

THE CORINE PROJECT ON SOIL EROSION RISK AND LAND QUALITY

Andrea Giordano

*Dipartimento di Economia e Ingegneria Agraria Forestale e Ambientale (DEIAFA),
Università di Torino, Italy.*

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Contents

1. Introduction
2. Methodological Approach
3. Factors affecting Soil Erosion Risk
 - 3.1. Soil Erodibility
 - 3.2. Erosivity
 - 3.3. Topography
 - 3.4. Vegetation Cover
 - 3.5. Potential Soil Erosion Risk
 - 3.6. Actual Soil Erosion Risk
4. Factors affecting Land Quality
 - 4.1. Soil Quality
 - 4.2. Climate Quality
 - 4.3. Topography
 - 4.4. Land Improvements
 - 4.5. Potential Land Quality
 - 4.6. Actual Land Quality
5. Data Collection and Retrieval
 - 5.1. Soils
 - 5.2. Climate
 - 5.3. Topography
 - 5.4. Vegetation Cover
 - 5.5. Land Improvements
6. Results
 - 6.1. The Corine Database
 - 6.2. Map Outputs
 - 6.2.1. Maps of Potential Soil Erosion Risk
 - 6.2.2. Maps on Actual Soil Erosion Risk
 - 6.2.3. Maps on Potential Land Quality
 - 6.2.4. Maps on Actual Land Quality
7. Applications
8. Limitations and Constraints
9. Conclusions
- Glossary
- Bibliography
- Biographical Sketch

Summary

Problems of land resources are acute in the Mediterranean region. Good quality land is scarce, and often negatively affected by inadequate use. Soil erosion is encouraged not only by physical conditions but also by agricultural intensification. Faced with these problems the European Commission has carried out a project to assess and map soil erosion risk and land quality, as a basis for policy formulation, within the context of the CORINE Programme. This paper describes the methods which have been developed, and indicates the achieved results. It is concluded that, whilst problems of data availability have meant that the methods are inevitably no more than a first approximation, the project represents the first genuine attempt to provide consistent information on soil erosion risk and land quality for policy applications at the European level. As such it both helps to highlight future research needs and forms a basis for a more adequate policy on land resources conservation.

1. Introduction

The CORINE (COoRdination INformation Environment) programme promoted by European Community DG XI "Environment, Consumer Protection and Nuclear Safety" is the continuation of the previous programme "Ecological Cartography of the European Community" (1977). Its main objective was to collect, treat and manage the environmental data to be utilized primarily for the definition of relevant environmental problems: biotopes inventory, acid rains, atmospheric pollution, water pollution, soil erosion and land quality in the European Community. These problems are mainly concerned with:

- The development of sustainable policies at national, communitarian and international levels;
- The integration of policies related to agricultural or industrial land use and urbanism, leading often to synergies and conflicts,
- The impact on natural systems (habitats, ecosystems, hydrological cycles, landscapes, etc.),
- And interactions with the atmosphere and with local and regional climate.

The CORINE programme includes also the development of a Geographic Information System (GIS) and the exchange of data.

Since soil erosion risk and land quality are extremely important in Southern Europe due to its mountainous structure, its rainfall intensivity and irregularity, and its long land use history, a special project has been carried out in the framework of CORINE. The aim and objectives of this "Corine Erosion Risk and Land Quality Project" was to associate soil erosion risk with land quality conditions. The concept of soil erosion risk involves two major facets: the physical phenomenon related to soil erosion and the economical loss due to land quality changes. Both aspects must therefore be studied in an integrated way in land use planning.

The project had been officially presented in Luxembourg in 1992.

2. Methodological approach

The methodology and the technical aspects of the project are mainly extracted from the publications by Giordano et al. (1991) and EC-DG.XI (1992). The methodological approach included three main phases:

- (a) The collection of basic information on land quality and soil erosion risk. This work was achieved from 1987 till 1990 by national working groups in Portugal, Spain, France, Italy and Greece. Data were collected and interpreted according to appropriate guidelines and conclusions were submitted to an international steering group.
- (b) Integration of the data into an informatisation system that was at the same time consistent and coherent to analyze and to map land quality and soil erosion at a scale suitable for actions. In this respect it became clear that the availability of basic data in the European Community (and especially in the southern regions) was often very limited. Lack of consistent data has therefore limited the quality of the final results obtained.
- (c) Evaluation and validation of methodologies and results in order to define future needs for research and to develop, extend and ameliorate the present land quality and soil erosion risk assessment. Once the results (mainly maps) had been validated they were transmitted to the GIS working group for digitization and integration into the CORINE database.

The geographic extent of the study also represents a major consideration. The area concerned covers the whole of the southern region of the European Community, south of 46°N – an area of approximately 1.2 million km². Clearly, to cope with such a large area, an analysis must be carried out at a relatively small scale. On the other hand, the Mediterranean region is highly variable and shows an important geographical diversity. Soil erosion and land quality both vary at the local scale and over-generalization must be avoided, especially when data are used for policy applications. For these reasons, the analysis was made at a scale of 1:1 million, providing thus a maximum resolution of about 1 km in real space. This level of resolution is obviously low, but constitutes a fair compromise between the availability of data and the objective of a 'first approximation'.

3. Factors affecting Soil Erosion Risk

The assessment of the soil erosion risk was based upon the principles and parameters defined in Wischmeier's Universal Soil Loss Equation (USLE):

- (i) Soil erodibility (factor K), itself a function of soil properties such as texture, organic matter content, permeability and structure (Wischmeier, Johnson and Cross 1971);
- (ii) Rainfall erosivity (R), computed in the USLE as the total rainfall kinetic energy of a given event multiplied by the kinetic energy of a maximum 30-minute storm (Wischmeier and Smith 1965);
- (iii) The topographic factor: slope angle (S) in %, multiplied by slope length (L) in m;

- (iv) Vegetation cover (C) taking account of both vegetation density and structure;
- (v) Management practices (P), including methods of cultivation, soil conservation practices, etc.

The results were then entered into the equation: $E = K \cdot R \cdot SL \cdot C \cdot P$ to calculate soil loss (E). For a number of reasons, however, the model could not be used in its original form. These reasons include, amongst others:

- (i) The model was developed specifically for USA conditions, and Wischmeier himself has warned against its use elsewhere without appropriate modification;
- (ii) The model was initially developed for use at a local scale, and as a basis for practical farm advice, as opposed to the more general regional scale and broader policy applications required here;
- (iii) The stringent data demands of the original method would never be achievable for much of the Southern regions of the European Community.

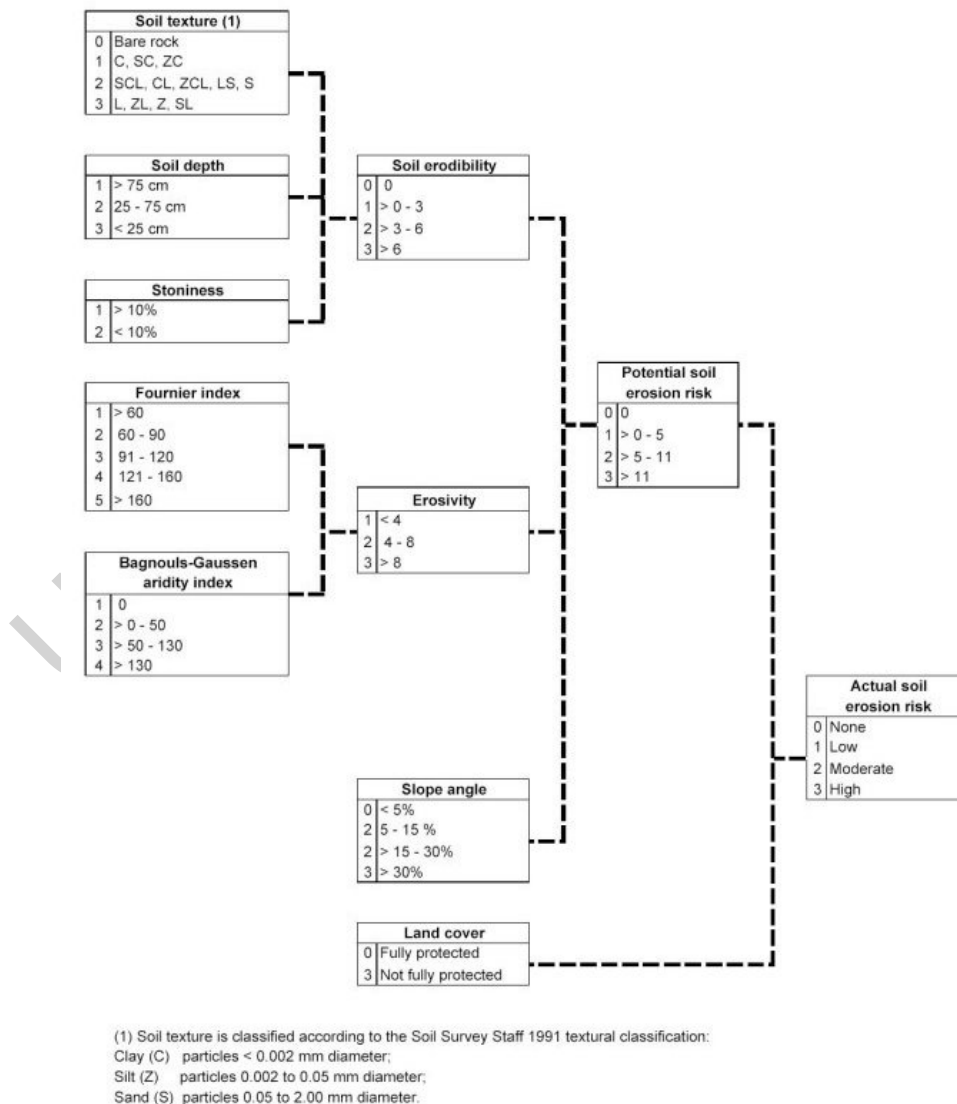


Figure 1: Soil erosion assessment methodology (EC-DGXI, 1992).

Consequently, the project team endeavored to modify and adapt the model to meet the requirements of this project. The method that was finally adopted is shown in Figure 1. As can be seen, the method of assessment relates only to soil erosion by rainfall (wind erosion is excluded), and it involves a separate assessment of two different (though related) indices of soil erosion risk:

- (i) Potential soil erosion risk which is taken to represent the inherent susceptibility of the land to erosion; it is derived from the basic physical factors of soil climate and topography;
- (ii) Actual soil erosion risk which refers to the risk of erosion under current land use and vegetation conditions; it is determined by adjusting the potential soil erosion risk to take account of the protection afforded by the present land cover.

3.1. Soil Erodibility

Soil erodibility refers to the susceptibility of the soil to erosion. Considering that the main source of information is the soil map of Europe the available data concerned with the soil erodibility are texture, depth and the amount of stones.

In terms of texture, soils in the sandy clay, clay or silty clay classes are regarded as being of inherently low erodibility, due to their high cohesiveness. In contrast, sandy loams, loams, silty loams and silts are considered to be highly erodible since they typically lack cohesiveness and have low structural stability whilst still permitting significant overland flow.

Soil depth is assumed to be an important factor in soil erodibility for two reasons. Firstly, deep soils typically absorb and hold larger volumes of water than shallow soils, and thereby generate overland flow less readily. Secondly, soil loss tends to be less damaging in deep soils because of their greater tolerance to erosion.

Stoniness, also, may be significant, though its effect varies according to circumstances: a surface cover of stones may protect the soil from rain splash but, once runoff is initiated, the stones may cause turbulence and thereby encourage rill formation.

Soil erodibility is calculated as the product of these three attributes, as follows:

Soil erodibility index = texture class x depth class x stoniness class

The index (Fig. 1) derived from the above calculation can be adjusted by up to one class on the basis of the following modifying factors:

- (i) Organic matter content – high organic matter contents are assumed to increase structural stability, and thus reduce the soil erosion index by one class;
- (ii) The presence of nearby bedrock areas are assumed to cause runoff to spill onto the surrounding soils, thereby increasing erosion risk. The soil erosion index is thus increased by one class.

Both of these modifying conditions are based on expert judgment. To ensure

transparency of the method, however, any such modification is fully annotated on the base maps.

3.2. Erosivity

Erosivity of the environment is primarily a result of climatic conditions. Traditionally, rainfall intensity is considered to be the major determinant of erosivity and, therefore, the USLE assesses erosivity on the basis of maximum 30 minute rain intensity. This approach relies, however, on the availability of detailed rainfall data, and those do often not exist for most of the area studied. It also assumes that runoff is primarily a result of Hortonian overload flow, which is not universally valid. Hence, in this study two alternative indices were used to characterize erosivity: a modified version of the Fournier Index (Fournier 1960), and the Bagnouls-Gaussen Xerothermic Index (Bagnouls and Gaussen 1953).

The modified Fournier index is defined as:

$$FI = \frac{\sum_{I=1}^{12} pi^2}{P}$$

where: pi is the precipitation total in month i , and P is the mean annual precipitation total.

Correlation between the Fournier index and the USLE rainfall erosivity index is relatively weak (Gabriels, 1989). Nevertheless, a broad relationship has been demonstrated, at least at the catchment scale (Arnouldous 1977). It is worthy of note that FAO-UNEP-UNESCO (1987) uses the Fournier index for assessing the risk of soil erosion in maps at scale 1:5 million.

Whilst the Fournier index is believed to give a broad estimate of rainfall concentration, it is not considered satisfactory as a measure of erosivity in its own right. In particular, it can be argued that, in Mediterranean areas especially, aridity tends to encourage erosion by reducing vegetation cover and exposing the soil surface to raindrop impact (splash erosion).

Consequently, to strengthen the assessment of erosivity, a second climatic index was included: the Bagnouls-Gaussen aridity index (BGI). This is defined as follows:

$$BGI = \sum_{i=1}^{12} (2ti - pi) \cdot ki$$

where: ti = mean temperature ($^{\circ}C$) in month i , pi = precipitation total (mm) in month i , ki = proportion of month i for which $2ti - pi > 0$

The value range of the Bagnouls and Gaussen aridity index goes for the Mediterranean countries from 0 (humid) to 130 and more (very dry).

These two climatic indices are classified and combined to give the erosivity index:

Erosivity index = Fournier value x Bagnouls and Gaussen value

3.3. Topography

In the Universal Soil Loss Equation, the topographic influence on soil erosion is computed through a compound “slope angle-slope length” index. This reflects the circumstances that runoff velocity tends to increase with slope angle, while runoff volume increases with slope length. In the present study, however, the use of slope length was considered inappropriate due to the scale of analysis and the difficulties of data acquisition. Instead, a simple index of slope angle was used.

Computations were made for a 1 km² grid covering the entire study area. Due to the different procedures in calculating the slope angle (see 2.3.3.), comparisons between different Member States should therefore be made with care. Slope angle, as thus measured, is then classified as presented in Figure 1.

3.4. Vegetation Cover

Vegetation cover presents possibly the most crucial element in the erosion model, since it is the only factor that can be altered. Hence, it provides the main opportunity for erosion control. Ideally, detailed and reliable information on land use and vegetation cover needs to be available as an input to the model. At the scale of analysis used here, this was unfortunately not feasible. Available maps on land use and vegetation cover were generally much generalized, seldom consistent from one area to another, and often out of date.

Remote sensing has not been applied sufficiently to provide the data required (although the CORINE land cover project has been able at that time to supply data for Portugal). Instead, and solely as an interim measure, a simple binary classification of vegetation cover has been used:

Vegetation Index	Description	Vegetation type
1	Fully protected	Forest, permanent pasture and dense scrub
2	Not fully protected	Cultivated or bare land

3.5. Potential Soil Erosion Risk

As indicated in Figure 1, the potential soil erosion index (PSER) is calculated as:

$$\text{PSER} = \text{soil erodibility index} \times \text{climate index} \times \text{slope index}$$

This is classified into an erosion scale, ranging from 0 (no potential soil erosion risk – bare rock) to 3 (high erosion risk). This indicates the inherent risk of soil erosion on the basis of the physical environmental conditions, independently of current land use. Because it does not take into account the potential protective role of vegetation, it thus represents a ‘worst possible case’ scenario and can be interpreted as the erosion risk assuming the absence of any protective measures.

3.6. Actual Soil Erosion Risk

The actual soil erosion risk index relates to the current risk of erosion under the present vegetation and land use conditions. It is derived by modifying the estimated potential soil erosion risk index according to the vegetation cover, as follows:

Potential soil erosion risk index		None	Low	Moderate	High
		0	1	2	3
Vegetation index	1	0	1	1	2
	2	0	1	2	3

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Biographical Sketch

Andrea Giordano is an Associated Professor at the Faculty of Agronomy, University of Torino, Italy. He holds a "*Laurea in Agraria*", University of Florence, Italy (1958) and a M.Sc. in Soils, University of Wisconsin, USA (1965).

He has been active for thirty years both in private companies and in the FAO as expert. Since 1988 he is Associated Professor of Pedology at the University of Torino. His research is mainly directed toward soil survey and cartography, land evaluation, desertification, and soil erosion. He has been the team leader of the EU project "Soil Erosion Risk and Important Land Resources in the Southern European Countries"(1986-1992) in the framework of the Programme CORINE (COoRdination Information Environment). His didactic activities concern, besides the Faculty of Agronomy, the Professional Master "Geomatics and Natural Resources Evaluation" at the IAO (*Istituto Agronomico per l'Oltremare*), the course of Pedology at the Polytechnical School of Torino, the international course "Hydroaid" at the ILO (International Labour Organization) and the Master in Environmental Engineering at the COREP (*Consorzio Educazione Permanente*).

He has directed or has participated to projects and courses in several Developing Countries in Africa, South America and Asia.