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A cross-country comparison under the impact of climate change

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Cost-effectiveness analysis of nutrient mitigating measures: A cross-country comparison under the impact of climate change

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Background

Eutrophication (mainly caused by nitrogen and phosphorus) represents a major ecological problem for the water quality in streams, rivers and the Baltic Sea. As part of the MIRACLE project, this study focuses on innovative approaches to reduce nutrient inputs in the most effective way. This study aims to assess the cost-effectiveness of stakeholder-suggested measures in four different river catchments. It thereby combines the impact of the measures, as simulated with the HYPE model, and the assessment of investment and on-going costs associated with these measures.

Cost-Effectiveness Analysis

- To provide a ranking of the relative performance of measures, based on their cost and effects
- Costs are estimated according to system design and life-time

$$CER_i = \frac{C_i}{E_i}$$

i = 1…n measures
CER_i = cost-effectiveness ratio of measure i
C_i = cost of measure i
E_i = environmental indicator (e.g. nutrient mitigation capacity) of measure i in physical units

Measures and climate scenarios

- The mitigation measures were suggested by local stakeholders from each of the four catchment sites (Helge Å in Sweden, Berze River in Latvia, Selke River in Germany and Reda River in Poland).
- RCP 8.5 climate scenario from CMIP5 ensemble Global climate model with the projections by EURO-CORDEX (www.cordex.org, e.g. [Jacob, D et al., 2013]) to Regional climate models was used
- Two regional climate model data sets selected to show the highest increase of precipitation rate and temperatures until 2030
  1) WRF-IPSL-CM5A-MR (Institut Pierre Simon Laplace (IPSL))
  2) RCA4-CanESM2 (SMHI)
- The current time period is 2005-2014, and the future model period centered around 2030 (2016 to 2045)

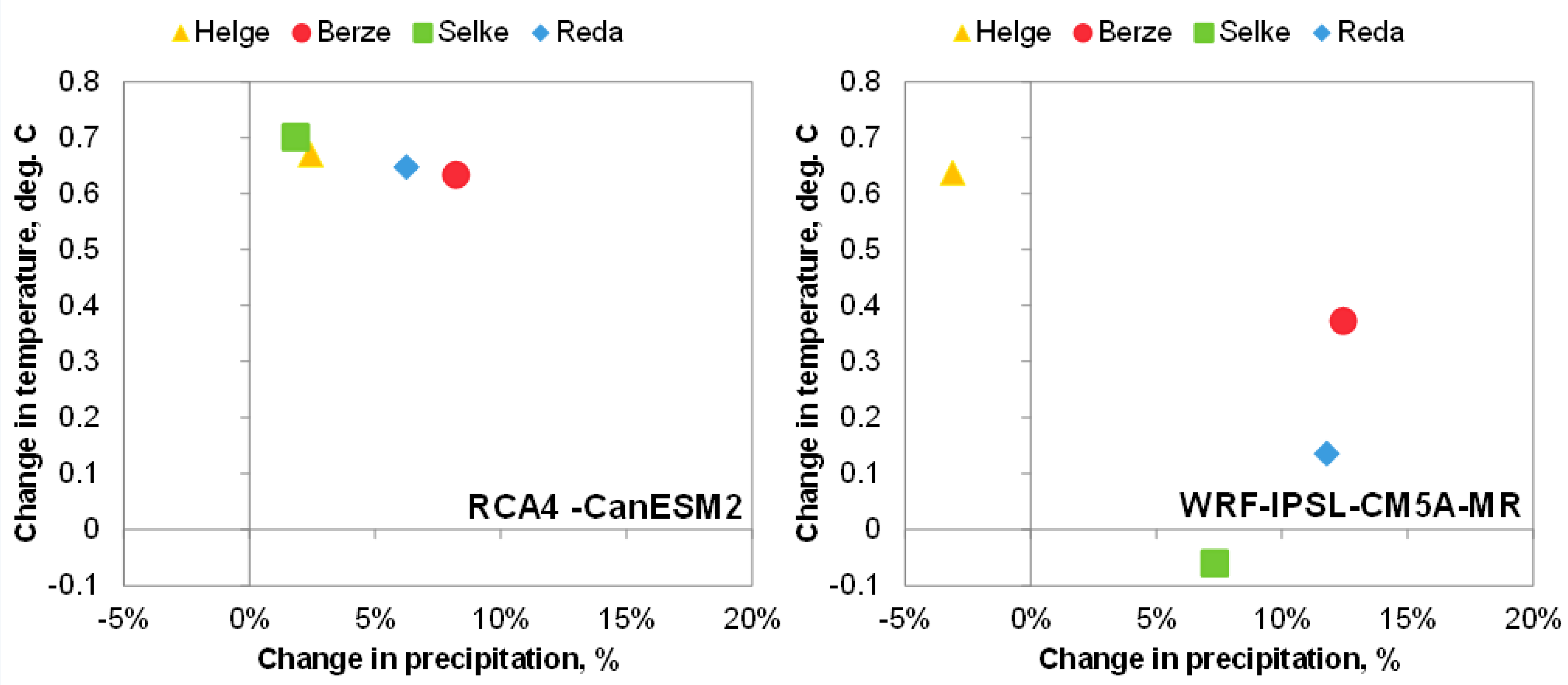

Figure 1. Change in precipitation and temperature between the current and future model period for each case study and climate model

The HYPE model

- The Hydrological Predictions for the Environment (HYPE) model is a dynamic, semi-distributed, process-based integrated catchment model developed by SMHI. The model is able to simulate both water quantity and quality variables: http://hypecode.smhi.se/
- The HYPE model was set up for each case study to simulate benefits of the measures with respect to the removed mass of nutrients

Figure 2. Geographical locations of the four case study areas

Figure 3. Land distribution in the four case study areas

Results

Case area	Measure	Cost-Effectiveness Ratio (in EURO per kg N/P reduction)					
		current climate		RCP 8.5			
		Nitrogen (N)	Phosphorus (P)	Nitrogen (N)	(CER change in %)	Phosphorus (P)	(CER change in %)
Berze	Crop Rotation	-3,128.26	63,007.82	52.04	(101.66%)	3,643.60	(-94.22%)
	Grasslands	91.52	6,659.52	4.67	(-94.90%)	389.95	(-94.14%)
	Organic Farming	561.62	64,580.16	-122.14	(-121.75%)	17,080.74	(-73.55%)
	Buffer Strips (2+5 m)	no effect	459.62	no effect	(0.00%)	205.74	(-55.24%)
	Buffer Strips (2+10 m)	no effect	381.56	no effect	(0.00%)	159.52	(-58.19%)
	20% reduction of mineral fertilizer application	49.92	55,881.83	36.33	(-27.22%)	18,291.09	(-67.27%)
	Municipal Waste Water Treatment Plants	67.85	253.38	68.09	(0.37%)	254.01	(0.25%)
Helge	Re-Meandering	298.57	no effect	298.57	(0.00%)	no effect	(0.00%)
	Riparian Zones	no effect	9,876.39	no effect	(0.00%)	12,345.49	(25.00%)
	Stormwater ponds	446.07	4,695.51	446.07	(0.00%)	4,956.37	(5.56%)
	Wetlands	150.33	2,802.80	143.80	(-4.35%)	2,926.82	(4.42%)
Selke	Buffer strips (10m)	no effect	202.91	no effect	(0.00%)	93.69	(-53.82%)
	Buffer strips (20m)	no effect	339.78	no effect	(0.00%)	91.26	(-73.14%)
	Contour ploughing	no effect	0.00	no effect	(0.00%)	0.00	(0.00%)
	20% reduction of N mineral fertilizer	-9.14	no effect	-6.42	(29.68%)	no effect	(0.00%)
Reda	Buffer zone (0.9/0.1)	no effect	2.50	no effect	(0.00%)	2.43	(-3.10%)
	Buffer zone (0.7/0.2)	no effect	2.95	no effect	(0.00%)	2.89	(-1.95%)
	"Greening"	38.41	262.66	36.57	(-4.78%)	228.10	(-13.16%)

Important Discussion Points and Results

- Significant difference in cost-effectiveness among the different measures and case areas
- Nutrient mitigation is only one of many benefits of the measures in terms of ecosystem service provision (such as biodiversity, recreation or erosion and flood risk control)
- Climate change affects the cost-effectiveness both positively and negatively depending on the measure and case area
- For P, the trend mostly varies with the case study

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Sources
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