

Soil Erosion Measurement Techniques and Field Experiments, 2nd Edition

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1. Introduction

The soil erosion processes involve the detachment of soil particles from the soil surface, followed by their transport by erosive agents, such as rainfall, overland flows, and channelized flows (rills, ephemeral gullies, and gullies) [1–3]. Soil erosion determines a decrease in soil organic matter and nutrients, with a consequent reduction in soil productivity in both natural and anthropogenic ecosystems [4,5]. Other on-site consequences of soil erosion include reduced cultivable soil layer depth and degradation of soil structure [6]. Erosion also determines off-site impacts caused by soil particles entering the water system, such as contamination from chemical pesticides and fertilizers, eutrophication of waterways, siltation of reservoirs with a consequent loss of storage, and sedimentation into channels [7].

To comprehend and implement accurate soil erosion models, precise and consistent measurements of erosion processes are necessary [8]. Experiments offer a chance to examine the degree to which the ideas employed in models accurately describe the erosion processes taking place.

The objective of the second edition of this Special Issue was to combine manuscripts concerning (1) experimental areas for soil erosion measurements at different spatial scales (plot, hillslope, and basin), (2) field experiments for studying the soil erosion in its different forms (interrill, rill, and gully erosion), and (3) innovative techniques and procedures (e.g., tracers, three-dimensional photo-reconstruction, and aerial and terrestrial acquisition platforms) for measuring soil erosion processes.

2. Main Contributions of the Special Issue

This Special Issue brings together nine papers (eight research articles and one review) that explore different aspects of soil erosion processes. The contributions examine cause–effect relationships, propose new predictive models, and analyze how factors such as rainfall and agricultural practices influence erosion. Both rill and gully erosion are addressed, alongside studies on interrill erosion and sediment deposition.

The importance of measuring soil erosion at the field scale is underlined by the only review included in this Special Issue. This review by Nicosia et al. [9] reports recent scientific developments on the measurement of rainfall erosivity, soil loss at the plot scale, and rill and gully erosion using close-range photogrammetry. A critical analysis of all the literature papers leads to the conclusion that the available techniques can be considered a solid basis, which, however, could still be improved.

Among the research papers, those by Čupić et al. [10] and Ghaderi Dehkordi et al. [11] deal with erosion and sedimentation tracing by using the radioisotope cesium-137 (¹³⁷Cs).



Received: 15 December 2025

Accepted: 12 January 2026

Published: 13 January 2026

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In particular, the first [10] assessed soil erosion intensity and soil properties across the Crveni Potok catchment in Serbia, based on ^{137}Cs activities and the profile distribution model. These authors found a significant negative correlation between erosion rates, soil organic matter, and indicators of soil structural stability, and compared the applied model with the RUSLE (Revised Universal Soil Loss Equation) one, finding similar mean erosion rates but significantly different median values. The second [11], instead, employed geochemical tracers and ^{137}Cs to assess sediment contributions in a small sub-basin located in western Iran to quantify how various land uses (i.e., rangeland, rainfed agriculture, irrigated agriculture, and orchards) contribute to sediment yield over time. The findings revealed significant changes in sediment yield contributions over the past 60 years in dependence of land use.

Only the paper by Chen and Wu et al. [12] deals with interrill erosion, studying the impact of antecedent soil moisture content on the loss of clay soil through two-year runoff plot experiments under natural rainfall. The main result of this study showed that the impact of antecedent soil moisture on interrill erosion is conditional, and the impact only exists in erosion events with a low rainfall–runoff erosivity index.

The article by Li et al. [13] studied the sediment deposition characteristic of ecological riverbanks associated with vegetation restoration in the deep waterway regulation scheme of Yangtze River, by using two types of typical ecological riverbanks (i.e., lattice gabion ballasted vegetation mat riverbank LGBVR and mesh grid riverbank MGR) and a traditional riprap riverbank (TRR). The findings demonstrated that the ecological restoration effect of the LGBVR was better than that of the mesh grid riverbank (MGR), while that of the TRR was relatively poor.

The paper by Todisco et al. [14] studied the spatio-temporal dynamics of rainfall erosivity in the Umbria region (Italy), using a wide database of 30 min precipitation records from 54 stations collected for 20 years. In particular, using the RUSLE2 framework, the authors evaluated models of varying complexity to estimate the R-factor (the original model, or models based solely on event rainfall depth or daily rainfall depth). All the models showed consistency in the spatial and temporal patterns of the R-factor, revealing that most of the annual erosivity is concentrated in the summer because of the high average intensity of rainfall events.

Rainfalls were also studied from another point of view in the paper by Caruso et al. [15], who characterized a rainfall simulator originally designed to assess the erosive effects of precipitation on heritage surfaces. Using volumetric methods and disdrometric techniques with a Parsivel2 optical disdrometer, the study confirmed that the simulator generates rainfall velocities comparable to natural rainfall. The authors highlighted the value of combining multiple measurement approaches to improve accuracy and reliability.

Lu et al. [16] investigated the spatial coupling between geohazard susceptibility and soil conservation capacity in Guangdong Province, China, using integrated spatial analysis and machine learning approaches. Through kernel density estimation, hotspot analysis, principal component analysis, and t-SNE clustering applied to 11,252 geohazard records and nine soil conservation factors, they identified some critical mechanisms.

Finally, Rodrigo-Comino et al. [17] combined controlled field experiments with proximal remote sensing-derived geomorphometric variables and machine learning to identify key factors of erosion in a Mediterranean citrus orchard located close to Seville and the National Park of Doñana (Southern Spain) on Gleyic Regosols (clayic, arenic). Results showed that soil loss was most strongly linked to maximum compaction and hydraulic conductivity, while sediment concentration increased with surface compaction but had weak correlations with topography. Runoff decreased with average infiltration, which is tied to compaction. The study concluded that integrating standardized field protocols with

proximal morphometrics and machine learning is an efficient way to prioritize explanatory variables, reducing experimental effort while maintaining explanatory power.

3. Concluding Remarks and Future Perspectives

The papers collected in this Special Issue highlight the complexity of soil erosion processes and the diverse methodologies available to study them, ranging from isotopic tracing and rainfall simulation to machine learning and spatial analysis. Together, they demonstrate that integrating traditional field measurements with innovative technologies can significantly improve our understanding of erosion dynamics across scales and land uses. The novel and significant results of these studies will aid in the investigation of soil erosion and the comprehension of the dynamics of certain processes related to this subject. The selected articles contribute to our understanding of how water soil erosion can be managed and minimized. They may also provide more insights into future research directions and the primary obstacles in this area of study. Looking ahead, future research should focus on refining measurement techniques, enhancing predictive models through interdisciplinary approaches, and promoting the application of advanced tools such as remote sensing and artificial intelligence. Strengthening the link between scientific advances and practical land management strategies will be essential to mitigate erosion risks, safeguard ecosystems, and ensure sustainable agricultural and environmental practices.

Author Contributions: Writing—original draft preparation, V.F. and A.N.; writing—review and editing, V.F. and A.N. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflicts of interest.

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