Erosion Risk Map of Samos island using a simple probability model

T.Gournelos*, N. Evelpidou*, V. Kotinas*

**University of Athens, Faculty of Geology and GeoEnvironment, Department of Geography and Climatology, Panepistimioupoli, Zografou, 15784, Athens, Greece, gournelos@geol.uoa.gr*

Abstract

The relief of the island of Samos is characterized by the Kerketeas mountain in the western part and the Karvouni mountain in the central part. The Geology of Samos consists of a metamorphic substratum, a non metamorphic unit, neogene and quaternary sediments. This island has been affected many times by natural hazards, such as forest fires, soil erosion, flash floods and gravity movements. The aim of this paper is to create an erosion risk map of Samos Island. This has been achieved by a series of separate stages, such as the creation of a database of geological, geomorphological and topographic data, extensive field observations and analyses of aerial photos and satellite images, within a GIS based platform. The final step involves the application of a functional relationship based on a probability model to input data consisting of the lithology, slope, mean altitude, and the vegetation-land use for each drainage basin to produce the final erosion risk map

Keywords: Erosion, G.I.S., Natural Hazards

Introduction

The island of Samos is located in the eastern part of the Aegean Sea near the coast of Minor Asia, its shape is elongated and its area is 476 km^2. The topography of the island is characterized by an alternation of mountainous areas and low basins of North-South direction.

The geology of Samos consists of a pre-neogene complicate substratum of gneiss, schists, marbles and a non metamorphic unit (Philippson 1959; Guernet 1972; Durr 1978; Theodoropoulos 1979; Papanikolaou 1979; Okrush et al 1984; Mezger and Okrush 1985).

The neogene sediments are mainly located in two neotectonic basins in the island, the Karlovasi and Mytilinii basins, and consist of marls, conglomerates, limestone and tuffs. (Stamatakis, 1989). Recent sediments overlay the pre-neogene and neogene formations and are mainly alluvial formations.

The presence of neogene and recent sediments and the relatively high morphological slopes favor the erosional processes in the island of Samos. In the past we have treated the erosional problem of Samos using fuzzy models (Gournelos et al, 2001).

Methodology

Samos island apart from its lithology (Fig. 1) and the steep slope relief has experienced severe fire events that repeatedly changed its vegetation cover and accelerated erosion processes.

The aim of this paper is to create an erosion risk map of this island based on probabilities. This has been achieved by the following steps in a G.I.S. platform:

1. Digitising Topographical and Geological maps (scale 1:50.000)

2. Creating a land use and vegetation map using Corine 2000 data and interpreting air photos and satellite images (using ILWIS G.I.S / Remote sensing software).

3. Mapping soil erosion and mass movements

4. Formulating a Probability model in a MATLAB software system.

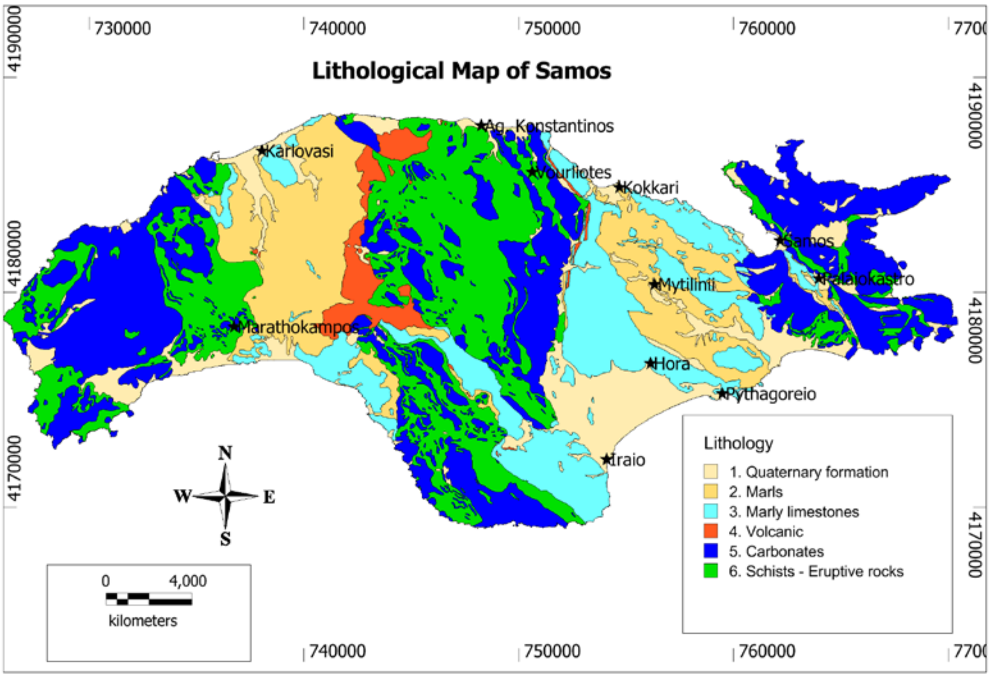

Figure 1: Simplified Lithological Map of Samos Island

In the above described methodological steps the input data sets (topography, lithology, land use type) are transformed by the probability model to the output variance, the probability of erosion risk.

We consider the drainage basins of Samos (Fig.2) as independent autonomous geomorphological units and we have processed the data sets for each such unit.

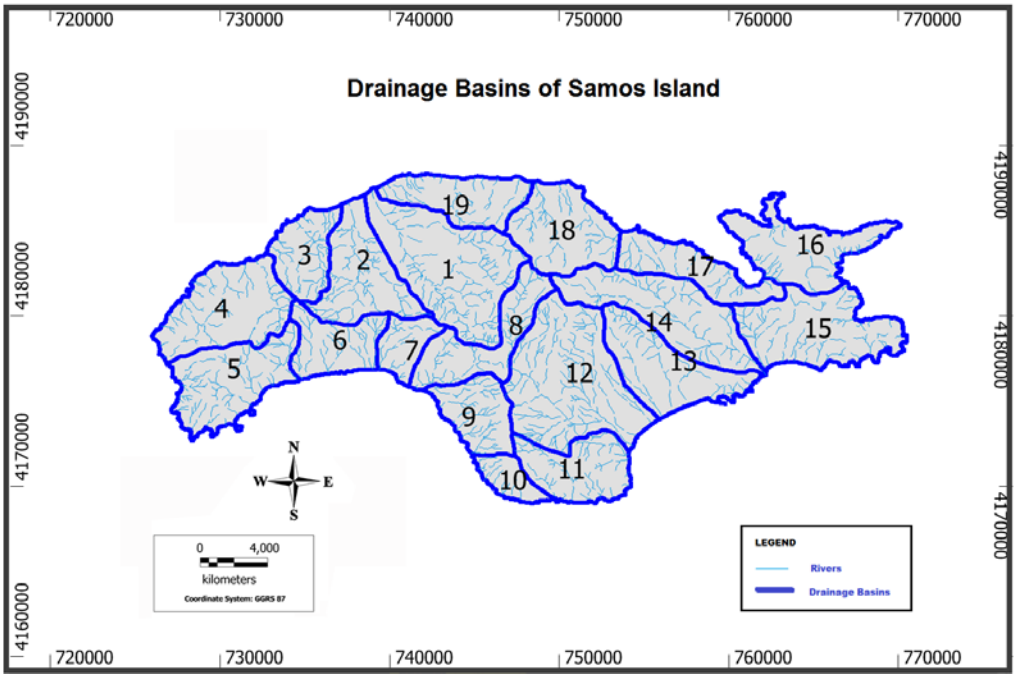

Figure 2: Drainage Basins in Samos Island

The probability model consists of four input variables which correspond to lithology (x1), mean slope (x2), mean altitude (x3) and vegetation land use (x4) of a drainage basin.

Thus if X=(x_1, x_2, x_3, x_4) the vector of the input variables we define the conditional

probability $P(Erosion/X)$

Then we form the inner product: $S = W^T \cdot X$ with $W^T = \begin{Bmatrix} w_1 \\ w_2 \\ w_3 \\ w_4 \end{Bmatrix}$

where w_1, w_2, w_3, w_4 **: the coefficients** which we estimate, from the input data**.** These coefficients are related to the input variables (lithology, mean slope, mean altitude, land use).

Finally the probability of erosion is considered as a function of S (the result of the above inner product) and so the final equation of probability of erosion is given by :

$$P(Erosion/X) = f(S) = \frac{e^S}{1+e^S} \text{ where } S = W_i^T \cdot X$$

Thus if **x = (x_1,x_2,x_3,x_4) the input variables** ,which correspond respectively to lithology, mean slope of a drainage basin, mean altitude, and vegetation land use , we define :

$S = W^T \cdot X$ with $W^T = \begin{Bmatrix} w_1 \\ w_2 \\ w_3 \\ w_4 \end{Bmatrix}$

where w_1, w_2, w_3, w_4 **: the coefficients** which we estimate, from the input data**.**

Finally the probability of erosion is given by :

$$P(Erosion/X) = f(s) = \frac{e^s}{1+e^s}$$

Table 1: The main Drainage Basins and the input data.

Basin Id	**Area (km^2)**	**Slope %**	**Mean Elevation (m)**	**Quaternary %**	**Marls %**	**Marly Limestones %**	**Volcanics %**	**Limestones Marbles %**	**Schists Eruptive %**	**Dominant Vegetation**
1	46,46	18,82	498,52	4,2385	27,2878	2,8856	14,1871	13,1140	38,2867	Forrest-Barren Land
2	26,41	14,00	224,27	12,6039	65,6751	4,7579	1,4024	0,1845	15,3766	Forrest-Vineyards
3	15,82	22,90	299,99	6,0655	7,3252	5,9180	0,0000	48,7166	31,9747	Forrest-Bushes
4	31,88	29,06	456,59	4,3951	0,0000	0,0000	0,0000	67,2810	28,3242	Forrest-Bushes

5	28,68	27,10	475,29	12,6694	0,0000	0,0000	0,0000	63,6296	23,7010	Forrest-Bushes
6	16,86	17,19	247,82	12,8270	30,8959	5,3480	0,0000	8,1601	42,7686	Vineyards
7	9,54	16,01	258,91	2,3688	48,0277	20,2510	29,0000	0,2071	0,1454	Bushes-Fruit Trees
8	22,10	20,07	515,31	2,4829	7,6627	19,5090	4,1170	18,7022	47,5266	Forrest-Bushes
9	16,22	18,63	303,96	2,4199	7,0510	16,4095	0,0000	32,1025	42,0171	Bushes-Fruit Trees
10	7,15	21,58	252,25	2,3361	0,0000	0,0000	0,0000	57,8506	39,8132	Bushes
11	20,85	18,19	257,16	4,4239	0,0000	47,5293	0,0000	24,4600	23,5869	Forrest-Fruit Trees
12	51,99	14,68	333,36	24,1021	1,8814	21,1048	0,1951	24,7353	27,9813	Forrest-Fruit Trees
13	27,37	11,42	135,89	27,9653	14,5112	57,5231	0,0000	0,0000	0,0000	Bushes-Barren Land
14	34,41	13,66	260,00	12,1501	42,3320	30,2068	0,5974	12,5714	2,1423	Bushes-Barren Land
15	34,25	14,07	138,62	15,0693	3,5161	5,8368	0,0000	58,0977	17,4801	Bushes-Barren Land
16	25,87	18,84	152,11	12,9021	0,0000	0,0000	0,0243	78,8070	8,2667	Bushes
17	18,92	13,53	138,98	11,2439	34,3371	43,2987	0,0000	10,6467	0,4736	Barren Land
18	26,28	23,28	384,35	7,8718	0,8645	8,6817	1,4606	30,8429	50,2786	Forrest-Barren Land
19	19,58	25,26	353,08	11,0694	17,7709	2,2818	16,5251	13,3273	39,0254	Forrest-Barren Land

The creation of Erosion risk map of Samos island based on a probability model

The creation of the erosion risk map involves the following stages:

1. Analysis of the Drainage Basins of Samos
2. Analysis of Geological, topographical ,vegetation-land use data of each drainage basin

3. Application of a functional relation to input data consisting of the lithology, slope, mean altitude, and the vegetation-land use for each drainage basin to produce the final erosion risk map.

The proposed probability models transform the four above mentioned input variables, to the output one which is the probability of erosion for each of the drainage basins of Samos island. Table 1 shows the input data sets (lithology, mean slope, mean elevation and vegetation land use) and the drainage basins of the island. Figure 3 shows the distribution of the output variables and consequently maps the probability of erosion for each basin. It is observed that the drainage basins with medium and high probability values are located mainly in the central part of the island where lithology and relatively high slope favors the denundation processes.

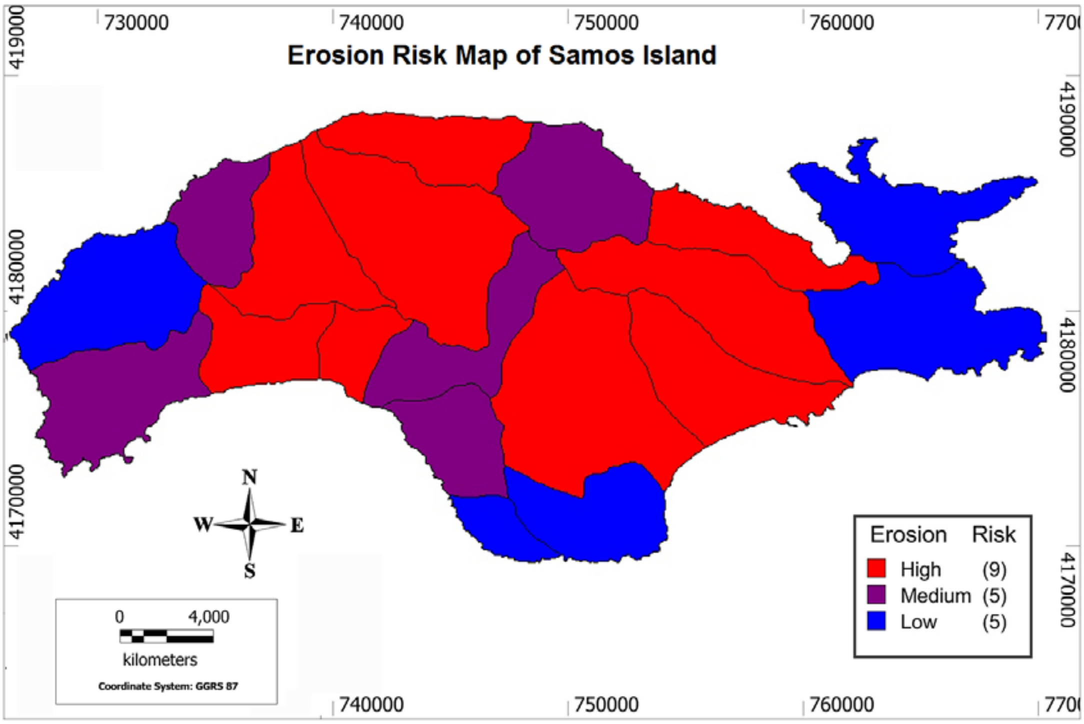

Figure 3: Erosion risk Map of Samos Island

Conclusion

The island of Samos has been affected many times in the past by many erosional events. In this paper we have created an erosion risk map of the island based on a probability model. This final map attributes to each drainage basin a value of probability for erosion. The basin with high values of probability are located to the central part of the island. The high values are related mainly to lithology and the steep slope, but also to the vegetation – land use and finally the mean altitude. Basins with low probability of erosion are located in the North West, South and Eastern part of the island where the dominant lithological units are the marbles.

The proposed model aims to contribute to the mapping of the erosion risk areas in order to suggest the appropriate measures to avoid further devastating effects.

Acknowledgements

This work is supported by the project ECOFLOW (11SYN_8_917) that is funded by the Action "Cooperation 2011-2015" of the Operational Programme "Competitiveness and Entepreneurship" co-funded by the European Regional Development Fund (ERDF) and the General Secretariat for Research and Technology (Hellenic Ministry of Education).

References

Durr, St., A ltherr, R., Keller, J., Okrusch, M., Seidel, E., 1978. The median Aegean Crystalline Belt: stratigraphy, structure, metamorphism, magmatism. In: Alps, Apennines, Hellenides; Closs H. et al., ed., p. 455- 478.

Gournelos Th., Vassilopoulos A., Evelpidou N., 2000. An erosion risk study on Samos Island, based on fuzzy models, taking into consideration landuse situation after the fire of July 2000, 7th International Conference on Environmental Science and Technology Ermoupolis, Syros island, Greece.

Guernet, C., 1972. 'Le "cristallin" de l'Eubee du Sud et ses problemes. Comparaisons avec le "cristallin" du Laurium et de Samos', Z. Deutsch. Geol. Ges., t. 123, p. 353-364.

Okrusch, M., Richter, P., Katsikatsos, G., 1984. High-pressure rocks on Samos, Greece. In: The Geological Evolution of the Eastern Mediterranean (Dixon J.E., Robertson, A.H.F., eds.). Geol. Soc. Spec. Publ. 17, 529-536. Oxford: Blackwell.

Mezger K. and Okrusch M., 1985. Metamorphism of the Variated Sequence at Kallithea, Samos, Greece, TMPM Tschermaks in. Petr. Mitt. 34, 67-82, Wurzburg.

Papanicolaou D., 1979. Unites tectoniques and phases de deformation dans l ile de Samos, Mer Egee, Grece. Bull. Soc. De France 21: 745-752.

Philippson, A., 1959. Die griechischen Landschaften. Eine Landeskunde: IV, Das Agaische Meer und seine Inseln, p. 412.

Stamatakis M., Hein J, Magganas A, 1989. Geochemistry and diagenesis of Miocene lacustrine siliceous sedimentary and pyroclastic rocks, Mytilinii basin, Samos Island, Greece. Sed Geol 64:65–78.

Stamatakis, M., 1989. Authigenic silicates and silica polymorphs in the Miocene saline-alkaline deposits of the Karlovassi basin, Samos Island, Greece, Economic Geology Vol. 84, pp.788-798.

Theodoropoulos D, D., 1979. Geological map of Greece 1:50,000, sheet Neon Karlovassi. IGME publication, Athens.

Theodoropoulos D., 1979. Geological map of Greece 1:50000, sheet Vathi port , IGME publication, Athens.