Chapter VIII

Assessing the Impacts of Land Use Policy on Soil Erosion Risk: Possibilities and Constraints of Geographical Information Systems

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INTRODUCTION

Soil erosion is regarded as a major and widespread soil degradation process. The consequences of soil erosion occur both on- and off-site. On-site consequences are particularly important on agricultural land where the redistribution of soil within a field, the loss of soil from a field, the breakdown of soil structure and the decline in organic matter and nutrients result in a reduction of the cultivable soil depth and a decline in soil fertility (Morgan, 1996). Off-site problems result from sedimentation downstream which reduces the capacity of rivers and drainage ditches, enhances the risk of flooding, blocks irrigation canals and shortens the design life of reservoirs (Verstraeten and Poesen, 1999). Sediment is also a pollutant in its own right, and through the chemicals absorbed it can increase the levels of nitrogen and phosphorus in water bodies and result in eutrophication (Steegen et al., subm.). The rate of soil loss is normally expressed in units of mass or volume per unit area per unit time. Young (1969) quotes annual rates of the order of 0.0045 Mg ha^{-1} for areas of moderate relief and 0.45 Mg ha^{-1} for steep relief. For comparison, rates from

agricultural land are in the range of 5 to 500 Mg ha^{-1} (Morgan, 1996; Van Rompaey et al., 2000).

Erosion and land use change are strongly related. Because of the intensification of agricultural activities in most parts of the world, the severity, frequency and extent of this environmental problem increased significantly over the last decades. Therefore erosion assessment is an important aspect to consider in the development of an integrated water management policy. It is not surprising that the soil erosion problem became an important topic on the agenda of the policymakers both at national and supranational level. A well-founded land resource management policy requires that the dynamic relationship between agriculture and the environment is quantified at a regional scale. Policymakers therefore need adequate tools and models to assess and evaluate the impact of land use policies on soil erosion. Information is needed by planners about the impact of the effect of landscape changes and about the best possible types and locations for erosion control measures.

Until now many scientists have concentrated on the development of a theoretical structure for soil erosion models and have tried to fill the gaps in our understanding of hydrological and soil erosion processes. As a consequence, these models are characterised by a detailed process description and a high temporal resolution. However, the application of existing soil erosion models at a regional scale was hitherto not very successful (Jäger, 1994, De Roo, 1998; Van Rompaey et. al. 1999). Reasons for the disappointing results of existing models must be sought in:

(i) The uncertainty involved in estimating and measuring the large number of input variables for these complex models at a regional scale. The uncertainty is sometimes summed so that the model output contains more noise than significant information. Often it is not even known what the magnitude of this uncertainty is.

(ii) The limited spatial detail of these models. Most models can be used to study the effect of temporal changes within a given parcel or small land unit in detail. However, they can not deal with the increasing spatial complexity of topography and landscape structure when upscaling from a single plot or field to a watershed or regional scale.

These limitations are unreconcilable to the needs of policymakers who are especially interested in the spatial patterns of long to midterm erosion rates and an estimate of their accuracy.

This chapter presents a modelling structure that allows assessment of the effect of landscape structure changes on soil erosion by water and tillage on a watershed scale. The model emphasises a good prediction of two-dimensional patterns of soil redistribution while process description is rather simple. Furthermore it is illustrated how aggregation strategies can be used to produce reliable results at a regional scale. The integration of this model with a Geographical Information System (GIS) makes it a flexible tool for the assessment of the impact of different environmental policy decisions. In the first part the modelling structure and its integration in a GIS is described. In the second part its use in environmental decision making is illustrated in a case study: the impact of the European set-aside policy on the regional soil erosion risk.