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A sedimentological connectivity approach for assessing on-site and off-site soil erosion control services

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Soil erosion, a widely-occurring phenomenon in the terrestrial environment, affects land productivity and infrastructure security negatively both on-site and off-site. Therefore, soil erosion control services (SECS) are one of the most fundamental ecosystem services for human well-being. Although previous SECS assessments elaborate the benefits from preventing on-site soil erosion and soil loss comprehensively, the off-site benefits remain vague. They are usually estimated only through multiplying the capacity of on-site soil erosion prevention by a land-use-based, and spatially consistent, allocation coefficient. The corresponding overestimation, item omission, and inability to represent the spatial heterogeneity of SECS may lead to great uncertainties. In addition, the SECS decay with travel distance is not well represented, because of a neglect of the cascading nature of SECS formation and its delivery. Here, to address these deficiencies, a cascade framework for SECS assessment is developed that incorporates the concept of sedimentological connectivity over the landscape. This approach quantifies both the on-site soil erosion prevention and mitigation of sediment delivery over the landscape, based on an understanding of the cascading nature of soil erosion and sediment delivery, by referring to the framework of WATEM/SEDEM that potentially reveals the sedimentological connectivity over landscape. A monetized valuation of SECS delivered to local communities was derived by employing a land-use based replacement cost technique, which takes cultivated land units as a SECS receiver and conveyer. The approach was applied in a loess catchment located in the middle Yellow River basin, China as a case study. For this watershed, with an area of 54.2 km^2, the gross soil erosion reduction was up to 156.93 × 10^4 t; the reduction of sediment input was 11.28 × 10^4 t; and the reduction in gross sediment export is up to 181.34 × 10^4 t. The monetized value delivered to utilized land units was 910.13 × 10^4 CNY. The approach described provides a tool that specifically addresses the SECSs directly useful to humans, contributes to quantifying the soil erosion control services provided by the landscape, and improves the reliability of evaluating SECS.