Chapter 5
Spatial Analysis of Soil Erosion in the Ceyhan Basin (Turkey) With GIS and the RUSLE Model

Ersin Ateş
http://orcid.org/0000-0002-1956-2017
Ankara University, Turkey

ABSTRACT

The RUSLE model applied in the Ceyhan Basin revealed a heterogeneous erosion pattern driven by topography, land use, and rainfall erosivity. Low R-factor values dominate the northern plains, while Mediterranean influence increases erosivity in the south. Moderate erodibility soils cover most of the basin, yet steep slopes with high LS values form critical hotspots. Protective land cover remains limited, and more than half of the basin lacks conservation practices. As a result, although 60% of the basin experiences low erosion, nearly 13% shows extremely high soil loss, mainly in areas where steep gradients, weak vegetation, and inappropriate land-use practices overlap. These findings highlight the need for targeted conservation strategies and spatially informed land-management planning.

INTRODUCTION

Healthy soil structure is essential for the functioning of ecosystems and for meeting fundamental human needs (Borrelli et al., 2017). Although soil is vital for the continuation of human life, soil erosion induced by human activities threatens food security, land productivity, and socioeconomic systems worldwide (Borrelli et al.,

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2017). Soil provides approximately 95% of global food supply, making it one of the most critical components of human well-being (FAO, 2016). The increase in global population further intensifies pressure on soil resources by expanding demands on natural resources and agricultural lands (Foley et al., 2011).

A global assessment showed that soil erosion reached 35 billion tons per year in 2001, and increased by 2.5% to 35.9 billion tons per year by 2012 (Borrelli et al., 2017). In 2001, the highest soil erosion rates were observed in South America (3.53 tons/ha/year) and Asia (3.47 tons/ha/year), while by 2012 the most significant increase occurred in Africa, where erosion rates rose to 3.88 tons/ha/year (Borrelli et al., 2017, 2020). A United Nations study conducted in 2016 reported that approximately 33% of the world's soils are moderately to highly degraded. The same report indicated that agricultural lands lose an estimated 75 billion tons of soil annually on a global scale, and that erosion alone results in an annual loss of 7.6 million tons in cereal production (FAO, 2016).

Turkey has a predominantly rugged and mountainous topography, with an average elevation of 1,250 m, and 62% of its land surface exhibiting slopes greater than 15% (Imamoglu and Dengiz, 2017; TOKB, 1987). Each year, approximately 642 million tons of soil are displaced in Turkey—equivalent to about 2.5 times the total area of the country's agricultural lands (24 million ha)—which corresponds to 20 tons of soil becoming unusable every second (Erpul et al., 2018). Nationwide assessments indicate that 60.28% of Turkey's surface area experiences very slight water erosion, 19.13% slight, 7.93% moderate, 5.97% severe, and 6.7% very severe erosion (Erpul et al., 2018, 2020). These values reveal that 41% (99,400 km^2) of cultivated agricultural lands are subject to severe or very severe water erosion, posing a significant threat to agricultural sustainability. In terms of land-use categories, water erosion in agricultural areas predominantly occurs at very slight (44.3%) and slight (28.78%) levels, while moderate (11.91%), severe (8.2%), and very severe (6.37%) erosion are relatively limited. In contrast, rangeland areas exhibit notably higher proportions of moderate (13.59%), severe (11.57%), and especially very severe (17.2%) erosion, indicating that rangelands are more vulnerable to erosion processes (Erpul et al., 2018).

According to the GASEMT database, which compiles 24 different erosion models (Borrelli et al., 2021), the RUSLE model is the most widely used soil erosion estimation method globally, with a utilization rate of 17.1% (Bezak et al., 2021). Empirical models such as RUSLE have been employed extensively for assessing erosion risk in large river basins (Burrough, 1986). Advances in geographic information systems (GIS) and remote sensing (RS) have enabled the development of more cost-effective and scalable approaches for environmental analyses, facilitating applications over larger areas with improved accuracy (Imamoglu and Dengiz, 2017; Millward and Mersey, 1999; Wischmeier and Smith, 1978). The RUSLE approach is preferred