



Spatial Behavior of Soil Erodibility in the La Villa River Basin, Panama

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Authors' contributions:

This work was carried out in collaboration among all authors. Author LAM designed the study, performed the statistical analysis, wrote the protocol and the first draft of the manuscript. Author JVN wrote the final text of the paper. Author JVP collaborated with the taking of samples and laboratory analysis. Author IRZ drew up the maps of the basin.

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Short Research Article

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ABSTRACT

Introduction: Soil erodibility is an important factor in understanding the erosion that takes place in a territory. This is a parameter that can behave erratically in small spaces, but that describes a trend in larger spaces.

Aim: Determine the K factor of soil erodibility in the La Villa-Panama river basin.

Place and Duration of Study: La Villa River Basin-Azuero Peninsula, Panama. 2010-2012.

Methodology: 98 points of the La Villa river watershed were sampled. Factor K was calculated using the adaptation to the soil-erodibility nomogram. The percentage of organic matter, structure class (in the field), permeability (combination permeameter) and the percentages of sand, silt and very fine sand (Bouyoucos method) were determined. To obtain the most complete information possible on the distribution of erodibility, a superficial interpolation of the point values corresponding to the soil samples taken was carried out. The software used was Arcview 3.3 and the Spatial Analyst extension. The interpolation method was IDW (Inverse Distance Weight). The erodibility values were categorized into seven intervals in such a way that it was possible to observe the differences on the map.

Results: The erodibility values were influenced by the content of organic matter and coarse

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particles (percentage of sand and silt + very fine sand) of the soil. In the province of Herrera, 86% of the land surface and 76% in the province of Los Santos presents susceptibility to erosion in the ranges of 0.032 to 0.043 Ton ha h ha⁻¹ Mj⁻¹ mm⁻¹.

Conclusion: The results indicate that 80% of the soils of the La Villa river basin present a moderately high erodibility factor, with the highest values being registered in the upper middle zone.

Keywords: K factor; soil erosion; erodibility nomogram; permeability; sand and silt; very fine sand; organic matter; inverse distance method.

1. INTRODUCTION

Soil Erodibility or K Factor is an index of the Universal Soil Loss Equation that describes the susceptibility or vulnerability (Wishmeier, 1978; Kirkby and Morgan, 1984; Röder et al. 2006) [1] [2] of the soil to be eroded. Likewise, the K factor represents soil erosion per unit of pluvial erosion index, determined in plots with a slope of 9% and lengths of 22.1 m [3,4,5]. The knowledge of the behavior of the K factor in specific sites or geographic regions could be a guide or determinant of the measures (policies) leading to give it [6].

Comparison between appropriate land use, the K factor and other factors that come into play in erosive fact can provide more detailed data on the extent of soil erosion risk.

The most widely known method for calculating the soil erodibility factor is the soil-erodibility nomogram [7]. This method was used in this

research to make specific determinations; and the interpolations within the La Villa River Basin were obtained by means of the inverse distance method making use of Geographic Information Systems (GIS) tools.

2. MATERIALS AND METHODS

98 points were sampled throughout the geography of the La Villa river basin, trying as far as possible to do so according to a 4 km by 4 km reticular mesh at a density of approximately one sample every 16 km² (Fig. 1).

The K factor for each sampled point was calculated using the adaptation [8] to the soil - erodibility nomogram [9] as shown in Fig. 2. For this, it was necessary to determine the percentages of organic matter (Wakley Black method), structure classes (in the field), permeability (combination permeameter) and the percentages of sand and silt plus very fine sand (Bouyoucos method) [10].

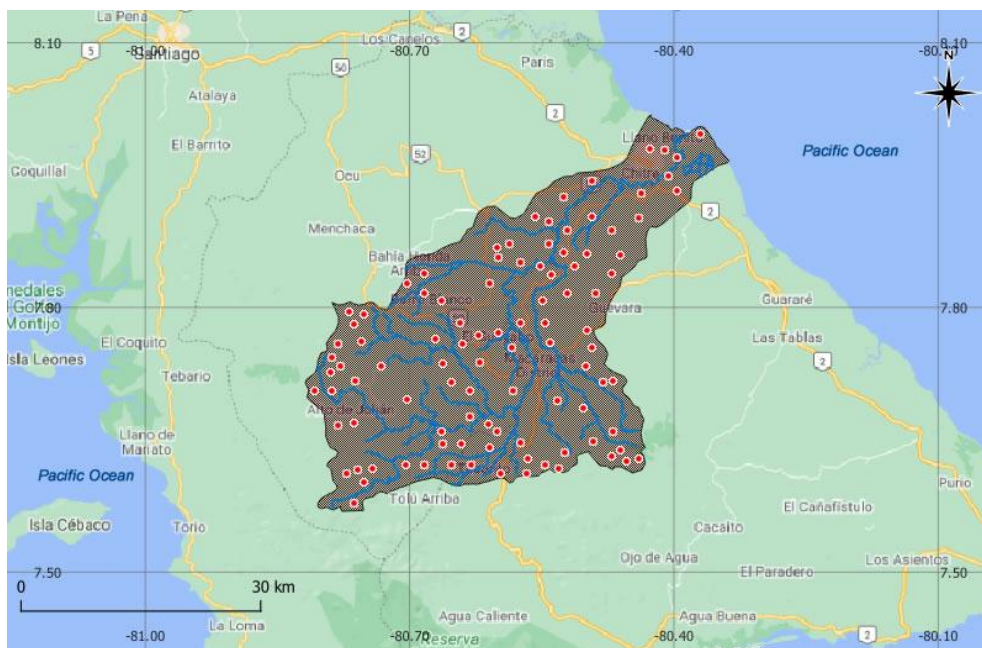


Fig. 1. Points sampled throughout the geography of the La Villa river basin-Panama

According to this nomogram, the erodibility factor is obtained using the value of the % silt + very fine sand in the sample and by drawing a horizontal line it is intercepted with the corresponding % sand curve and then another line is drawn vertically and intercepts the % Organic Matter curve. From this point of interception, by drawing another horizontal line to the right it intercepts with the curve of the type of soil structure and then vertically and downwards intercept the type of permeability (Fig. 2). Finally, from this same point of interception, a horizontal line is drawn to determine the soil erodibility factor (on the vertical axis).

To obtain the most complete information possible on the distribution of erodibility, a superficial interpolation of the point values corresponding to the soil samples taken was carried out. The software used for this was Arview 3.3 and the Spatial Analyst extension. In this way, images were generated in raster format with a spatial resolution of 15 m. The interpolation method used was IDW (Inverse Distance Weight) [11], according to which the "weight" of each station at

a given point decreases compared to the others with distance.

The erodibility values were categorized into seven intervals so that the intervals allowed to observe the differences on the map.

3. RESULTS AND DISCUSSION

3.1 Relative Frequency of the Erodibility Factor

In total, 98 soil samples were taken from the La Villa river basin using a density of one sample per 16 km². The laboratory analyzes and the calculations carried out allowed determining that the mean of the erodibility factors in the basin was 0.037 Mg ha h ha⁻¹ Mj⁻¹ mm⁻¹ and the standard deviation was 0.009 Mg ha h ha⁻¹ Mj⁻¹ mm⁻¹, with extremes of 0.012 as a minimum and 0.056 as a maximum. The most frequent values were included in the intervals between 0.026 and 0.043 as can be seen in Fig. 3.

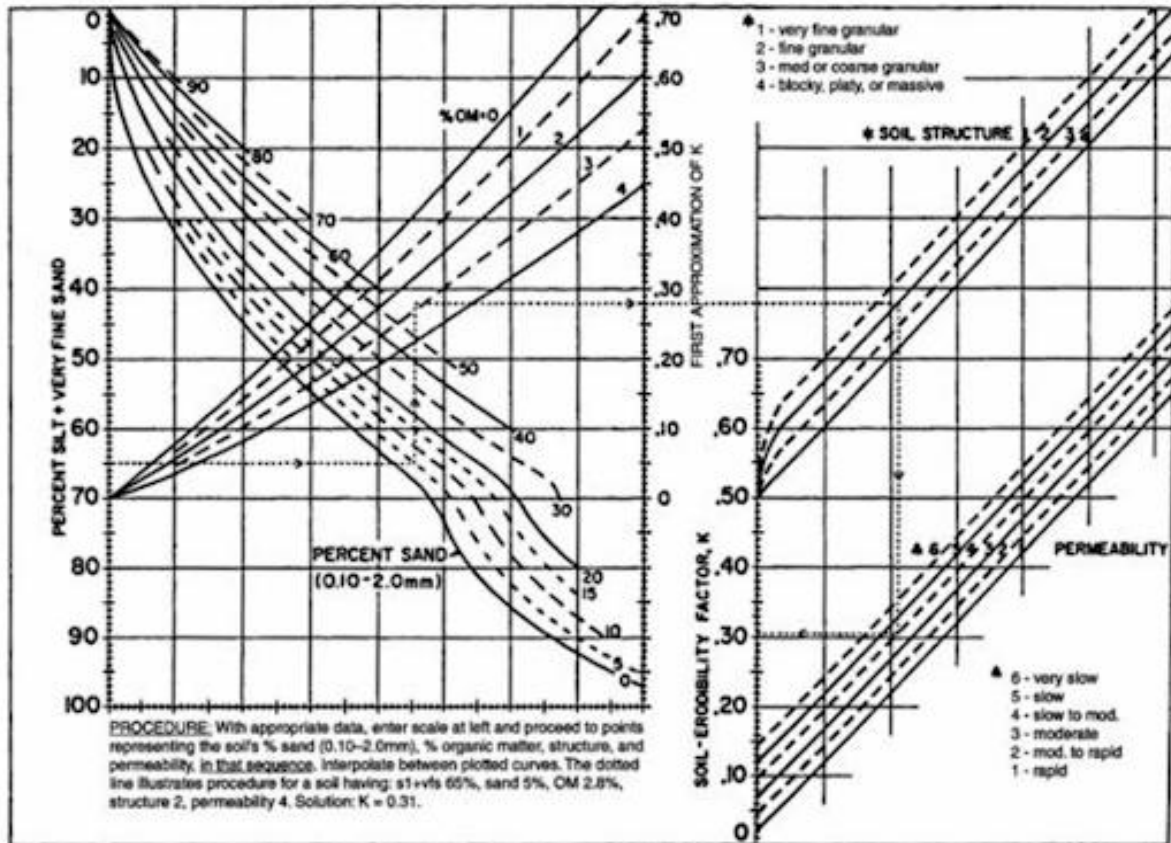


Fig. 2. Soil nomogram - erodibility [9,8]

3.2 Distribution of the Erodibility factor in the La Villa River Basin

The interpolations carried out by means of the inverse distance, produced the distribution that is presented in Fig. 4. It illustrates the values of soil erodibility by means of an increase in the color tone. The erodibility values obtained are higher towards the southern region of the study area and the lowest values are more frequent towards the northeast zone and towards the flat regions of the basin. This trend is apparently influenced by the organic matter content and the content of coarse particles (% sand and silt + very fine sand) of the soil. Radziuk and Switonak [12], in northeastern Poland soils, found values of the K factor between 0.0172 and 0.0352 $\text{Mg ha h ha}^{-1} \text{Mj}^{-1} \text{mm}^{-1}$, relating the high susceptibility to erosion with the low carbon content in this soil.

The results found are closely related to the low coverage and land use in the basin. In Fig. 5. it is observed that only to the south of the basin, in the highest part, there is a remaining forest, almost 90% of the basin has agricultural use with low content of organic matter (< 2%). To the northeastern you can see, in red color, the two main cities in the lower part of the basin.

Fig. 6 shows that in the province of Herrera, the largest land area, 86%, presents soils with susceptibility to erosion in the ranges of 0.032 to 0.043 $\text{Mg ha h ha}^{-1} \text{Mj}^{-1} \text{mm}^{-1}$ and corresponds to the districts of Los Pozos and Las Minas followed by Pesé and Chitré. The highest values found are located in the Los Pozos district, he upper-middle region of the La Villa River Basin.

Similarly, for the province of Los Santos, it was possible to determine that the largest surface area corresponds to soils with susceptibilities in the interval from 0.032 to 0.043 $\text{Mg ha h ha}^{-1} \text{Mj}^{-1} \text{mm}^{-1}$, according to the sample (Fig. 7). In Brazil, working on ultisol soil, Cassol et al. [13], found a K factor of 0.0338 $\text{Mg ha h ha}^{-1} \text{Mj}^{-1} \text{mm}^{-1}$ characterizing it as a soil highly susceptible to water erosion.

The percentage of surface, in this case corresponds to 76%, based on the surface of the province of Los Santos coinciding with the La Villa River Basin; and the district that registers the highest susceptibility is Macaracas followed by Los Santos. The highest values found were in the Macaracas district.

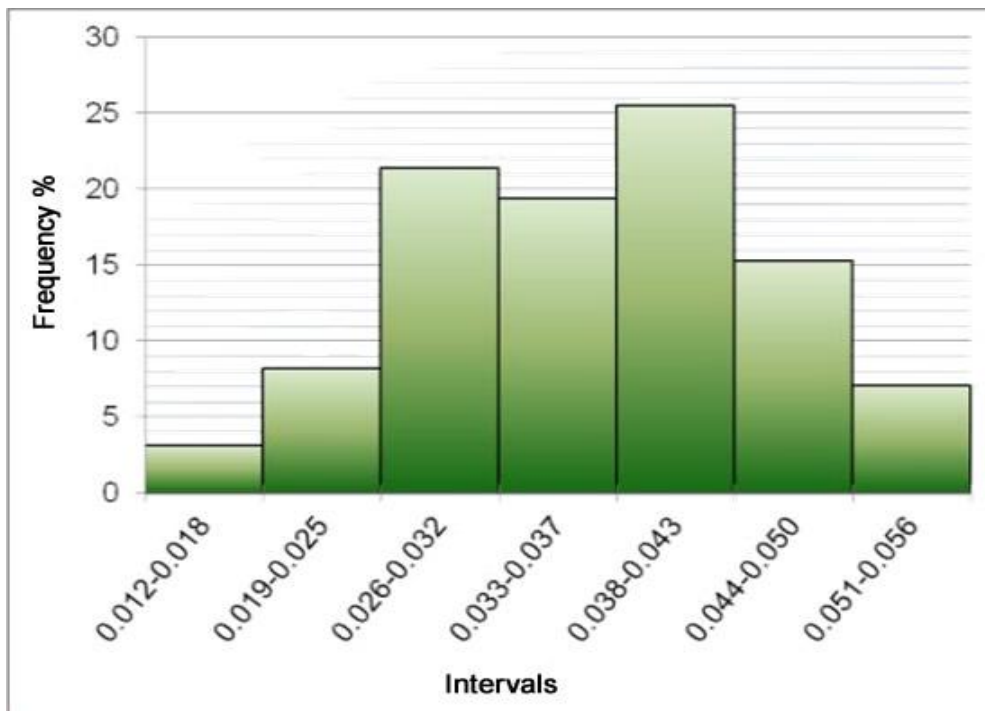


Fig. 3. Frequency of existence of the K factor for the study area by interval

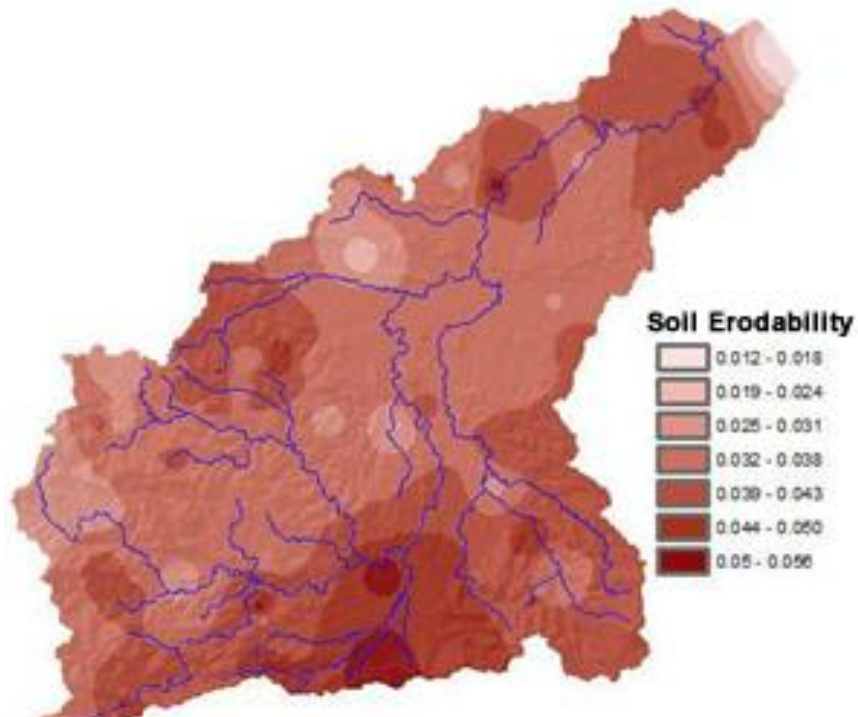


Fig. 4. Distribution of erodibility in the La Villa river basin Panama

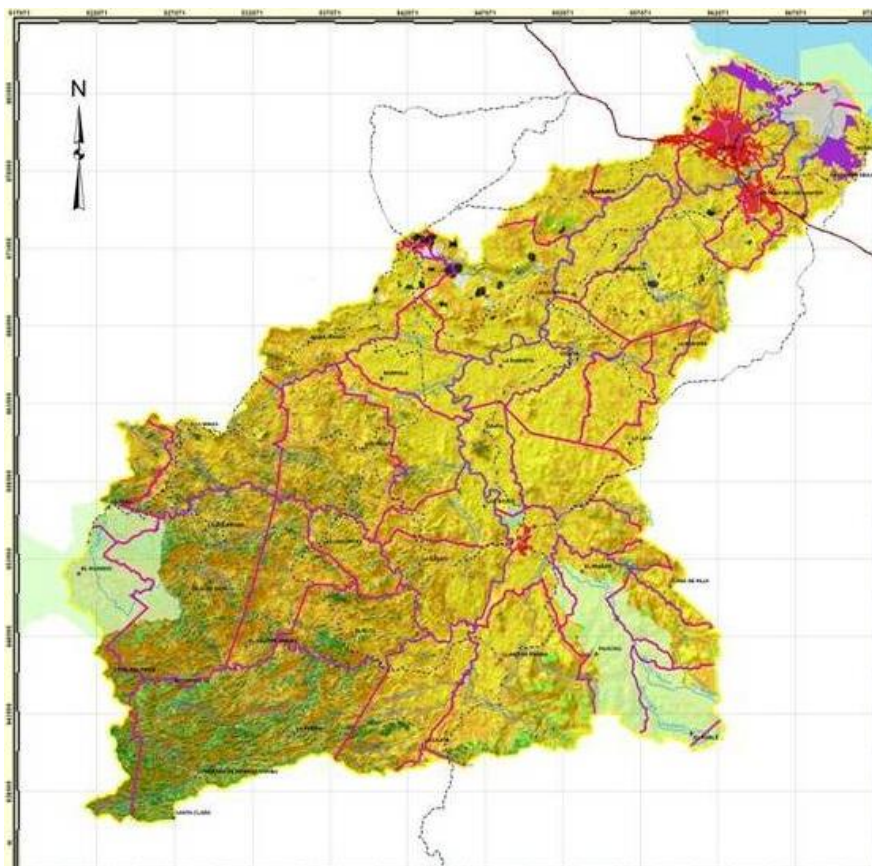


Fig. 5. Land cover map in the La Villa river basin [14]

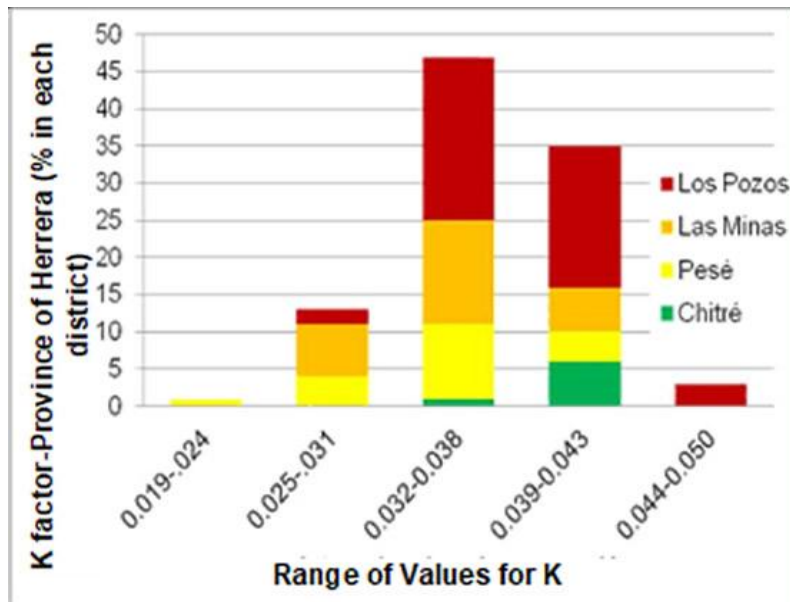


Fig. 6. Percentage of surface area of the La Villa river basin within the province of Herrera according to District and erodibility factor

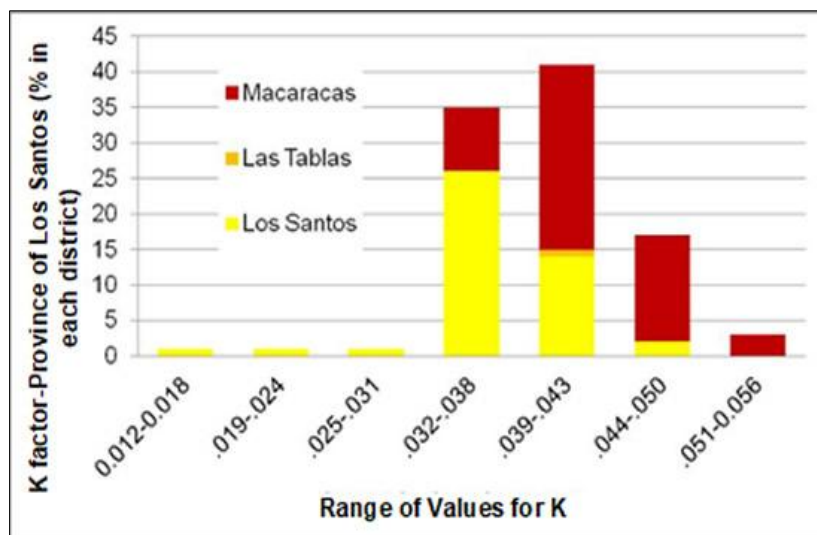


Fig. 7. Percentage of surface area of the La Villa river basin within the province of Los Santos according to District and erodibility factor

4. CONCLUSION

The results obtained indicate that 80% of the soils of the La Villa river basin have a moderately high erodibility factor and that the highest values are registered towards the upper-middle part of it.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kirkby MJ, Morgan RPC. Soil erosion. Editorial Limusa, México D.F. 1984;375.

2. Röder J, Villavicencio GR, Zarazúa VP. Application of the Universal Soil Loss Equation "USLE" in GIS to estimate the potential risk of erosion in the protected area "Sierra de Quila". In: XVII Week of Scientific Research. University Center for Biological and Agricultural Sciences. University of Guadalajara, Guadalajara, Jalisco, Mexico. 2006;156-162.
3. CORINE-CEC. CORINE soil erosion risk and important land resources. An assessment to evaluate and map the distribution of land quality and soil erosion risk. Office for official publications of the European Communities. EUR 13233. Luxembourg; 1992.
4. Morgan RPC. Soil erosion and conservation. Ed. Mundi-Press. Madrid; 1997.
5. Suárez DJ. Erosion control in tropical areas. Santander Industrial University Editions. 2001;555.
6. Andrade O, Kappas M, Erasmi S. Evaluation of erosion risk in the municipality of Torres, Lara state (Venezuela) based on GIS. *Interciencia*. 2010;35(5):348-356.
7. Wischmeier WH, Smith DD. Predicting rainfall erosion losses. USDA Agr. Res. Serv. Handbook. 1978;537.
8. Foster GR, McCool DK, Renard KG, Moldenhauer WC. Conversion of the Universal Soil Loss Equation to SI metric units. *Journal of Soil and Water Conservation*. 1981;36(6):355-359.
9. Wischmeier WH. Use and misuse of the Universal Soil Loss Equation. *J. Soil and Water Cons.* 1978;31:5-9.
10. Villarreal JE, Name B. Analytical techniques of the soil laboratory. IDIAP, Panama. 1996;120.
11. Watson DF, Philip GM. A Refinement of Inverse Distance Weighted Interpolation, *Geo-Processing*. 1985;2:315-327.
12. Radziuk H, Switoniak M. Soil erodibility factor (K) in soils under varying stages of truncation. *Soil Sci. Ann.* 2021; 72(1):134621. DOI:<https://doi.org/10.37501/soilsa/134621>
13. Cassol EA, Silva TS, Eltz FL, Levien R. Soil erodibility under natural rainfall conditions as the K Factor of the Universal Soil Loss Equation and application of the nomograph for a subtropical ultisol. *Rev. Bras. Cienc. Solo.* 2018; 42:e0170262. DOI:<https://doi.org/10.1590/18069657rbcscs20170262>
14. National Environmental Authority, Tropical Agricultural Research and Teaching Center, National Land Administration Program (ANAM-CATIE-PRONAT). Land Use Plan for the La Villa River Basin. National Environment Authority (ed.), Panama City, Republic of Panama. 2008;132.

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