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Regional soil erosion risk mapping in Lebanon

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Abstract

Soil erosion by water is one of the major causes of land degradation in Lebanon. The problem has not yet been treated in detail although it affects vast areas. This study elaborates a model for mapping soil erosion risk in a representative area of Lebanon at a scale of 1:100,000 using a spatial database and GIS. First, three basic maps were derived: (1) runoff potential obtained from mean annual precipitation, soil-water retention capacity and soil/rock infiltration capacity; (2) landscape sensitivity based on vegetal cover, drainage density and slope; and (3) erodibility of rock and soil. Then two thematic maps were derived: potential sensitivity to erosion obtained from the runoff potential and landscape sensitivity maps, and erosion risk based on the potential erosion and erodibility maps. The risk map corresponds well to field observations on the occurrence of rills and gullies. The model used seems to be applicable to other areas of Lebanon, constituting a tool for soil conservation planning and sustainable management.

Keywords: Water–soil erosion; Erosion modelling; Land degradation; GIS; Risk assessment; Lebanon

1. Introduction

Soil erosion is a serious geo-environmental issue causing land degradation in sub-humid to arid Mediterranean countries including Lebanon. It causes damages to vulnerable agricultural lands having shallow soils with low organic matter content, water pollution by soil particles and chemicals, and mudflows which may affect urban areas (Poesen and Hooke, 1997). FAO (1986) indicates that erosion rates in the Lebanese mountainous areas reach 50–70 tons ha^{-1} $year^{-1}$, which far exceed the rate of pedogenesis under the Mediterranean climate. Some agricultural areas have already declined due to soil erosion. It is necessary to establish soil conservation measures which can reduce land degradation and assure a sustainable management of soil resources. The implementation of effective soil conservation measures has to be preceded by a spatially distributed erosion risk assessment (Moussa et al., 2002; Souchère et al., 2005).

Previous studies on soil resources in Lebanon have dealt with soil classification and distribution (Darwish and Zurayk, 1997; Darwish et al., 2002) as well as some aspects related to land degradation (Khawlie et al., 2002). However, quantitative studies on erosion processes in Lebanon have been scarce. Although general situations of soil-water erosion in Lebanon have been described (Ryan, 1983; Khawlie, 1991; Zurayk, 1994; Bou Kheir et al., 2001, 2003), mapping erosion risks at a regional scale (e.g., 1:100,000) has not been performed. At a regional scale, large spatial variabilities of

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landscape characteristics such as land use, topography, soil and climate inhibit the application of complex models established from localised measurements at small experimental plots (Kirkby et al., 1996; Renschler and Harbor, 2002). Therefore, proper soil erosion mapping based on advanced information techniques including remote sensing (RS) and Geographic Information Systems (GIS) is needed.

In Mediterranean Europe, empirical soil erosion models such as the CORINE (CORINE, 1992) and more deterministic models such as PESERA (Gobin and Govers, 2001) have already been used at a regional scale. The CORINE model is based on the USLE (Wischmeier and Smith, 1978) which was not originally developed for regional applications, and it tends to overestimate the effect of slope (Wischmeier and Smith, 1978; Gobin et al., 2003). The PESERA model was elaborated using European data and is thus mostly valid for European soils (Le Bissonnais et al., 2005), but its applicability to other areas is uncertain. It seems necessary to develop a "cognitive" soil erosion model for Lebanon based on factors influencing soil-water erosion. In this context, the objective of this study is to provide a soil erosion risk map of a representative region of Lebanon and to evaluate its accuracy. Available data from existing maps, satellite images and local expert knowledge are combined based on qualitative decision rules and hierarchical organization of effective parameters in order to define homogeneous response units in terms of the severity of erosion risk.

2. The study area

The study area (955 km^2; Fig. 1) corresponds to 9% of the total area of Lebanon. It represents the environmental diversity of the country in terms of geology, soil, hydrography, land cover and climate. It extends from west to east Lebanon with three major landform zones: coastal (<100 m altitude), the Lebanon mountainous chains (100 to >1500 m) and Bekaa Valley (500–1500 m).

Geology of the study area comprises mainly of sedimentary rocks (Jurassic, Cretaceous, Tertiary and Quaternary) with minor occurrence of basaltic rocks (Dubertret, 1945). Thirty-two soil units occur in the study area according to a 1:200,000 soil map (Gèze, 1956). The majority of rain and snow (75–85%) falls between November and April, and the rest

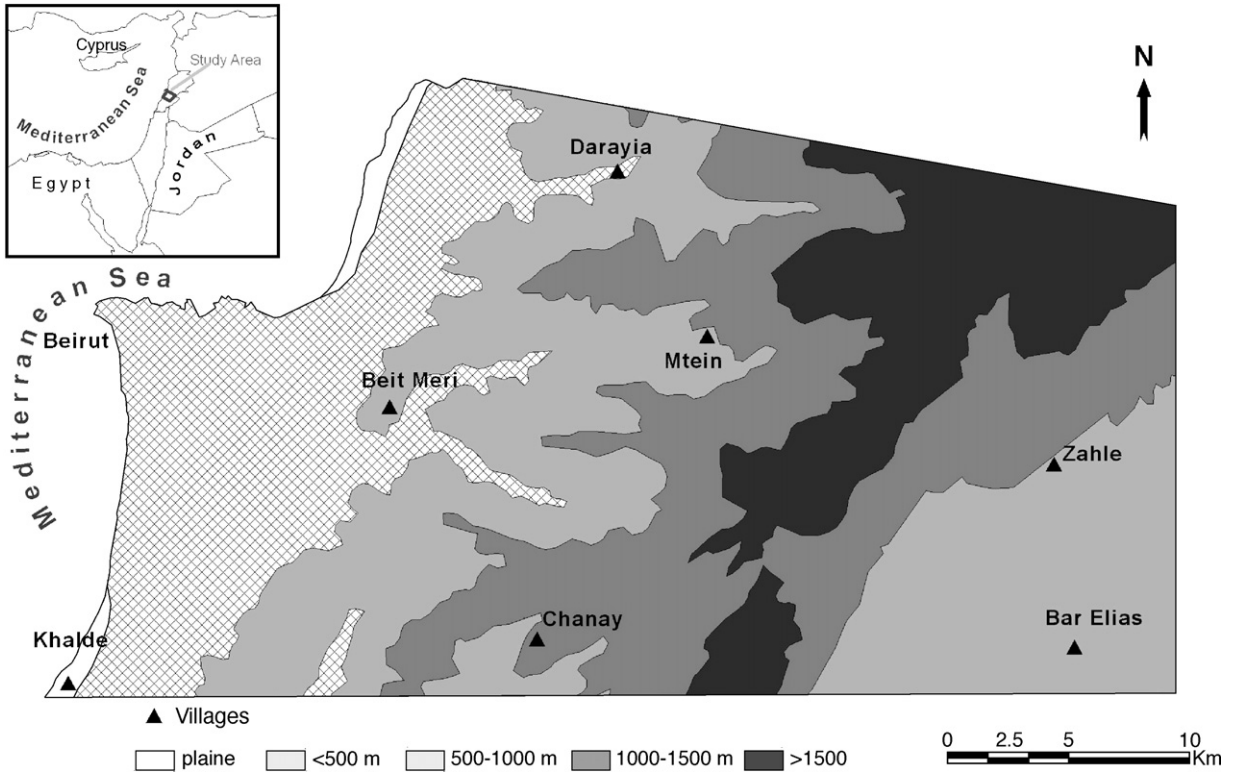

Fig. 1. Location of the study area within Lebanon.