Soil Water Erosion

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1. Introduction

Soil erosion by water is considered to be one of the major forms of soil degradation (other than soil erosion by wind, acidification, salinization, desertification, etc.) and causes the majority of problems related to the degradation of soil resources, leads to the largest amount of soil loss, and covers the greatest extent of areas affected worldwide [1]. This subject is very wide, and there are even many forms of soil water erosion, from splash erosion to gully erosion and sedimentation. It would be worth running a Special Issue just one the numerous soil erosion models now available. As the final product of soil water erosion, sedimentation has been investigated by many interested parties. Each one of these related issues would be worth a separate Special Issue, as all keywords listed have been investigated by many researchers and have been the subject of many papers published in various journals. There have been efforts to provide a wider view of problems related to erosion, such as non-agricultural uses—e.g., industrial pollution and contamination; the disposal of wastes; the restoration of polluted and degraded areas; and recreational uses [2]. The IPCC Report [3] also describes numerous issues relating to desertification, land degradation, sustainable land management, and their interlinkages in some of its chapters—e.g., land–climate interactions, land degradation, etc.

This is the reason why this Special Issue does not aim to serve as a collection on one very specific topic but rather to provide insight into a number of related topics, including soil erosion modelling using the classic USLE as well as more recent models; field research, including rainfall simulations; and mitigation technics and their related problems—e.g., the use of dams as sediment traps.

This Special Issue was also a subject of finding interested researchers. Who is submitting manuscripts and what types of papers are submitted and from which countries? On the one hand, the time of researchers is limited and, on the other hand, most researchers wish to reach the widest possible audience, so it was rather difficult for someone to decide if they wanted to publish in this Special Issue or another. We feel that the purpose of this Special Issue was achieved, as various publications submitted showed a good variety of information on soil water erosion and novel analyses.

I hope that this Special Issue will provide new and useful information on the mitigation of soil water erosion-induced problems across the entire world. I also believe that, regardless of the localities used (which is an aspect that is often criticized when a paper is under review), many other countries under different climatic conditions as well as people in other geographical regions can learn from the presented results and methodologies and thus move closer to achieving degradation-free land use, as this it is the core interest of the population of Earth.

2. Summary of this Special Issue

Nowadays, as resources such as time and research personnel are limited, computer-based methodologies are receiving more attention and greater popularity. Perhaps this is also the reason why the first paper submitted to this Special Issue used machine learning

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techniques [4]. These techniques were used to investigate gullies—more precisely, gully head-cuts. A total of 119 gully head-cuts were identified and mapped in N.W. Iran. The authors found that, based on goodness-of-fit and AUROC (Area Under the Receiver Operating Characteristic is a performance metric that we can use to evaluate classification models) of the success rate curve (SRC) and prediction rate curve (PRC), the results indicate that the bagging-ADTree ensemble model had the best performance.

Following this approach, another gully erosion investigation was performed for land management purposes by another author from Russia [5]. Four models were used: two models calculated gully depth and width along with its longitudinal profile, while another two models were used for the novel modification of the area-slope approach, which gives the most probable position of possible gullies. The author suggested the use of the dynamic gully erosion model GULTEM (GULLy erosion and Thermoerosion Model) was recommended for calculations of gully geometry transformation in time and space for the most detailed projects of land management.

The third article related to gully erosion identified and assessed the areal and temporal changes of badlands in Italy [6]. The case study area was in the Modena Province (Emilia Apennines), which was important because there was no previous detailed investigation. The authors revealed a general stabilization trend of the badlands in the study area due to an intensified revegetation process around the badlands. This trend is mainly the result of intensive land-use changes—namely the increase in forest cover and the reduction in agricultural land (occurring in the study area from the 1970s onwards). There was another article related to gullies, but its main purpose was to handle sediment-related issues [7] which is also an important part of the whole issue.

Soil erosion models were used by various authors and some of the model details were also analyzed. Kreklow et al. [8] compared rainfall erosivity (R-factor) estimation methods with the utilization of weather radar data in Germany. Their results showed that R-factors have increased significantly due to climate change and that the current R-factor maps need to be updated. One of the possible options to accomplish this is using more recent and spatially distributed rainfall data.

Almohamad [9] used the RUSLE model to show the impact of armed conflicts on soil erosion through the land cover change in Syria. Land cover was decreased due to the increase in forest fires as a result of armed conflict. Damage to coniferous forest and transitional woodland and scrub, especially on steep slopes, had the biggest impact on factor C after the fire. The soil loss was 200% to 800% higher than it had been in the pre-fire situation.

Keller et al. [10] performed a rainfall simulation for soil erodibility calculation using various models, such as USLE (Universal Soil Loss Equation), RUSLE (Revised USLE), USLE-M (USLE Modified), and EPIC (Erosion-Productivity Impact Calculator). Based on the soil loss measured during the rainfall simulation, the authors found that the RUSLE model resulted in the best performance in event soil loss estimation.

Another type of field experiment was conducted by Li et al. [11], who were interested in the effects of infiltration on preferential flow characteristics and solute transport in a Chinese area. The impact of three precipitation amounts of 20, 40, and 60 mm was investigated. Solute concentration was found to peak around the end of the preferential flow path and when preferential flow underwent lateral movement. The results indicated that the infiltration volume and transport capacity of preferential flow had important effects on the distribution of Br^- and NO_3^- concentrations. The results can help in the management of protected forests in China.

Su et al. [12] analyzed the effects of thawing on the slope erosion and hydraulics in the sand-covered Loess Plateau in China. The authors conducted laboratory experiments on meltwater flow to quantify the temporal and spatial distribution of the hydraulic parameters of sandy soils concerning runoff and sediment yield under a constant flow on unfrozen and frozen slopes of variable sand thickness. Their results showed that sand can prolong the initial runoff time, and that unfrozen and frozen slopes have significantly

different initial runoff times. A significant linear relationship was found between the cumulative runoff and the cumulative sediment yield.

Lu et al. [13] went further than Su et al. [10] by investigating the effects of freeze–thaw cycling on the soil detachment capacities of three loamy soils on the Loess Plateau of China. After 20 freeze–thaw cycles, the degree of decline of silt loam was the greatest (77.72%), while sandy loam (63.18%) and clay loam (39.77%) showed smaller degrees of decline. The soil detachment capacity of silt loam and sandy loam was positively correlated with the freeze–thaw cycle and negatively with that of clay loam. The authors believe that their results can provide references for further studies on the mechanism of soil erosion in seasonal freeze–thaw regions.

The RUSLE model was used in numerous articles for estimating the sediment yield of certain areas. One of these estimations was conducted in the watershed of the Chenab River at the border of Pakistan and India [14]. The 30-year average annual sediment yield was estimated as 4.086, 6.163, and 7.502 million tons based on different approaches.

Gurmu et al. [15] simulated sediment influx using the RUSLE model and compared it to the amount of sediment removed during desilting campaigns. They found the sediment deposition rate to be 308 m³/km and 1087 m³/km, respectively, for the Arata-Chufa and Ketar schemes. The spatial soil losses amounted to up to 18 t/ha/yr for the Arata-Chufa scheme and 41 t/ha/yr for the Ketar scheme. The authors concluded that overland sediment inflow is not considered properly related to canal sedimentation, and this is a major cause of excessive sedimentation problems (among others) in Sub-Saharan Africa.

Jáchymová et al. [16] used the RUSLE-based WATEM/SEDEM model in their research. This modelling approach allowed for the modelling of sediment fluxes at 127,484 < risk points, meaning that a good coverage for the entire Czech Republic could be achieved. Risk points were defined for the study as follows: outlets of contributing areas 1 < ha, wherein the surface runoff enters residential areas or vulnerable bodies of water. The authors found that the most important factor for risk definition is a combination of morphometric characteristics (specific width and stream power index), followed by the watershed area, the proportion of grassland, the soil erodibility, and the rain erosivity (described by PC2).

Szabó et al. [17] analyzed the use of various rainfall simulators in the determination of the driving forces of changes in sediment concentration and clay enrichment. The authors compared a field and a laboratory rainfall simulator. They found that the slope gradient is an effective regulator only in the laboratory. Rainfall intensity was also more effective in the laboratory than in the field simulations. These findings suggest that soil-related properties play a prominent role in driving sediment concentration in the field, whereas, in the laboratory, slope and rainfall intensity were found to be driving factors independent of soil-regulated sediment concentrations.

As we can see, on the one hand, there is a great deal of information on soil water erosion-related issues; on the other hand, as we go into more detail, there are always new findings. After all, we can conclude that a lot more research is still needed [18] in order to find the relations between the factors leading to water erosion. These findings can help in mitigation. We highly encourage the creation of more Special Issues in this same field of research.

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References

1. García-Ruiz, J.M.; Beguería, S.; Nadal-Romero, E.; González-Hidalgo, J.C.; Lana-Renault, N.; Sanjuán, Y. A meta-analysis of soil erosion rates across the world. *Geomorphology* **2015**, *239*, 160–173. [\[CrossRef\]](#)
2. Lal, R. (Ed.) *Soil Quality and Soil Erosion*; CRC Press: Boca Raton, FL, USA, 2019. [\[CrossRef\]](#)
3. IPCC, 2019: Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems. Available online: <https://www.ipcc.ch/srccl/cite-report/> (accessed on 19 January 2022).
4. Arabameri, A.; Chen, W.; Blaschke, T.; Tiefenbacher, J.P.; Pradhan, B.; Tien Bui, D. Gully head-cut distribution modeling using machine learning methods—A case study of N.W. Iran. *Water* **2020**, *12*, 16. [\[CrossRef\]](#)
5. Sidorchuk, A. Models of gully erosion by water. *Water* **2021**, *13*, 3293. [\[CrossRef\]](#)
6. Coratza, P.; Parenti, C. Controlling factors of badland morphological changes in the Emilia Apennines (Northern Italy). *Water* **2021**, *13*, 539. [\[CrossRef\]](#)
7. Bai, L.; Jiao, J.; Wang, N.; Chen, Y. Structural connectivity of sediment affected by check dams in loess hilly-gully region, China. *Water* **2021**, *13*, 2644. [\[CrossRef\]](#)
8. Kreklow, J.; Steinhoff-Knopp, B.; Friedrich, K.; Tetzlaff, B. Comparing rainfall erosivity estimation methods using weather radar data for the State of Hesse (Germany). *Water* **2020**, *12*, 1424. [\[CrossRef\]](#)
9. Almohamad, H. Impact of land cover change due to armed conflicts on soil erosion in the basin of the Northern Al-Kabeer River in Syria using the RUSLE model. *Water* **2020**, *12*, 3323. [\[CrossRef\]](#)
10. Keller, B.; Centeri, C.; Szabó, J.A.; Szalai, Z.; Jakab, G. Comparison of the applicability of different soil erosion models to predict soil erodibility factor and event soil losses on loess slopes in Hungary. *Water* **2021**, *13*, 3517. [\[CrossRef\]](#)
11. Li, M.; Yao, J.; Yan, R.; Cheng, J. Effects of infiltration amounts on preferential flow characteristics and solute transport in the protection forest soil of Southwestern China. *Water* **2021**, *13*, 1301. [\[CrossRef\]](#)
12. Su, Y.; Li, P.; Ren, Z.; Xiao, L.; Wang, T.; Zhang, Y. Slope erosion and hydraulics during thawing of the sand-covered loess plateau. *Water* **2020**, *12*, 2461. [\[CrossRef\]](#)
13. Lu, J.; Sun, B.; Ren, F.; Li, H.; Jiao, X. Effect of freeze-thaw cycles on soil detachment capacities of three loamy soils on the loess plateau of China. *Water* **2021**, *13*, 342. [\[CrossRef\]](#)
14. Ali, M.G.; Ali, S.; Arshad, R.H.; Nazeer, A.; Waqas, M.M.; Waseem, M.; Aslam, R.A.; Cheema, M.J.M.; Leta, M.K.; Shauket, I. Estimation of potential soil erosion and sediment yield: A case study of the transboundary Chenab River Catchment. *Water* **2021**, *13*, 3647. [\[CrossRef\]](#)
15. Gurmu, Z.A.; Ritzema, H.; Fraiture, C.d.; Riksen, M.; Ayana, M. Sediment influx and its drivers in farmers' managed irrigation schemes in Ethiopia. *Water* **2021**, *13*, 1747. [\[CrossRef\]](#)
16. Jáchymová, B.; Krása, J.; Dostál, T.; Bauer, M. Can lumped characteristics of a contributing area provide risk definition of sediment flux? *Water* **2020**, *12*, 1787. [\[CrossRef\]](#)
17. Szabó, J.A.; Centeri, C.; Keller, B.; Hatvani, I.G.; Szalai, Z.; Dobos, E.; Jakab, G. The use of various rainfall simulators in the determination of the driving forces of changes in sediment concentration and clay enrichment. *Water* **2020**, *12*, 2856. [\[CrossRef\]](#)
18. Poesen, J. State of science. Soil erosion in the Anthropocene: Research needs. *Earth Surf. Process. Landforms* **2018**, *43*, 64–84. [\[CrossRef\]](#)