due to the beneficial effects of the vegetation (Jaimez *et al*. 2003, Zhou *et al*. 2008 and Zhanga *et al*. 2011), that in the form of "biological barrier" has remained in the sectors of the most inaccessible slopes.

In these two localities, representative of the milk production area of the San José de las Lajas municipality, the CORINE methodology was applied (CORINE Program 1992). In it, the maps of risk of erosion are the result from the analysis of the spatially distributed data about the edaphic coverage, the landscape, rainfall and soil utilization (figure 2). The processing was performed in the environment of a Geographical Information System (GIS) to establish the risk categories.

The methodology consisted in evaluating four diagnosis indices: erodibility, erosivity, topographic and soil protection. These data were processed through the algebra of maps in the GIS and allowed obtaining maps of the indices of potential and current erosion, according to the sequence of combination illustrated in figure 2.

Due to the region under study is characterized by high rainfall; the calculation of the index of the aridity was underestimated. The source of the data to apply the methodology was the table of properties of the digital version of the National Map of Soils, 1:25 000 scale (Paneque *et al*. 1991). The data of texture, depth and rocks were selected out of it.

The rainfall data were collected from a base of 38 pluviometers and the digital model of elevations (DME), with 25-m pixel (GER 2004).

The different indices were calculated according to the following equations:

Index of erodibility = classes of textures x classes of

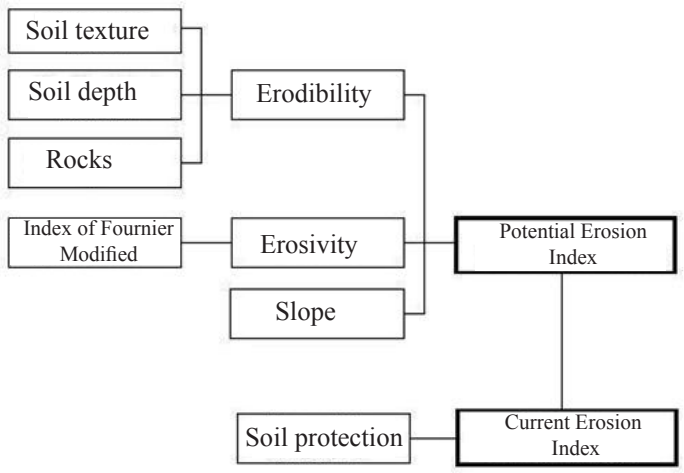


Figure 2. CORINE methodology (CORINE Programme 1992) to evaluate soil erosion.

depth x classes of rocks.

For the index of erosivity, the index of Fournier modified (IFM) was used, as proposed by Arnoldus (1978):

$$IMF = \sum_{i+1}^{12} \frac{p_i^2}{P_t}$$

Where,

p_i: monthly mean rainfall (mm)

P_t: annual mean rainfall (mm)

The topographic was evaluated processing the DME to obtain the slope.

Potential erosion index = erodibility index x erosivity index x topographic index.

The cartographic modeling to obtain all the indices was performed in the GIS environment and the operations of reclassification were conducted according to the classes established by the CORINE methodology.

Results and Discussion

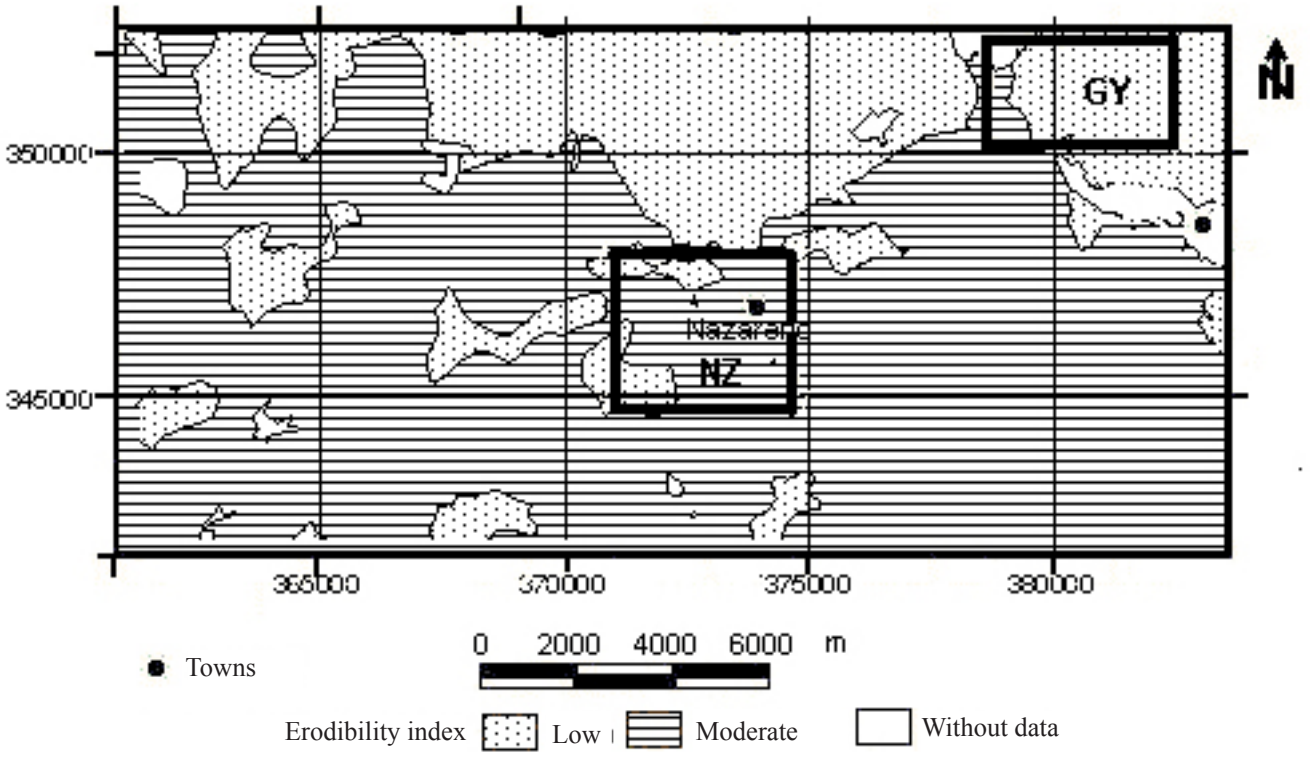
Through the thematic cartography of the erosion factors in the environment of a GIS, it was obtained the indices showing the susceptibility inherent of the soils to the erosion in the cattle establishments under study.

The erodibility index performance (figure 3) qualifies the anti-erosive resistance of the edaphic coverage, conditioned by the intrinsic susceptibility of the soils, according to their properties and with the geological formation environments. These criteria agreed with the results of Orellana and Moreno (2001). The low erodibility class predominated in the Guayabal district, whereas in Nazareno, it was the moderate. This showed that the soil particles in Nazareno are removed better than those of the soils of the Guayabal district. However, only with the comprehensive evaluation of all the factors controlling the genesis and the sequential evolution of the erosive processes, it could be qualified the true susceptibility of these soils to erosion.

The map of the IFM (figure 4) corroborated the degree of climatic aggressiveness characterizing the region under study, with values ranging from 180 to 220 for both districts. These values, according to the CORINE methodology, are assessed as very high and show that the rainfall erosivity is, in general, high with significant influence on the erosive process generation.

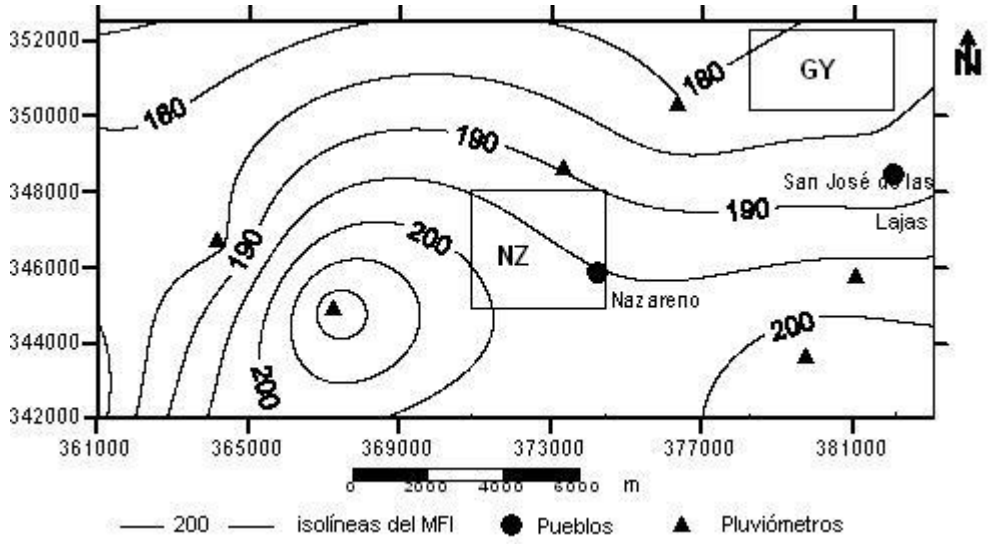
The map of the topographic index (figure 5) showed that in the region of the Guayabal district there was predominance of the category 1 (very mild). This implied that, in general, the factor generating the phenomenon in this locality was associated basically with the erosion by impact, and with the ephimeral leakage during rainfall. On the contrary, in Nazareno, the very mild, mild and inclined classes were represented, and, thus, the factor generating the erosive process was related to the leakage in each rainfall.

The combination of the indices of erodibility, erosivity and the topographic contributed with the values of potential erosion for the region under study. In the map of the index of potential erosion (figure 6), the Guayabal district, with predominance of red ferrallitic soils, was classified with predominance of the low category. In



NZ: Nazareno cattle district, GY: Guayabal cattle district, Black squares: limits of the districts

Figure 3. Map of the index of erodibility of the region under study



NZ: Nazareno cattle district, GY: Guayabal cattle district, Black squares: limits of the districts

Figure 4. Map of index of Fournier modified (IFM) in the region under study

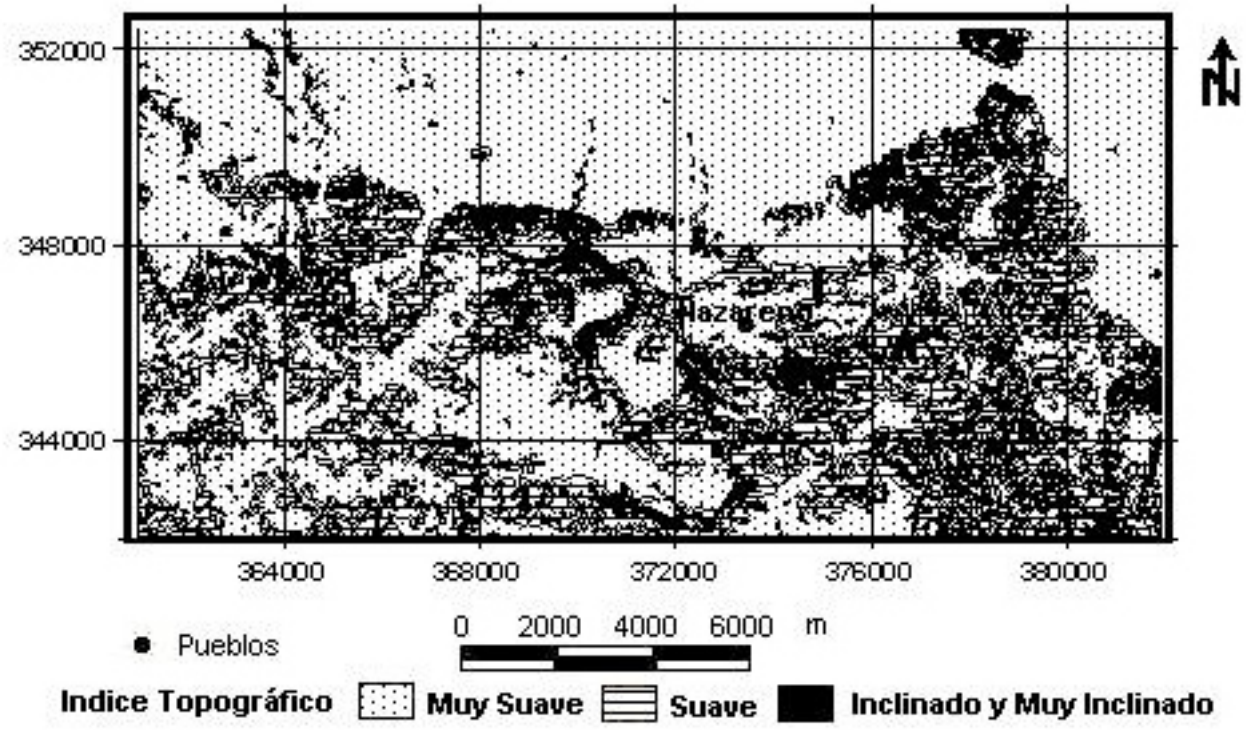


Figure 5. Map of the topographic index of the region under study

Nazareno, with the gradual increase of the energy values of the landscape, and the presence of brown soils with carbonates, moderate and high categories were obtained, implying higher susceptibility to erosion. In this locality, the dynamics of the erosion processes by leakage plays a predominant function in respect to the erosion by impact, situation identified by Hernández *et al*. (1980) in similar regions. An adequate maintenance of the plant coverage in these sectors will contribute to control the potential erosion of these soils (Bellina *et al*. 2011).

Out of the indices assessed by the CORINE methodology, that of erosivity was the only one revealing a similar performance in both districts. The rest, in the Nazareno district, showed increment in the values, particularly the topographic index. This influenced on the increment of the category of the potential erosion index. These conditions confirmed the report of Kirkby and Morgan (1984), Febles and Febles (1988), Lal (1990) and Morgan (1997), that although the climate was the factor generating the erosive processes, the landscape was the one controlling them.

It was concluded that the susceptibility to the erosive processes in both districts, revealed by the potential

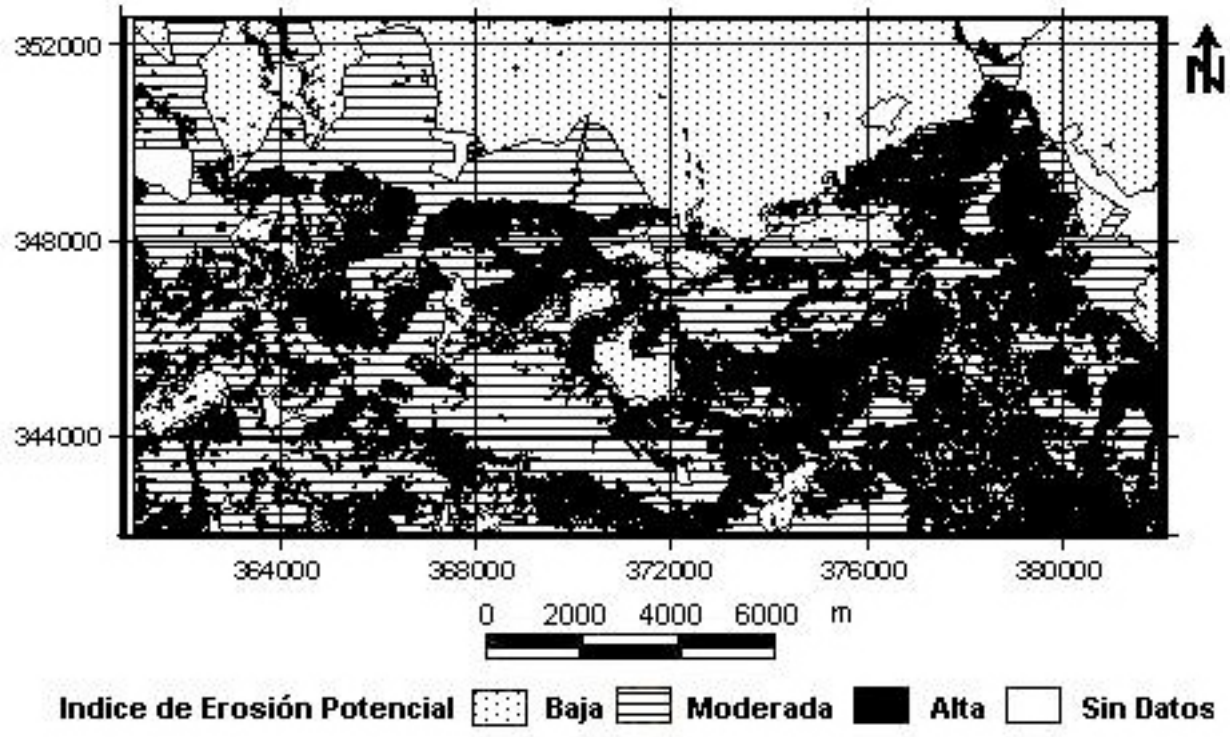


Figure 6. Map of the potential erosion index in the region under study.

erosion index, was given by the rainfall erosiveness in this territory. This latter characteristic was modulated by the erodibility of the soils and the energy values showed by the landscape, particularly in Nazareno. This was characterized by slope sectors, where the erosive dynamics was particularly complex, because there was area and space coexistence of erosion processes of different nature: hydric and erosive-gravitational, with functions defined, but interrelated. In it, there was coincidence with the descriptions of Camacho *et al*. (1986) and De Pedraza *et al*. (1996).

The results only keep certain correspondence with the descriptions of Gounou and Febles (1997) and Febles *et al*. (2005), due to, in their researches, they did not have indices of climatic aggressiveness. With the application of the CORINE methodology, the influence of the rainfall erosiveness expressed by the IFM was considered objectively. It was evaluated as high for the region where the two cattle districts in view are located.

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