THALES Project No. xxxx

Investigation of the relation between geologic, geomorphologic and physiographic parameters of hydrologic basins and their effects on the inland and coastal environment: Application to Evrotas basin.

Research Team

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Introduction

This research project deals with the investigation of different geologic, geomorphologic and physiographic parameters and their effects on the soil erosion and sediment yield of a hydrologic basin. The processes of weathering, soil erosion and deposition, that affect the shape of the landscape of a hydrologic basin, are depending mainly on climatic, topogtaphic, morphologic, geologic and human-induced parameters. These parameters control the flow conditions through the hydrographic network, accelerate the weathering-erosion processes and shape the geometry of the riber basins. This project encompasses two different approaches for the estimation of these processes; the first one called “investigation of the catchments’ vulnerability to erosion”, which is a qualitative approach with various indices according to the prone of erosion and a quantitative approach, namely the Universal Soil Loss Equation (USLE), that yields quantitative results of soil erosion. These methods are applied to the Evrotas river basin located in the Southern Peloponnese in Greece.

Methodology

Investigation of the catchment vulnerability to erosion

The essence of the methodology is to develop a series of three maps. The scope of the maps is to work out and analyze the factors that affect the configuration of the relief. These maps are relative to the lithology of the formation, as well as their behavior under the affect of the exogenic processes in connection with he morphological slope. The maps that we prepared can be divided into three groups:

1. A map providing information about the lithology and hydrogeology. In this map, two areas are distinguished according to the behavior and resistivity to erosion.
2. A map providing geomorphological data due to the shape and the evolution of the drainage networks of the island. In order to investigate the drainage texture, drainage

density and drainage frequency maps were prepared. In each of these maps, three different areas of density and frequency values were distinguished. A combination of these maps leads to a final map of the drainage texture in which two different areas can be distinguished.

3. A map of the slope of the valley sides. According to the gradient values of the slopes, two areas were distinguished. One area with gradient of less than 12% and one of more than 12%. The value of 12% was considered as a marginal value.

The combination of the three final maps, of drainage texture, relief slopes and lithologic areas susceptible to erosion produced the erosivity map. On a next step, the effect of the vegetation cover is investigated with reference to the change of vulnerability characteristics. Below the reader may find details on the constuction of the maps with association with the Evrotas river basin.

Map of the lithologic formations prone to erosion

Formations with high infiltration rates are not prone to erosion because they do not cause high runoff rates. On the opposite, formation with medium infiltration rates, like modern deposits, are very prone to erosion, especially after prolonged rainfall events. A categorization of the geologic characteristics has been made and the map of the lithologic formations prone to erosion (L) has been constructed (L)». The geologic characteristics have been extracted from relative references [5]. The categorization of L makes two categories. The first one is the vulnerable formations (L1) and the second one is the non-vulnerable formations (L2). For their characteristics see Table 1 below and the map for the Evrotas river basin is shown in Figure 1.

Map of relief gradient (S)

This map is a result of a GIS treatment of the Digital Terrain Model (DTM) of the catchment. According to the numerical values of the slope gradient we make two categories of relief gradients. The first one is with values less than 12% (S1) and the second on with values more than 12% (S2). The angle of 12% threshold is characteristic of the slope that the κώνοι κορημάτων, that is created with condition of diffusive flow and has been assumed that is a threshold angle of constant deposition [2]. For their characteristics see Table 1 below and the map for the Evrotas river basin is shown in Figure 1.

Map of hydgrographic texture (Y)

This map expresses the morphometric parameters of the hydrographic density and hydrographic frequency. The digitization of 1:50000 scale maps has been carried out and then a grid with cell size of 2 km^2 has been made and the associated value has been measured for each cell of the grid. Then at Table 1 we can see the three categories of hydrographic density and frequency of high, medium and small D1, D2, D3 and F1, F2, F3 correspondinly. From the combination of these, tha map of hydrographic texture has been made with two categories, one which is small to medium texture (Y1) and the other medium to high texture (Y2) (see Table 1, Figure 2).

Map of erosion vulnerability (T)

From the cross validation of the three final maps, the map of the erosion vulnerability has been made. We make four categories of erosion vulnerability (Table 2).

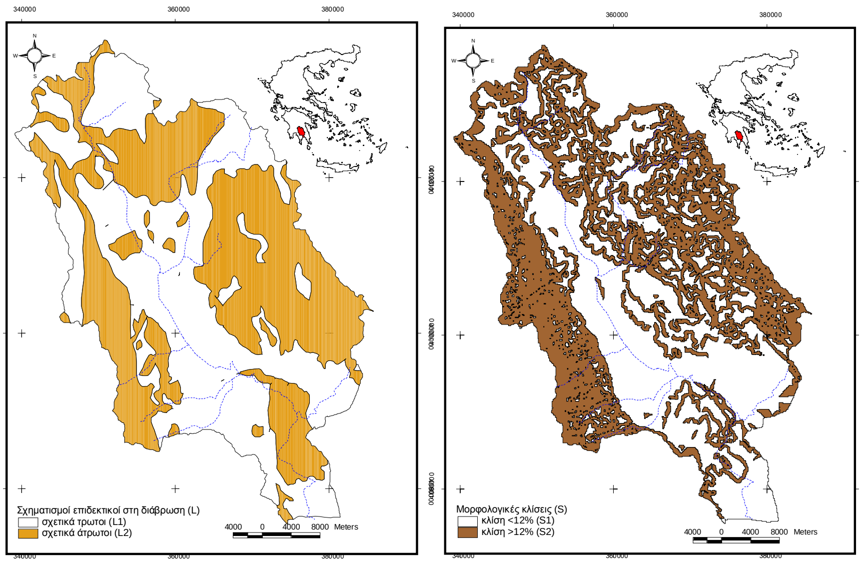

Figure 1 Map of lithologic formations prone to erosion (L) of the Evrotas river basin (left) and map of relief slopes (S) (right)

Table 1: Categorization of vulnerability parameters

1a) Hydrographic frequency (F)	**Small** F1: F ≤ 1.9	**Medium** F2: 1.9 <F ≤ 3.3	**High** F3: 3.3 <F
1b) Hydrographic density (D)	**Small** D1: D ≤ 6.9	**Medium** D2: 6.9 <D ≤ 14.0	**High** D3: 14.0 < D
1) Hydrographic texture (Y)	**Small to Medium** Y1: Combinations of F1, F2 and D1, D2		**Medium to high** Y2: Combinations ofF2, F3 and D2, D3
2) Geologic formations prone to erosion (L)	**Vulnerable** L1: Limestones, dolomites, phyllite, grauwacke, et al.		**Non-vulnerable** L2: Alluvial, clays, silts, sands, conglomerate, clastic sediments, flyschs et al.
3) Relief gradient (S)	S1: <12%		S2: >12%
4) Vegetation cover (C)	C1: sparse bushes, pasture lands and areas without vegetation	C2: various cultivations	C3: Forests

Table 2: Classification and categorization of the culnerability from the cross evaluation of the properties of the thematic maps considering the vegetation cover parameter.

VULNERABILITY WITHOUT THE INFLUENCE OF VEGETATION COVER				
Vulberability	**Small (T1)**	**Small to Medium (T2)**	**Medium to high (T3)**	**Very High (T4)**
	L1,S1,Y1	L1,S1,Y2 & L1,S2,Y1 & L2,S1,Y1	L1,S2,Y2 &L2,S1,Y2 & L2,S2,Y1	L2,S2,Y2
Area (km^2)	304.5	601.3	605.0	225.3
Percentage (%)	17.5	34.6	34.8	13.0

Map of erosion vulnarablity considering the effect of vegetation cover (TV)

At the methodology shown before the effect of the vegetation cover had been excluded from analysis. The vegetation cover, however, is a factor that contradicts erosion and this factor should be taken into consideration. We make three categories of vegetation cover: (a) sparse bushes, pasture lands and areas without (C1), (b) various cultivations

(C2) and, (c) forests (C3) [2]. The protection of the vegetation cover against erosion is dependent of the type of vegetation. High protection offer the forests and the various cultivations, less are offred from lee vegetated areas. From the combination of the erosion vulnerability and the vegetaton cover map, a new map has come which is the “Erosion Vulnerability map with Vegetation” (TV)" (see Figure 3 and Table 3).

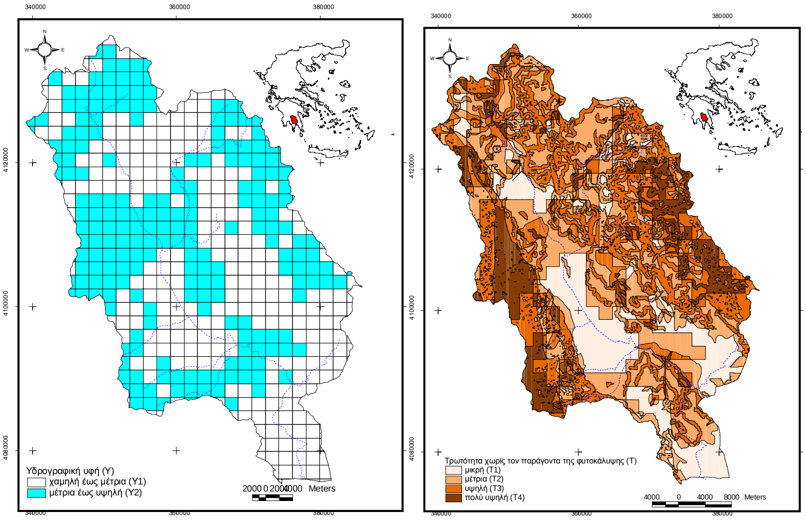

Figure 2: Map of hydrographic texture (Y) (left) and map if vulnerability without the influence of vegetation for the Evrotas river basin (T) (right)

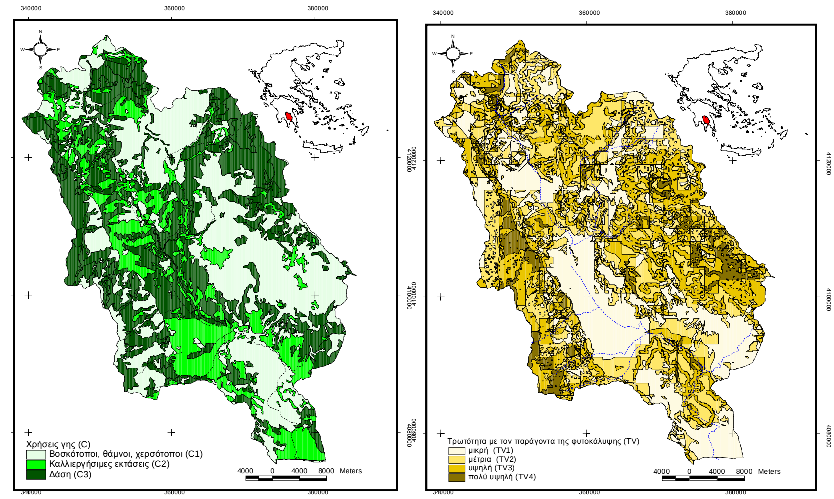

Figure 3. Map of land cover(C) (left) and map of erosion vulnerability considering the effect of vegetation cover (TV) (right) for the Evrotas river basin.

Table 3: Classification and categorization of the culnerability from the cross evaluation of the properties of the thematic maps considering the vegetation cover parameter.

VULNERABILITY WITH THE INFLUENCE OF VEGETATION COVER				
Vulnerability	**Small (T1)**	**Small to Medium (T2)**	**Medium to High (T3)**	**Very High (T4)**
	Combination of T1 & V1,V2,V3 T2 & V3	Combination of T2 & V1,V2 T3 & V3	Combination of T3 &V1,V2 T4 & V3	Combination of T4&V1,V2
Area (km^2)	534.2	609.0	478.1	114.1
Percentage (%)	30.8	35.1	27.6	6.6

The factor of vegetation cover shows less areas woth medium to high erosion vulnerability at 13.5%, which is a dignificant variation. The assessment of the vulnerability without the influence of vegetation gives a first estimation of soil erosion in the case of catastrophic land use alternation (i.e. a severe fire or deforestation. Therefore, vegetation cover is a significant control of soil erosion.

Identification of regions with high risk of soil erosion using the Universal Soil Loss Equation (USLE)

The USLE [7,8,9] is a simple empirical model, based on regression analyses of soil loss rates on erosion plots in the US. The model is designed to estimate long-term annual ero-sion rates on agricultural fields. Although the equation has many shortcomings and limitations, it is still widely used because not only of its relative simplicity and robustness but also because it represents a standardized approach. Soil erosion is estimated using the following empirical equation:

$$A = R \times K \times L \times S \times C \times P \qquad (1)$$

where, A is the mean annual soil loss, R is the rainfall erosivity factor, K is the soil erodibility factor, L is the slope factor, S is the slope length factor, C is the cover management factor and P is the conservation practice factor. The numerical values of the different factors of the equation have been computed after processing data collected in small catchments in the United States. This obviously suggests a weakness of the method in case of applying it elsewhere from the US with different climatic and topographic conditions. Additionally, USLE does not account for sediment transport in hillslopes and streams and does not perform well in large scale catchments. However, in terms of computing only the catchment soil erosion, USLE is a quite satisfactory preliminary approximation.

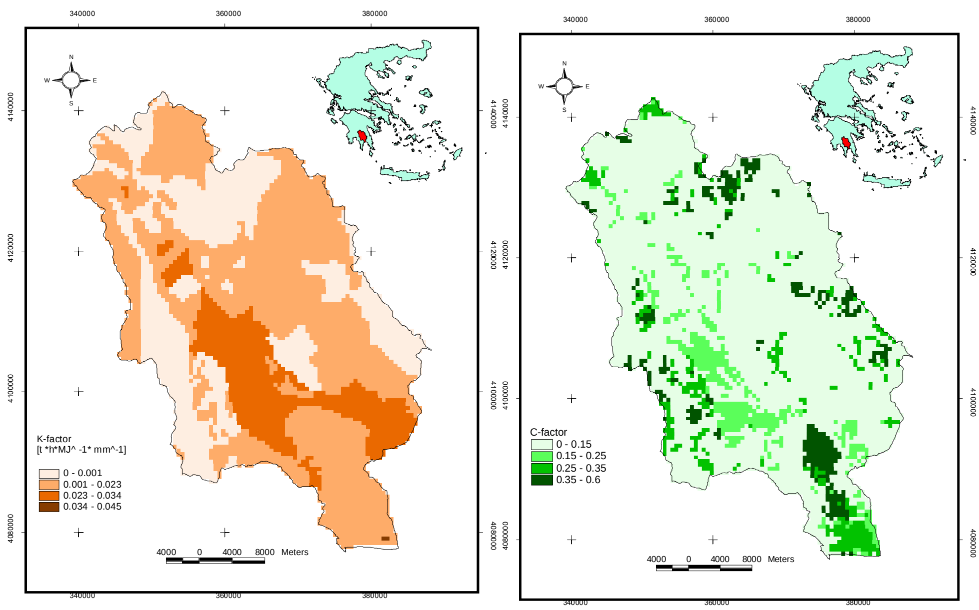

Figure 4. Map of soil erodibility factor (K) (left) and Map of the topographic factor (right).

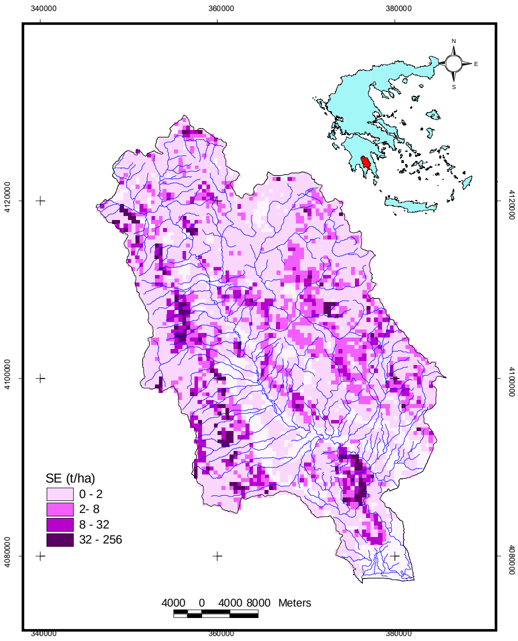

Figure 5. Map of the cover management factor (C) (left) and map of the soil erosion (SE) (right).

References

1. Alexouli-Livaditi, A., 1999. Qantitative geomorphological study of Eurotas river drainage network (Greece) *5ο Πανελλήνιο Γεωγραφικό Συνέδριο*, Αθήνα.
2. Αλεξούλη-Λειβαδίτη, Α., Λειβαδίτης, Γ., Λυκούδη, Ε., 2002. Investigation and delineation of areas of intense erosion and product of wasting materials at Lesvos Island, Greece.. *6ο Πανελλήνιο Γεωγραφικό Συνέδριο*, Θεσσαλονίκη (in greek).
3. DHI, *SEAGIS 1.0:*, 1999. *Documantation and user's manual*.
4. HRISSANTHOU, V. AND A. PYLIOTIS, 1995. Appraisal of the river sediment inflow in a reservoir under construction, 6th PanHellenic Conference HYS, Thessaloniki (in greek).
5. Ινστιτούτο Γεωλογικών και Μεταλλευτικών Ερευνών, *Γεωτεχνικός χάρτης της Ελλάδας*, Κλίμακα 1:500,000, Αθήνα, 1993.
6. Knijff, J. M., Jones, R.j.A., Montanarella, L., 2000. Soil risk Assessment in Italy. *European Commission, European Soil Bureau*.
7. Wischmeier, W.H. & Smith, D.D., 1978. Predicting rainfall erosion losses; A guide to Conservation planning, *Agriculture Handbook No. 537*, USDA Sci. and Edyc. Admin., Washington D.C.
8. Schwertmann, U., W. Vogl and M. Kainz, 1990. *Bodenerosion durch Wasser*, Verlag Eugen Ulmer, Stuttgart.
9. Zarris, D., E. Lykoudi and D. Koutsoyiannis, 2002. Sediment yield estimation from a hydrographic survey: A case study for the Kremasta reservoir basin, Greece, *Proceedings of the 5th International Conference "Water Resources Management in the Era of Transition"*, Athens 4-8 September 2002, pp. 338-345.