SEVENTH FRAMEWORK PROGRAMME

THEME 6: Environment (including Climate Change)

Adaptive strategies to Mitigate the Impacts of Climate Change on European Freshwater Ecosystems

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PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

1 Lake Pyhäjärvi and its catchment in SW Finland

The Finnish demonstration site Lake Pyhäjärvi and its catchment area (Fig 1, 2) in the region where agriculture has traditionally been intensive in comparison to the rest of the country, both in terms of number of active farms and in the importance of agriculture for regional economy. Intensity of agriculture can be clearly seen in spatial variability of nutrient loading from agriculture, i.e. the flagship site Yläneenjoki river basin is nationally located in the hot-spot area.

The Pyhäjärvi Lake is the largest lake in south-western Finland, and of high importance both regionally and nationally. It is shallow and mesotrophic with exceptionally high fish productivity, which makes it an important lake also for commercial fishing. Increased eutrophication of the Lake Pyhäjärvi – mostly due to agriculture - has been a major concern since the late 1980s as Cyanobacteria blooms have become more and more frequent.

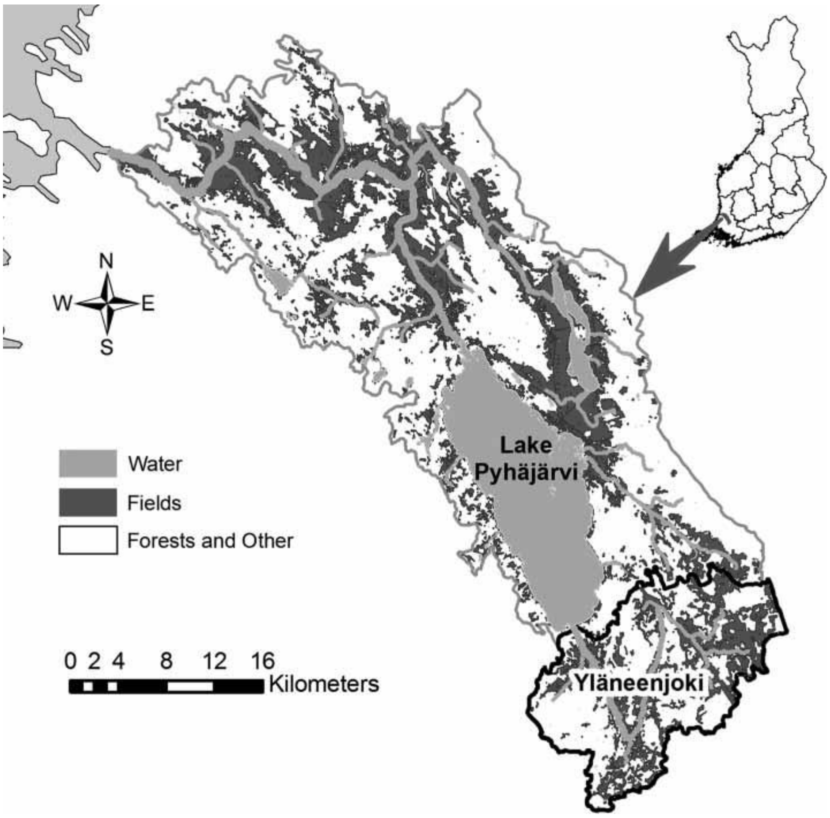

Fig 1. Lake Pyhäjärvi with Yläneenjoki river catchment, located in SW Finland.

2 Ecological response of the lake – use of catchment-lake model chaining

The ecological response of Lake Pyhäjärvi - due to climate and land use changes – has been evaluated by chaining watershed, river and lake models in the WP5 of REFRESH (Lepistö et al, 2013). Within the model chain, hydrological watershed model WSFS provides boundary conditions to INCA-P and N catchment/river models, whilst INCA-P output time series serve as input data to MyLake lake model. INCA-P and INCA-N output time series together serve as input data to LLR model (Figure 3). The model chains seem to work adequately as the results were logical throughout the model chain.

Fig. 2a) Turbid Yläneenjoki river at Vanhakartano dam, during spring flood. Vanhakartano is a few kilometers upstream of the inflow of the Yläneenjoki river into Lake Pyhäjärvi. b) The real-time lake monitoring station was set up on 22 May 2010 in Lake Pyhäjärvi at the Finnish demonstration site. Photo: Pia Mattila-Lonka

Responses to total phosphorus and chlorophyll -*a* concentrations are simulated to detect if the changes in air temperature and precipitation due to climate change will enhance the algae growth in lakes. In contrast, the planned changes in the mitigation measures are hypothesized to decrease the algae concentrations. By the reductions in nutrient loading through different management actions, the WFD compliance and better water quality might be able to reach, together with a number of benefits for use of the lake such as recreation, fishing etc.

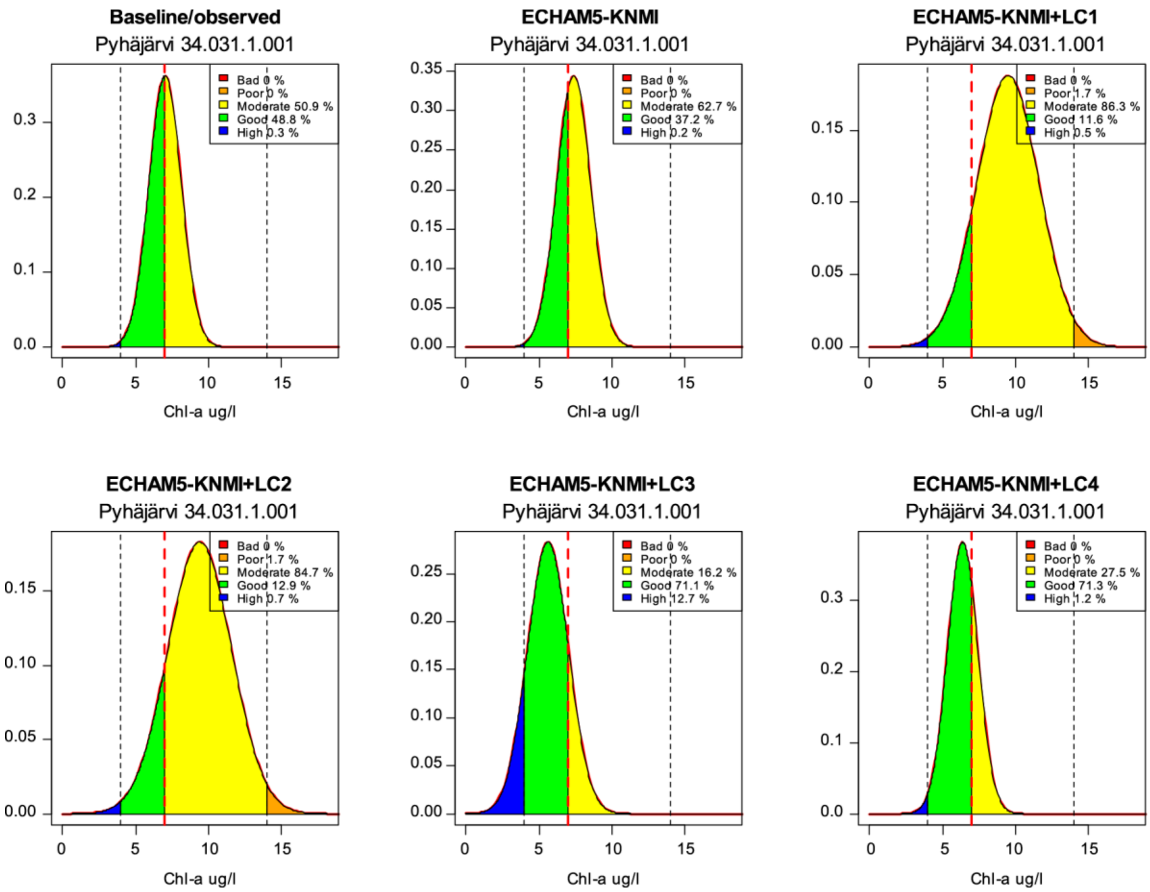

Fig 3. The probabilities to reach a certain water quality status in the Lake Pyhäjärvi, with chl-a used as an indicator. Baseline, CC ECHAM5-KNMI + four land-use scenarios LC1 to LC4 are given.

Three climate change scenarios are used together with four land-use scenarios and mitigation measures to reduce nutrient loading. When preparing the land-use scenarios and mitigation measures for modelling, there has been close links between environment policy researchers (WP6), and biophysical modellers / process researchers (WP5) at SYKE, a well as with stakeholders at Pyhäjärvi Institute, and elsewhere in the study region.

3 Climate and land use change scenarios

For all three CC scenarios, the LLR model estimated increase for both Chl-a (major ecological indicator of the lake) and total P was quite similar, changing the status of the lake from *Good* to slightly *Moderate*. The reason is most probably that for the P concentration estimates, the internal loading affects the model results quite strongly. The P concentration and external loading relationship is rather weak, and the changes in the external loading do not clearly show in the lake – at least not in the shorter time periods. This affects also to the chlorophyll estimates. On the other hand, we have quite reasonable and logical results with all used CC scenarios – which increases confidence of the results obtained.

Four land-use scenarios produced logical results, when comparing intensive agriculture scenarios (1 and 2) to environmental 'green' scenarios (3 and 4). Intensive agriculture scenarios changed the status of the lake from *Good* to clearly *Moderate,* while environmental scenarios (3 and 4) remained it clearly as *Good.*

The response of Chl-a to KNMI (average scenario) and Hadley scenarios (warm, dry summers) was quite similar. For SMHI-BCM scenario (cold, wet), Chl-a response to all CC+LC scenarios was smoother, lower increase for LC1 and LC2, and lower decrease for LC3-LC4, respectively.

The land-use change scenarios seem to have a more pronounced impact on the lake than CC scenarios. But the LC scenarios include also CC scenarios in the background, and it is possible that land-use changes are needed to 'catalyze' climate change impacts. The interactions and feedback mechanisms between these changes in the time period of 50 yrs are highly complex, however, with numerous changes in hydrological dynamics, snow/frost conditions in milder winters, catchment and lake processes, cultivation practices and timings, crop types etc.

4 Mitigation measures, best and worst scenarios

Particularly increase in winter vegetation (e.g. 40%) seems to decrease Chl-a while decrease in P fertilization seems not to have a clear impact. Probability of achieving *Good* status in the lake is higher if P is the target variable. With Chl-a as target variable, probabilities are somewhat lower, with higher risks to obtain *Moderate* class during certain years. These model estimates of impacts of mitigation measures were used further in WP6 CEA analysis.

Climate-proof of the effectiveness of measures (40% increase in winter vegetation) was tested with more scenarios (Step 8 in modelling procedure) – worst and best cases with and without measures. Worst case means most adverse ecological impact in terms of ecological indicator from land cover plus climate. Best case means least adverse ecological impact, respectively. Based on our model runs the above measure seems to be climate-proof, and even more effective in future climate. Measure did improve also somewhat the state of the lake, both with worst and best scenarios (Lepistö et al, 2013).

5 Cost-effectiveness of water protection measures

Cost-effectiveness of water protection measures in agriculture was studied in WP6 of REFRESH, together with possible benefits that can be gained from improved water quality. The setting in the studied case is such that the water protection problem in the Lake Pyhäjärvi is caused by agriculture in the catchment area of River Yläneenjoki, while the benefits of water protection are experienced at a Lake Pyhäjärvi where the river discharges. We studied costs, effects and benefits in two different time horizons: until 2015 and until 2027 (Varjopuro et al., 2013).

The lake is presently in *Good* water status, but very close to the threshold between *Good* and *Moderate*. This means that the status is only *Moderate* during half of the years, and problems occur related to eutrophication. The protection objective in this study is to ensure the likelihood for the lake to remain in the good status. In this study the measures are applied by farmers in the catchment area where, in a sense, the costs of protection are thus borne. The farmers are compensated for conducting mitigation measures, which makes the state and the tax payers the actual cost-bearer.

The research reported here is based on a transdisciplinary approach, in which economic analysis for costs and benefits and catchment modelling to study effectiveness of protection measures are supplemented by input received from local stakeholders. Two stakeholder workshops discussed possible mitigation measures and potential benefits of water protection, respectively. The study utilises also various previous studies on water protection in agriculture and on benefits of water protection pertaining to fresh water in Finland.

6 Combinations of mitigation measures

We estimate cost-effectiveness of several combinations of mitigation measures, since none of the individual measures alone can be implemented to the extent which would achieve the set target. Three different types of farming practices to increase winter time vegetation coverage were considered in the case study. The actual CEA studied costs and effects of different combinations of these:

1) Increasing the amount of winter cereals
2) Changing from cultivator tillage to direct sowing
3) Increasing the amount of nature management fields

The analysis of costs and effects of mitigation measures showed that there are cost-effective combinations of above measures to reduce nutrient load. Some of the combinations could even reduce the costs of farming (Varjopuro et al., 2013). In comparison to economic results of the farms the combinations would lead to modest decrease or modest increase of economic result on a farm level. Only the most costly combinations of measures would mean a significant increase of costs of farming. It can be concluded that on the other hand affordability should not form an obstacle for applying the methods, but on the other hand the possible, modest reduction of costs of farming is not a strong incentive for adopting them. Choices that farmers make are strongly influenced by agri-environmental scheme of the EU's Common Agriculture Policy. Future agri-environmental schemes should be targeted for creating incentives for farmers to adopt more effective measures, but especially such that do not lead to unnecessary increase of costs, since there are cost-effective alternatives.

7 Benefits are higher than the costs

The benefits are experienced in a lake, into which the river discharges. There are approximately 27 500 persons (permanent and leisure time dwellers) in vicinity of the lake who can potentially benefit from the lake. A stakeholder workshop was organised to identify the types of benefits that can be gained by use of water and water areas of the Lake Pyhäjärvi. Five groups of main uses were identified: i) water as a resource, ii) recreational use by the local people, iii) professional fishing, iv) tourism and v) significance of good water quality for the reputation and living conditions in the area.

A benefit transfer method was used to quantify the potential benefits that can be gained from reaching the set protection target.

The study shows that the lake's *Good* water status is precarious and increased water protection measures are needed to ensure that the status remains. The lake is unique in its size and high water quality in South West Finland, which gives the lake a high value for inhabitants and recreational users. The analysis of potential benefits suggests that considerable benefits can be gained from meeting the protection goal. There is thus a social need to continue protection of the lake and high benefits to be gained. Comparison of costs of protection and potential benefits to be gained indicates that benefits are clearly higher than the costs.

References

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