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Supplementary Information

Assessing Impacts of Land Use and Land Cover (LULC) Change on Stream Flow and Runoff in Rur Basin, Germany

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This File contains:

Figures S1–S5, Tables S1–S6, and their captions

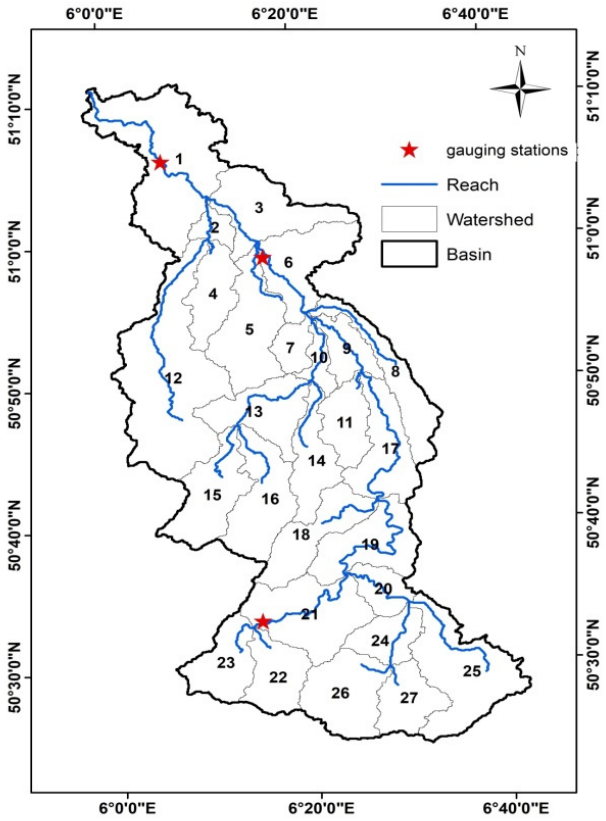

Figure S1. Sub-basin boundaries (formed during watershed delineation) and reach network with monitoring stations.

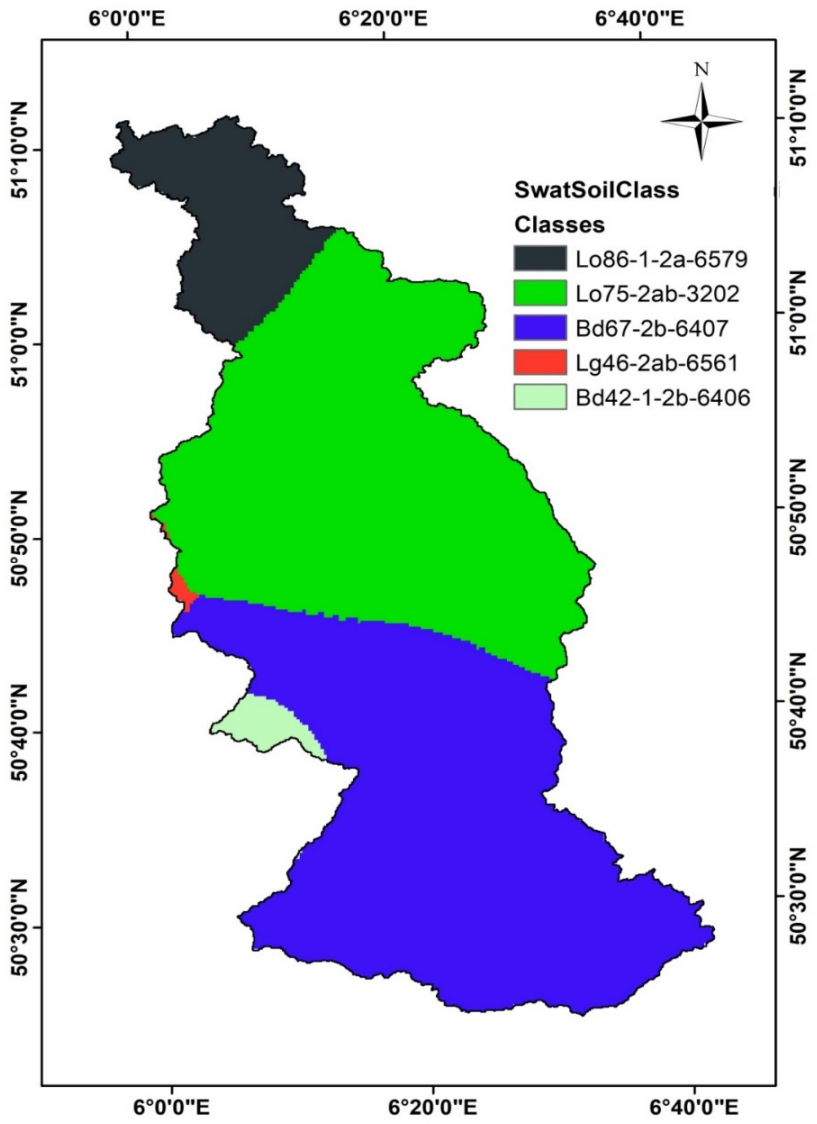

Figure S2. Soil classes in the Rur catchment.

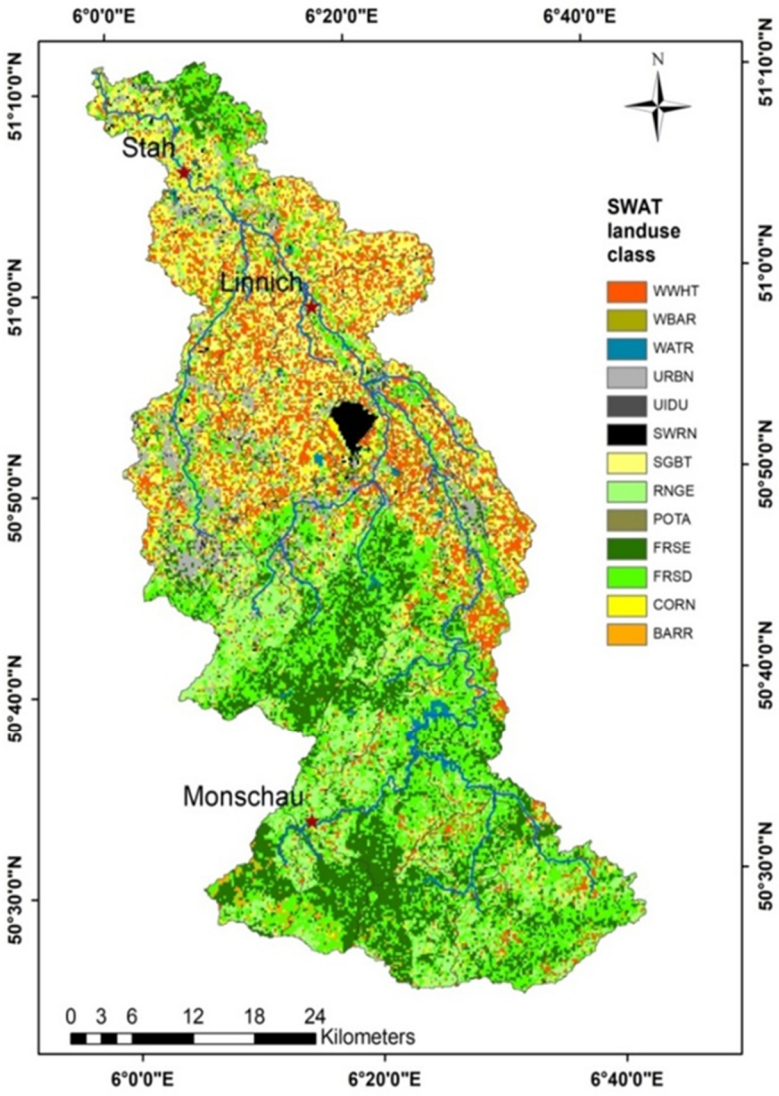

Figure S3. Land Use map of the Rur catchment classified into 13 land use classes.

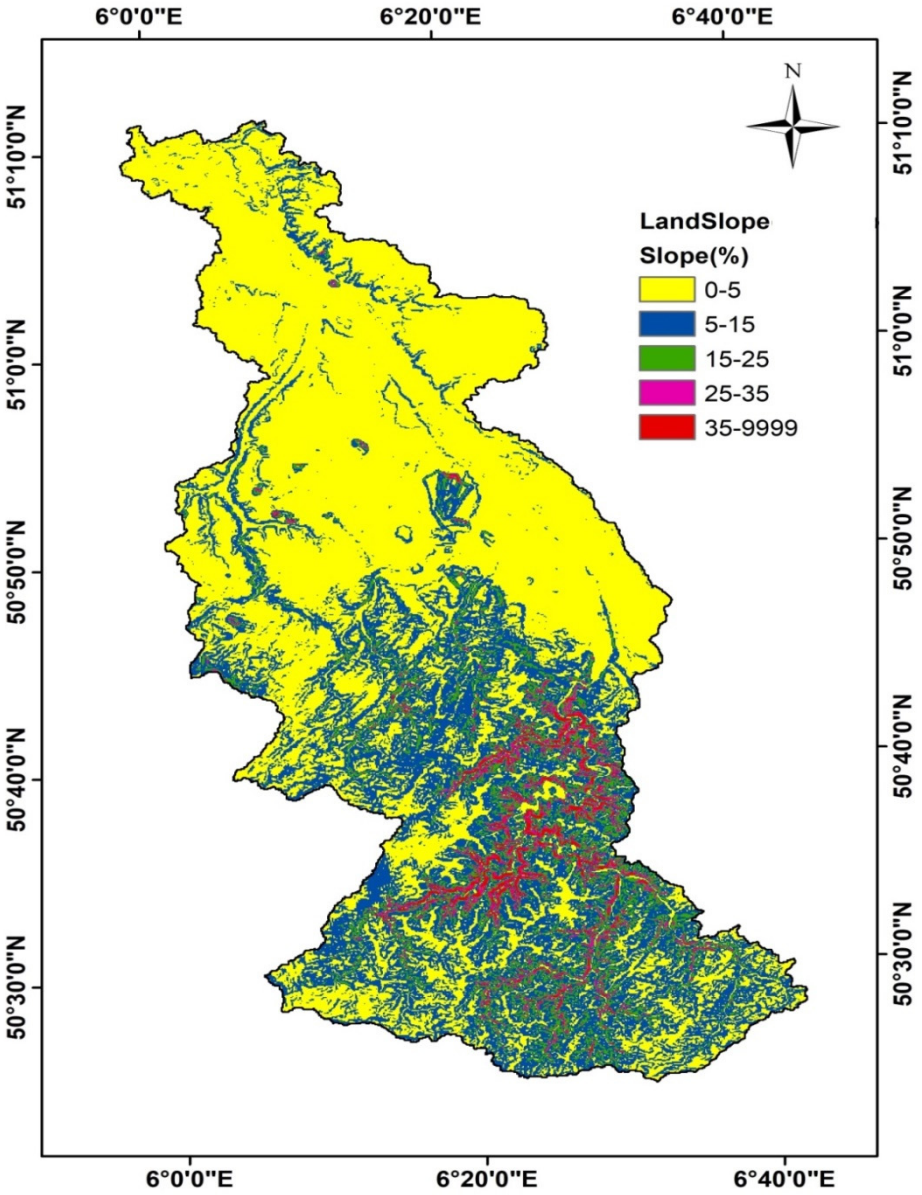

Figure S4. Slope classes for the Rur catchment.

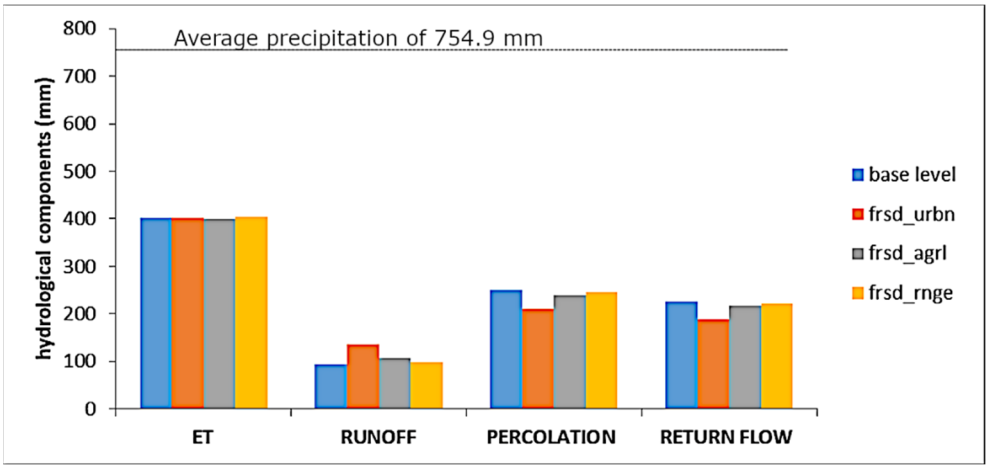

Figure S5. The evapotranspiration (ET), runoff, percolation and return flow for different scenarios.

Table S1. Characteristics and texture of the SWAT soil classes used in the simulations**.** **(**http://www.fao.org/soils-portal/data-hub/soil-maps-and-databases/en/).

SWAT soil class	Clay %	Silt %	Sand %	Texture
Lo86-1-2a-6579	15	22	62	Sandy-loam
Lo75-2ab-3202	21	34	44	loam
Bd67-2b-6407	20	32	48	loam
Lg46-2ab-6561	21	29	50	loam
Bd42-1-2b-6406	20	30	50	loam

Table S2. Weather stations used for temperature, precipitation and relative humidity.

Station ID	Name	Latitude	Longitude	Elevation (m.a.s.l)
1	Hein	51.0410 N	6.1040 E	57
2	Kall	50.5020 N	6.5260 E	505
3	Nide	50.6740 N	6.4240 E	350

Table S3. Different model inputs, their description, and sources.

S.no	Spatial data	Description	Source
1	Digital Elevation Model (DEM)	90 m × 90 m grid DEM for watershed delineation which is helpful in stream definition and calculating sub-basin parameters.	Shuttle Radar Topography Mission (SRTM) of USGS
2	Landuse and landcover (LULC)	2006 LULC map in100 m × 100 m resolution from Corine Lancover Map (CLC) data	https://land.copernicus.eu/pan-european/corine-land-cover
3	Soil data	The soil data in 100 m × 100 m resolution from FAO.	Food And Organization (FAO) Digital Soil Map http://www.fao.org/soils-portal/data-hub/soil-maps-and-databases/en/
4	Weather data	Weather data (Temperature, precipitation, relative humidity, solar radiation, wind speed)	TERENO observatory, Germany
5	Hydrological data	Hydrological data (runoff)	TERENO observatory, Germany

Table S4. Calibrated parameter for Monschau, Linnich and Stah stations. The parameters are ordered as per sensitivity rank with the most sensitive parameter at the top.

Monschau station					
Rank.	**Parameter name**	**Physical description**	**Lower and upper bounds**	**Fitted values**	Units
1.	CN2	Initial curve number II	-0.5 to 0.1	-0.473	none
2.	GW_DELAY	Groundwater delay	0 to 50	10.25	days
3.	ALPHA_BF	Base flow alpha factor	0 to 1	0.265	none
5.	GWQMN	Threshold depth of water in the shallow aquifer required for return flow to occur	0 to 50	38.75	Mm
6	SLS_SUBBSN	Average slope length	0.0995 to 0.1476	0.136	none
7	HRU_SLP	Average slope steepness	0 to 1	0.695	Mm
8	SOL_K	Saturated hydraulic conductivity	0 to 1	0.755	none
9	ESCO	Soil evaporation compensation factor	0 to 1	0.855	none
10	OV_N	Manning's n value for overland flow	0.01 to 1	0.5	none
11	SOL_AWC	Available water capacity of the soil layer	0 to 1	0.805	none
12	SOL_BD()	Moist bulk density	0 to 1	0.595	none
13	REVAPMN	Threshold depth of water in the shallow aquifer for "revap" to occur	0 to 4	3.9	Mm
Linnich station					
1	CN2	Initial curve number II	-0.7 to 0.1	-0.415	none
2	AL-	Base flow alpha factor	0 to 1	0.635	none

	PHA_BF				
3	GWQMN	Threshold depth of water in the shallow aquifer required for return flow to occur	0 to 50	33	Mm
4	GW_DELAY	Groundwater delay	0 to 50	13.95	days
5	SLS_SUBBSN	Average slope length	0.0995 to 0.1476	0.147	none
6	SOL_BD()	Moist bulk density	0 to 1	0.695	none
7	GW_REVAP	Groundwater "revap" coefficient	0.02 to 0.2	0.161	Mm
8	HRU_SLP	Average slope steepness	0 to 1	0.885	Mm
9	SOL_K	Saturated hydraulic conductivity	0 to 1	0.715	none
10	ESCO	Soil evaporation compensation factor	0 to 1	0.675	none
11	SOL_AWC	Available water capacity of the soil layer	0 to 1	0.725	none
12	REVAPMN	Threshold depth of water in the shallow aquifer for "revap" to occur	0 to 4	0.82	Mm
13	OV_N	Manning's n value for overland flow	0.01 to 1	0.837	none
		Stah station			
1.	CN2	Initial curve number II	-0.7 to 0.1	-0.415	none
2	AL-PHA_BF	Base flow alpha factor	0 to 1	0.635	none
3	GWQMN	Threshold depth of water in the shallow aquifer required for return flow to occur	0 to 50	33	Mm
4	GW_DELAY	Groundwater delay	0 to 50	13.95	days
5	SLS_SUBBSN	Average slope length	0.0995 to 0.1476	0.147	none
6	SOL_BD()	Moist bulk density	0 to 1	0.695	none
7	GW_REVAP	Groundwater "revap" coefficient	0.02 to 0.2	0.161	Mm
8	HRU_SLP	Average slope steepness	0 to 1	0.885	Mm
9	SOL_K	Saturated hydraulic conductivity	0 to 1	0.715	none
10	ESCO	Soil evaporation compensation factor	0 to 1	0.675	none
11	SOL_AWC	Available water capacity of the soil layer	0 to 1	0.725	none
12	REVAPMN	Threshold depth of water in the shallow aquifer for "revap" to occur	0 to 4	0.82	Mm
13	OV_N	Manning's n value for overland flow	0.01 to 1	0.837	none

Table S5. Description of all the land use land cover scenarios used in this study.

Scenario code	Description	Final configuration (% area relative to total catchment)
Base level	Using the land-use map for 2006	Unchanged
frsd_urbn	deciduous forest converted to the urban settlement	0% frsd and 29.55% urbn
frsd_agrl	deciduous forest converted to the agri-cultural land	0 % frsd and 57.23% agrl
frsd_rnge	deciduous forest converted to the grass-lands	0 % frsd and 39.37% rnge

Table S6. Mann-Kendall test results for trend analysis in the average annual observed runoff data (2000-2015).

Station	z	Significance level	Trend
Linnich	-0.765	0.444	No statistically significant decreasing trend
Monschau	-0.855	0.392	No statistically significant decreasing trend
Selhausen	-2.03	0.042	Statistically significant decreasing trend
Stah	-1.936	0.052	No statistically significant decreasing trend
Kall	-3.287	0.001	Statistically significant decreasing trend