Supplementary Material for "Global impact of climate change on soil erosion and potential for adaptation through soil conservation"

J.P.C. Eekhout[1] and J. de Vente[1]

[1]Soil and Water Conservation Research Group, CEBAS-CSIC, Spanish Research Council, Campus de Espinardo 30100, P.O. Box 164, Murcia, Spain

Correspondence: Joris Eekhout (joriseekhout@gmail.com)

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Text S1: Systematic review

The systematic literature review (SLR) process was performed following the SALSA framework (Search, AppraisaL, Synthesis and Analysis) (Grant and Booth, 2009), which is a structured and contextual approach widely used for SLRs based on 4 steps. It includes the definition of the research questions, the search term, the criteria used based on which publications are included or excluded, the list of variables extracted from the publications, and the way the data were used to extract conclusions from the publications.

Step 1: Search

The first step of the SLR defines the research scope, leading to the main research questions. The framework of Population, Intervention, Comparison, Outcome, and Context (PICOC) (Booth et al., 2012) was applied to determine the research scope. The PICOC framework is listed in Table S1. The refined objectives of the SLR presented in the form of research questions are listed below:

1. What is the relative change in soil erosion under climate change?
2. Are there significant differences in the projected change in soil erosion between the methods applied in soil erosion impact assessments?
3. What are the differences in relative change between climatic zones, continents and future periods?
4. How does land use change affect the soil erosion projections under climate change?
5. How effective are soil conservation practices to prevent increased soil erosion under climate change?

Table S1. SLR research scope based on the application of the PICOC framework to the determined objectives.

Concept	Definition (Booth et al., 2012)	SLR application
Population	The problem or situation the research is dealing with.	Scientific research that quantifies the impact of climate change on soil erosion.
Intervention	Existing techniques utilised to address the problem identified.	Soil erosion models forced by climate model output.
Comparison	Techniques to contrast the intervention against.	Methods applied to quantify soil erosion under climate change.
Outcome	The measures to assess the effect of the techniques in the population.	Relative change in soil erosion due to climate change.
Context	The particular settings or areas of the population.	The use of climate model data, based on established emission scenarios.

This step also describes the search strategy applied. We used the SCOPUS search database, with the following search string (2 February, 2021):

TITLE-ABS-KEY ("soil erosion" OR "sediment yield*" OR "soil loss*" OR "sediment export*" OR "sediment load*" OR "hillslope erosion" OR "erosivity") AND TITLE ("climate change*" OR "changing climate" OR "future" OR "expect*" OR "projected" OR "projection*" OR "global change*" OR "climate and land use change*" OR "21st century" OR "climate impact*")

We included all search results for further analysis, regardless of publication year and source. The search string resulted in a total of 971 documents, which were further evaluated in the next step.

Step 2: Appraisal

The second step of the SLR describes how the search results were evaluated in order to select only those studies that are relevant according to the research scope. We used a set of predetermined inclusion and exclusion criteria to make the process as systematic and reproducible as possible (Table S2). The process resulted in a selection of 224 papers that comply with the selection criteria.

Table S2. SLR appraisal: study selection inclusion and exclusion criteria.

Criteria	Decision
Papers that apply a soil erosion model	Inclusion
Papers that apply established climate change scenarios based on climate model output	Inclusion
Papers not written in English	Exclusion
Papers that are not accessible	Exclusion

Step 3: Synthesis

The third step of the SLR consists of the extraction and classification of relevant data from the selected papers. The variables of interests were divided over seven main themes, which include bibliographic information, study objective, study area, climate models, soil erosion model, land use change, soil conservation practices and soil erosion projections (Table S3). The data were extracted into an Excel spread sheet and analysis was performed using R (version 3.6.3).

The projected change in soil erosion was calculated from the reported reference (or baseline) values and the projected values under climate change. Data were extracted from the reported text, tables and graphs, using image analysis software (WebPlotDigitizer) when necessary. In the case relative changes were reported, we used those values directly. We determined the ensemble average in the case the values were reported per individual climate model. We determined the average among the methods in the case of method comparison studies.

Table S3: SLR synthesis: definition of main and specific variables used for data extraction and identified categories in data synthesis.

Variable	Category	Definition
Bibliographical information		
Year of publication	-	-
Source title	-	-
Study objective		
Type of study	Evaluation of soil conservation practices	
	Evaluation of the impact of climate and land use change	
	Input data comparison	
	Method comparison	
	Case studies	Studies that only evaluate the impact of climate change on soil erosion
	Other	Sensitivity to precipitation indices, post-fire
Study area		
Number of study areas	-	-
Name of the study area	-	-
Size of the study area (km^2)	In number	-
	Field-scale	< 0.05 km^2
	Micro-scale	≥ 0.05 & < 10 km^2
	Small-scale	≥ 10 & < 1000 km^2
	Medium-scale	≥ 1000 & < 10000 km^2
	Large-scale	≥ 10000 km^2
Latitude (°)	-	Latitude at the geographic centre of the study area
Longitude (°)	-	Longitude at the geographic centre of the study area
Polygon	-	For study areas > 100 km^2. Obtained from HydroSHEDS (Lehner et al., 2008), Natural Earth (https://www.naturalearthdata.com/) or other sources

Climate zone	Tropical	Includes Af, Am and Aw Köppen-Geiger climate classes (Beck et al., 2018)
	Semi-arid	Includes BSh, BSk, BWh and BWk Köppen-Geiger climate classes (Beck et al., 2018)
	Humid subtropical	Includes Cfa and Cwa Köppen-Geiger climate classes (Beck et al., 2018)
	Oceanic	Includes Cfb, Cwb, Cfc and Cwc Köppen-Geiger climate classes (Beck et al., 2018)
	Mediterranean	Includes Csa, Csb and Csc Köppen-Geiger climate classes (Beck et al., 2018)
	Humid continental	Includes Dfa, Dfb, Dsa, Dsb, Dwa and Dwb Köppen-Geiger climate classes (Beck et al., 2018)
	Subarctic/tundra	Includes Dfc, Dwc, Dsc, Dfd, Dwd, Dsd, EF and ET Köppen-Geiger climate classes (Beck et al., 2018)
Contintent	Africa	-
	Asia	-
	Australia	-
	Europe	-
	North America	-
	South America	-
Climate models		
Generation of emission scenarios	IS92	IPCC Scenarios 1992 (Leggett et al., 1992)
	SRES	Special Report on Emissions Scenarios (IPCC, 2000)
	RCP	Representative Concentration Pathways (Moss et al., 2008)
Emission scenarios	IS92a	From the IS92 emission scenarios
	A1B	From the SRES emission scenarios
	A1FI	From the SRES emission scenarios
	A2	From the SRES emission scenarios
	B1	From the SRES emission scenarios
	B2	From the SRES emission scenarios
	RCP2.6	From the RCP emission scenarios
	RCP4.5	From the RCP emission scenarios

	RCP6.0	From the RCP emission scenarios
	RCP8.5	From the RCP emission scenarios
	Other	A, D, IPCC BaU, 1.5 degrees, 2 degrees
Number of climate models	-	-
Type of climate model	GCM	Global Circulation Model
	RCM	Regional Climate Model
Statistical downscaling	Stochastic weather generators	AWE-GEN, CLIGEN, MarkSIM + CLIGEN, SDSM + CLIGEN, SYNTOR + CLIGEN, LARS-WG, LARS-WG / SDSM, RainSim, SDSM, SDSM + LS-SVM, SYNTOR, WACS-Gen, WETTREG, WGEN, WXGEN
	Temporal and spatial analogues	ANA method, BCCA, constructed analogues + BCSD, fragments method, local intensity scaling, localized constructed analog (LOCA), multivariate adapted constructed analogs, Multivariate Adaptive Constructed Analog (MACA), spatial analogue
	Distribution fitting	ANO, FREQ, FREQnorm, asynchronous regional regression model, gamma distribution, GLIMCLIM, probabilistic downscaling
	Other	ANN, BPCDG, BCSD, CCWorldWeatherGen, MarkSim, MODAWEC, SimCLIM, Spatial disaggregation
Bias correction	Delta change	Delta change, change factor
	Quantile mapping	Quantile mapping
	Trend preserving quantile methods	Detrended quantile mapping, quantile delta mapping, distribution mapping with linear scaling, scaled distribution mapping, nonstationary quantile mapping, trend-preserving
	Various	Studies that apply more than one bias correction method
Application of downscaling and bias correction	No downscaling and no bias correction	Studies that do not apply downscaling (dynamical (RCM) or statistical) nor bias correction (as listed above)
	Bias correction only	Studies that do not apply downscaling (dynamical (RCM) or statistical) but apply bias correction (as listed above)

	Downscaling only	Studies that apply downscaling (dynamical (RCM) or statistical) but do not apply bias correction (as listed above)
	Downscaling and bias correction	Studies that apply downscaling (dynamical (RCM) or statistical) and bias correction (as listed above)
Reference period	-	-
Future period	Near-century	Period centre < 2035
	Mid-century	Period centre ≥ 2035 & period centre < 2065
	End-century	Period centre ≥ 2065
Soil erosion model		
Name of the model	-	-
Model concept	Forced by rainfall	CropSyst, D-RUSLE, EI30, EI60, EPIC, EPM, GloSEM, PSED, R-factor, RUSLE, RUSLE2, RUSLE, EPM, RUSLE + SCS, RUSLE + SDR, USLE, USLE + SDR, USLE + sediment rating curve, WATEM/SEDEM
	Forced by runoff	BQART, CEASAR, CAESAR-Lisflood, HydroTrend, Macromodel DNS/SWAT (MUSLE), PESERA, PESERA-PEAT, SedCas, STREAM, SWAT (MUSLE), TETIS
	Forced by rainfall and runoff	AnnAGNPS, Bao (1993), DHM, EROSION 2D, EROSION 3D, INCA, INCA-SED, GeoWEPP, HSPF, LandSoil, MEFIDIS, RHEM, SedNetNZ, SHETRAN, SPHY-MMF, SPHY-MMF, RUSLE, MUSLE, tRIBS, tRIBS-Erosion, VIC-WEPP, WEPP, WEPP-CO2
Time step	Sub-daily	< 1 day
	Daily	1-2 days
	Monthly	30 days
	Yearly	365 days
Output variable	Hillslope erosion	-
	Rainfall erosivity	-
	Sediment yield	-
	Suspended sediment	-
Land use change		

Land use model	Land use model	Based on Verburg et al. (2006) and Verburg et al. (2008), CA, CA-markov model, CLUE, CLUE-S, CLUE-s model, DYNA-Clue, Land Change Modeler, Multi-Layer Perception, Spatial Logistic Regression, Similarity Weighted Instance-Based Learning (SimWeight), TerrSet (neural networks), based on the slope and proximity to roads, local growth rates, based on CAP, statistical population projections, change in protected areas, local slopes, regression NDVI based on temperature and precipitation, Markov chain
	Linear extrapolation of historical trend	Based on historical trend, extrapolation of cropland development, historical trend based on Landsat, hypothetical scenarios based on historical trends, linear downscaling of EU trends + local trends
	Stakeholder consultation	Based on stakeholder consultation, based on Reed et al. (2013), based on Viola et al. (2014b), Hoyer & Chang (2014)
Land use scenario	Agricultural abandonment	Land use change is dominated by a decrease in agricultural area
	Agricultural expansion	Land use change is dominated by an increase in agricultural area
	Reforestation	Land use change is dominated by an increase in forested area
	Deforestation	Land use change is dominated by a decrease in forested area
	Other	Land use is not dominated by a change in a single land use class
Soil conservation practices		
Soil conservation practices	Conventional management	-
	Reduced tillage	-
	Conservation tillage	-
	No tillage	-

	Sustainable agriculture	Cover crop, double cropping, grazing control, green fallow, strip cropping, tile drainage, winter wheat double crop, crop rotation
	Structural measures	Buffer strips, combined CPs, porous gully plugs, non-grazing policy + stone bunds + exclosures + check dams, best management practices, vegetation strips, terrace, hedgerow planting
Soil erosion projections		
Relative change in soil erosion under climate change	-	Specified per emission scenario, period, land use scenario and soil conservation practice

Step 4: Analysis

The fourth step of the SLR consists of the extraction of meaningful conclusions from the synthesized data, which serves to answer the formulated research questions from the first step. We divided the analysis step into two parts. The first part encompasses the analysis of the methods used, subdivided by the main themes defined in step 3 (Table S3). From this analysis we determined which methodological aspects of the model chain show significant differences in the projected change in soil erosion among their categories. We assigned weights to those methodological aspects that show significant differences, which we obtained from an online questionnaire, as explained further in Text S4. In the second part of the analysis we aim to answer the research questions, based on the weighted soil erosion projections under climate change.

Text S2: Questionnaire

Soil Erosion under Climate Change

In this questionnaire we would like to ask you for your expert knowledge on the uncertainty of methods used in climate change impact assessments on soil erosion. The questionnaire is organised around 6 major aspects of uncertainty, i.e. (1) size of the climate model ensemble, (2) generation of the emission scenarios, (3) downscaling and bias correction, (4) bias correction methods, (5) soil erosion model concepts, and (6) output variables. We would like to ask you to value each of these aspects, by assigning weights to a number of categories per subject. We will use your responses in an ongoing research project regarding the uncertainty around the projected impacts of climate change on soil erosion.

The questionnaire will take about 5-10 minutes to complete. We thank you for your valuable input and collaboration.

This questionnaire forms part of research funded by the Spanish Ministry of Science and Innovation (PID2019-109381RB-I00/AEI/10.13039/501100011033).

1 Size of the climate model ensemble

Climate models (GCMs and RCMs) provide a range of climate projections due to the variety of numerical formulations and physical parametrization schemes. As a result, climate model output is one of the main sources of uncertainty in climate change impact studies. To quantify this uncertainty, many studies apply a climate model ensemble of multiple climate models.

1a What is the minimum ensemble size required to reduce the uncertainty from climate models in climate change impact studies on soil erosion?

0-10

Please provide any additional comments regarding the size of climate model ensemble (optional)

2 Generation of emission scenarios

Emission scenarios aim to explore possible future trajectories of greenhouse gas emissions. The first generation of emission scenarios were introduced in the 1990s with the 1992 IPCC Scenarios (IS92). These scenarios were succeeded by the Special Report on Emissions Scenarios (SRES). The latest generation of emission scenarios are the Representative Concentration Pathways (RCP).

Please assign a weight to each of the three generations of emission scenarios regarding their robustness for climate change impact studies on soil erosion, with a value between 1 (uncertain) and 10 (robust). At least 1 method should get a value of 10 (most robust). If you don’t feel capable to differentiate between options, please assign an equal weight.

2a IS92

The IS92 scenarios consist of 6 scenarios, i.e. IS92a-f.

Uncertain 1-10 Robust

2b SRES

The SRES consist of 6 scenarios, i.e. A1FI, A1B, A1T, A2, B1, and B2.

Uncertain 1-10 Robust

2c RCP

The RCP consist of 4 scenarios, i.e. RCP2.6, RCP4.5, RCP6.0 and RCP8.5.

Uncertain 1-10 Robust

Please provide any additional comments regarding the generation of emission scenarios (optional)

3 Downscaling and bias correction

Global climate projections are obtained from General Circulation Models (GCMs). Due to their global domain, these models have a coarse spatial resolution, in the order of 100 km. Downscaling is used to increase the spatial and temporal resolution of GCMs. Climate models also produce a bias between the historical model output and observations, which can be corrected by applying bias correction methods. Hence, soil erosion model assessments may apply both downscaling and bias correction, only one of the two or neither.

Please assign a weight to each of the four options regarding the application of downscaling and bias correction in climate change impacts studies related to soil erosion, with a value between 1 (uncertain) and 10 (robust). At least 1 method should get a value of 10 (most robust). If you don't feel capable to differentiate between options, please assign an equal weight.

3a Downscaling and bias correction

Studies that apply downscaling AND bias correction. Downscaling can be either dynamic downscaling, for instance by using Regional Climate Models, or statistical downscaling, using statistical techniques or weather generators. Bias correction may involve the following methods: delta change/change factor, quantile mapping and trend preserving quantile methods.

Uncertain 1-10 Robust

3b Downscaling only

Studies that apply only downscaling. This can be either dynamic downscaling, for instance by using Regional Climate Models, or statistical downscaling, using statistical techniques or weather generators.

Uncertain 1-10 Robust

3c Bias correction only

Studies that apply only bias correction. This may involve the following methods: delta change/change factor, quantile mapping and trend preserving quantile methods.

Uncertain 1-10 Robust

3d No downscaling or bias correction

Studies that do not apply downscaling or bias correction and use the climate model output from GCMs directly without any post-processing.

Uncertain 1-10 Robust

Please provide any additional comments regarding the application of downscaling and/or bias correction methods (optional)

4 Bias correction methods

Climate models (GCM and RCM) produce a bias between the historical model output and observations, which can be corrected by applying bias correction methods. We have identified three common bias correction methods that are used in soil erosion model assessment, i.e. delta change/change factor, quantile mapping and trend preserving quantile methods.

Please assign a weight to each of the three bias correction methods considering their robustness for climate change impact studies on soil erosion, with a value between 1 (uncertain) and 10 (robust). At least 1 method should get a value of 10 (most robust). If you don't feel capable to differentiate between options, please assign an equal weight.

4a Delta change/change factor

Delta change/change factor is based on the ratio between climate observations and the historical climate model run, which is subsequently applied to correct the future climate model run. This method is either applied at monthly or yearly time steps.

Uncertain 1-10 Robust

4b Quantile mapping

Quantile mapping is based on the empirical cumulative density distribution function (ECDF) of the precipitation time series and preserves projected changes in precipitation intensity and frequency. It assumes that the ECDF of the observations can be applied to the projected time series (stationarity assumption), which is responsible for altering (often overestimating) the raw model projections.

Uncertain 1-10 Robust

4c Trend preserving quantile methods

Trend preserving quantile methods are often similar to quantile mapping, however, they include methods to overcome the stationarity assumption. Trend preserving quantile methods include non-stationary quantile mapping, distribution mapping with linear scaling, de-trended quantile mapping, scaled distribution mapping, and quantile delta mapping.

Please provide any additional comments regarding bias correction methods (optional)

5 Soil erosion model concept

To study the impact of climate change on soil erosion, a number of different soil erosion models are commonly applied. These erosion models use different model concepts, which is foremost expressed by the forcing used, that determines which soil erosion processes are accounted for. The two principal soil erosion processes that are responsible for most hillslope erosion are detachment by raindrop impact and detachment by runoff. Most soil erosion models can be subdivided into the following three categories: models forced by precipitation, models forced by runoff, and models forced by precipitation and runoff.

Please assign a weight to each of the three model concepts considering their robustness to assess the impacts of climate change on soil erosion, with a value between 1 (uncertain) and 10 (robust). At least 1 method should get a value of 10 (most robust). If you don't feel capable to differentiate between options, please assign an equal weight.

5a Models forced by precipitation only

Detachment by raindrop impact is a function of the amount and size of the raindrops that reach the soil surface. High intensity precipitation consisting of many large drops often causes most soil erosion. This notion was applied in models forced by precipitation, such as EPIC, EPM, PSED, RUSLE, USLE and WATEM/SEDEM.

Uncertain 1-10 Robust

5b Models forced by runoff only

Detachment by runoff is accounted for in many process-based soil erosion models, which are often embedded in hydrological models to simulate (surface) runoff generation. Models forced by runoff include BQART, CEASAR, PESERA, STREAM, SWAT (MUSLE) and TETIS.

Uncertain 1-10 Robust

5c Models forced by precipitation and runoff

Soil erosion models that are forced by precipitation and runoff have been developed to account for both detachment processes. Models forced by precipitation and runoff include AnnAGNPS, EROSION 2D/3D, INCA-SED, HSPF, LandSoil, MEFIDIS, RHEM, SHETRAN, SPHY-MMF, tRIBS-Erosion, and WEPP.

Uncertain 1-10 Robust

Please provide any additional comments regarding soil erosion model concepts (optional)

6 Model output

Soil erosion model assessments not always report how soil erosion is impacted by environmental change, but often report indirect output variables. We have identified four common output variables, i.e. hillslope erosion, rainfall erosivity, suspended sediment, and sediment yield, from which the latter two variables are often obtained at the catchment outlet.

Please assign a weight to each of the four model output variables to indicate to what degree they are representative to assess the impacts of climate change on soil erosion, with a value between 1 (least representative) and 10 (most representative). At least 1 method should get a value of 10 (most representative). If you don’t feel capable to differentiate between options, please assign an equal weight.

6a Hillslope erosion

Hillslope erosion is defined as the amount of eroded material originating from the hillslopes and is often reported in t/ha/yr.

Least similar 1-10 Most similar

6b Rainfall erosivity

Rainfall erosivity is the capability of rainfall to cause soil loss from hillslopes by water and is determined by the R-factor of the (R)USLE model. The rainfall erosivity is often reported in MJ mm/ha/hr/yr.

Least similar 1-10 Most similar

6c Suspended sediment

Suspended sediment is the amount of sediment in suspension that is transported by the river and is often reported as the sediment concentration, such as kg/s or mg/l.

Least similar 1-10 Most similar

6d Sediment yield

Sediment yield is the total amount of sediment that is transported towards the outlet of a (sub)catchment. The sediment yield is often reported in t/yr.

Least similar 1-10 Most similar

Please provide any additional comments regarding model output (optional)

Personal information, not required

We would like to ask you for some personal information to get a demographic overview of the respondents of this questionnaire. The personal data will not be published alongside the results of the questionnaire and will not be shared with third parties.

Please select your career stage

PhD student / Postdoctoral researcher / Senior researcher / Prefer not to say / Other

Please provide the country of residence (optional)

Please provide your name (optional)

All answers will be anonymized. In the case we publish the results of this questionnaire, we will acknowledge the respondents who provided their name, but never alongside their individual answers.

Figures

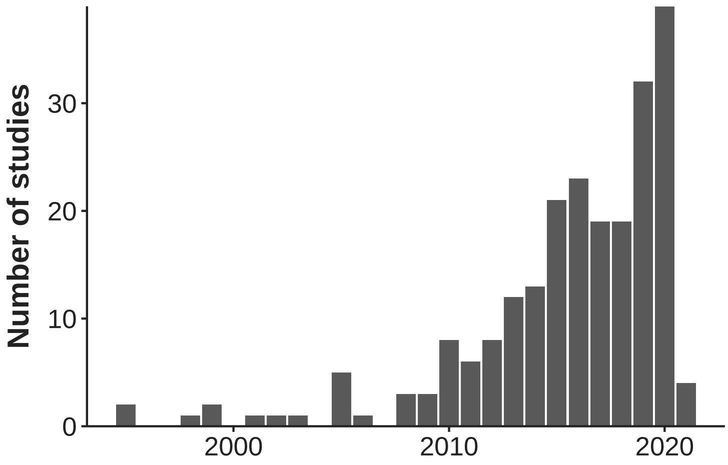

Figure S1. Number of studies published per year.

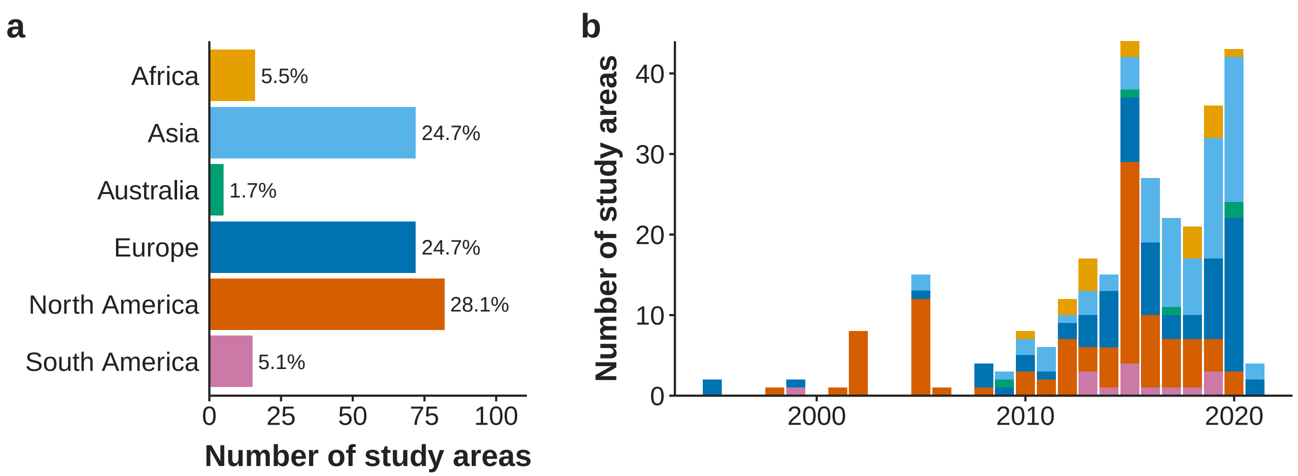

Figure S2. (a) Number of study areas per continent. (b) Yearly contribution of study areas per continent.

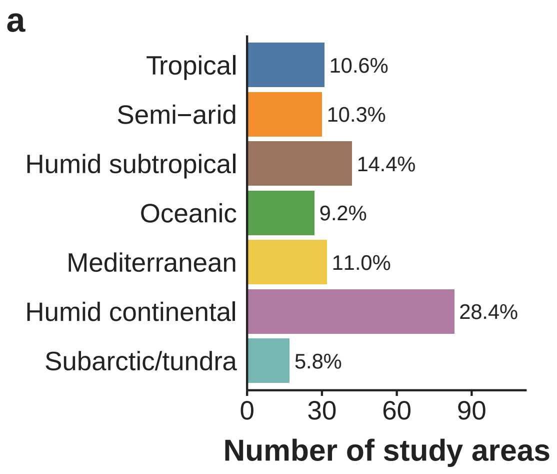

Figure S3. (a) Number of study areas per climate zone. (b) Yearly contribution of study areas per climate zone.

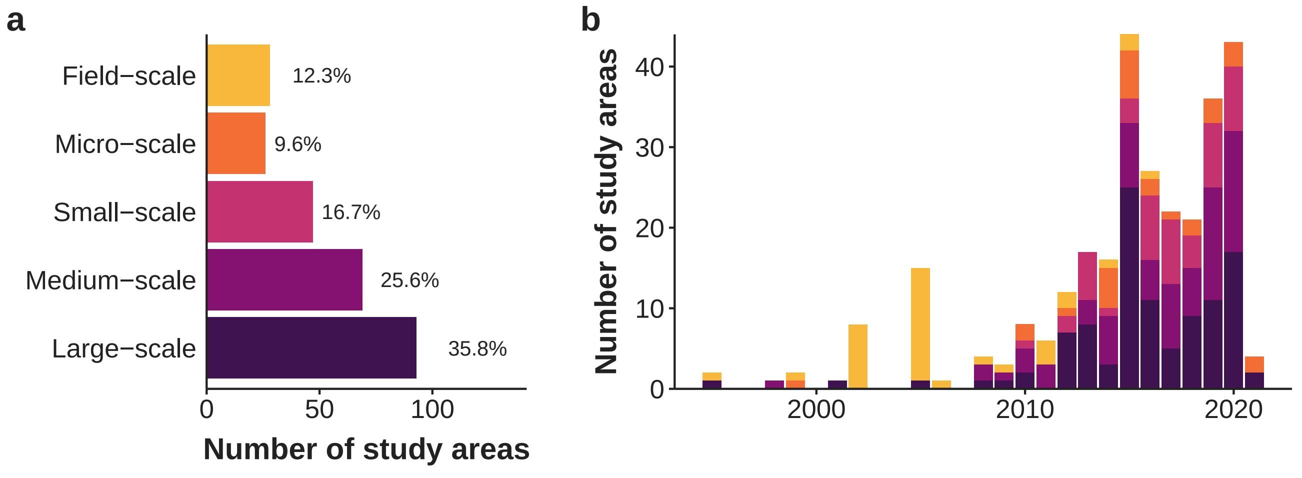

Figure S4. (a) Number of study areas per study area size class, with field-scale (< 0.05 km^2), micro-scale (0.05-10 km^2), small-scale (10-1,000 km^2), medium-scale (1,000-10,000 km^2) and large-scale ($\geq$ 10,000 km^2). (b) Yearly contribution of study areas per study area size class.

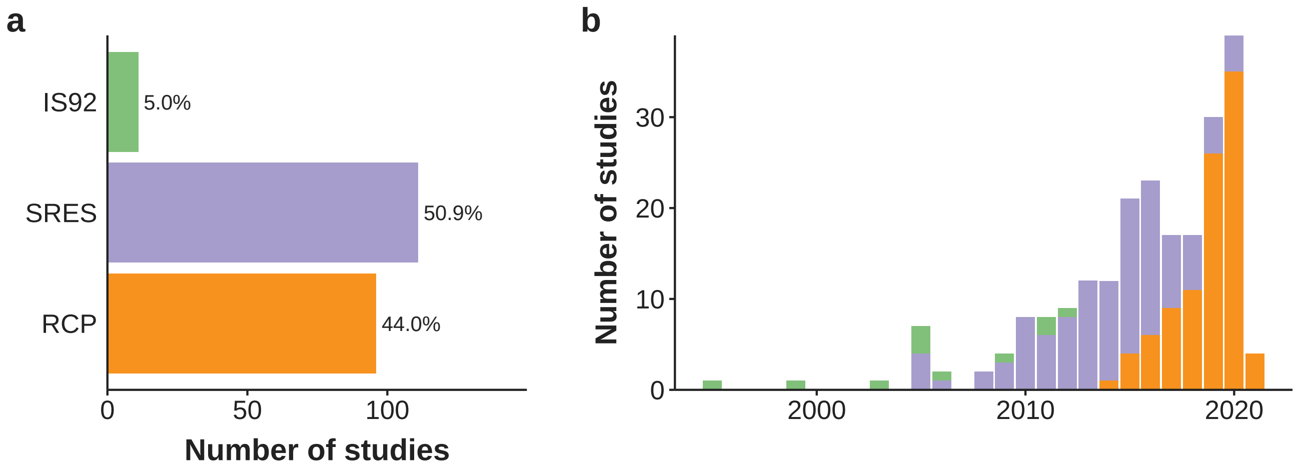

Figure S5. (a) Number of studies per generation of emission scenarios. (b) Yearly contribution of studies per generation of emission scenarios.

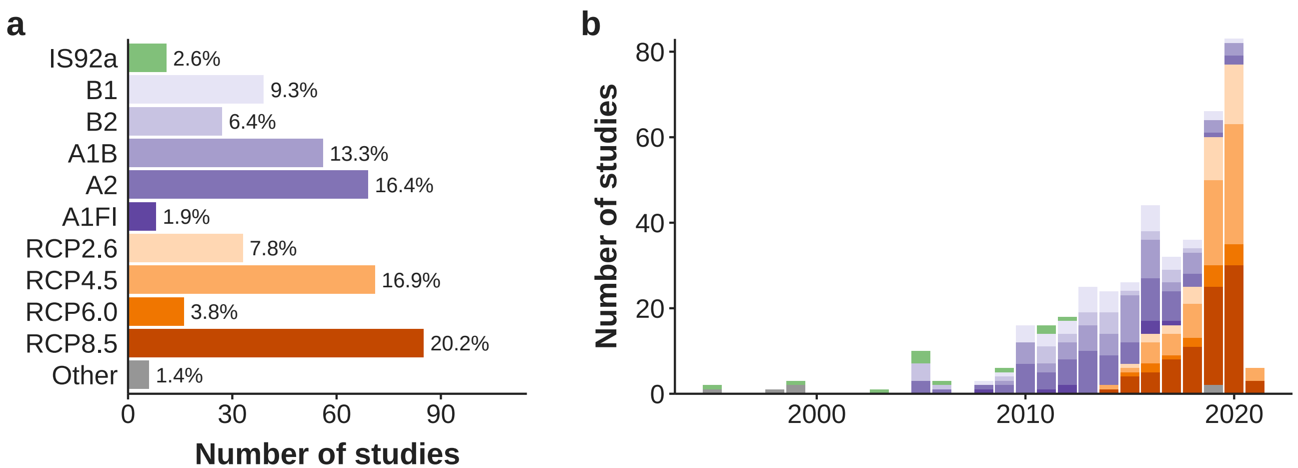

Figure S6. (a) Number of studies per emission scenarios. (b) Yearly contribution of studies per emission scenarios.

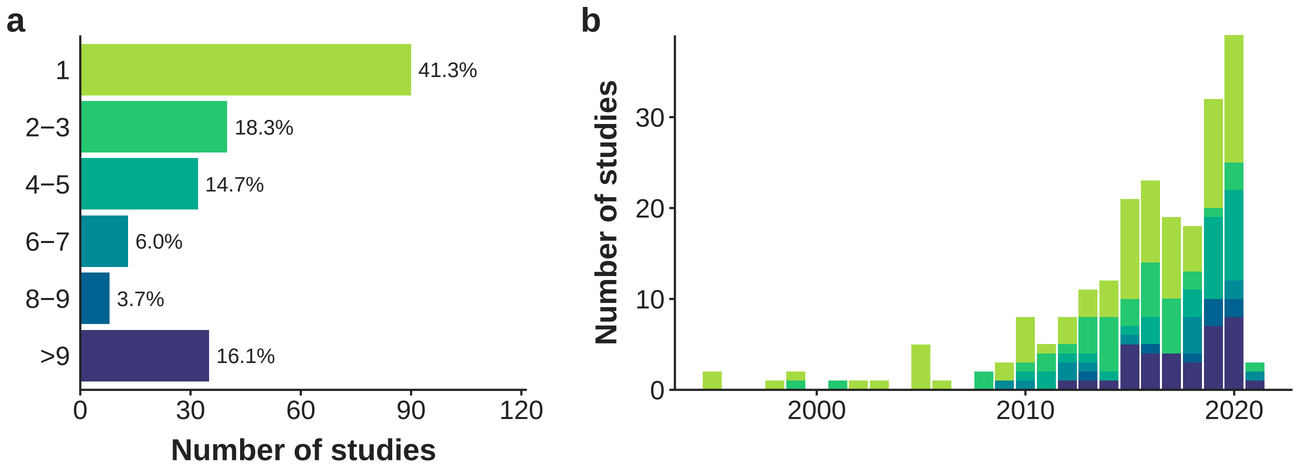

Figure S7. (a) Number of studies per climate model ensemble size class. (b) Yearly contribution of studies per climate model ensemble size class.

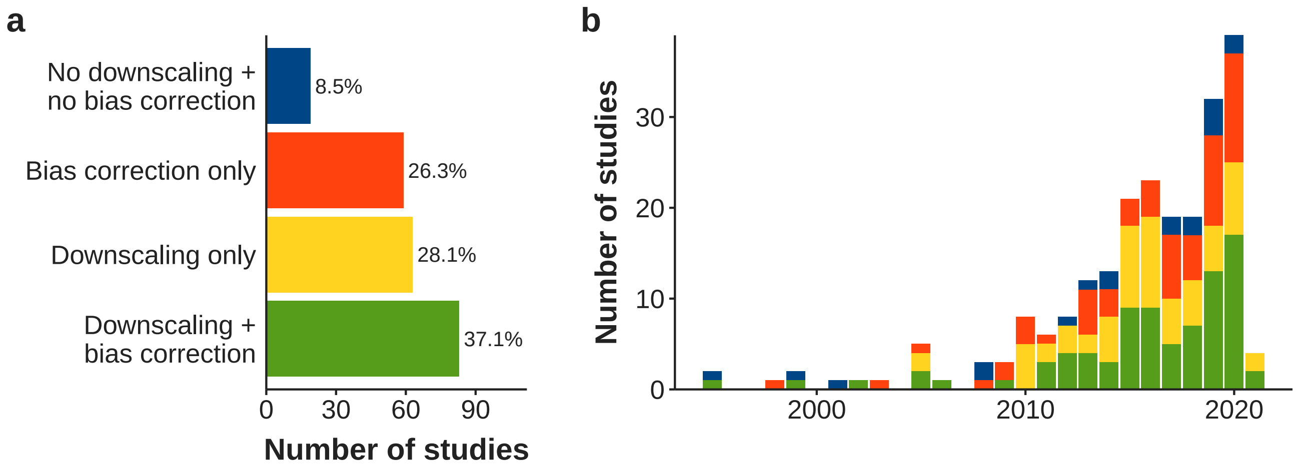

Figure S8. (a) Number of studies that apply downscaling and/or bias correction. (b) Yearly contribution of studies that apply downscaling and/or bias correction.

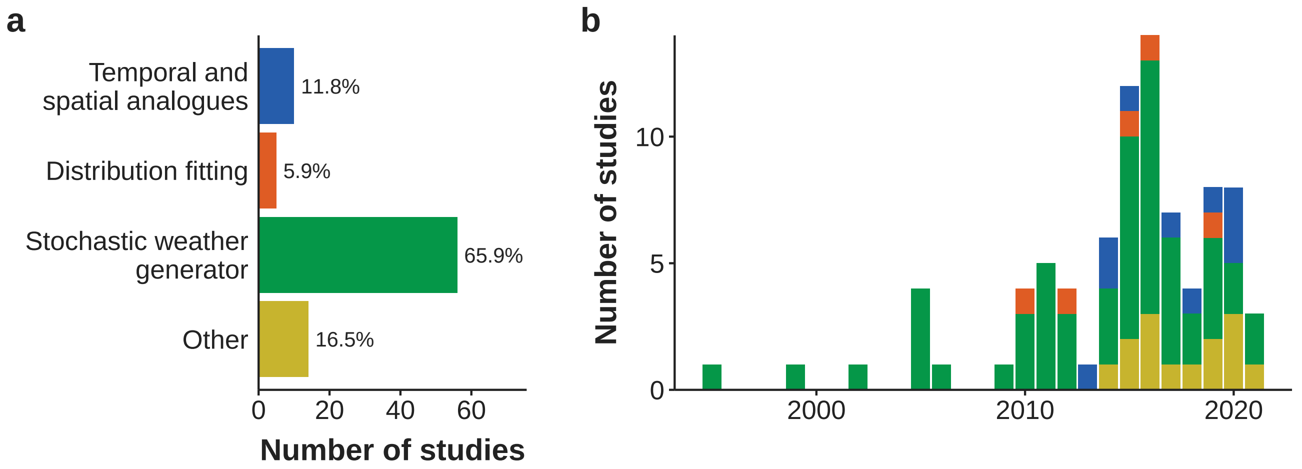

Figure S9. (a) Number of studies per statistical downscaling method method. (b) Yearly contribution of studies per statistical downscaling method.

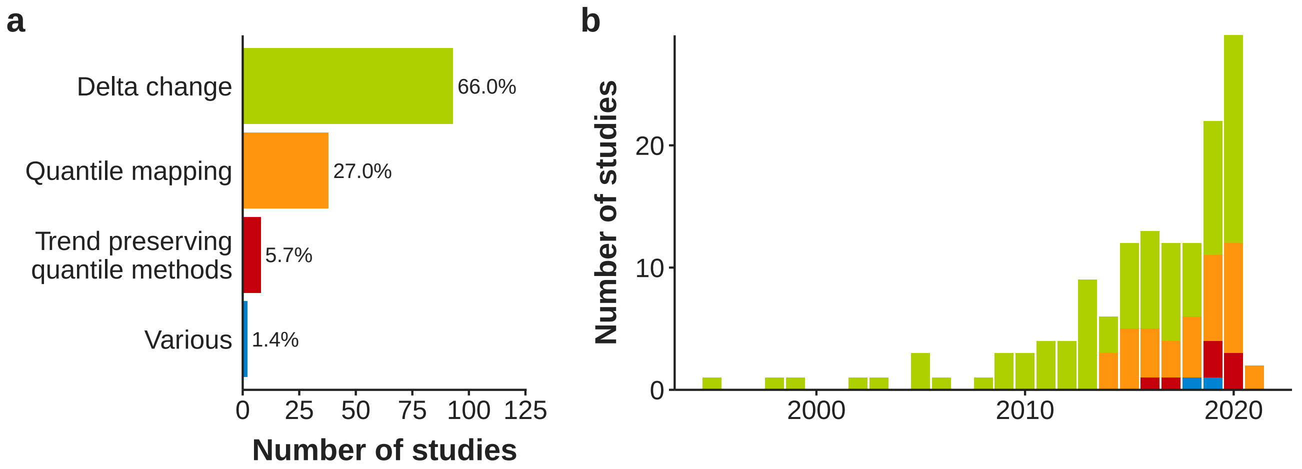

Figure S10. (a) Number of studies per bias correction method. (b) Yearly contribution of studies per bias correction method.

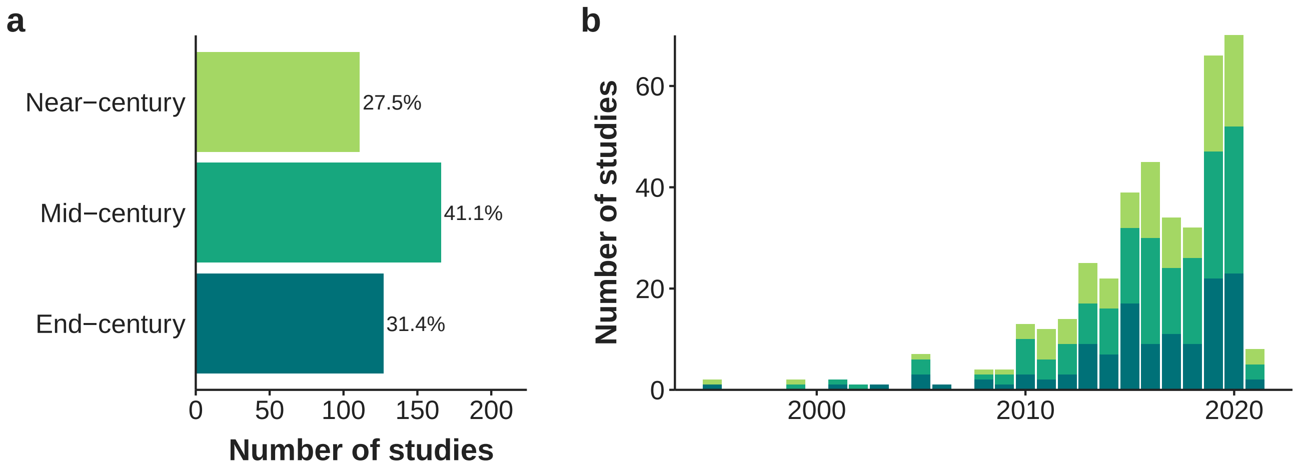

Figure S11. (a) Number of studies per future period, where near-century is centred before 2035, mid-century is centred in the period 2035-2065 and end-century is centred after 2065. (b) Yearly contribution of studies per future period.

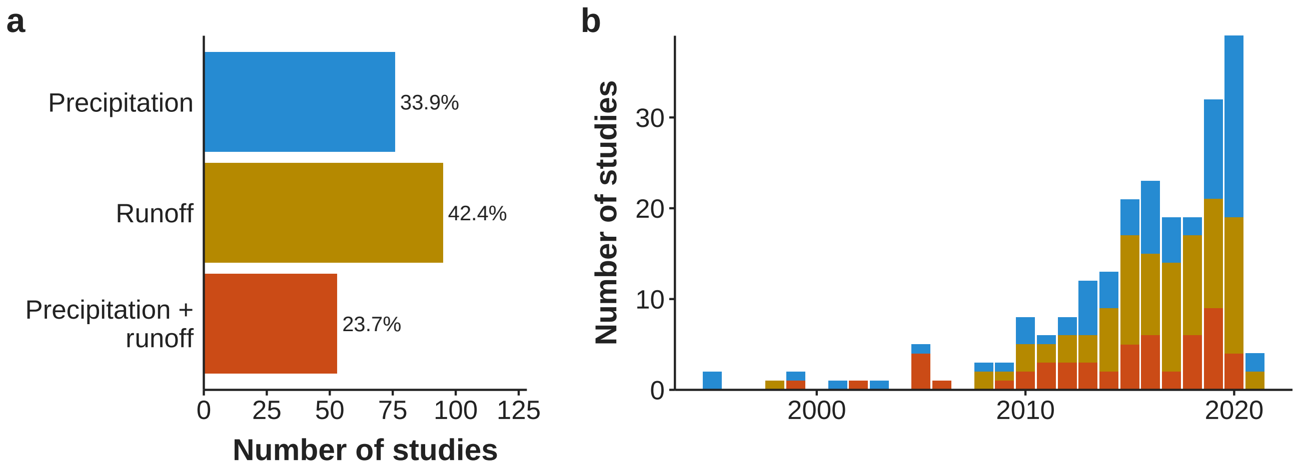

Figure S12. (a) Number of studies per model concept. (b) Yearly contribution of studies per model concept.

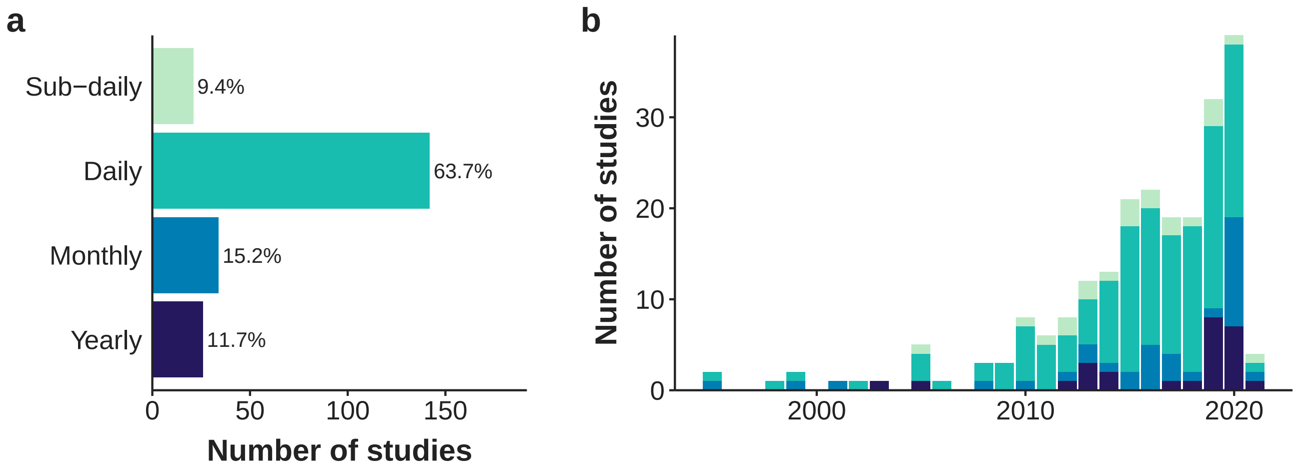

Figure S13. (a) Number of studies per time step class. (b) Yearly contribution of studies per time step class.

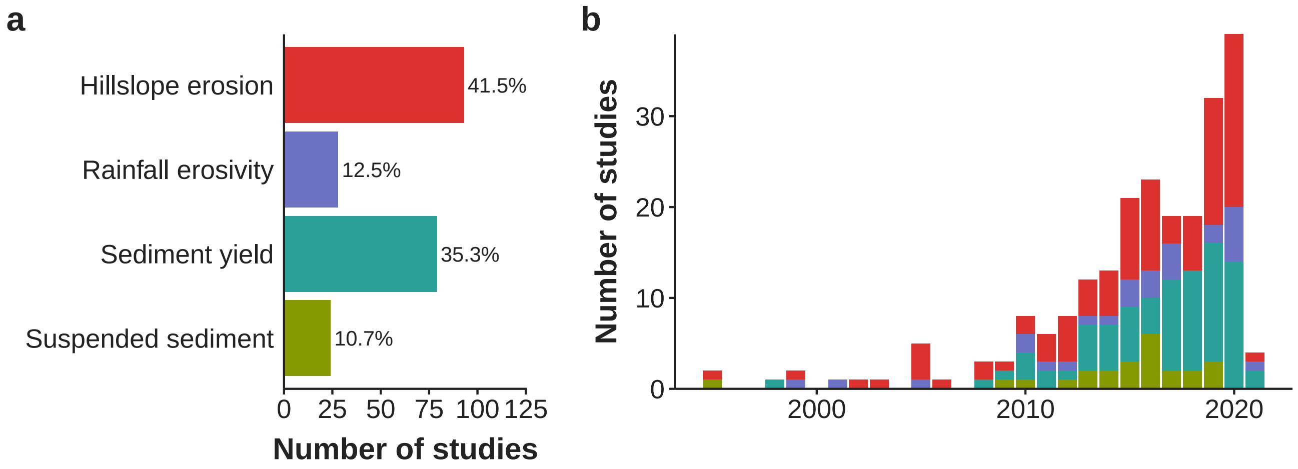

Figure S14. (a) Number of studies per output variable. (b) Yearly contribution of studies per output variable.

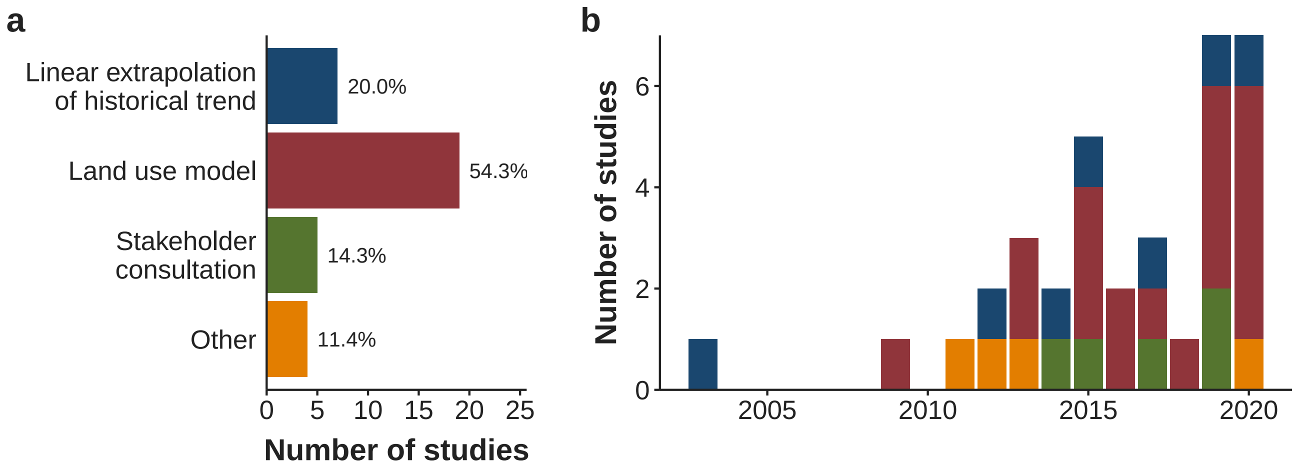

Figure S15. (a) Number of studies per land use model category. (b) Yearly contribution of studies per land use model category.

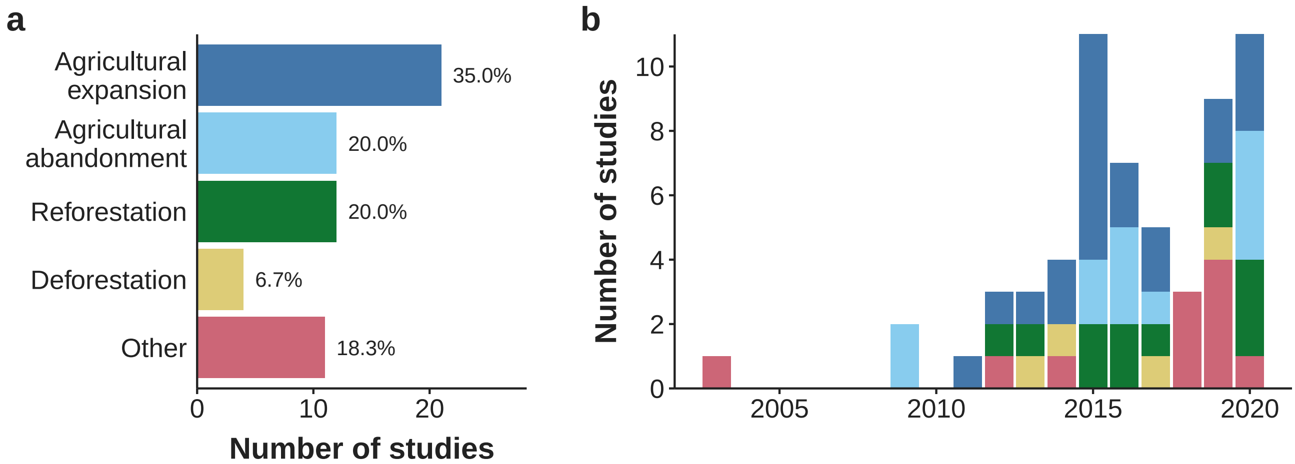

Figure S16. (a) Number of studies per land use scenario. (b) Yearly contribution of studies per land use scenario.

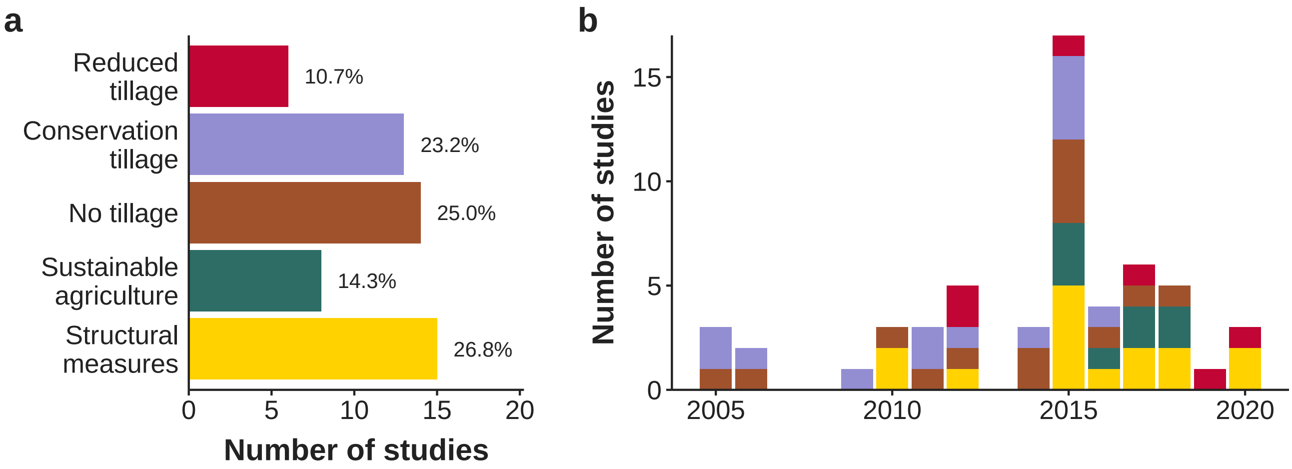

Figure S17. (a) Number of studies per soil conservation practice. (b) Yearly contribution of studies per soil conservation practice.

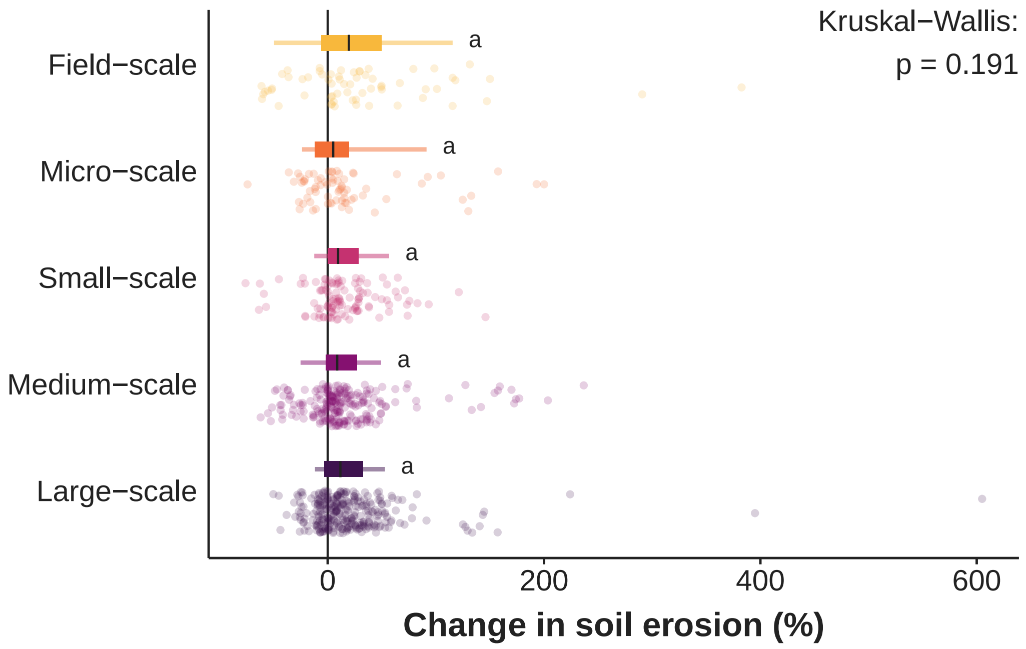

Figure S18. Change in soil erosion (%) under climate change per study area size class as shown in a jitter plot, where each dot is the change in soil erosion per study, differentiated per future period and emission scenario. The colored boxes indicate the inter-quantile range (25th and 75th percentiles), the black line the median (50th percentile) and the whiskers extend to the 10th and 90th percentiles. The box-plots followed by a common letter are not significantly different by the Wilcoxon rank-sum test at the 5% level of significance. The significance of the Kruskal-Wallis test is shown in the upper right corner.

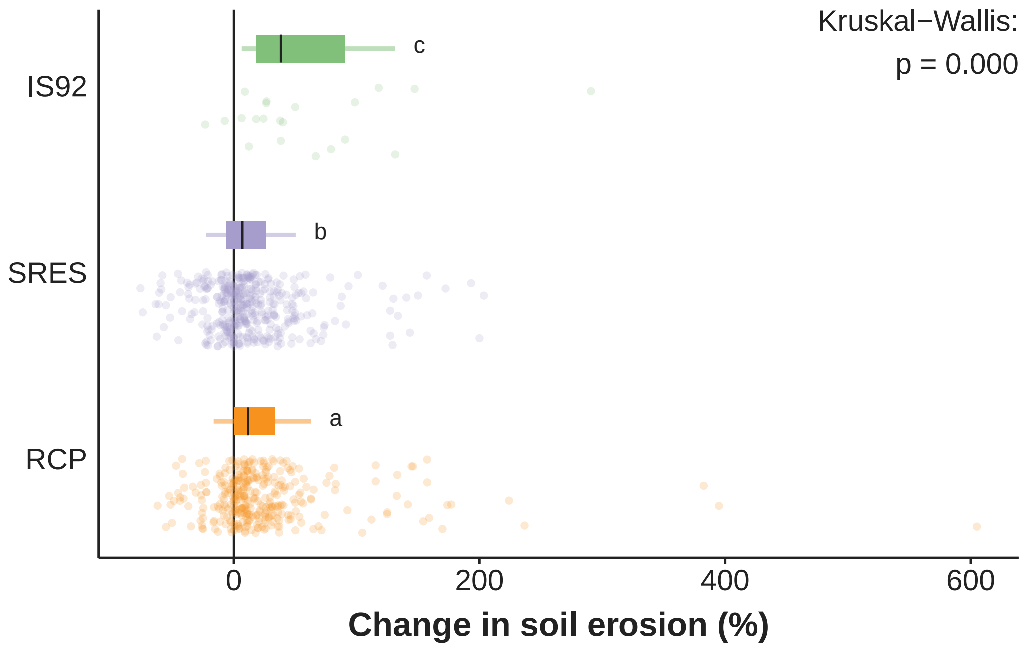

Figure S19. Change in soil erosion (%) under climate change per generation of emission scenarios as shown in a jitter plot, where each dot is the change in soil erosion per study, differentiated per future period and emission scenario. The colored boxes indicate the inter-quantile range (25th and 75th percentiles), the black line the median (50th percentile) and the whiskers extend to the 10th and 90th percentiles. The box-plots followed by a common letter are not significantly different by the Wilcoxon rank-sum test at the 5% level of significance. The significance of the Kruskal-Wallis test is shown in the upper right corner.

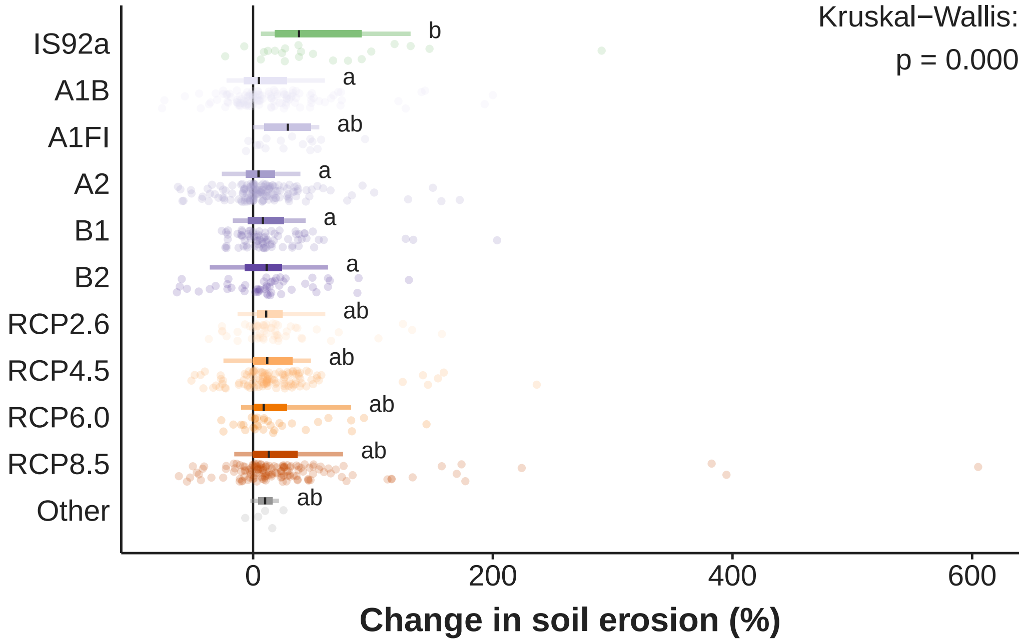

Figure S20. Change in soil erosion (%) under climate change per emission scenario as shown in a jitter plot, where each dot is the change in soil erosion per study, differentiated per future period and emission scenario. The colored boxes indicate the inter-quantile range (25th and 75th percentiles), the black line the median (50th percentile) and the whiskers extend to the 10th and 90th percentiles. The box-plots followed by a common letter are not significantly different by the Wilcoxon rank-sum test at the 5% level of significance. The significance of the Kruskal-Wallis test is shown in the upper right corner.

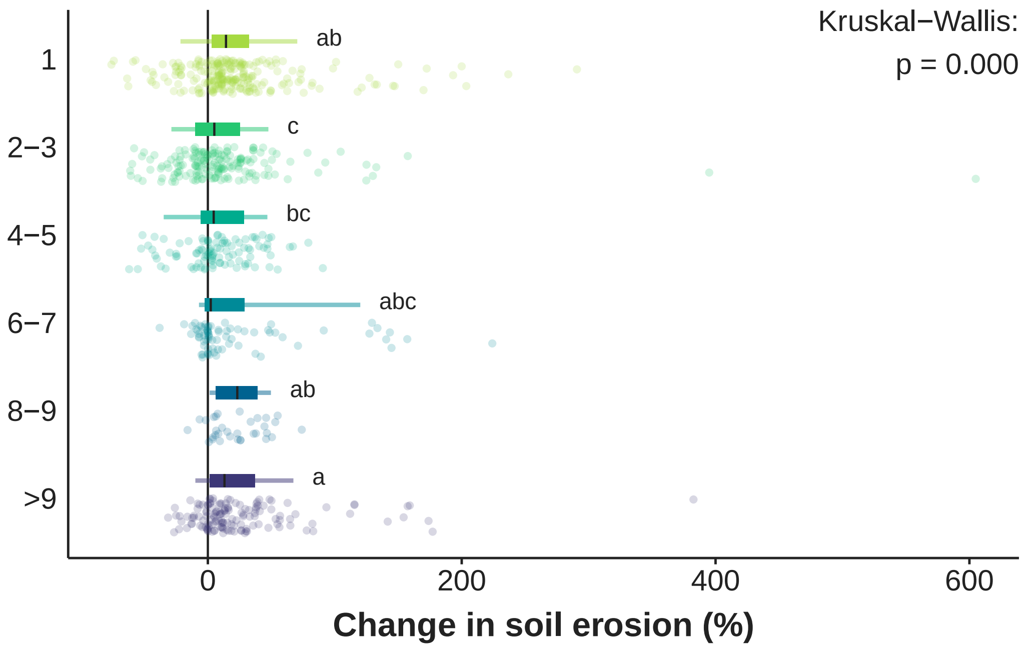

Figure S21. Change in soil erosion (%) under climate change per climate model ensemble size class as shown in a jitter plot, where each dot is the change in soil erosion per study, differentiated per future period and emission scenario. The colored boxes indicate the inter-quantile range (25th and 75th percentiles), the black line the median (50th percentile) and the whiskers extend to the 10th and 90th percentiles. The box-plots followed by a common letter are not significantly different by the Wilcoxon rank-sum test at the 5% level of significance. The significance of the Kruskal-Wallis test is shown in the upper right corner.

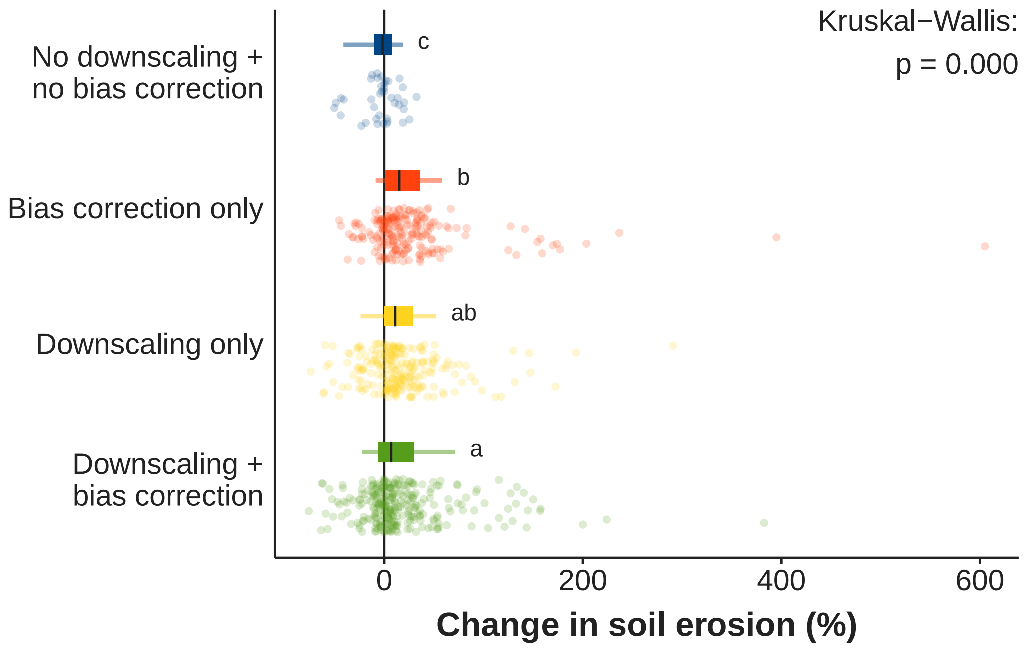

Figure S22. Change in soil erosion (%) under climate change for the application of downscaling and/or bias correction as shown in a jitter plot, where each dot is the change in soil erosion per study, differentiated per future period and emission scenario. The colored boxes indicate the inter-quantile range (25th and 75th percentiles), the black line the median (50th percentile) and the whiskers extend to the 10th and 90th percentiles. The box-plots followed by a common letter are not significantly different by the Wilcoxon rank-sum test at the 5% level of significance. The significance of the Kruskal-Wallis test is shown in the upper right corner.

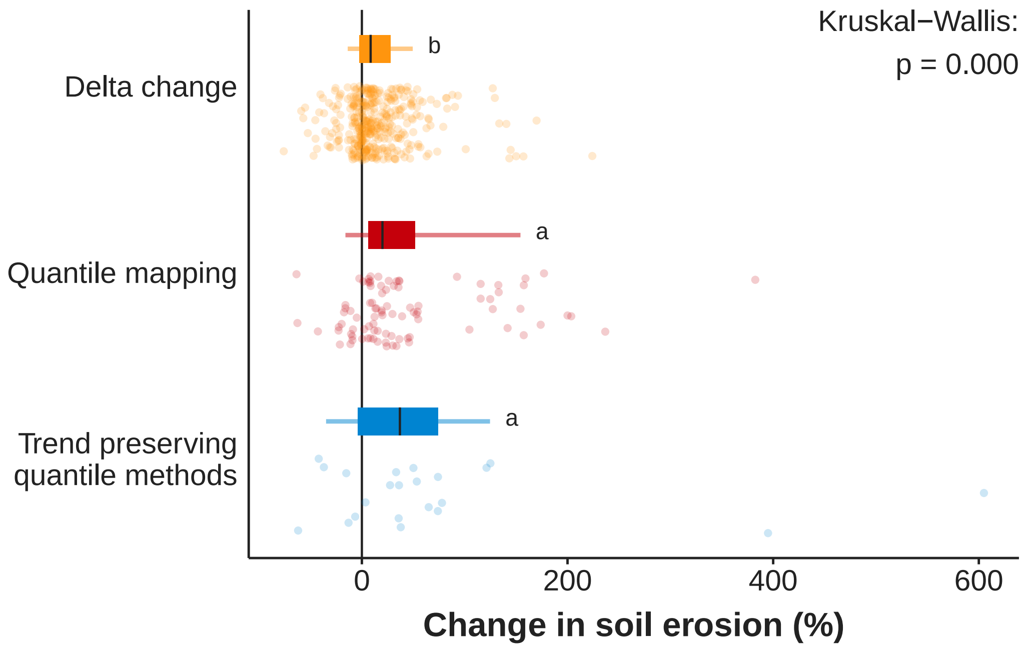

Figure S23. Change in soil erosion (%) under climate change per bias correction method as shown in a jitter plot, where each dot is the change in soil erosion per study, differentiated per future period and emission scenario. The colored boxes indicate the inter-quantile range (25th and 75th percentiles), the black line the median (50th percentile) and the whiskers extend to the 10th and 90th percentiles. The box-plots followed by a common letter are not significantly different by the Wilcoxon rank-sum test at the 5% level of significance. The significance of the Kruskal-Wallis test is shown in the upper right corner.

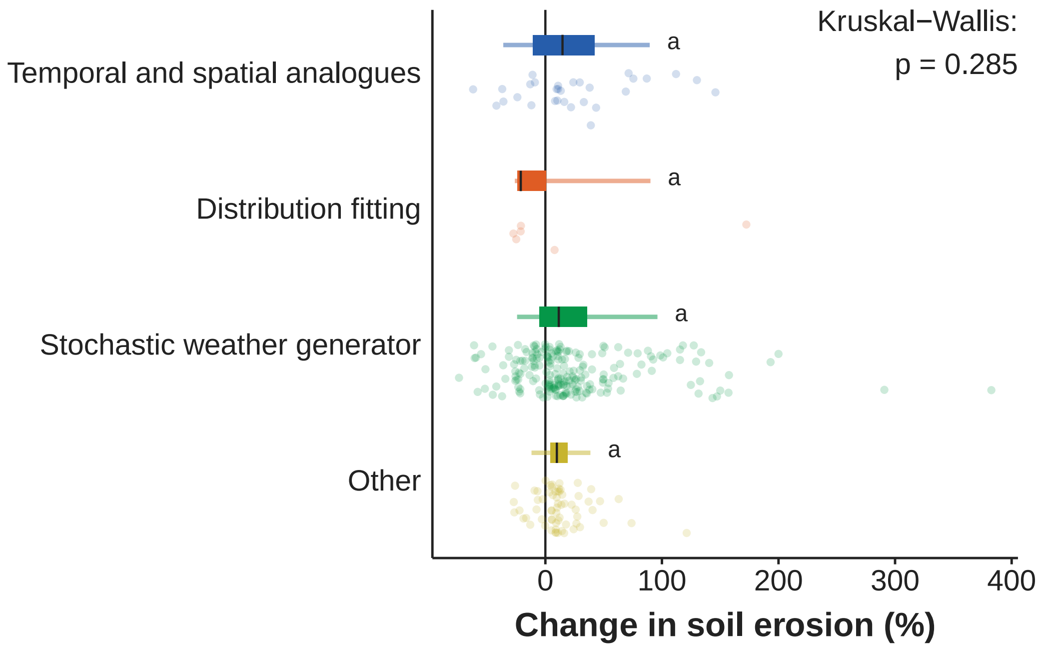

Figure S24. Change in soil erosion (%) under climate change per statistical downscaling method as shown in a jitter plot, where each dot is the change in soil erosion per study, differentiated per future period and emission scenario. The colored boxes indicate the inter-quantile range (25th and 75th percentiles), the black line the median (50th percentile) and the whiskers extend to the 10th and 90th percentiles. The box-plots followed by a common letter are not significantly different by the Wilcoxon rank-sum test at the 5% level of significance. The significance of the Kruskal-Wallis test is shown in the upper right corner.

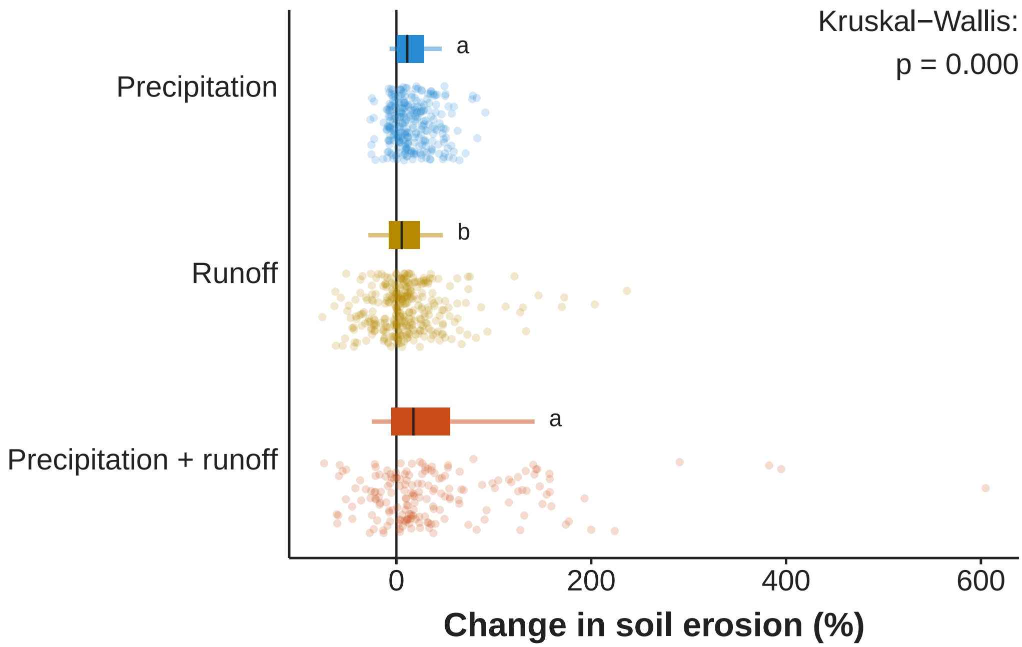

Figure S25. Change in soil erosion (%) under climate change per model concept as shown in a jitter plot, where each dot is the change in soil erosion per study, differentiated per future period and emission scenario. The colored boxes indicate the inter-quantile range (25th and 75th percentiles), the black line the median (50th percentile) and the whiskers extend to the 10th and 90th percentiles. The box-plots followed by a common letter are not significantly different by the Wilcoxon rank-sum test at the 5% level of significance. The significance of the Kruskal-Wallis test is shown in the upper right corner.

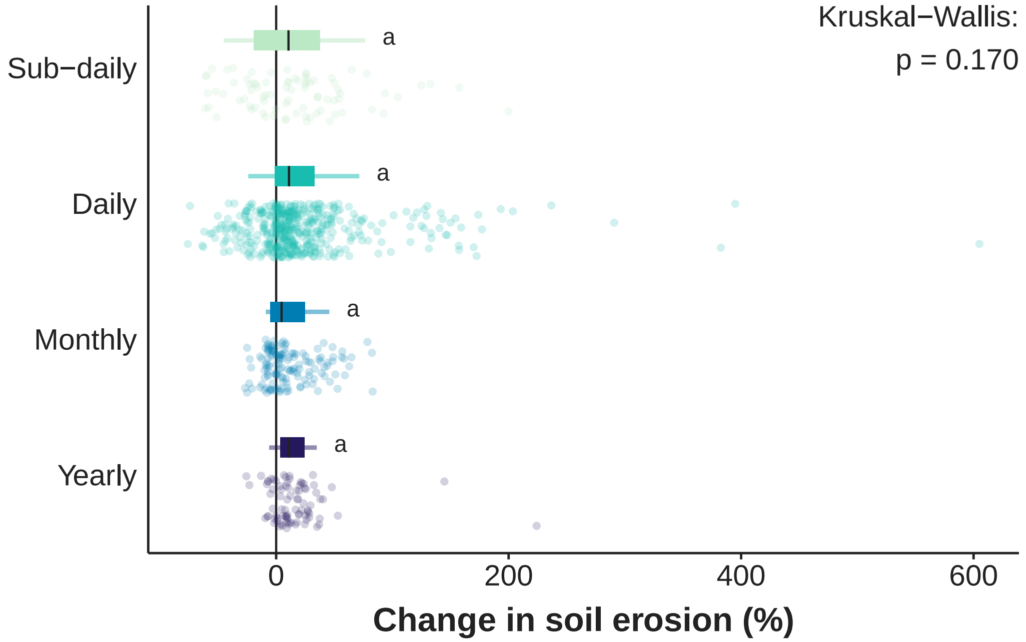

Figure S26. Change in soil erosion (%) under climate change per time step class as shown in a jitter plot, where each dot is the change in soil erosion per study, differentiated per future period and emission scenario. The colored boxes indicate the inter-quantile range (25th and 75th percentiles), the black line the median (50th percentile) and the whiskers extend to the 10th and 90th percentiles. The box-plots followed by a common letter are not significantly different by the Wilcoxon rank-sum test at the 5% level of significance. The significance of the Kruskal-Wallis test is shown in the upper right corner.

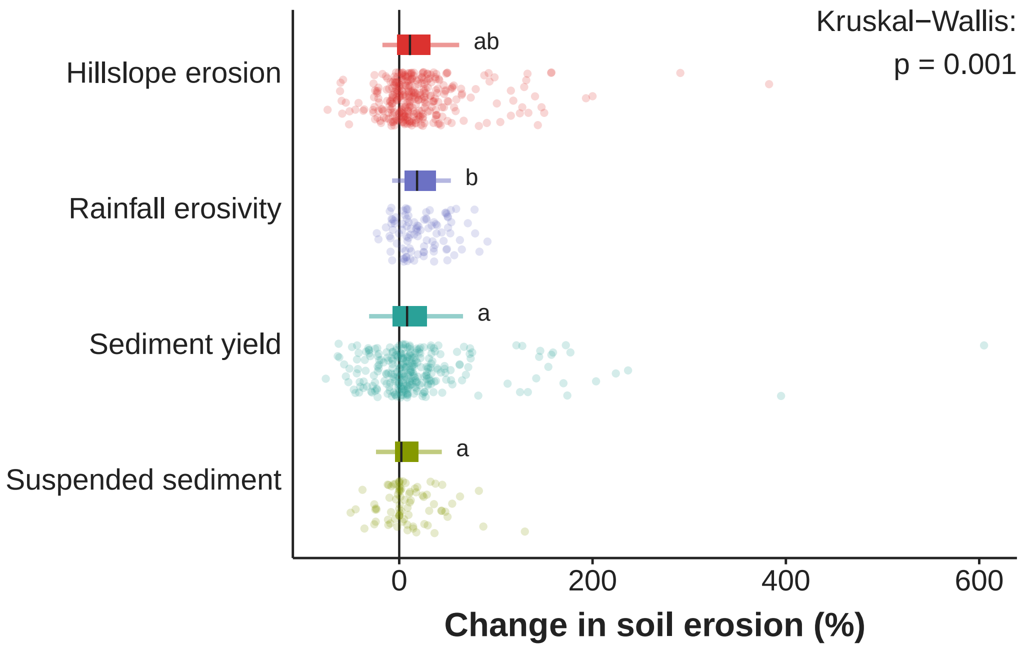

Figure S27. Change in soil erosion (%) under climate change per output variable as shown in a jitter plot, where each dot is the change in soil erosion per study, differentiated per future period and emission scenario. The colored boxes indicate the inter-quantile range (25th and 75th percentiles), the black line the median (50th percentile) and the whiskers extend to the 10th and 90th percentiles. The box-plots followed by a common letter are not significantly different by the Wilcoxon rank-sum test at the 5% level of significance. The significance of the Kruskal-Wallis test is shown in the upper right corner.

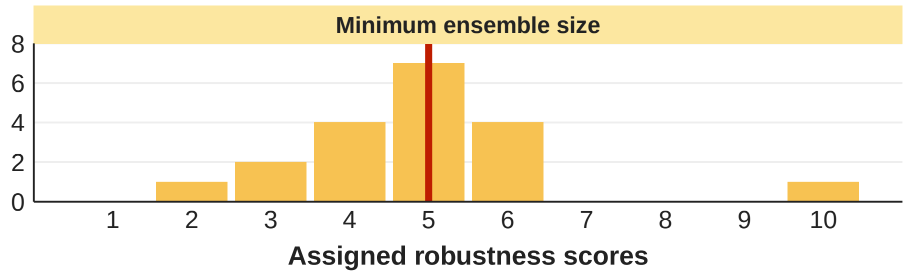

Figure S28. Assigned robustness scores for the minimum size of the climate model ensemble. The vertical axis represents the number of experts. The vertical red line denotes the median robustness score.

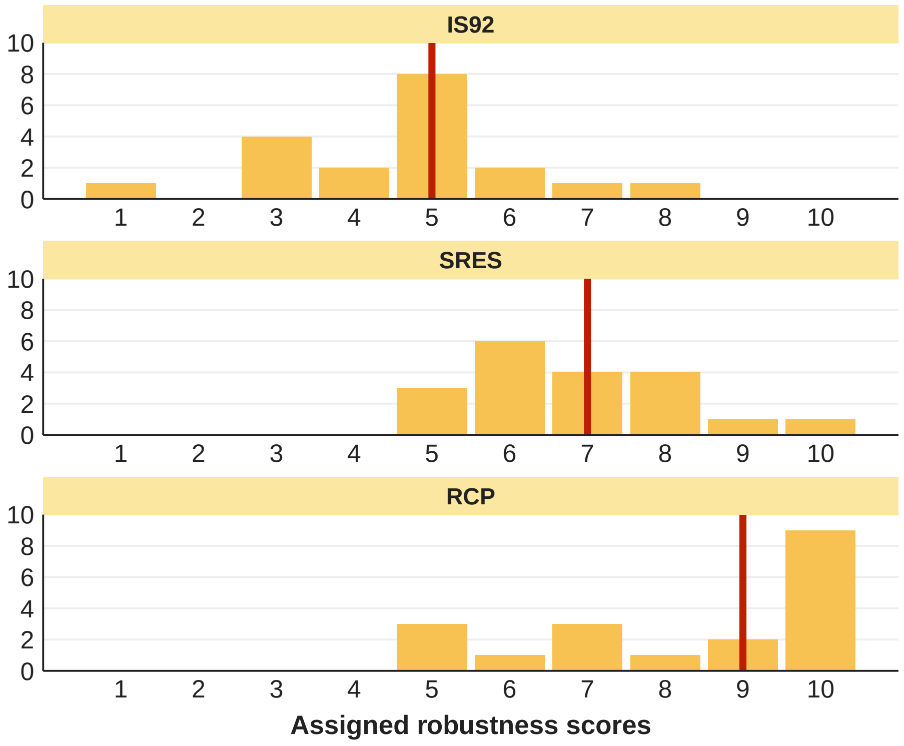

Figure S29. Assigned robustness scores for the generation of emissions scenarios. The vertical axis represents the number of experts. The vertical red line denotes the median robustness score.

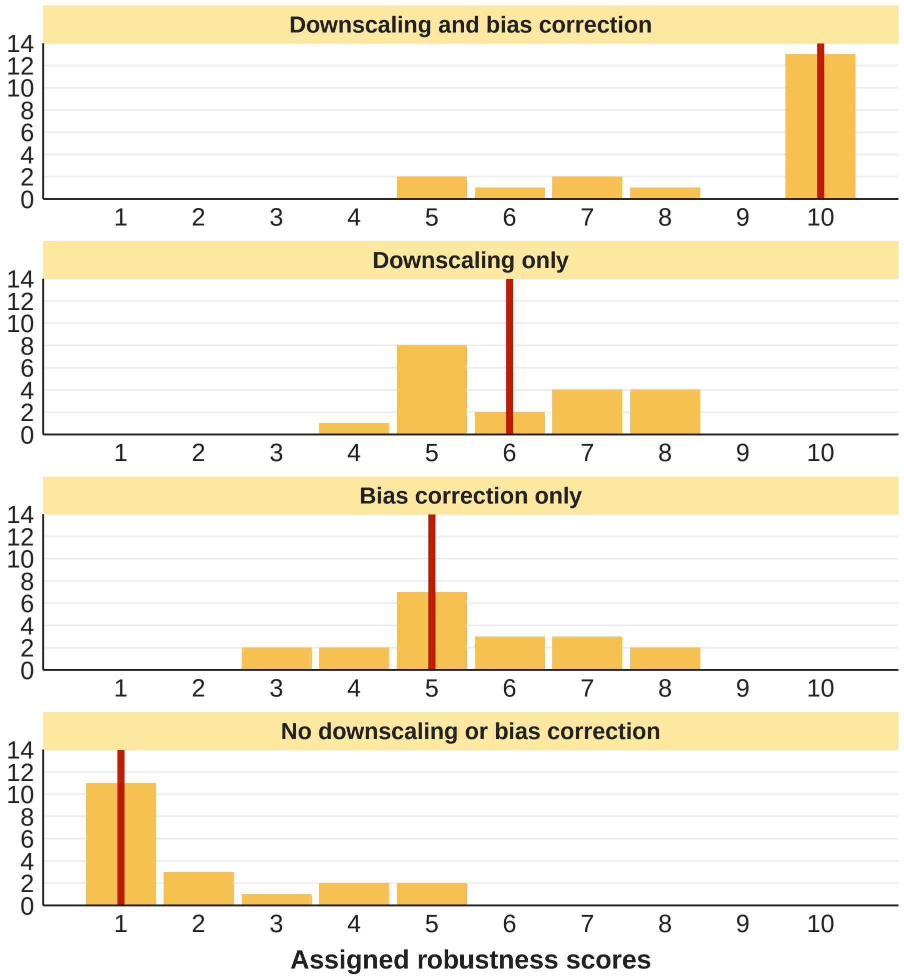

Figure S30. Assigned robustness scores for the application of downscaling and bias correction. The vertical axis represents the number of experts.The vertical red line denotes the median robustness score.

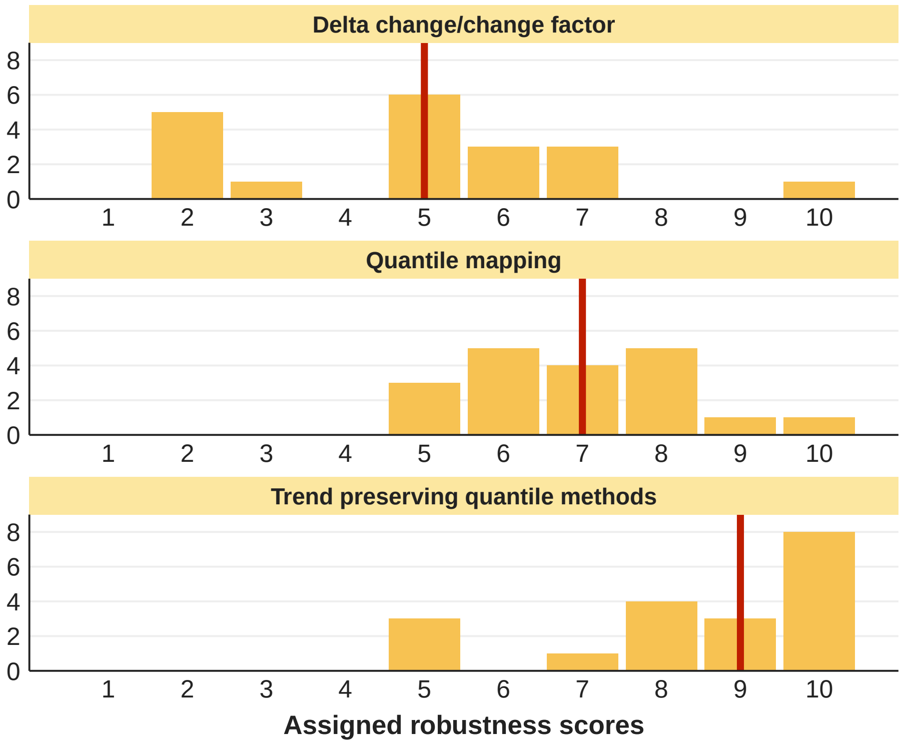

Figure S31. Assigned robustness scores for bias correction methods. The vertical axis represents the number of experts.The vertical red line denotes the median robustness score.

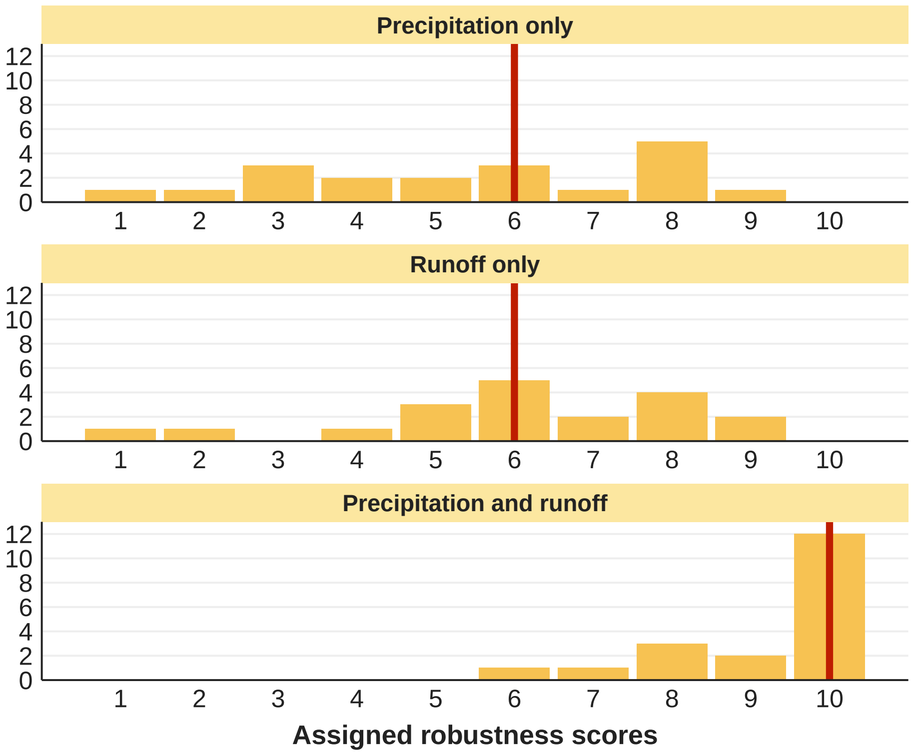

Figure S32. Assigned robustness scores for model concepts. The vertical axis represents the number of experts.The vertical red line denotes the median robustness score.

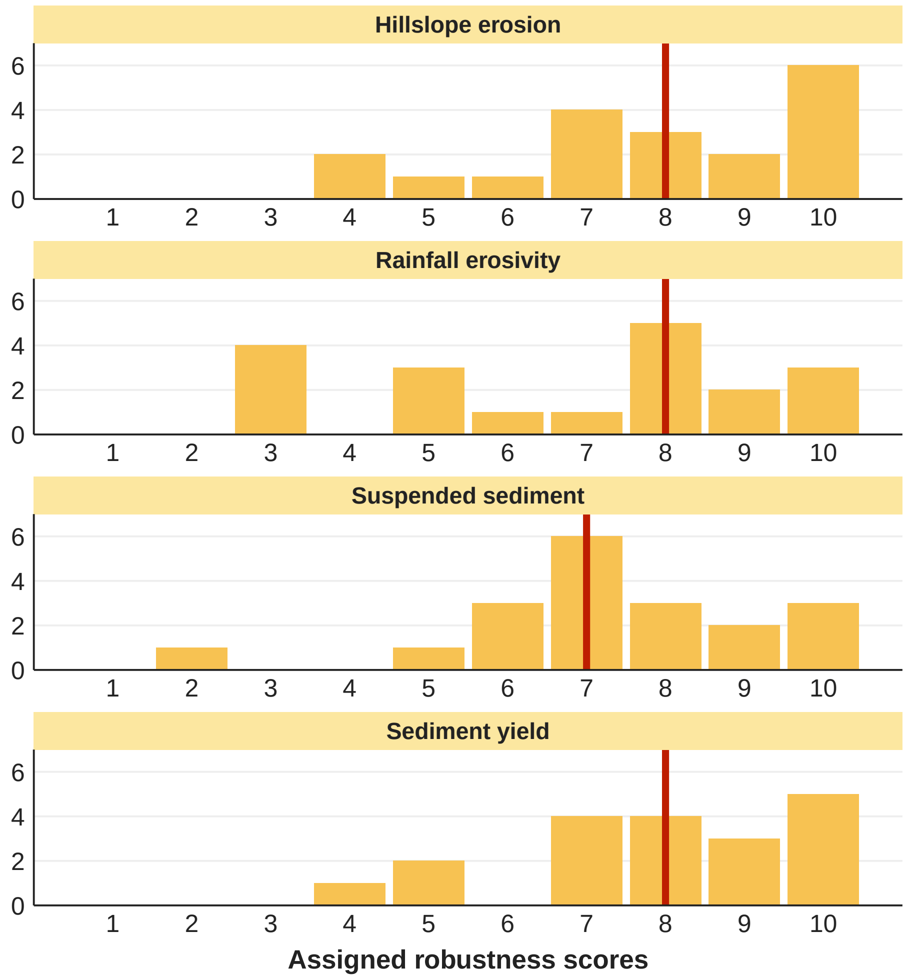

Figure S33. Assigned robustness scores for output variables. The vertical axis represents the number of experts.The vertical red line denotes the median robustness score.

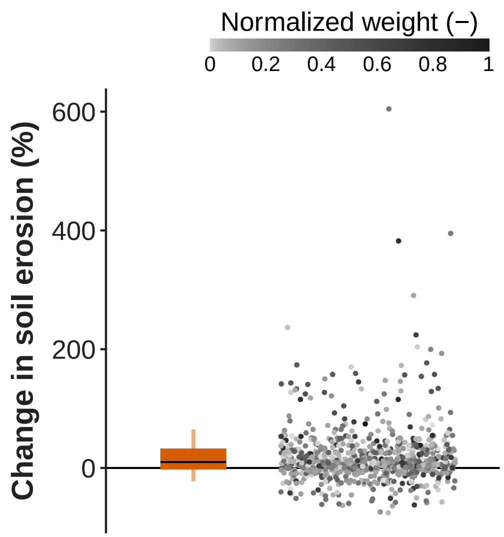

Figure S34. Projected change in soil erosion (%) considering all future periods, for the full range of the soil erosion projections. The coloured boxes indicate the weighted inter-quantile range (25th and 75th percentiles), the black horizontal line the weighted median (50th percentile) and the whiskers extend to the weighted 10th and 90th percentiles. The jitter plot shows the projected change in soil erosion per study, differentiated per period and emission scenario. The grey shades indicate the robustness of the studies, quantified with the weight.

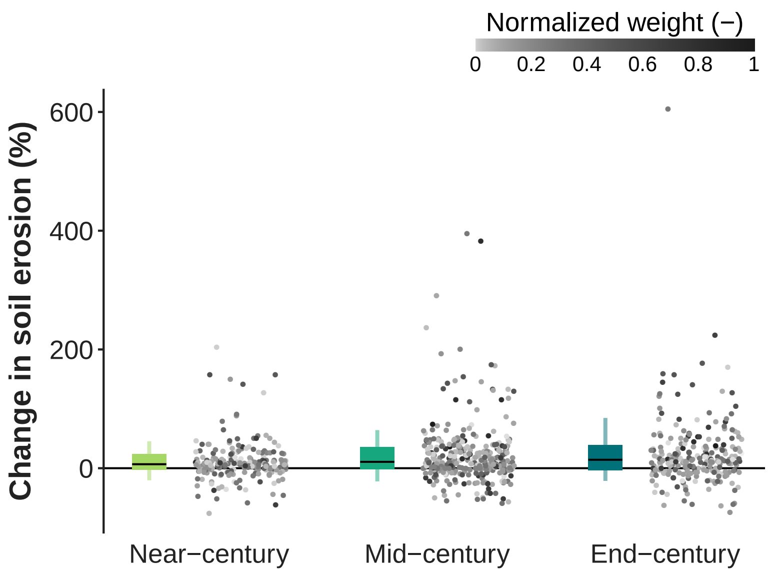

Figure S35. Projected change in soil erosion (%) per future period, for the full range of the soil erosion projections. The coloured boxes indicate the weighted inter-quantile range (25th and 75th percentiles), the black horizontal line the weighted median (50th percentile) and the whiskers extend to the weighted 10th and 90th percentiles. The jitter plot shows the projected change in soil erosion per study, differentiated per period and emission scenario. The grey shades indicate the robustness of the studies, quantified with the weight.

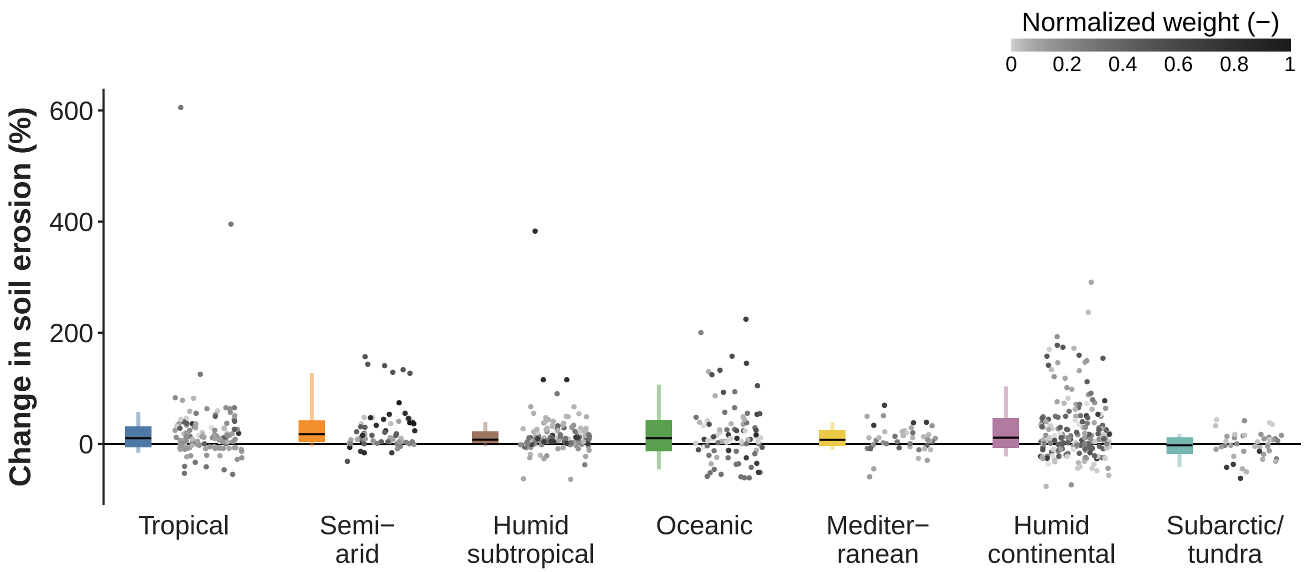

Figure S36. Projected change in soil erosion (%) per climate zone, for the full range of the soil erosion projections. The coloured boxes indicate the weighted inter-quantile range (25th and 75th percentiles), the black horizontal line the weighted median (50th percentile) and the whiskers extend to the weighted 10th and 90th percentiles. The jitter plot shows the projected change in soil erosion per study, differentiated per period and emission scenario. The grey shades indicate the robustness of the studies, quantified with the weight.

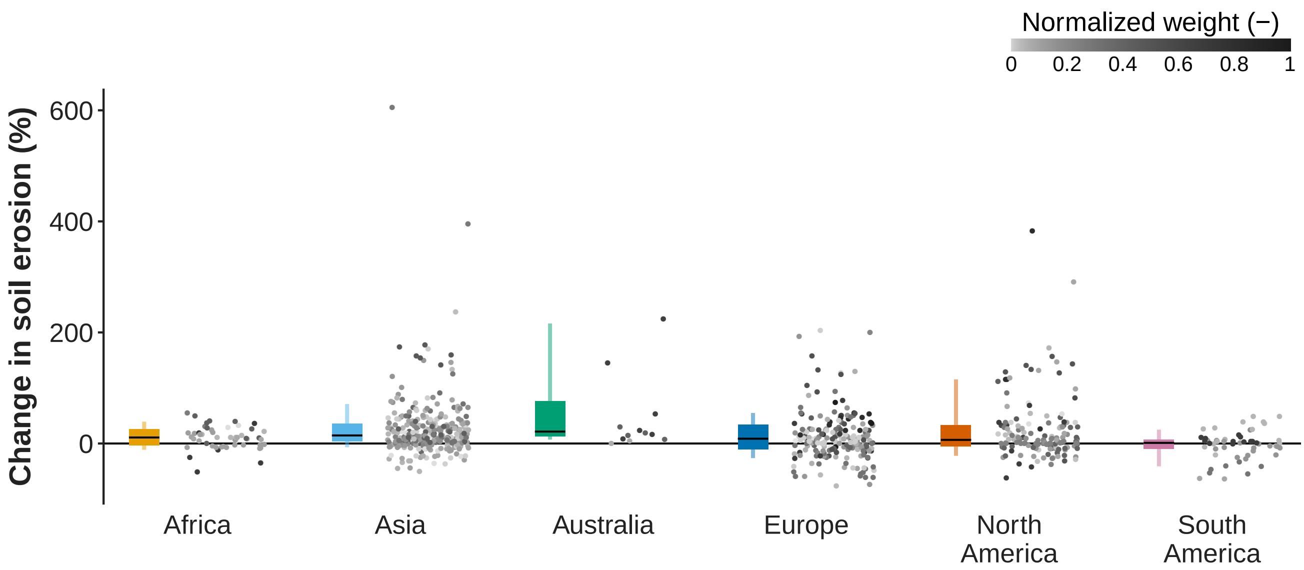

Figure S37. Projected change in soil erosion (%) per continent, for the full range of the soil erosion projections. The coloured boxes indicate the weighted inter-quantile range (25th and 75th percentiles), the black horizontal line the weighted median (50th percentile) and the whiskers extend to the weighted 10th and 90th percentiles. The jitter plot shows the projected change in soil erosion per study, differentiated per period and emission scenario. The grey shades indicate the robustness of the studies, quantified with the weight.

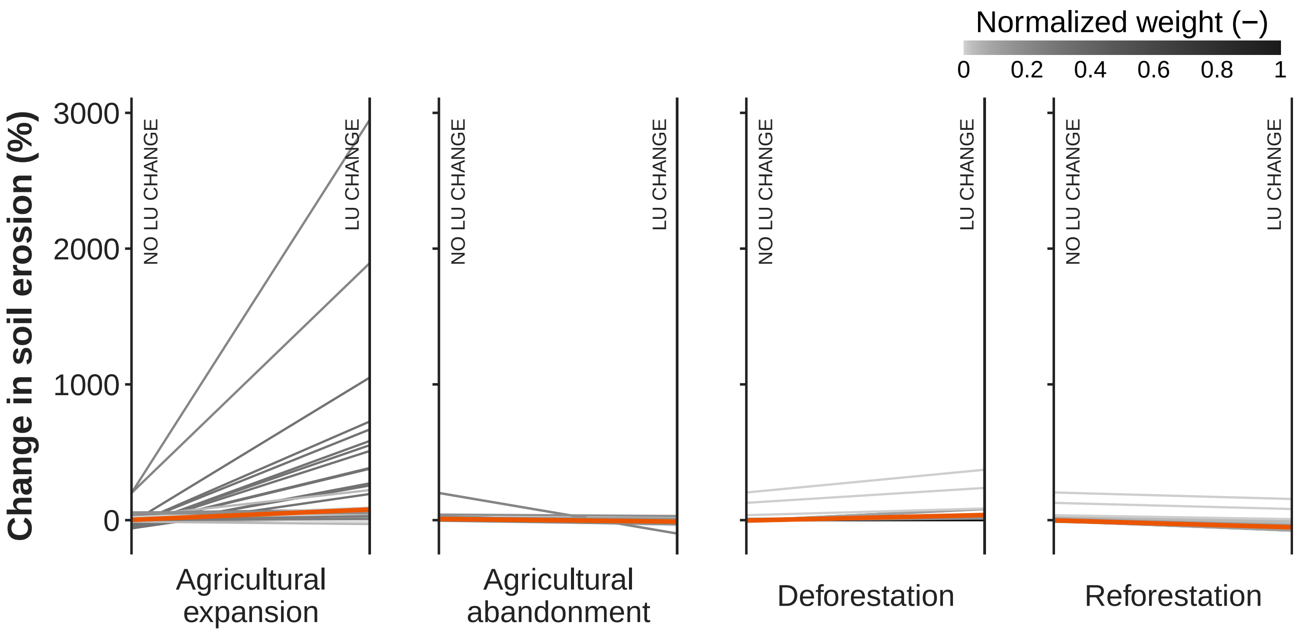

Figure S38. Projected change in soil erosion (%) with respect to the reference period for the main land use change scenarios. Each line belongs to a single study, defined by a future period and emission scenario. The grey shades indicate the weight that was applied to each study based on the six robustness criteria, from light gray (uncertain) to black (robust). The orange line shows the weighted median.

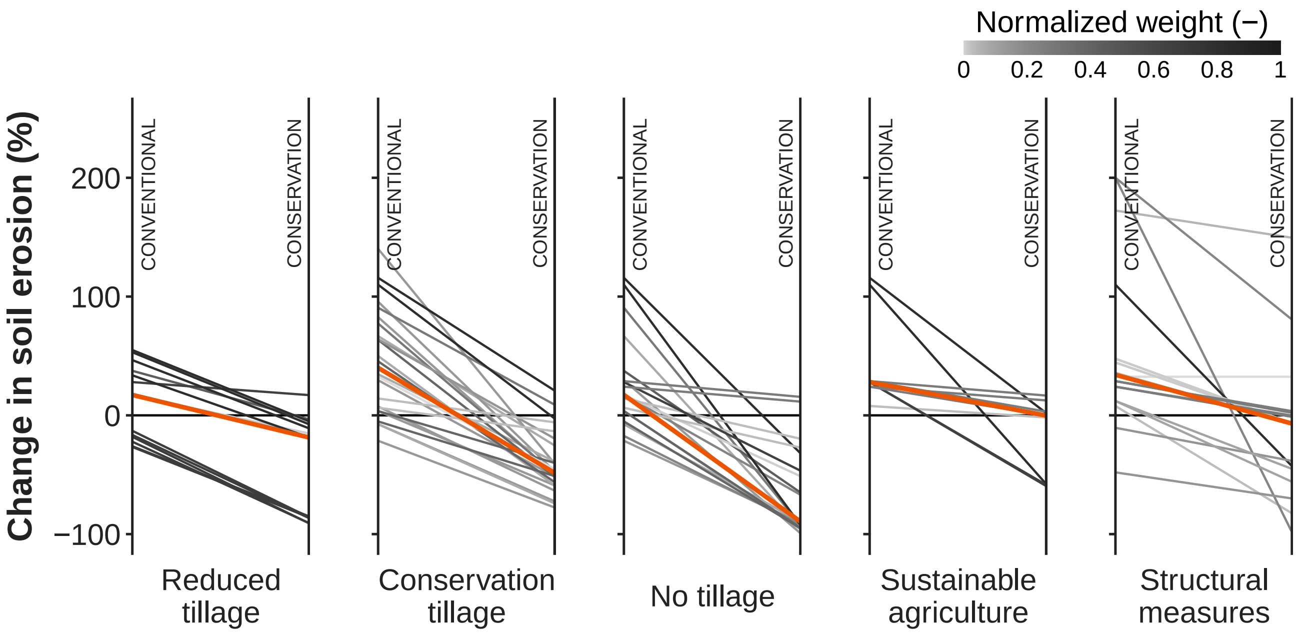

Figure S39. Projected change in soil erosion (%) with respect to the reference period for the soil conservation practices. Each line belongs to a single study, defined by a future period and emission scenario. The grey shades indicate the weight that was applied to each study based on the six robustness criteria, from light gray (uncertain) to black (robust). The orange line shows the weighted median.

Tables

Table S4. Number of publications per journal, with a minimum of 4 published studies.

Journal	Number of publications
Catena	17
Water (Switzerland)	16
Science of the Total Environment	15
Journal of Hydrology	12
Geomorphology	6
Climatic Change	5
Ecological Engineering	5
Hydrological Processes	5
Hydrology and Earth System Sciences	5
Journal of Soil and Water Conservation	5
Hydrological Sciences Journal	4
Hydrology	4
Journal of Soils and Sediments	4

Table S5. Number of study areas per country, with a minimum of 5 studies.

Country	Number of study areas
United States of America	74
China	20
Spain	14
India	12
Portugal	10
Brazil	10
Germany	10
United Kingdom	8
Iran	7
Ethiopia	7
Greece	6
Vietnam	5

Table S6. Number of studies per soil erosion model, with a minimum of 3 studies.

Soil erosion model	Model concept	Number of studies
MUSLE (Williams, 1995)	Runoff	81
RUSLE (Renard et al., 1997)	Precipitation	40
WEPP (Nearing et al., 1989)	Precipitation + runoff	23
R-factor (Renard et al., 1997)	Precipitation	14
USLE (Wischmeier and Smith, 1978)	Precipitation	8
EI30 (Renard et al., 1997)	Precipitation	6
SHETRAN (Ewen et al., 2000)	Precipitation + runoff	5
HSPF (Bicknell et al., 1993)	Precipitation + runoff	4
PESERA (Kirkby et al., 2008)	Runoff	4
TETIS (Bussi et al., 2014)	Runoff	4
EROSION 3D (Schmidt, 1990)	Precipitation + runoff	3
INCA-Sed (Lazar et al., 2010)	Precipitation + runoff	3
SPHY-MMF (Eekhout et al., 2018)	Precipitation + runoff	3

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