Supplementary Materials

Table S1. Description of land use (including wastewater treatment), water use and nitrogen deposition changes under the scenarios: LU1 = SRES A1, World market; LU2 = SRES A2, National enterprise, LU3 = SRES B1, Global sustainability, LU4 = SRES B2, Local stewardship. Nitrogen deposition was modelled based on European Monitoring and Evaluation Programme data and a chemical transport model developed at the Meteorological Synthesizing Centre – West (MSC-W). Wet and dry forms and land cover where accounted for in the catchment nitrogen deposition estimate. Further details are given in Jackson-Blake et al. 2008.

Study area	**Scenario**	**Land cover**	**Water use**	**Total nitrogen deposition** **Kg/ha/year**
Yläneenjoki (FIN)	LU1	No subsidies; increase of oil crops by 15-25%, increase in animal husbandry, increase in agricultural area.	Current irrigation is negligible and no change anticipated with climate projection.	NOx: 2.3 NHy: 1.9
	LU2	Focus on domestic markets; 50-60% of arable land used for winter cereals, no change in animal husbandry, increase in agricultural area.	As for Yläneenjoki LU1.	As for Yläneenjoki LU1.
	LU3	Environmental farming; increase in vegetation cover area during winter by up to 100%; increase in organic production for European markets.	As for Yläneenjoki LU1.	As for Yläneenjoki LU1.
	LU4	Nature conservation; change of 15-20% arable land to forest; permanent grassland and ecological set-aside areas.	As for Yläneenjoki LU1.	As for Yläneenjoki LU1.
Hobøl (NOR)	LU1	Non-sustainable management with projected population growth and intensification of food production; 10% reduction in forest which is converted to arable; shift of 25% of grass production to vegetable production; increase in fertiliser application of 25%; 25% increase in P load from effluents from septic tanks and wastewater treatment plants.	Current irrigation is negligible and no change anticipated with climate projection.	NOx: 3.3 NHy: 2.7
	LU4	Water quality focus: a 10% reduction in agricultural land which is converted to forest; 25% reduction in vegetable production which is converted to grass production; 25% reduction in fertiliser application; 90%	As for Vansjø LU1.	As for Vansjø LU1.

		improvement in wastewater treatment plant performance.		
Tarland (GBR)	LU2	Increase in arable from 20 to 31% of total area but a reduction in improved grassland, marginal increase in woodland in line with Land Use Strategy for Scotland targets.	Little abstraction in the catchment and this is not expected to change.	NOx: 2.6 NHy: 4.0
	LU3	Reduction in agricultural land area by 10% which is converted to woodland.	Little abstraction in the catchment and this is not expected to change.	As for Tarland LU1.
Thames (GBR)	LU1	Arable extent increased to 50% of total catchment area through grassland conversion.	No change	NOx: 4.0 NHy: 6.0
	LU2	Arable extent increased to 60% of total catchment area through grassland conversion.	No change	As for Thames LU1.
	LU3	Arable extent increased to 50% of total catchment area through grassland conversion.	Reservoir built in catchment and removes 10 $m^3 s^{-1}$ of flow at Abingdon during winter and returns same flow during summer.	As for Thames LU1.
	LU4	Arable extent increased to 60% of total catchment area through grassland conversion.	Reservoir built in catchment and removes 10 $m^3 s^{-1}$ of flow at Abingdon during winter and returns same flow during summer.	As for Thames LU1.
Vltava (CZE)	LU1	Agricultural land will be used in areas with good soil quality only, but with higher intensities; less productive and uneasily manageable agricultural areas will be abandoned and spontaneously change to forest. Hence, an increase by 10% in forest areas off the agricultural areas is supposed in 206 Fertiliser applications will increase from the current approximate applications of 70 and 5 kg/ha of N and P, respectively, to the level of maximum agricultural intensities in the country in the 1980s (i.e., to 100 and 15 kg/ha of N and P, respectively), livestock breeding will increase (from the current value of 0.6 to	Water use in the Orlík reservoir catchment includes mainly withdrawals for drinking water production, industry, and power and heat stations. These withdrawals are relatively small and represent less than 3% of the mean total water runoff from the catchment. Most of this withdrawn water is returned back to the river network as wastewaters, except for the evaporative losses of cooling waters used by power and	NOx: 3.5 NHy: 5.9

		approximately 1.1 LU per hectare of agricultural land) (LU = livestock unit of 500 kg alive weight, i.e., 1 cattle, 5 pig, 250 hen, 10 sheep). Mean fish production intensity in fishpond fisheries will increase to approximately 700 kg/ha in comparison with the current 500 kg/ha. Municipal sewerage and wastewater treatment will improve and will gradually reach the standard of western European countries; i.e. wastewater treatment plants will be built also at small settlements and nutrient discharges will decrease by approximately 50% compared to the current situation. Hence, the input of P by wastewaters into the river network in the Orlík catchment will decrease in a twenty-year period from the current value of 150 to 75 t/a.	heat stations (less than one third of the withdrawn volume). Any significant demands for irrigation by agriculture occur in this catchment and neither are expected for the future. Hence, no water-use scenarios were designed and simulated.	
	LU2	State interventions and subsidies for agriculture will keep agricultural land resources in a similar state as today; areas of forests and farmland will increase and decrease according to the long-term trend of the last 50 years, i.e. by approximately +3% and -3%, respectively. The use of fertilisers, fishpond production, wastewaters discharges, and the eutrophication of the Orlík reservoir similar to the previous scenario A1.	As for Vltava LU1.	As for Vltava LU1.
	LU3	A lower proportion of agricultural areas will be used as tilled fields and the rest will be changed to grassland or meadows; part of less fertile agricultural areas will be used for production of energetic woody species; the forest areas will increase by 3% off the agricultural areas.	As for Vltava LU1.	As for Vltava LU1.

		The tree structure of forests with the current predominance of Norway spruce and conifers will change and the proportion of deciduous trees will increase from the current 15% to approximately 40% (with consequences for the atmospheric deposition of pollutants into the catchment, which decrease in winter and early spring due to less horizontal precipitations). Productive agricultural areas will be used extensively with fertilisation intensities similar to the current level or even lesser; pastures will be used extensively with the current livestock density (i.e., on average 0.6 LU per hectare of agricultural land). Fishponds will be used extensively, without fertilisation and fish feeding, i.e. with production based on natural productivity; hence, fishponds will relatively efficiently retain phosphorus. Municipal wastewaters will be treated with respect to maximising phosphorus removal; export of P into streams in the catchment will decrease to approximately 30% of the current state.		
	LU4	Very similar to the LU2 scenario.	As for Vltava LU1.	As for Vltava LU1.
Arbúcies (ESP)	LU1	Globalisation and market forces dominate, meaning that land use receives no government subsidies and there is little environmental protection. Intensive agriculture is favoured on the best quality land. For the Arbúcies catchment, agriculture is reduced due to fierce competition with regional and global markets, following the current trend. Abandoned land is not actively managed, and is mostly converted to grassland or shrubland. 10% of arable land is converted to forest, the	Abstraction rates were affected by both climate and land use scenarios. Relative to the baseline period (where 0.1 m^3 s^{-1} is abstracted in May, June and September, and 0.2 m^3 s^{-1} in July-August), the abstraction rates were increased by the same relative rates as summer precipitation (May-September) decreased. There is a restriction to the	NOx: 5.8 NHy: 5.4

		remaining agricultural land is managed intensively. No change in fertilsier use. Weak limitations on urban growth; population grows at nearly the mean growth rate (applied for a period of thirty years). Growth rate applied, 1.018; resulting population for the scenario period = 12,000 person equivalents. +20 % increase in STW concentration (low environmental regulations; increased overflows)	abstraction so that the stream-flow must never fall beneath 0.02 $m^3 s^{-1}$.	
	LU2	Protectionism at national and trade-bloc (EU) level with food security given the highest priority and land subsidised to provide this. Low environmental protection and regulation. For the Arbúcies catchment, agriculture in marginal lands will be abandoned in favor of other uses, including forest products, but in competition with grasslands and pastures. 10% of arable land is converted to grassland; the remaining arable land is managed intensively. 50% increase in fertiliser use. Weak limitations on urban growth; population grows at the mean growth rate. Growth rate applied, 1.022; resulting population for the scenario period = 13,500 person equivalents. No change in STW inputs.	As for Arbúcies LU1	As for Arbúcies LU1
	LU3	Global co-operation and binding treaties mean that a high degree of environmental protection is enforced. Land use planning is strongly regulated resulting in zoning associated with best utilisation of natural resources.For the Arbúcies catchment, agriculture will be maintained on high quality lands; abandoned marginal lands are actively managed for forest products. 30% of arable land is converted to forest. 50% reduction in fertiliser use.	As for Arbúcies LU1	As for Arbúcies LU1

		Strong limitations on urban growth; most population growth in seasonal inhabitants. Growth rate applied: 1.010; resulting population for the scenario period = 9,450 person equivalents. -30 % in concentration (assuming soft-engineering post-treatment is applied, such as constructed wetland, in-stream restoration to enhance nutrient retention)		
	LU4	Decision-making is dominated by local issues, particularly sustainable solutions to local food and energy supply.There will therefore be little large-scale co-ordination, and land use and resources are strongly based on the needs of the local community. For the Arbúcies catchment, agricultural lands are environmentally-managed but are all kept for food security. Forest cover does not increase. 30% reduciton in fertiliser use. Very strong limitations on growth. Rate applied: 1.005; resulting population for the scenario period = 8,140 person equivalents. -50 % in concentration (assuming a part of the sewage produced in Arbúcies is taken to the STW in Hostalric).	As for Arbúcies LU1	As for Arbúcies LU1
Louros (GRC)	LU1	Increase in arable (+5%), other crops (+2.5%, citrus, olives, nuts), grassland (+0.5%) and decrease in forest (-5%). Livestock increased in proportion to grassland area. Arable crops were cotton, maize, medic, pulses, potatoes, melons, cereals, vineyards.	Abstraction rates were recalculated based on the changed crop areas and assumptions of crop water usage. The amount of irrigation applied each year was calculated as the deficit between the total summer (May-September) precipitation and the total water demand. The total	NOx: 2.6 NHy: 1.7

			amount of water abstracted for summer irrigation was then distributed between summer months according to: May – 10%, June – 20%, July – 30%, Aug – 30% and Sep – 10%.	
	LU2	Increase in arable (+10%), other crops (+5%) grassland (+3%) and decrease in forest (-10%)	As for Louros LU1	As for Louros LU1
	LU3	Increase in arable (+4%), other crops (+2.5%) grassland (+0.25%) and decrease in forest (-5%)	As for Louros LU1	As for Louros LU1
	LU4	Increase in arable (+8%), other crops (+5%) grassland (+0.5%) and decrease in forest (-10%)	As for Louros LU1	As for Louros LU1
Beyşehir (TUR)	LU1	*Assumptions: agricultural productivity will increase, the less productive areas will be abandoned, and there will be some degree of urbanization within the catchment.* • Change 15% of agricultural area to forest (8%) and medium density urban area (7%) in areas where these land uses are present and able to expand • No change in fertilizer use • Change sugar beet (if any in subbasin) to barley	Irrigation is stopped (this is only done for sugar beet in the base scenario)	NOx: 2.4 NHy: 3.7
	LU2	*Assumptions: agricultural productivity will increase; the less productive areas will be abandoned, and there will be some degree of urbanization within the catchment. Increased food demand and economic growth will intensify the agricultural production by increased fertilizer use.* • Change 10% of agricultural area to forest (5%) and medium density urban area (5%) in areas where these	Irrigation is stopped (this is only done for sugar beet in the base scenario)	As for Beyşhir LU1

		land uses are present and able to expand • Increase in fertilizer use by 20% • Change sugar beet (if any in subbasin) to barley		
	LU3	*Assumptions: agricultural productivity will increase; the less productive areas will be converted to forest, and there will be some degree of urbanization within the catchment. Some rotations will change to barley.* • Change 15% of agricultural area to forest (13%) and medium density urban area (2%) in areas where these land uses are present and able to expand Change all winter wheat and sugar beet (if any in subbasin) rotations to barley	Irrigation is stopped (this is only done for sugar beet in the base scenario)	As for Beyşhir LU1
	LU4	• Assumptions: agricultural productivity will increase; the less productive areas will be converted to forest, and there will be some degree of urbanization within the catchment. Measures are taken to reduce the impact of agricultural production on downstream water bodies. • Change 20% of agricultural area to forest (15%) and medium density urban area (5%) in areas where these land uses are present and able to expand • Decrease fertilizer use by 10% in agricultural areas • Change sugar beet (if any in subbasin) to barley • Insert 5 metre buffer strip along all agricultural areas in SWAT	Irrigation is stopped (this is only done for sugar beet in the base scenario)	As for Beyşhir LU1

IJsselmeer (NLD)	LU1	Reduction in Total N input by 19% and Total P input by -19%	Heavily managed and no change assumed.	Small component of nutrient budget and not included.
	LU3	Reduction in Total N input by 47% and Total P input by -51%	Heavily managed and no change assumed.	As for IJsselmeer LU1

Table S2. Summary of GCM-RCM model combinations and land use scenarios consisdered at each study area. For some study areas, there are two rows to note that the climate model combinsations and land use scenarios varied when considering different aspects of water quality. This was done to make best use of existing model set-ups and simulations to integrate these within the study and increase the number of model simulations overall.

Study area	Climate model			Land use scenario				Simulated water quality			
	ECHAM5-KNMI	HadRM3P-HadCM3Q0	SMHIRCA-BCM	LU1	LU2	LU3	LU4	NO_3-N	TP	SRP	Chl-a
Yläneenjoki (FIN)	✓			✓	✓	✓	✓	✓			
Yläneenjoki (FIN)	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Hobøl (NOR)			✓	✓	✓	✓	✓	✓			
Hobøl (NOR)	✓	✓	✓	✓	✓				✓		✓
Tarland (GBR)	✓		✓		✓	✓			✓	✓	
Tarland (GBR)		✓		✓	✓	✓	✓	✓			
Thames (GBR)	✓			✓	✓	✓	✓		✓	✓	
Vltava (CZE)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Arbúcies (ESP)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Louros (GRC)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Beyşehir (TUR)	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
IJsselmeer (NLD)	✓	✓	✓	✓	✓	✓	✓	✓			
IJsselmeer (NLD)	✓					✓					✓

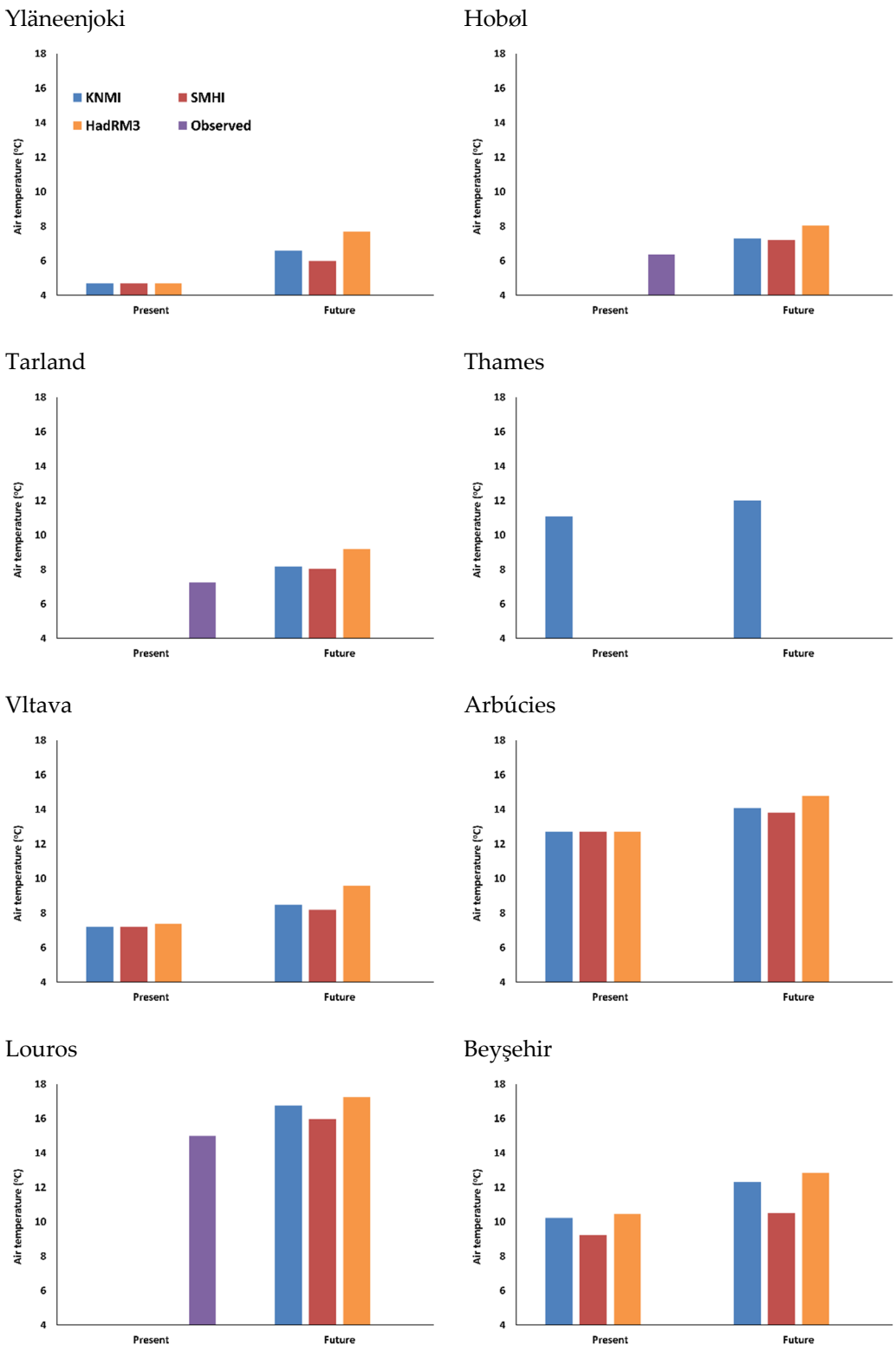

Figure S1. Mean air temperatures, present (1981- 2010) and future (2031 – 2060), at the study areas based on runs with three different climate models: ECHAM5-KNMI (blue); SMHIRCA-BCM (red); and HadRM3P-HadCM3Q0 (orange). At some sites, observed temperatures are used instead of modelled values (purple).

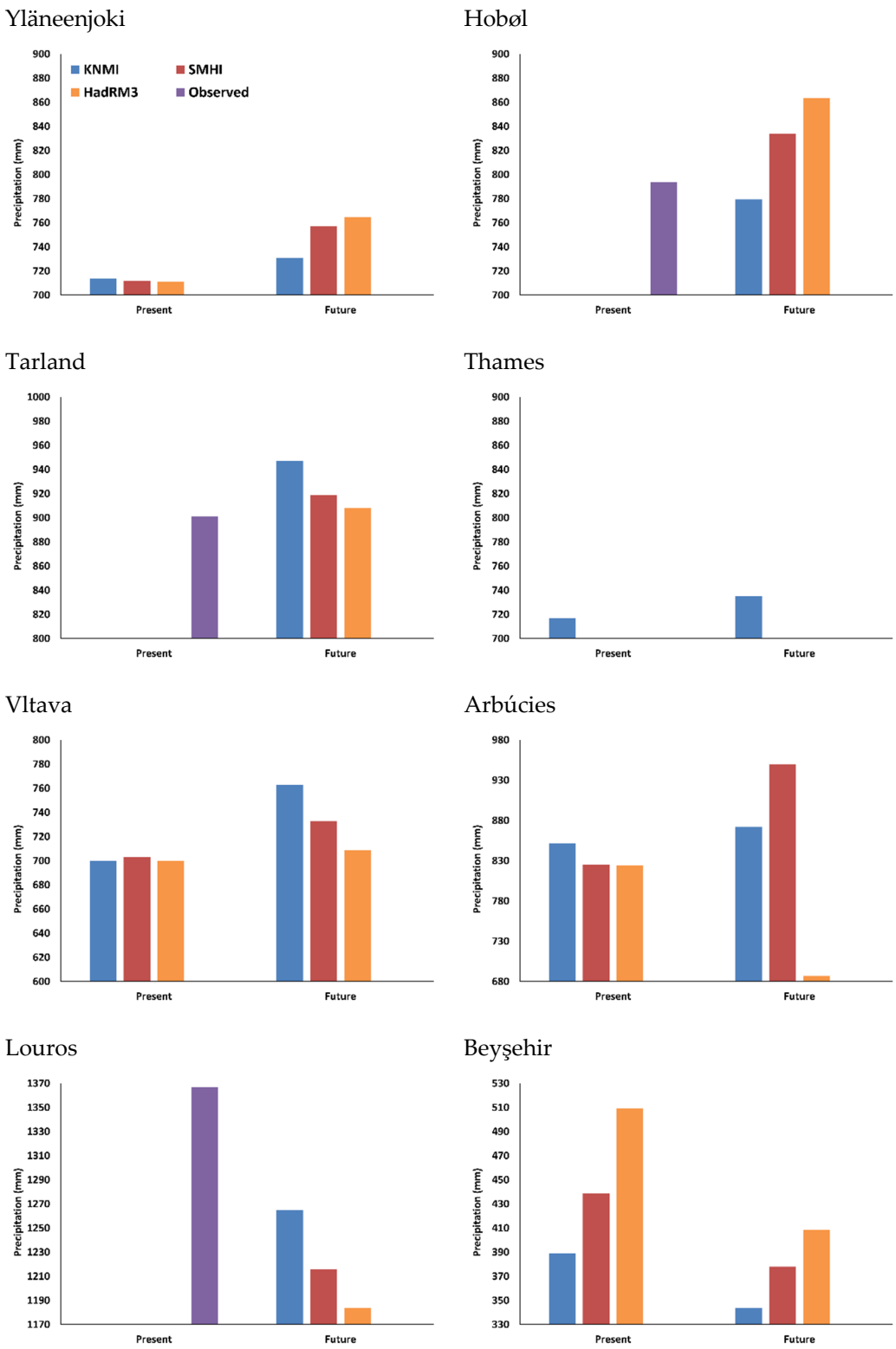

Figure S2. Mean annual precipitation, present (1981- 2010) and future (2031 – 2060), at the study sites based on runs with three different climate models: ECHAM5-KNMI (blue); SMHIRCA-BCM (red); and HadRM3P-HadCM3Q0 (orange). At some sites, observed precipitation was used instead of modelled values (purple).

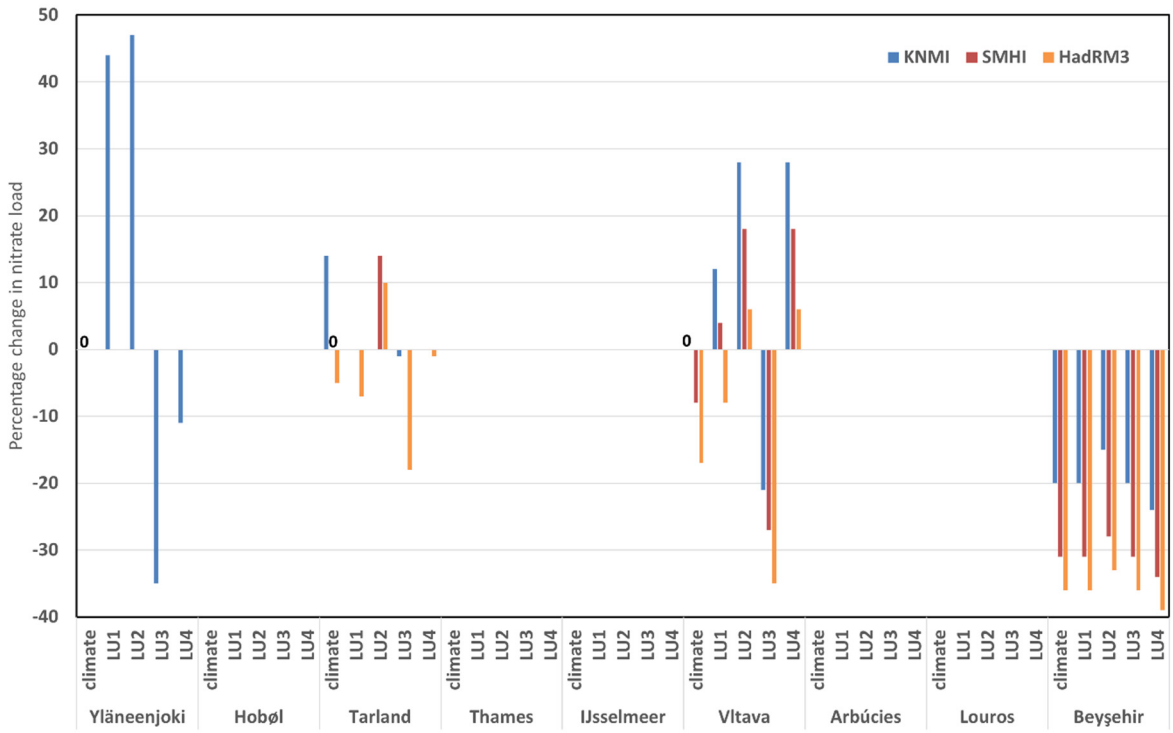

Figure S3. The percentage change in stream water nitrate load at each of the study areas between the baseline (1981-2010) and future (2031-2060) periods due to climate change (climate) and climate and land cover change (LU1 – 4). Blank columns indicate that GCM-RCM combination was not used for a study site. A '0' notes a percentage change of zero.

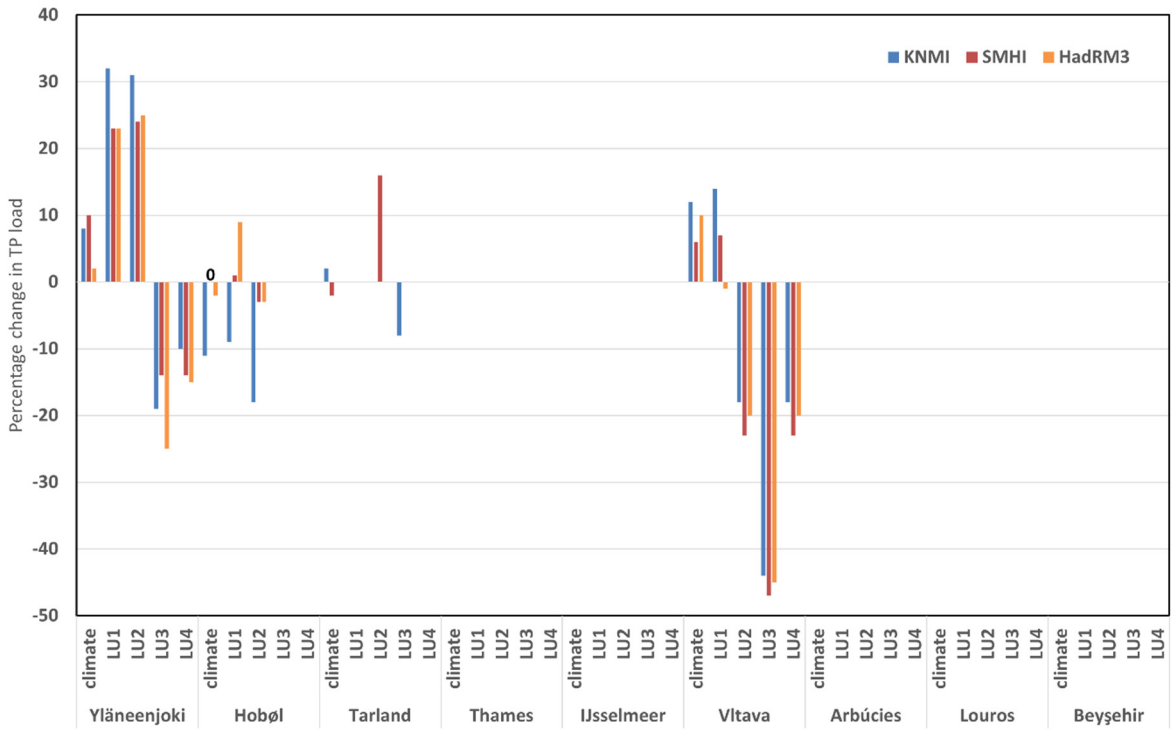

Figure S4. The percentage change in stream water total phosphorus load at each of the study areas between the baseline (1981-2010) and future (2031-2060) periods due to climate change (climate) and climate and land cover change (LU1 – 4). Blank columns indicate that GCM-RCM combination was not used for a study site. A '0' notes a percentage change of zero.

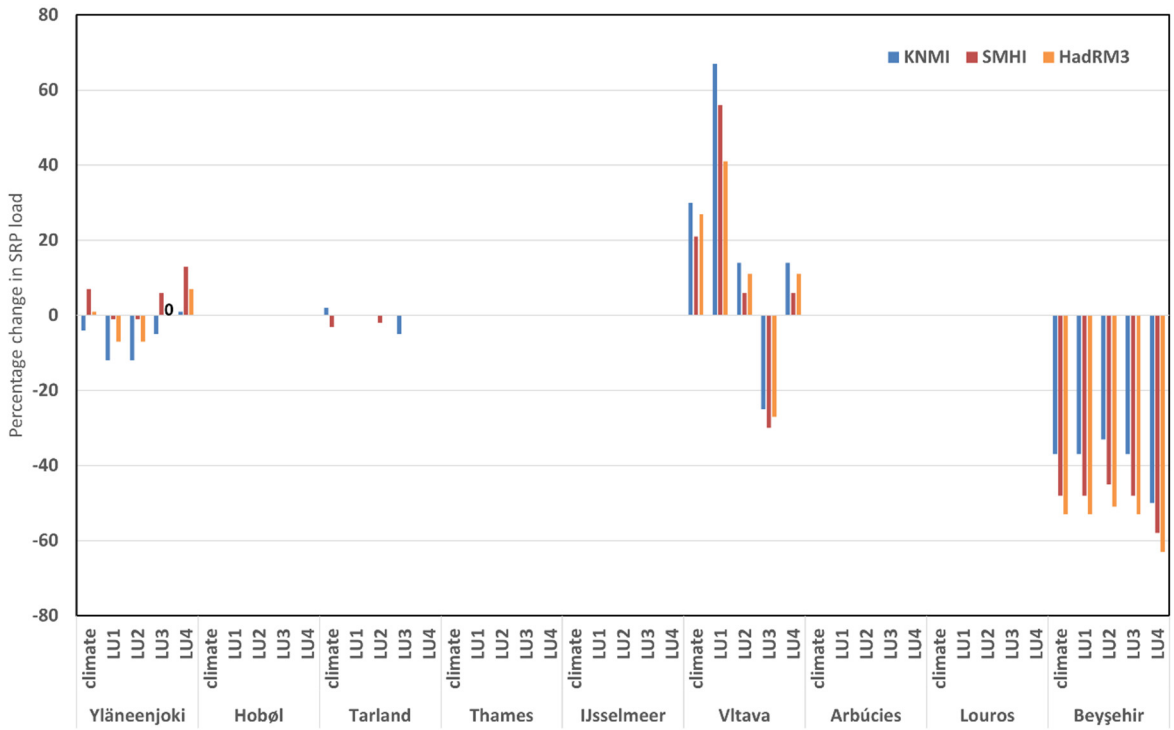

Figure S5. The percentage change in stream water soluble reactive phosphorus load at each of the study areas between the baseline (1981-2010) and future (2031-2060) periods due to climate change (climate) and climate and land cover change (LU1 – 4). Blank columns indicate that GCM-RCM combination was not used for a study site. A '0' notes a percentage change of zero.