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The impact of climate change on soil erosion: a systematic review

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Climate change is expected to cause an increase of extreme precipitation and consequently an increase of soil erosion in many regions worldwide, although large differences are reported. Therefore, this study systematically reviews research presenting projected changes in soil erosion under climate change, focussing on studies that forced soil erosion models with precipitation from climate model output. A total of 766 documents were analysed and further evaluated based on predetermined inclusion criteria, resulting in a selection of 168 documents published between 1995 and 2021. From these documents a total of 35 variables were recorded, including information related to bibliography, objective, study site, climate model, soil erosion model, land use change scenarios, soil and water conservation techniques, and the projected change in soil erosion under climate change. Studies were performed on all continents, with the majority in Europe (32%), Asia (29%) and North America (23%). The study sites were mainly located in humid continental (28%) and humid subtropical climates (22%). The studies were equally distributed over the future periods (i.e. near-, mid- and end-century) and emissions scenarios (i.e. low, intermediate and high). The majority of the studies were forced by a single climate model (44%), while 67% of the studies used a climate model ensemble smaller than 5. MUSLE (31%), RUSLE (18%) and WEPP (9%) are the most applied soil erosion models. Of these models, most were applied with a daily time step (65%). In addition to climate, the impacts of land use change and soil and water conservation techniques were considered in 13% and 17% of the studies, respectively.

Climate model output is an important source of uncertainty, therefore, we used the climate model ensemble size as a measure for uncertainty, assigning studies based on a larger climate model ensemble a larger weight in the estimation of the (weighted) median change in soil erosion under climate change. Soil erosion is projected to increase from near-century (+5% with respect to the reference period) to mid- and end-century (+17% and +15%, respectively). Soil erosion is projected to increase most in semi-arid (+23%) and humid continental climates (+20%), while soil erosion is projected to decrease in Mediterranean climates (-2%). Higher increase of soil erosion is projected for models that apply sub-daily (+26%) and daily time steps (+14%), than monthly (0%) and yearly time steps (+8%). Significantly different results were obtained between studies using bias-correction methods based on delta change (+9%) and quantile mapping (+37%). On the other hand, no significant differences were obtained between the emission scenarios. Our review further highlights that changes in land use or soil and water conservation measures can either mitigate (i.e. no tillage, agricultural abandonment, reforestation) or aggravate (i.e. agricultural expansion) the impacts of climate change. This review illustrates that most studies project an

increase of soil erosion under future climate change, while environmental (e.g. climate, land use) and methodological (e.g. erosion model, bias-correction, climate ensemble) differences between studies determine the strength and significance of the projected impacts.

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