Summary of the Plenary Speech

Quantification of Soil Erosion as an Effective Tool for Environmental Conservation and Sustainable Development

Prof. Tilak Hewawasam
Department of Geography and Center for Environmental Sustainability, University of Peradeniya

Soil, the skin of the Earth, provides a multitude of ecosystem services critical for life on earth such as agricultural production, plant growth, animal habitation, biodiversity, carbon sequestration and environmental quality which are also vital for accomplishing the United Nations' Sustainable Development Goals (SDGs), specifically zero hunger (SDG 2), climate action (SDG 13), and life on land (SDG 15). Erosion, the removal of soil from Earth's surface, impedes the SDGs; hence improving soil quality through conservation is an integral step towards achieving the SDGs.

In the natural state, there is a balance between soil formation and erosion but mostly human interventions have broken this balance leading to what is known as 'accelerated soil erosion'. If this process is allowed to continue, the productive soil layer can be lost to the present and future generations to sustain their lives. The end result of accelerated soil erosion is degraded lands and regaining its productive potential is extremely difficult. A range of measures such as biological conservation techniques, terrain structural techniques and agronomic practices are widely applied to conserve the soil. Application of such conservation measures is always based on identifying erosional hotspots, where soil erosion rates have extensively exceeded the natural rates. Quantification of natural benchmark levels (natural erosion rates and/or the rate of soil formation) was a great challenge until the isotopic techniques were developed. A key objective of this presentation is to reveal the natural erosion rates and soil production rates in the Central Highlands of Sri Lanka, quantified through the measurement of in-situ produced cosmogenic nuclides in mineral grains with mass balance approaches. Then, the soil erosion rates derived from field measurements over short-term time scales, in anthropogenic landscapes, are compared with natural benchmark levels to show the magnitude of soil erosion in the hilly regions of Sri Lanka.

The Central Highlands of Sri Lanka is considered as the heart of the country, where all the rivers originate and supply water for hydropower, irrigation, engineering and domestic requirements. The region is located in the wet and intermediate climatic zones of the country. It is believed that a large part of the Central Highlands was completely covered with natural forest, mainly montane rain forests, before the British conquest in the early 19th century. Subsequently, the forest cover was cleared on a large scale for plantation agriculture leaving only segregated patches of natural rain forests at higher elevations. The soil production rates of the regolith in the Central Highlands were quantified as 10 mm/ky by measuring in-situ produced cosmogenic nuclides (*Hewawasam et al., 2013)*. The natural erosion rates in the Central Highlands, which integrate erosion over the 10-20x10^4 time scale, vary from 4 to 45 mm ky^{-1}. In contrast, short-term erosion rates derived for small catchments in Walawe, Kalu and Mahaweli Rivers using sediment yield data over a 1-10 y time scale range from 50 to 800 mm ky^{-1}. Comparison of these rates estimated over the two time scales clearly illustrates that erosion in the Central Highlands has increased up to 10 to 100 times over the natural benchmark levels due to recent increase in erosion by anthropogenic activities. When these short-term erosion rates are compared directly to the soil production rates determined at the regolith site, it can be concluded that soil is being lost at a rate of up to 100 times over its production rates. Hence, this comparison highlights the significance of implementing soil management activities in the human disturbed catchments to save this non-renewable resource of soil (*Hewawasam et al., 2003 and Hewawasam, 2010*).

In order to conserve soil, different types of conservation measures are applied at catchment scale, but their effectiveness is rarely evaluated by quantifying stream loads. Therefore, the second attempt of this presentation is to illustrate the effectiveness of soil conservation strategies with the aid of actually measured sediment loads in the stream before and during of two soil and water conservation projects in Sri Lanka. Mahaweli Authority of Sri Lanka embarked on two soil conservation projects in the Upper Uma Oya catchment, one of the tributaries of the Mahaweli River, from 1995 to 2005 along with monitoring of sediment yields in the stream. Soil loss measurements in the agricultural plots of the catchment and sediment yields in the stream measured before 1995 have revealed that soil erosion is intense in the catchment. In contrast, sediment yield measurements in the stream, after the implementation of conservation programmes in 1995, revealed that the suspended load in the stream had been reduced by a factor of five, emphasizing the effectiveness of soil conservation measures applied (*Diyabalanage et al., 2017)*.

Generally, erosion rates of agricultural plots or catchments are assessed in the field by applying different field based methods that integrate erosion over short-term periods or advanced techniques such as application of cosmogenic nuclides that integrate erosion on a long-term time scale. However, all of these methods are laborious, and hence it is challenging to apply them at a wider spatial scale to cover more field sites. Therefore, the tendency is to apply empirical models such as the Universal Soil Loss Equation (USLE), Revised Universal Soil Loss Equation (RUSLE) and Modified Universal Soil Loss Equation (MUSLE) to predict rates of soil loss in croplands and catchments as an indirect approach. The advantage of this approach is that it can be applied to any geographical area as a rapid tool that can be integrated with GIS/RS-based methods. This method has become very popular, even in Sri Lanka, but its key limitation is the lack of validation in the field. Therefore, the final aim of this presentation is to validate the RUSLE model for Sri Lankan settings and then to apply it for soil erosion hazard mapping. Soil erosion hazard maps are enormously useful for policy makers for effective land management and also to identify erosional hot spots rapidly for conservation. In this study, soil erosion of six sub-catchments of the Mahaweli River of Sri Lanka was modeled with RUSLE in the GIS environment and their rates were compared with field-based actually-quantified measurements. The mean modeled soil erosion rates of the catchments were within 0.12 and 7.70 t ha^{-1} y^{-1}, whereas the field-based rates range from 1.14 to 15.83 t ha^{-1} y^{-1}. Most importantly, modeled erosion classes of the sub-catchments were comparable with localized erosion rates quantified from plot experiments. Therefore, it can be concluded that erosion rates calculated from the model and field-based observations were on the same order. Hence, the use of RUSLE for soil erosion hazard mapping is recommended for Sri Lankan settings (*Somasiri et al., 2021*).

References

Diyabalanage Saranga, K K Samarakoon, SB Adikari and Tilak Hewawasam, Quantifying Effectiveness of Soil and Water Management Practices Adopted in a Tropical Watershed in the Central Sri Lanka, 2017, Applied Geography, 79, 103-114 http://dx.doi.org/10.1016/j.apgeog.2016.12.004.

Hewawasam Tilak, Friedhelm von Blanckenburg, Julien Bouchez, Jean Dixon, Jan Schüssler and Ricarda Behrens, Slow advance of the weathering front during deep, supply-limited saprolite formation in the tropical Highlands of Sri Lanka, 2013, Geochimica et Cosmochimica Acta, 2013, 1: 202–230, doi: 10.1016/j.gca.2013.05.006.

Hewawasam Tilak, Effects of land use on erosion, landslides and siltation in hydropower reservoirs: a review for the Upper Mahaweli Catchment, Sri Lanka, 2010, Journal of National Science Foundation of Sri Lanka, 38(1):3-14.

Hewawasam Tilak, Friedhelm von Blanckenburg, Mirjam Schaller and Peter Kubik; Increase of human over natural erosion rates in tropical Highlands constrained by cosmogenic nuclides, 2003, Geology, 31, 597-600.

Somasiri IS, Rambukkange M and Tilak Hewawasam, Adaptation of the universal soil loss equation to map spatial distribution of soil erosion in tropical watersheds: a GIS/RS-based study of the Upper Mahaweli River Catchment of Sri Lanka, 2021, Modelling Earth Systems and Environment https://doi.org/10.1007/s40808-021-01245-x.