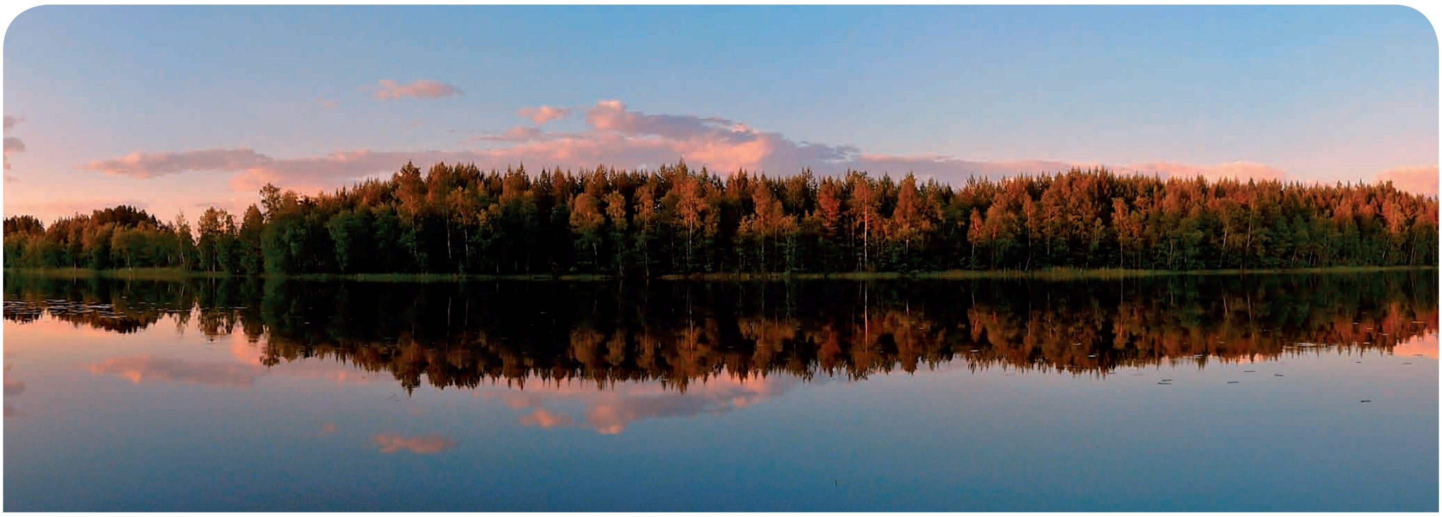

Symposium on Climate Change Challenges in River Basin Management

17–19 January 2011 · Oulu · Finland

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Preface

The Symposium on Climate Change Challenges in River Basin Management was held in the University of Oulu in Finland on 17–19 January 2011. The Symposium was organised by the Baltic Sea Region Programme 2007–2013 project Waterpraxis – From theory and plans to eco-efficient and sustainable practices to improve the status of the Baltic Sea, in cooperation with the following initiatives:

- VACCIA – Vulnerability Assessment of Ecosystem Services for Climate Change Impacts and Adaptation;
- GENESIS – Groundwater and Dependent Ecosystems: New Scientific and Technical Basis for Assessing Climate Change and Land-use Impacts on Groundwater Systems;
- CEWIC – Centre of Expertise in the Water Industry Cluster;
- GISBLOOM – Participatory Monitoring, Forecasting, Control and Socio-Economic Impacts of Eutrophication and Algal Blooms in River Basins Districts;
- VALUE – Doctoral Program in Integrated Catchment and Water Resources Management;
- Human-Environment Relations in the North: resource development, climate change and resilience (Fidipro, Finnish Academy).

The Symposium aimed to be a forum where information exchange between policy makers, stakeholders and scientists can take place on issues that are closely related to the implementation of EU water policies. Particular emphasis was paid to the impacts of climate change within the context of other multiple stressors, such as agriculture and eutrophication. The main themes of the Symposium were:

- Integrated modeling as a part of river basin and groundwater management;
- Using Water Framework Directive (WFD) for mitigation of climate effects;
- The influence of climate change scenarios on the processes of WFD implementation;
- Research on groundwater and dependent ecosystems for Groundwater Directive (GWD);
- Climate change effects on hydrology and water availability;
- Land use and climate change impacts on groundwater and dependent ecosystems;
- Methodology on climate change scenarios and land use in European case studies;
- Interactions between climate, hydrology and ecosystems;
- Assessing land use and climate effects on water quality and water security
- Institutional issues in climate integration in river basin planning;
- Socio-economic analysis for assessment and adaptation to climate change;
- Participatory methods for integrated and adaptive water resources management.

During the Symposium more than 40 oral and poster presentations, covering versatile topics related to challenges that climate change is posing on the management of water resources, were held. This publication consists of the abstracts of presentations.

The organising committee

- Seppo Hellsten, Finnish Environment Institute SYKE – Chair
- Teemu Ulvi, Finnish Environment Institute SYKE – Co-chair
- Anne-Mari Rytkönen, Finnish Environment Institute SYKE
- Jouko Inkeröinen, NorNet, University of Oulu
- Hannu Heikkinen, Thule Institute, University of Oulu
- Kari Laine, Thule Institute, University of Oulu
- Riitta Kamula, Thule Institute, University of Oulu
- Bjørn Kløve, University of Oulu
- Natalie Fischer, Hamburg University of Applied Sciences
- Veronika Schulte, Hamburg University of Applied Sciences

Session 1: Climate Change Scenarios and Assessment

An Overview of the Climate Change Challenges in River Basin Management in the Baltic Sea

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This paper presents an overview of the climate change challenges related to river basin management in the Baltic Sea region, along with some of the on-going and planned actions to cope with climate change in the region. The first part of the paper outlines the extent to which climate change influences Baltic countries and describes some of the efforts undertaken by governments across the regions to cope with it. The second part outlines the potential or expected impacts of climate changes on river basins, while the third part of the paper describes some of the on-going efforts to measure and reduce potential climate change impacts on river basins seen in a sample of Baltic countries. Finally, the paper presents some of the challenges they face.

Impact of Past and Future Climate Variability on Snowmelt Hydrology in Central Finland

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The water resources are one of the main issues which is affected by climate change. It can be seen in e.g. changes at availability, timing and magnitude in precipitation, stream runoff, snow melting and groundwater seepage. These changes can affect human life, industrial, energy production, irrigation and aquatic ecosystems. Precipitation and runoff, two important parameters in water resource system, can change due to climate change. In addition, changes in temperature play a major role in runoff behaviour, especially in cold regions as it can change snow melting behaviour. This further affects the runoff extreme behaviour in catchments.

In this paper, changes in temperature and rainfall and the effect on runoff behavior and snow melting is evaluated in West-Central Finland. More than 200,000 temperature and rainfall data from 7 climatology stations (Seinäjoki, Jyvaskyla, Vesanto, Ähtäri, Vieremä, Kauhajoki and Viitasaari) from the years 1959–2009 were analyzed. The impact of past and future climate was analyzed in a region of 45,000 km². For each station, data were analyzed by dividing the 50 year time series into 3 categories for comparison of change in time: I) two 25 years periods for the first category, II) three 17 years periods for second category and III) five 10 years periods for third category. Data analysis was done for average and extreme hydrological and climatologically parameters. The highlights of the results are:

- The rainfall amount increased in all stations from 1.5 % to 11.5 % in the second half of time duration (1984–2009) compared with the first half (1959–1984).
- The increasing trend of rainfall can be seen in 17 years periods in all stations except for Jyväskyla.
- The increasing trend of rainfall can be seen in 10 years periods only in Vieremä and Kauhajoki stations.
- During December to March, May to July and October the amount of rainfall was increased.
- The strongest increasing in rainfall was found for February.
- Maximum rainfall accrued in August and July, but it seems this will changed in the future.
- Average temperature increased in all stations. On monthly scale the temperature changed -0.48 – +2.2 °C, and fastest increasing was occurred in January with average increase of about +1.7 °C (circa 1.1 °C more than annual average).
- In the last five decades, the third decade was the coldest and the fourth decade was the warmest. This indicates some long term fluctuations.
- An important parameter in cold region hydrology is the temperature difference between two continuous days effecting on snow melting rates and frost. The present data indicate that this will change more than single day values.

Finally, it can be predicted that in future, the type and timing of rainfall is changing in central Finland with an increase in runoff and flood risk due to rainfall and snow melting occur simultaneously.

Meeting the Climate Change Challenges in River Basin Planning – a Scenario Based Approach

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Introduction

During the last decennium climate change has received much attention and especially various mitigation and adaptation strategies have gained political awareness. Particularly the water management will be affected by derived consequences like sea level rise, changed precipitation patterns, increasing ground water level, and flooding. In order to mitigate the most severe consequences for the society it is decisive that regional planners and water managers address the climate change issue in their planning efforts. Using modelling and simulation, we can increase our understanding of the future land-use system under influence of a changing climate and accordingly reduce uncertainty concerning decisions. The current paper describes how to combine land-use simulations with regional climate change scenarios and perform impact assessments of future regional development. We describe how the definition of adaptation strategies can facilitate spatial planning measures to counteract the consequences of potential climate changes.

The Modelling and Assessment Framework

The land-use modelling is carried out with the LUCIA framework for land-use change impact assessment (Hansen, 2007, Hansen, 2010) and the land-use scenarios are based on the SRES narratives which represent different future societal developments path for the world in two dimensions. A focus on economic or environmental concern in the first dimension, and global or local development patterns on the second dimension. LUCIA has a multi-level structure, where the upper regional level represents the drivers, whereas the detailed lower level represents the land-use. The driving forces for the amount of rural-urban change are basically population growth and economic growth. These drivers represent what we call macro-level drivers, and they are modelled externally to our model in various sector models, and basically define the demand for land from each active land-use type. The future climate data – mainly precipitation data – are provided by the PRUDENCE and ENSEMBLE projects, and the daily runoff is estimated by the well known curve number method, which is closely linked to land-use.

The impact assessment is concerned with flooding and soil erosion. Flood hazard mapping is used to determine the areas susceptible to flooding when discharge of a stream exceeds the bank-full stage. Using future precipitation and runoff data, along with topographic data, maps can be constructed to show areas expected to be covered with floodwaters. The topographic dimension of flooding is obtained by an algorithm, which finds the elevation difference between a specific grid-cell and its closest neighbouring grid-cell containing a river, while respecting the overall catchment structure. The soil erosion risk assessment takes outset in the revised universal soil leach equation (RUSLE) that predicts long-term, average-annual erosion by water.

Finally, several alternative land-use plans are introduced to mitigate the enhanced risk of flooding.

Land-use and Climate Change Scenario Integration in a River Basin Management Perspective

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Introduction

There is a need to integrate the use of climate change and land-use scenarios in activities related to land-use planning and resource management. Depending on the climate and land-use patterns of the future, runoff and the nutrient loads will change, affecting the water quality within river basins. Climate change and land-use scenario integration is therefore a relevant issue for evaluating different land-use development alternatives in a river basin management perspective. This paper describes and tests a set of tools for climate change and land-use scenario integration in a study area in the Oulujoki-Iijoki River Basin District in North Ostrobothnia.

Storytelling is being used to express the possibilities, challenges and development options of the future. The Intergovernmental Panel on Climate Change (IPCC) has developed emission scenarios called SRES that correspond to the storylines and driving forces used in the IPCC framework. According to the SRES scenario of type A, the world will face a technology-driven future, where the challenges of today will be solved by technological innovations and not by changes in lifestyle. In the SRES scenarios of type B, the future developments are driven to a larger degree by environmental concern, changing in many ways the world of today. In the SRES scenarios of type 1, e.g. A1 and B1, the solutions are of global nature, while in the SRES scenarios of type 2, e.g. A2 and B2, the solutions are based on regional approaches. The latter A2 and B2 scenarios are used in our approach, due to the regional scale of our study.

Simulating SRES scenarios with the LUCIA modelling framework

Land-use is strongly related to the development of society. Therefore the land-use pattern of a technology driven world will on regional level look very different from a land-use pattern in a world driven by environmental concern. To be able to evaluate the environmental effects of different SRES scenarios, land-use patterns that correspond to the SRES scenarios need to be simulated. The Land Use Change Impact Analysis (LUCIA) framework can be used for producing land-use scenarios, based on the land-use pattern and changes within it of today (Hansen 2007). LUCIA is based on a constraint cellular automata approach, where the sum of factors such as proximity, accessibility and suitability and zoning constraints together determine the land-use pattern of the outcome.

In particular in the western part of the study area, rapid population growth has taken place during the calibration period, between year 2000 and 2008. During this period, the total area of fields has also increased. As a first step, GIS analyses were carried out in ArcGIS to find the factors and constraints which best could explain the changes within the land-use pattern that had taken place during the calibration period. CORINE Land Cover data, the Urban Structure Monitoring System, the Field Parcel Register, soil, road, river and stream data where used to produce the land-use, the accessibility and the suitability map layers in a 250 meter resolution for the whole study area. Additionally the Natura 2000 network and land-use planning data were used to indicate the constraints of the built-up area expansion. By changing the weight of the factors, the individual factors themselves and the type of constraint in comparison with the baseline values and datasets, land-use scenarios representing SRES A2 and B2 for the year 2040 were produced. The population projections on municipal level obtained from the Statistics of Finland were assumed to affect the extent of built-up area expansion.

Integration of land-use and run-off data in RiverLifeGIS

Land-use induced diffuse loading plays the most important role in deteriorating water quality. In order to evaluate the effects that our simulated land-use changes may have on water quality and nutrient loads in a river basin, another raster-based freeware, the RiverLifeGIS tool, was used. In RiverLifeGIS, the amount of nutrient loads can be estimated based on run-off and the relative abundance of a particular land-use class (Karjalainen & Heikkinen 2005). In RiverLifeGIS, the nutrient loads for the land-use patterns of today and of the A2 and B2 scenarios were calculated based on run-off values produced by the FINESSI project (FINESSI). Land-use data of the year 2007 and average runoff figures for the period 1961–1990 were used to represent the nutrient loading of the baseline situation. Average run-off data modelled by the FINESSI project to match the SRES A2 and B2 scenarios for the relevant time period 2040–2069 were used. To produce this 10 kilometer resolution run-off data representing the baseline and the A2 and B2 scenarios, the Hydrological Modelling System of the Finnish Environment Institute had been used in conjunction with several global climate models, such as HadCM3, EH4OPYC and NCAR/PCM. With tools and datasets described in this paper, the nutrient loads of today and of the future development alternatives, in this case the SRES A2 and B2 land-use scenarios, could be evaluated from a river basin management point of view.

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A Conceptual Approach for Delimiting Set-back Lines for the Guadiana Estuarine System as a Means of Managing Retreat in Response to Sea-level Rise

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Introduction

A better understanding of the sensitivity of estuarine systems to forcing from sea-level rise or from human interference is required if the sustainable management of estuarine habitats is to be achieved. However, due to the uncertainty of determining the magnitude of sea-level rise and sediment supply into an estuary, we propose a conceptual scenario-based approach to model the morphological evolution of an estuary in response to the above mentioned pressures during the 21st century. The approach was applied to the Guadiana estuarine system, which has been subjected to a drastic reduction in river flow and sediment discharge due to the construction of more than 40 dams along the Guadiana River. In addition, the construction of jetties at the mouth of the Guadiana River has reduced marine sediment supply to the estuary. We adopted an estuarine sedimentation model – an idealized behaviour-oriented model – to predict the long-term morphological evolution of the Guadiana estuary. Three IPCC (2007) sea-level rise scenarios were used in this study: (1) the global sustainability scenario (B1); (2) balanced use of fossil fuel under a globalized economy scenario (A1B); and (3) intensive use of fossil fuel under a globalized economy scenario (A1FI). Under each sea-level rise scenario, four simulations were carried out for four, locally derived, sedimentation rates: (1) human-intervention (approximately half of the 2nd scenario), (2) minimum long-term rate (millennial-scale), (3) average (average of the second and the fourth scenarios) and (4) maximum (equals to sea-level rise rate).

Set-back lines for the Guadiana estuarine system

Based on the overall impacts of sea-level rise and sediment supply scenarios, three sets of set-back lines for human activities are proposed for the Guadiana Estuary. As the present sediment discharge is too low to maintain a stable effective water depth in the lower estuary, the morphological evolution of the estuary during the 21st century is probably best represented under the scenario that combines the A1FI sea-level rise scenario (59 cm) and the human intervention sedimentation scenario (0.65 mm/yr). The first set-back line (outer perimeter) therefore represents the landward limit of the intertidal zone in response to the above scenario. The landward migration of the intertidal zone would be more significant on the Portuguese margin of the estuary compared to the Spanish margin. Although there may be a loss of salt marsh habitats on the western margin, there is likely to be a landward shift in the entire system. Even though submergence may be considered as a loss, in terms of restricting the type of economic activities able to take place there, from an environmental point of view it is recommended that the process be allowed to occur. Managed retreat would be a better option for economic activities such as salt production. On the Spanish margin, due to the limited landward migration of the intertidal zone, there is likely to be a high risk of salt marsh habitats disappearing. In addition, the landward translation of mean sea-level will be significant on the Spanish margin, and its salt marshes will experience more pressure due to accelerated sea-level rise than will be the case on the Portuguese margin. Thus, salt marsh habitats along the eastern margin would be squeezed further. Mitigation measures should be taken to improve the natural adaptability of this region. The second (intermediate) set-back line was demarcated based on the landward limits of intertidal zone resulting from the A1B (48 cm) sea-level rise scenario and the minimum sedimentation scenario (1.3 mm/yr). The third set-back line was delimited based on the limits of horizontal translation of the 0 m contour of the Guadiana River in response to the A1FI sea-level rise scenario and the human-intervention sedimentation scenario. Beyond this limit, a complete managed retreat is recommended because the area will be drowned permanently by the end of the 21st century. From a river basin management perspective, if the sediment flushing frequency of the Alqueva dam can be increased, deterioration of salt-marshes can be minimized. Thus, the concept of environmental flow should be redefined to include the sediment flushing frequency of large reservoirs.

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Modelling Future Nutrient Emissions for a Well Coordinated River Basin Management

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Nutrient emissions by river systems are one of the main pollution sources into the Baltic Sea. Annual emissions and loads have been used to describe general nutrient fluxes. By the recently improved and implemented method to calculate monthly fluxes with MONERIS the link between spatial patterns of nutrient emissions and their temporal effect on water quality aspects in aquatic systems has been established.

Beyond that, an implementation of development scenarios concerning socio-economic, land-use and climate change helps to achieve meaningful results. This delivers helpful arguments for management options and the implementation of management plans. Results of the calculations show significant changes for the future development of nutrient emissions to the Oder River Basin and loads to the Szczecin Lagoon.

Introduction

Under the framework of BONUS, the EU-Project AMBER (Assessment and Modelling Baltic Ecosystem Response) was established in 2009. Main focus of the project is to link ecological needs and appropriate political management options. Direct atmospheric deposition on the sea and loads from the surrounding river systems are the dominant nutrient sources and strongly influence the Baltic Ecosystem. To derive appropriate management options it is necessary to know the functional relationship between emissions in the river basin, transformation and retention in limnic systems and the resulting loads from the river to the coastal waters. The nutrient emissions model MONERIS has been used to model the current and future nutrient emissions from the catchment to the surface waters and the loads from the river system to the following connected water body.

The Oder as an important emitter of nutrients to the Szczecin Lagoon and the Baltic Sea has been chosen as a study area. Beyond that, the expected climate, socio-economic and land-use changes, as well as their effect on the hydrology and the nutrient emissions were considered for the modelling of future conditions in the Oder River Basin. [3]

Materials and Methods

Site description

The Oder River basin is located south of the Baltic Sea and covers an area of 118,611 km² [2] with an maximum dimension between latitudes 49°30′ N to 53°50′ N and longitudes 13°00′ E to 20°00′ E. With a mean discharge of 550 m³/s, the 912 km long river flows into the Szczecin lagoon. Concerning the Baltic Sea the river basin is one of the dominant emitter. This fact is caused by intensive agricultural use and the emission of 15.5 million Inhabitants. [1]

Data Source

The Oder River basin was divided into 493 subcatchments with a mean size of 240 km². Most of the required data for model runs have been derived from a geographical information system (GIS) based data sets. For precipitation information global data by GPCC (Global Precipitation Climatology Centre) were used. In addition to this, precipitation data for the future scenarios were provided by the REMO (Regional Climate model) [5]. Data sets for the atmospheric deposition by EMEP (European Monitoring and Evaluation Programme) were utilized. The socio-economic and land-use development scenarios originate from the IKZM-Oder Project and were developed by the Institute for Ecological Economy Research (IÖW) [4].

Method

MONERIS has been applied to model nutrient inputs by point sources and diffuse pathways for the period of 1983 to 2005 on yearly and monthly basis. For modelling of future conditions, socio-economic and land-use changes have been calculated by integrating of development scenarios. There have been implemented a "business as usual", "Intensification" and a "Liberalisation" scenario [4]. The effect of the development and climate change scenarios on nutrient emissions and loads have been calculated separately and in combination to identify the net-effect of these scenarios on the nutrient balance.

Results

For monthly calculations in present times (1983 to 2005), hot spots of emissions have been identified in the mountainous parts in the south (erosion), in central parts (agriculture) and single subcatchments (urban systems). The monthly results suggest that temporal variation of emissions and loads are mainly driven by hydrology and temperature.
The climate change scenarios assume a decrease in the precipitation and run-off and subsequently cause a decrease in the nutrient emissions and loads. The development scenarios range from increased to decreased agricultural activities. As a result emissions from agriculture will increase or decrease, too. Although the effect of the development scenarios is in general rather low, but a combination of increased land-use and decreasing water availability may cause significant changes in in-stream loads and concentrations. Therefore loads to the lagoon decrease, but at the same time higher nutrient concentrations and possible negative effects on the water quality can be expected. On the other hand, the "Liberalisation" scenario will have a positive effect on the water quality, due to a more moderate agricultural use.

Conclusion

By identifying temporal and spatial distribution of nutrient emissions with an apportionment of different diffuse pathways, a strong prerequisite for the evaluation of effective measures to reduce emission have been determined. The net-effect of the development scenarios is quite low. Considering climate change, dryer climatically conditions may cause a further reduction of nutrient emissions, but could also lead to increase concentrations in the river system. For the implementation of sustainable management plans these results can offer useful arguments for the development of options for reduction of nutrient emissions into the Oder River Basin.

Acknowledgments

This research is financially supported by the Federal Ministry of Education and Research (BMBF) and the European Union (EU).

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Session 2: Hydrology and Ecology

Lake Ice in Finland – Observed Trends and Future Outlooks

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In a country with 187,888 lakes, it is no wonder that long data series exist on lake ice variables – particularly because all those water bodies freeze every winter. The longest continuous observation series on break-up begins in 1822 (Lake Kallavesi), on freezing in 1833 (Lake Kallavesi) and on ice thickness in 1909 (Lake Muurasjärvi). – A much longer data series is available on the freeze-up of River Tornio, it starts as early as in 1693.

Unlike river ice, lake ice is virtually unaffected by man's actions in watercourses and river basins. Only exceptionally do e.g. thermal effluents, a road embankment or heavy regulation alter lake ice conditions to a certain degree. Thus the nature's fingerprint in lake ice is very pure – a fact which offers many possibilities in climate change research.

Lake Kallavesi is located in eastern Finland at the latitude of 63°N. According to the linear trends fitted to the whole series, the freezing date has shifted to 15 days later in 1833–2009 (figure 1), while the break-up date has shifted to 12 days earlier in 1822–2010 (figure 2). Both trends are significant at the level of 99.9 per cent.

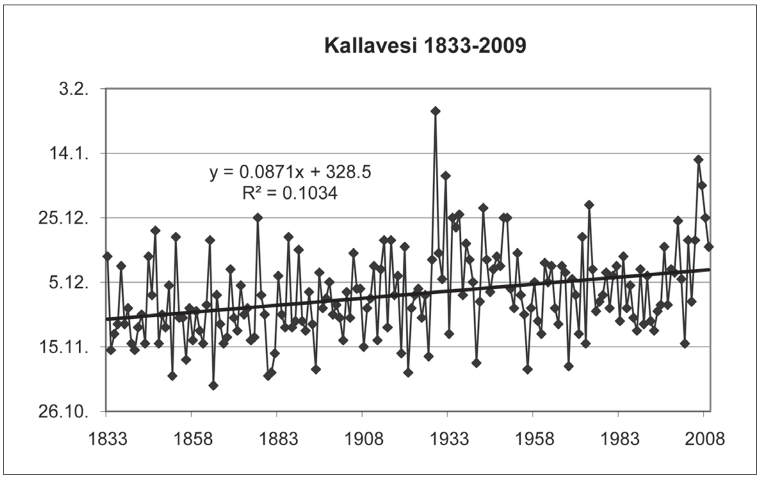

Figure 1: Freezing dates of Lake Kallavesi 1833–2009.

At sub-series level, very different trends could be found from these series. E.g. the shift towards later break-up in 1822–1867 is 14 days, significant at the level of 99.9 per cent. If this trend would have continued as such, the expectancy for the break-up date in 2008 would have been July the 8th. As to the freezing date, the trend in 1987–2008, significant at the level of 95 %, is as high as 26 days for that short period.

At Lake Oulujärvi, ice observations started in the winter of 1854–1855. During 156 winters, the freezing date has shifted nine days later and the breakup date eleven days earlier. The extremes of freezing have been October 22nd (1894, 1902) and December 24th (1929), those of break-up May 3rd (1921) and June 23rd (1867).

As to the thickness of lake ice, some long series from observation sites in Southern and central Finland have indications of a thinning trend, some in the Northern Finland of a thickening trend until 2002 (Korhonen, 2005). In recent years, lake ice has been relatively thin in the north, while the thickest ice in the whole observation series at almost all measuring sites in Southern Finland was observed in the winter 2002–2003.

How will ice conditions develop in Finnish lakes in the future? Climate change will inevitably be a powerful agent. Ice break-up will occur earlier, freezing will occur later and the ice cover period will be shorter. The effects will be stronger in the south than in the north. E.g. Weyhenmeyer & al (2005) found the break-up date to shift to around 14 days earlier per 1 °C rise in air temperature in Southern Sweden, but only 4 days per 1 °C rise in Northern Sweden.

The effects of climate change on the maximum ice thickness will not be straightforward. Ice thickness depends on both temperature conditions and snowfall. Increased snowfall could increase snow ice and this way also increase total ice thickness. Probably the maximum ice thickness will decrease in the south but in the north an opposite trend is possible, at least in the next one or two decades.

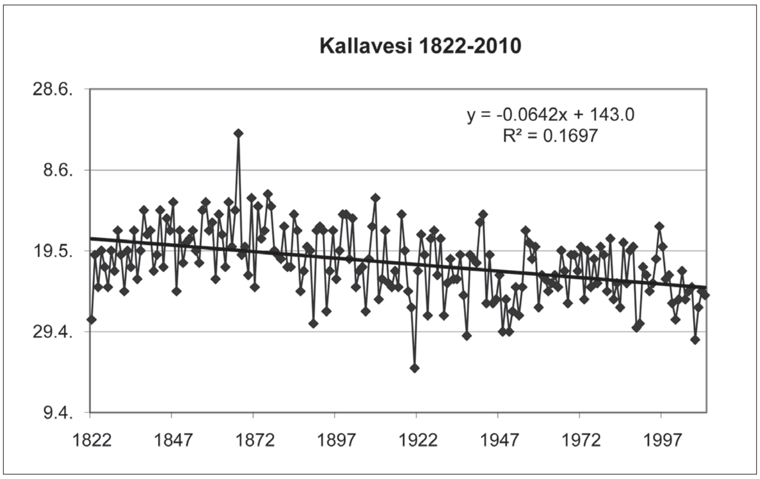

Figure 2: Break-up dates of Lake Kallavesi 1822–2010.

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Simulating Snowmelt Effects on Partially Frozen Soil along Fell Gradient in Finnish Lapland

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Nearly half of the annual precipitation falls as snow in northern Finland. Snowmelt provides substantial ground water reserves yet threshold conditions with respect to infiltration through partially frozen soil in spring are not well understood. We monitored snow and soil conditions in a small catchment of Sammaltunturi fell (67°99'N, 24°12'E), Finnish Lapland, in spring 2010. Two automatic monitoring stations are located inside the catchment area on a fell (mountain shaped by Pleistocene glaciations) gradient, forest at 370 m and tree line at 480 m a.s.l. Forest station is measuring soil and air temperature, as well as soil water content (SWC), whereas the tree line station records soil, snow and air temperature, SWC and electric conductivity, precipitation, snow depth and apparent snow water equivalent (ASW). A third monitoring station was established on a small stream for measurements of water quality: water temperature, electrical conductivity, pH, redox-potential, and dissolved oxygen. We also accomplished radar measurements of snowpack and soil thickness and measured snow water equivalent within the survey lines along the elevation gradients in late March 2010.

Part of the snow evaporates to the atmosphere, part of it flows as surface run-off having effect on floods and risk of landslides, and part of it infiltrates to the groundwater during spring melt even through partially frozen soil (Sutinen et al. 2008; 2009). In high altitudes we try to tackle these questions with monitoring, time series-measurements and hydrogeological models.

Radar data indicated soil thickness to vary between 0.5 and seven meters and snowpack thickness between 63 and 147 cm such that spatial variability was high in tree line, whereas forest sites had rather even snowpack. Before the onset of the snowmelt (on 28th of April) the snowpack was at the thickest, 94 cm, in the forest station as compared to that of 56 cm in tree line station. Soil temperature (20-cm-depth) remained below 0°C until the 1st of June. Due to air temperature rise notably above 0°C on 27th of April, the onset of snowmelt occurred throughout the elevation gradient. At both stations the effect of snowmelt was seen as the rise of ASW (29th of April) one day later. The rise of SWC was seen in the tree line station on 30th of April, and in the forest station on 5th of May, two and seven days after the onset of snowmelt. This suggests that snowmelt water infiltrates rather unimpeded through the soil. The maximum SWC was observed to be rather simultaneous with snow disappearance in the tree line, whereas in the forest snow disappeared almost a month later than maximum SWC. We contend that snowmelt infiltration through partially frozen soil significantly contributes to ground water reserves. Snowmelt was also seen in water quality of the catchment creek: water temperature increased, electrical conductivity decreased, ph decreased, redox-potential increased, and dissolved oxygen deacreased.

Our intention is to simulate soil water storage, groundwater recharge and runoff during 2010 with 1D coupled heat and mass transfer model for soil – plant – atmosphere systems – CoupModel (Jansson and Karlberg, 2004). In this study the CoupModel is validated with soil temperature, SWC and snow depth from the automatic monitoring stations. Other inputs are soil texture (from 3–5 different depths), slope in N-S and E-W directions, initial snow depth, and the thickness of the organic layer. The outputs of the CoupModel in this study are surface runoff, drainage flow and deep percolation to ground water, surface water infiltration rate into soil, snow water equivalent and frost depth. The input for the meteorological data, used as driving variables to the model, we use precipitation, air temperature, relative humidity, wind speed and global radiation, from April to June 2010.

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Improving the Ecological Status of Running Waters Based on Fish Community in WFD: Does Climate Change Affect the Mitigation Measures?

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Introduction

The Water Framework Directive (WFD) enforces the development of assessment methods for monitoring the ecological quality of waters using information from different biological quality elements (fish, invertebrates, plants). In Finland a fish-based assessment method (FiFI, Finnish Fish Index) was developed to estimate the ecological status of boreal rivers. In the FiFI five fish metrics are used to measure the ecological status of running waters based on fish abundance, species composition and age structure. The main pressures in the Finnish rivers affecting ecological status are morphological (dams, flood control, dredging) and water quality (agriculture, forestry and peat mining) pressures. In addition, the largest acid sulphate soil areas in Europe are found in Finland.

Based on our research water quality, especially loading of solids and phosphorus from agriculture land can have a large negative impact on riverine fish populations. Toxic responses and recruitment failures of fish have been reported due to acid releases from sulphate soils. Dredging and loading of sediments results in habitat loss especially for salmonid fishes. Where should we focus on in our mitigation efforts to improve the ecological status of rivers? Should we focus on diminishing anthropogenic acidification, loading of nutrients, loading of solids or physical habitat restoration? Based on recent scenarios climate will warm up in the Nordic countries especially in winter increasing winter precipitation and frequency of heavy precipitation events. This is likely to change the timing and increase the magnitude of loading of sediments and nutrients from agriculture, peat mining and forestry. Heavy precipitation events will increase the possibility of acid releases from acid sulphate soils releasing also metals like Fe and Al. Increased sedimentation together with extreme flow conditions will alter the fish habitat.

Mitigation of anthropogenic impact

Based on the long term fish data from in-stream physical restoration we show that changes in flow conditions are important regulators of the fish population. In the case of extreme flow conditions, for example after heavy drought, in stream restoration alone can be an ineffective method to mitigate fish populations. Our results suggested that in the future a wider perspective should be adopted in our restoration efforts; from in stream restoration to the restoration of the entire catchment. This was also supported by the results from the water quality – fish community relationships: the variability in fish community dynamics was largely driven by agricultural practices. Therefore, reducing loading of solids and phosphorus is an effective way to improve the fish community composition and ecological status. Focus should be in the whole catchment, for example, minimising the use of phosphorus fertilizers, preventing mobilisation of solids by vegetated buffer strips, or avoiding ditching and drainage. Climate change increases the risk for fish populations being negatively affected by acidic soils, and we need better understanding of the behaviour of these problem soils. Specifically, innovative methods to protect the waters from acidic leaks, and information how these methods work in a changing climate are sorely needed.

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Ecological Response to Climate Change Assessed by Phytoperiphyton Structure in Streams

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Introduction

Stream ecosystems are at risk for changes due to climate changes because the ecological processes in water are strongly influenced by temperature. Two main approaches dominate in the studies of temperature rise impact on river environments: analyses of the historical series of observation and modeling of changes in laboratory or field experiments. We attempted to resolve this task by comparing the structure and function of attached algal communities in rivers with similar morphometry and hydrological regime, but their basin in different geographical areas.

The use of algae seems to be appropriate for monitoring of freshwater ecosystem because their occurrence is influenced rather by water quality than the geographical location. Algae which inhabit rivers with high flow rates are constantly exposed to relatively equalized, average fluctuations for each given river. Periphyton was chosen of as research object is conditioned because attached communities are not subjected to short influence of accidental local changes in hydrobiological and hydrochemical regime and reflect the average prevalent one in a certain water body.

Study areas

More than 60 streams in north-western Russia from Lake Ladoga to the Barents Sea (Republic of Karelia) were chosen on the basis of the periphyton taxonomy investigated. Along the south-north latitudinal gradient total radiation ranges from 75 in Ladoga Lake region to 30 kcal/cm²/year in Kola Peninsula, and the mean annual air temperature ranges from 3.1 °C to 0.0 °C accordingly. As result the mean annual water temperature ranges from 6.1 °C for Lake Ladoga basin streams to 3.9 °C for Barents coast streams.

Results and discussion

The rising temperature produces direct and indirect effect on periphyton communities: in first case -due to biochemical and physiological processes in cells, in the second case-by modifying the conditions of the catchment area and very often indirect effects seem to be of greater significance.

Attached communities in the rivers of the Barents Sea region dominated by cold resistant species. Euglenophyta, Pyrrophyta and Charophyta drop out of algae flora. A decrease in diversity of blue-green algae as compared with green ones is also characteristic for the northern basin algae flora. It is noted that the ratio Cyanophyta/Chlorophyta is 1.2/1.0 and this apparently reflects specificity of the northern rivers periphyton algae flora. However, blue-green algae of Nostocales are rather diverse, widespread and dominate in the algocenosis of the rivers of Kola Peninsula, that is why Nostocales/Oscillatoriales ratio for the examined regions are respectively: Lake Ladoga -1.6, Barents Sea -4.0.

The decline in species diversity, characteristic of the Barents Sea zone, is often due to nutrient supply, rather than temperature, and is related to the chemical composition of water. Thus, temperature contributes to the selection of dominant species, and the presence of most species depends on nutrient supply. The species that show a high phosphorus and nitrogen demand are the first to drop out of algal coenoses. A rise in the number of single-taxon families and genera is due to decreased mineralization. As a result, a small number of leading families that account for over 70 % of the species begins to play a more important role. All taxonomically rare and scarce species are impoverished northwards, so that the taxonomic homogeneity of algal flora increases.

Decrease of mean temperature and biogens contains lead to decreased abundance and diversity of allochthonic plankton and benthic forms and also to the trivialization of the periphyton communiy structure which is followed by the decrease in dominant species number. Structure of allochthonic flora changes in dependence to the number of lakes, their morphometry and trophic status which changes from north to south. The shortening of phenophases observed northwards results in the closer growth maxima of periphyton: one indistinct maximum is recorded in July, and the other in August-September. However, in the Kola Peninsula one maximum is clearly observed in the rivers in late August to early September.

Low periphyton production intensity is also due to the low nutrient salt content of water, which, in turn, is caused by the absence of water macrophytes, an important producer. Therefore, the discharge basin is the only source of biogenes, but because it does not melt down until fall, a production intensity peak is observed in fall, when water bodies are enriched in biogenes, rather than in summer when favorable conditions are provided.

Conclusions

The data obtained can be used to assess changes in climate caused by human activities because changes brought about by warming will prove to be similar to those observed when comparing ecologically homogeneous algal coenoses forming in water bodies more or less similar in hydrological regime but differing in climatic conditions. This in its turn will allow to forecast the consequences of anthropogenic climatic changes by global worming, and to find out how it affects aquatic ecosystems. In order to implement rational and effective strategies for dealing with this problem, reliable information is required on the different aspects of climate change and its related effect.

In addition, the specificity of periphyton as a special ecological group was confirmed. It can be used as an indicator to determine the types of water bodies located in different geographic zones.

The Hydrological and Ecological Impacts of Climate Change in Large Lakes – Case Study of Lake Saimaa, Finnish Lake District

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Introduction

Recent climate change scenarios predict increase by 3–7 degrees in temperature and 13–26 % in precipitation in Central Finland (Ruosteenoja & Jylhä 2007). Changes are reflected in surface water runoff and water level fluctuations of lakes. Lake littoral is adapted for specific fluctuating water levels and therefore even small changes in extension and timing can cause significant changes in biota (Hellsten 2001). Further also recreational use of lake is easily hampered by changing levels.

Effects of different climate change scenarios on flows and water levels of large Lake Saimaa in Finnish Lake District was studied by using the watershed simulation and forecasting system (WSFS). The hydrological conditions were simulated by using five climate change scenarios for periods 2010–39 and 2040–69 with comparison to years 1971–2000. Hydrological and ecological effects were evaluated by using water level indicator system comprising of 22 different indicators.

Threatened species under threat

All scenarios are producing higher water levels during winter and increased out-flow from lakes. However, trends in summer and autumn water levels are depending on scenario. Most negative change related to nesting success of threatened ringed seal, which is suffered of increased water level fluctuation during ice covered period. Additionally risk of downstream floods is increasing and therefore water level regulation is needed more often in future. Our study confirms the obvious negative effect of climate change on vulnerable lake biota and use of lakes.

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Session 3:
River Basin Management

Introduction to the River Basin Management Practices in Finland

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Organizing in river basin planning and management

The Ministry of the Environment is responsible for the guidance and EU reporting in river basin planning and management on national level. It has close cooperation with the Ministry of Agriculture and Forestry, the Finnish Environment Institute and, in lesser degree, also with the Finnish Game and Fisheries Research Institute.

Mainland Finland is divided into five river basin districts (RBDs). In addition, two international river basin districts with Sweden and Norway are designated covering parts of Northern Finland. Centres for Economic development, Transport and the Environment are responsible for the planning of river basin management in their respective districts, with one of the centres being appointed to co-ordinate the management of each of the five RBDs, together with a steering group. The centres have additionally set up regional coordination groups, whose other members include invited representatives of the main national and local authorities, organizations, landowners and business interests responsible for the use, protection and state of water bodies. Moreover, the Government of Åland is responsible for the river basin district that covers the autonomous Åland Islands province.

The ecological state of water bodies

Most of Finland's classified surface water bodies (ca. 3000) are in a high or good ecological state. Waters with lower ecological status than good include almost a third of the classified lakes, but ca. 90 % of the total lake area is in good or excellent state. Rivers in Northern Finland are generally in excellent or good state. Rivers whose status is classified as being only moderate or poor are more numerous in coastal regions also affecting the state of the coastal waters. Aquatic ecosystems are affected by various factors including high nutrient loads from farmland, hydrological engineering, and in some cases high concentrations of metals and acidity, caused by artificial drainage, especially in areas with acid sulphate soils. The chemical state of the waters is generally good.

Of the 3800 ground water areas only 82 are in poor state. It has, however, been estimated that human impact may cause changes to the groundwater status at altogether 500 areas and there are risks in additional 250 areas.

Implementation of RBMPs

Technical, legal, economical and policy measures are needed in all the sectors. The biggest challenge will be in reducing the agricultural loads. Of other measures, reducing loads of domestic wastewater in areas outside sewerage networks and reducing the harmful impacts of hydrological engineering, water-level regulation and land use on acid sulphate soils are essential. Other measures include lake and river restorations, groundwater protection and reducing loads from forestry areas, peatland drainages and aquatic culture.

The so called additional measures presented in the RBMPs for improving the ecological status of the water bodies will increase the annual costs used for this purpose already now by approximately 15 %. This means additional annual costs of approximately 235 million euro (44 €/inhabitant/year).

When the Council of State approved the seven River Basin Management Plans (RBMPs) of Finland in late December 2009, it provided preparation of a National Implementation Strategy focusing on administrative and economical policy measures, responsibilities in implementation and funding. The Ministry of the Environment drafted the plan through cooperation with different governmental sectors and stakeholders at the national and regional level. For instance the regional cooperation groups were asked to give their input to the implementation strategy.

The measures in the RBMPs are not binding for single actors. The state government and municipalities will promote activities within the framework of their budgetary funds. Many actions are, however, voluntary and their success depends on the readiness and will of enterprises and individual citizens to implement them. The environmental authorities can support the implementation by taking the objectives of the RBMPs into consideration when granting environmental permits for certain activities.

Second planning round

The national coordination group for RBM planning, with representatives from all five river basin districts, Finnish Environment Institute, the Ministry of the Environment and the Ministry of Agriculture and Forestry, has started the second planning round for river basin planning and management. In the early phases of the work, issues such as revisions of water body characterization and ecological classification and also joint public consultation with Marine and Flood Risk Management will be highlighted. Revision of the Program of Measures will be made until 2013 and first revision of RBMPs for public consultation until September 2014 so that the national Government can approve the revised plans by the end of 2015.

Integrating Hydro-geomorphic and Landscape Metrics to Analyze the Response of Stream Water Quality to Land Use and Climatic Stressors

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Human land use has transformed natural landscapes rapidly in the last century, affecting spatial and temporal patterns (structure), and ecological and biogeochemical processes (function) of ecosystems (Wu et al. 2003). Several studies in catchment scale have found empirical relationship between the proportion of different land use types and water quality parameters, particularly agricultural areas explaining suspended sediment, N and P loading into water course (Ekholm et al. 1997). However, the spatial arrangement of land use has rarely been assessed. The short-term and seasonal variations in stream water chemistry are mainly driven by climatic variation and terrestrial biotic processes (Semkin, et al. 1994). Catchment properties play an important role in runoff generation and ground water recharge. In boreal landscape, water infiltration raises the water table, which eventually reaches the surface in floodplains and riparian areas, increasing subsurface and surface flow (Beldring 2002). Therefore, it is important to analyze the interaction between spatial pattern of land use, catchment properties and climatic variation in solute transport. In this paper, the effects of spatial land use patterns regulating stream water quality in boreal agricultural catchments (Yläneenjoki and Pyhäjoki, Southwest Finland) is studied using hydro-geomorphic and landscape metric index and monthly water quality data

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Analysis of Existing Water Protection Action Plans at Sulejow Reservoir in Poland

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Introduction

Sulejów Reservoir is a typical lowland reservoir situated in Central Poland. It is 15.5 km long the basin has an elongated, trough-like shape. It is characterized by a maximal width of 2.1 km and maximal depth of 4.5 m. Its mean annual retention time ranges from a dozen to four dozen days.

Dam reservoirs constructed on lowland rivers suffer numerous environmental and water quality problems. Eutrophication resulted from the river phosphorus supply, effects with a disturbance of the ecological balance of the ecosystem and occurrence of blue-green algae blooms during summers. They may have cancerous and toxic effect on humans, by degrading liver cells, damaging the nervous system or irritating the respiratory muscles. For nearly 30 years, the main function of the reservoir was supplying the City of Łódź (about 800,000 inhabitants) with drinking water, however problems with water quality restrict this function nowadays. The reservoir still serves as a recreational area, however the occurrence of toxic algal blooms may further restrict its use. The concentrations of nutrient indicators are within the norms for Class II in the Pilica and Class III in the Luciaza River. The physico-chemical analyses of the water indicated that diverse pollutant concentrations occur in the reservoir. The basic indicators that determine water quality belong to Purity Class I, although several of them, such as BOD_5, COD_{Mn}, COD_{Cr}, suspended matter, nitrates, phosphates, total phosphorus, and manganese, are at values that correspond to classes II and III. Thus, the overall water quality in the reservoir does not conform to the specifications of Purity Class I.

Water protection action plans at Sulejow Reservoir area

The most important tasks to improve the ecological status of the Sulejów Reservoir are:

- the reduction of point and non-sources pollution in entering the river originated from sewage, storm run-off and unsound agricultural and forestry practices;
- the improvement of water quality and reduction of eutrophication of the catchment – Pilica River – Sulejów Reservoir system;
- the reduction of health hazards due to the presence of toxic algal blooms in the Sulejów Reservoir – recreational area for the City of Łódź (800,000 inhabitants);
- providing new employment opportunities and awareness raising;
- involvement of local authorities, stakeholders and landowners.

The article contains the analysis of the existing water protection action plans and projects realized in the Sulejów Reservoir region. The plans ability to improve the ecological status of Sulejow Reservoir is assessed in the paper.

Adaptation of Land and Water Management to Climate Change in Central Asia Using Payments for Ecosystem Services

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Water and agriculture are two sectors in Central Asia that are highly vulnerable to climate change impacts due to domination of strong continental climate and desert and semi-desert ecoregions (Mizina et al, 1999). Calculations show that by 2050 the water runoff in the basins of the Amu Darya and the Syr Darya (the two main Central Asian regions) will dry up by 10 to 15 and by 6 to 10%, respectively (Ibatullin et al, 2009). More than two-thirds of the total available water resources in Central Asia are consumed by irrigated agriculture to grow rice, cotton, sugar beets, grapes, fruits and cattle forage. At the same time, the country assessments show that 70% of potential damage from unfavorable weather and climate conditions will affect agriculture.

This report aims to: a) describe the key climate change impacts and possible adaptation measures in water and agricultural ecosystems of Central Asia; b) provide recommendations on utilization of PES as a tool for climate change adaptation and IWRM in Central Asia. This research uses a combination of methods including document analysis, literature review and open-ended interviews with local and international experts.

The climatic conditions of Central Asia vary from region to region, however they have one thing in common: the climate is highly continental with extremely varying temperatures, and scant precipitation throughout the area. Over the last 100 years the average annual temperature in Central Asian region increased by 0.18 °C (Ibatullin et al (2009:13)). When looking into the future under pessimistic scenario (A2), by the end of XXI century the increase in average annual air temperature as compared with the base period (1960–1990) will vary from 4.7 °C in Kyrgyzstan to 5.5 °C in Turkmenistan, whereas in a more optimistic scenario (B2) the expected rise in annual air temperature will be around 1–1.5 °C lower.

The impacts on both water ecosystems and human use are to be substantial, since all models predict substantial declines in total natural water resources supply in the region of Central Asia largely due to the melting glaciers over the next century. These impacts comprise of the following, but are not limited to: a) natural resources: rapid glacier melting and reduction of snow cover, change of hydrographic regime of surface waters, increasing desertification processes, land degradation and salinization, loss of biodiversity, increased deforestation; b) human use: reduced access of the population to clean drinking water, projected reduction of crop yields, reduction in pastures productivity, reduction of feed capacity and the animal production, change in the employment structure of rural population, threat to the food security, energy security issues (CAREC, 2009).

In the context of unsustainable environmental resource use and high vulnerability of agricultural ecosystems to climate change, the adaptation policies should facilitate more effective, integrated and participatory approaches to watershed management (Genina, 2008; CAREC, 2009). Since 2000 at least on a political level a target in the region was taken towards a more integrated and participatory approach in water and land resource management. The recently created river basin councils and the draft National IWRM Plan in Kazakhstan showcase this trend. At the same time, the institutional changes are not enough. Diversification of financial sources and the use of economic incentive tools have been recommended as a needed adaptation measure in Central Asia.

Payment for Ecosystem Services (PES) represents a market-based tool for more efficient watershed and related ecosystems management to complement the command-and-control measures (UNECE 2007). This framework of incentives ensures greater involvement of stakeholders and sustainable financial mechanisms (contractual transaction) between ecosystem service users (irrigation, drinking, recreation) and sellers (farmer associations, forest owners, local authorities, private companies).

In this context, in 2009 the Regional Environmental Center for Center Asia (CAREC) initiated a first program on piloting and promoting PES schemes in Central Asia. The program started with the legislative and feasibility assessment of the pilot area of Chon Aksuu watershed, Issyk Kul oblast, Kyrgyzstan, with support from the Swiss Federal Office for the Environment (FOEN).

The Chon-Aksuu River watershed is situated in the North of the Issyk-Kul Lake. It includes high lands composed by pastures and forests where takes cattle is being raised and lower agriculture lands, close to the lake, where cereals, forage and fruits are being grown. Downstream farmers face water shortages during the irrigation period and high levels of suspended sediments in the river due to overgrazing which lead to the blocking of water pipes. Sustainable management of forests and pastures upstream would allow better water storage in the soil and lower erosion rates which leads to a more stable water supply of better water quality. At the preliminary workshop the stakeholders agreed that both water and pasture use associations will sign up the contract to devote 5 % from their collected fees to the state forest management agency if it improves in the grazing and forest management practices up-stream.

The pilot project will start to be implemented in the end of 2010 with support from GEF Small Grants Program. The lessons and recommendations on PES from this project once available will be shared locally, regionally and globally.

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Session 4: Groundwater

Application of ORP for the Characterisation of the Ground Drinking Water under Changing Climate Conditions

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Introduction

Global climate change has influence on both quantitative and qualitative characteristics of the groundwater. Redox reactions in groundwater are usually biologically mediated and therefore, the oxidation reduction potential (ORP) of groundwater systems depends upon biodegradation processes. Oxidation and reduction reactions control the behaviour of many chemical constituents in the groundwater. The determination of ORP is advisable in water that contains a relatively high concentration of a redox-active species, e.g., organic carbon, the salts of many metals (Fe^{2+}, Mn^{2+}) and strong oxidising (chlorine, oxygen) and reducing (sulfite ion) agents. Compared with surface water, ground water relatively isolated from the atmosphere leads to stronger reduction reactions (Weng et al., 2007). The objective of the study performed in France was to evaluate the use of ORP as a control tool and determine its relationship to dissolved oxygen and residual iron concentration in filtered water. Results showed that above a low minimum value of dissolved oxygen, residual iron concentration and ORP were not affected by varying the dissolved oxygen level. A non-linear regression was established to correlate total residual iron concentration to ORP (Catherine, V. et al. 1998).

Study area

Šešupė river sub-basin belongs to Nemunas river basin district and covers territories in Lithuania, Poland and Russian Federation (Kaliningrad oblast). The total area of the river basin is 6105 km², the major part of the river basin (> 78 %) is in the territory of Lithuanian Republic. Agriculture is the prevailing economic activity at Šešupė river basin. Major part of the ground water wells used for potable water does not meet requirements of the iron concentration in water (≥0.2 mg/l). The groundwater in the study area (Upper–lower Cretaceous) contains calcium sodium chloride bicarbonate, it is moderately hard, it is alkaline, it has some dissolved salts, it is a soda-type water. The concentration of chlorides in the water is high and also the norms-exceeding concentration of iron is recorded. The value of ammonium also exceeds the specified indicator value (Diliūnas J. et al, 2006).

Results

Paper provides results of the study, where oxidation reduction potential (ORP) was used as an indicator to track trends of the metallic pollution of the drinking ground water. Water wells with very high, medium and low concentrations of iron were selected for detail analysis. Measurements were performed at Barzdai and Keturnaujiena settlements (water consumption less than 100 m³/day). In 2010 authors have performed several sampling campaigns in drinking ground water wells, also tap water samples were taken in the selected residences.

The maximal concentration of total iron 6.93 mg/l was indicated in water well at Barzdai settlement, respectively minimal value 0.065 mg/l was registered at Keturnaujiena settlement. The concentrations of NH^{4+} in Barzdai water well have varied from 0.14 mg/l in June to 0.72 mg/l in March; the respective ORP values varied from -94 mV in March to -130 mV in June, 2010. The analysis results show high correlation between NH^{4+} and ORP values, however there were not noticed significant correlations between concentrations of total iron and ORP.

Comparative analyses of tap water in the water supply system (without devices for iron and manganese removal) have showed that in residences, where water was supplied from the water well with very high concentration of iron, considerable decrease of iron concentration (in average by 3 times). In the residences, where water was supplied from the water well with high concentration of iron, the concentration remained unchanged. Tap water at the residences with low concentration of iron in water well has indicated the increase of the iron concentration. In general, analyses of tap water have showed high correlation between concentration of iron and ORP, also some regularity was observed between concentrations of iron an distance in the water supply system from the water well.

Results of the study show that ORP monitoring data could be used to track conditions and seasonal variations of metallic pollution, and could provide feedback for more efficient metal removal process from the drinking ground water.

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Coupling of Soil Frost to Surface Water-groundwater Flow Model to Estimate the Effects of Climate Variability on Groundwater Levels in Cold Snow Dominated Region in Central Finland

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Introduction

In Finland, nearly 60 % of the community water supply is groundwater and its use is expected to increase to 70 % in the future. The groundwater requires less chemical treatment owing to its good quality and it is also better protected against pollution as surface waters. Most aquifers used for water supply in Finland are glaciofluvial deposits, i.e., eskers. Eskers are typically well sorted gravel and sand deposits that are common aquifers in boreal regions. In central Finland, the water table usually lies between 2 and 4 meters below the ground surface (Korkka-Niemi and Salonen, 1996). Central Finland is classified as having a mid-boreal climate and typically a permanent snow cover from November to April. Precipitation is highest in summer (June to August), and lowest in spring (March to May). The snow pack grows from November to April and melts in April-May. The last day of the snowmelt typically falls in mid-May. The soil freezes usually in October and thaws in mid-May. The groundwater level maximums occur in spring due to spring melt and fall due to precipitation and low evapotranspiration. The water level minimums occur in summer due to high evapotranspiration and winter due to snow cover and thereby lack of percolation.

One approach to understanding the possible impacts of changes in precipitation and temperature on groundwater can be analyzing groundwater recharge (Okkonen and Kløve, 2010). Temperature and precipitation are applied in hydrological models to estimate groundwater recharge which is then applied in groundwater flow models, such as MODLFOW (Harbaugh, 1990), to estimate changes in groundwater levels (e.g., Allen et al., 2004). Recent studies have been mainly centred in the regions where snow cover and soil frost do not play a key role in the aquifer recharge (e.g., Vaccaro, 1992; Bouraoui, 1999; Eckhardt and Ulbrich, 2003). Considerably less attention has been paid to the impacts of climate variability to snowmelt and soil frost and their effects on recharge (e.g., Jyrkama and Sykes, 2007), the impacts of soil frost on water infiltration (e.g., Sutinen et al., 2008) and the impacts of climate variability on groundwater levels in cold snow dominated regions (Okkonen and Kløve 2010; Mäkinen et al. 2008).

Coupling of soil frost to surface water-groundwater flow model to estimate the effects of climate variability on groundwater levels

The impacts of climate variability on the dynamics of a groundwater system in cold, snow-dominated regions can be understood only through a transient high resolution approach. To simulate the groundwater and surface water interaction would be an application of physically-based models. Models, such as HydroGeoSphere (Therrien et al., 2005), have the ability to simulate the surface runoff, the flow in the unsaturated and saturated zones and surface runoff. However the lack of sub-models such as freeze and thaw models and water infiltration through a partially frozen soil, make it difficult for physically based models to simulate the timing of the recharge and the minimum and maximum groundwater levels and the surface runoff. In this study, methodology is presented to assess the impacts of climate variability on groundwater levels in cold snow dominated region. The methodology was tested on an unconfined esker aquifer in central Finland. A 1D coupled heat and mass transfer model for soil-plant-atmosphere systems i.e. CoupModel (Jansson and Karlberg, 2004) was used to simulate snow cover, snowmelt and soil frost. The impact of soil frost on hydraulic conductivity on top soil layers was estimated and linked to a 3D integrated surface water-groundwater flow model, HydroGeoSphere, which was used to simulate the impacts of climate variability on groundwater levels.

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Studying Groundwater-River Water Interaction at the Catchment of the River Vantaa and Its Tributaries, South Finland

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Introduction

Management of water resources in Finland has traditionally focused on either surface water or groundwater. However, nearly all surface water features interact with groundwater. In Finland, this is the first attempt to study groundwater and stream water interactions in detail. This research was focused on River Vantaa and its tributaries. The River Vantaa is one of the reserve raw water sources for the capital area of Finland. In the river basin, there are also several significant aquifers used by the local municipalities or water companies. River Vantaa and its tributaries are widely used for recreational activities, too. The quality of the River Vantaa and its tributaries has been monitored regularly since 1970's to identify the incoming load and contaminants. The main target of the study is to increase the knowledge about aquifer-river interaction in the study area. The research gives valid information to the water management of the area as well as important data to evaluate possible effects of climate change to the river basin and its water management.

Field studies

Field studies were performed at Rivers Vantaa, Herajoki, Palojoki, Keravanjoki and Tuusulanjoki in July 2010. The total length of the rivers is approximately 220 km. The aim of the first field period was to define the best research methods to study groundwater-river water interaction and to identify the groundwater recharge and discharge zones in the river system. The methods used involved aerial infrared photography, thermal profiling of river sediments, water quality measurements (electrical conductivity, pH, main ionic concentration, 18O isotopic composition), river water temperature measurements and measurements with seepage meters and mini-piezometers (Korkka-Niemi et al. 2010). Aerial infrared photography data was collected using helicopter equipped with high resolution infrared imagery system (ThermaCAM) along with aircraft navigation and digital camera. Thermal infrared imagery was used to delineate areas of discrete and diffuse discharge of groundwater to stream water. AISA Eagle Hyperspectral sensor provided by SPECIM Spectral Imaging Ltd was used to detect changes both in the shoreline vegetation and quality of river water. Field measurements with multiparameter probe (YSI 600 XLM-V2-M) and multilevel sediment temperature probe (TP62_S, Umwelt Elektronik GmbH) were done at selected river sections concurrently with the aerial photography. Moreover, automatic YSI 600 sensors were installed at three water supply sites. Exceptionally arid and warm period preceded the time of the field activities resulting in the high difference between the temperature of river water (+20 – +24 °C) and groundwater (+4 – +8 °C). Thermal profiling with temperature probe revealed zones of groundwater discharge and provided reference data for aerial photography data. Seepage meters and mini-piezometers were tested at selected locations in order to quantify the observed flux of groundwater into the stream. Preliminary results of the field studies and feasibility of applied methods will be presented.

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Session 5: Socio-economical and Institutional Issues of the WFD

River Basins as Planning Institutions: How to Avoid the Place-centrist Trap

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The Water Framework Directive of the EU stipulates that river basin districts should constitute basic units of water management planning. According to one of the preambles, 'the objective of achieving good water status should be pursued for each river basin, so that measures in respect of surface water and groundwaters belonging to the same ecological, hydrological and hydrogeological system are coordinated'. Hence, the new planning instrument is to recognise the interconnectedness of watersheds and allow them to be treated as operations entities. This shift has been warmly welcomed by both natural and social scientists. Finally, it appears, planning of water management measures might coincide with a natural ecosystem and an ecological scale.

The risk with such an ecosystems-focused approach is that both researchers and administrators end up equating complex and open systems with places. Following Jessop et al. (2008:391), we might claim that river basin management falls into the 'place-centrist trap' in which river basins (or sometimes sub-units) appear as discrete, more or less self-contained, 'more or less self identical ensembles of socio-ecological interactions'. In other words, since it is geographically coherent, a basin is assumed to provide an unambiguous unit – and unambiguous boundaries – for management. However, social and economic processes influential for the development of water status easily extend beyond the territory of a river basin district. Moreover, that something affects a water body does not by any means guarantee that the processes would interact in any systematic fashion, or that they would be responsive to similar moves or fluctuations. Even things that are close spatially may not be so in terms of temporal sequences. Therefore, the rhythms of planning of the various regional public bodies may be hard to synchronise. When other activities are taken into consideration, the situation is complicated still further.

Both theory-based arguments and empirical evidence indicate that avoidance of the place centrist trap is crucial for effective river basin planning. In Finland, our paper argues, river basin planning has been effectively taken over by traditional sectoral thinking and administrative practice. This 'sectoral capture' tends to reproduce simple hierarchical thinking, failing to serve analysis of non-linear relationships. In South-west Finland, the plans have been unable to make visible the trajectories unique to the river basins, to deal with pressures emerging in a bottom-up fashion, and to analyse eco-social heterogeneity. Therefore, in the basin of the river Paimionjoki, for example, the planning process cannot sensitise to the apparent bifurcation taking place in agricultural production in the region and seriously affecting the conditions of water protection. Neither has the abstract administrative unit of the river basin offered meaningful attractants to activate citizen involvement. In fact, the circumstances in which people are to participate in adoption and modify their activities are multi-scalar. Accordingly, it may become surprisingly difficult to decide on common starting points for planning. Some preliminary definitions are needed as a starting point, but without the ability to contest demarcations – to rethink which are the relevant processes and scales of action and how they add up – planning is unlikely to reach its objectives.

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Institutional Approaches to the Implementation of the Water Framework Directive around the Baltic Sea

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Introduction

The eco-system based approach that is embodied in the Water Framework Directive breaks with traditional approaches in many countries and therefore the actual implementation of the directive requires considerable adaptation in relation to spatial fit of management units and management institutions, and poses challenges related to institutional interplay (Moss, 2004; Galaz et al. 2008). The river basin districts (RBDs) conceptually sit in the hub of intersecting institutional arrangements, requiring integration across vertical, horizontal and national administrative boundaries. Coordination problems may thus arise along these dimensions possibly leading to implementation gaps (Miller 2000; Scharpf 1997; Mickwitz et al, 2009).

A comparative study of institutional performance in WFD implementation

The paper presents first results from a comparative analysis of the ways these institutional challenges have been approached in the Baltic Sea countries, the solutions being sought and the barriers met.

The comparative study seeks to identify factors that affect institutional performance, based on theoretically derived criteria including institutional set-up and capacity, distribution of authority, and formal and informal decisions-making processes. Most countries have not yet considered climate change adaptation in their River Basin Management Plans, but this will probably be a major issue in the next round of preparing RBMPs. A short discussion on institutional aspects of this future challenge will be presented.

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Planning in Safe Waters – Institutional Continua of Water Management Planning and the Challenge of Responsiveness

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The institutionalisation of the Water Framework Directive is aimed at establishing a new fashion and new means to maintain awareness and respond to changes in water ecosystems. It aims to create better understanding of the ecological state of the waters, pressures affecting them, and actions needed for achieving good ecological status. Water management plans form the basic unit for the co-ordination of this understanding.

Crucial for alert and responsive water management is how the ecological status of a water system is made visible and becomes part of meaningful human activities. Hinchliffe (2008) has emphasised the import in such a process of what is entangled, what is disentangled, and how. Water management planning not just presents, but also actively creates understanding of what water and its management are. The outcome of planning is a contested understanding of the demands and means of public co-ordination. Planning actively contributes to the creation of the public subject in the realm of water protection.

This paper examines the challenges of responsive water management through an engagement with practice. In the water management plan of South-west Finland, diffuse pollution is raised as a major issue to be handled (Salmi & Kipinä-Salokannel 2010). The plan, however, has manifested difficulty in offering any new means or approaches for addressing this issue. The solution offered by the plan is more cost-effective assignment of the current policy measures.

This solution is clearly something that allows safe waters for all parties and enables their peaceful co-existence. It also follows the legal mandate of the plan. Engagement with practice shows, furthermore, that there exist particular knowledge technologies that actively keep apart the spheres of water and politics in water management. For example, the way in which nutrient reduction targets are derived from the ecological reference conditions demarcates the target-setting out of political deliberation. Environmental science is given the role of an 'ordering device', and the linkage between human activities and water becomes simply a relationship of pressure. On the other hand, the identification of actions is assigned to the political sphere, wherein the various interests try to safeguard their positions. With these spheres of water and politics kept separate, the institutional continua of water protection are incorporated into policy. This division enables safe waters but makes the policy incapable of capturing the complex eco-social dynamics that are unique to a particular river basin and of becoming more responsive to these. For development of more responsive water management, how institutional continua are enacted and maintained by particular planning technologies and practices needs critical attention.

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Integrated Modelling of Cost-effective Reductions of Nutrients to the Baltic Sea

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Introduction

The discharge of nutrients to the Baltic Sea causes serious water quality problems with respect to eutrophication and oxygen deficits. Several plans and directives are relevant for the achievement of improved water quality in the Baltic sea region; and the most important are the Baltic Sea Action Plan (BSAP) (HELCOM 2007), the Water Framework Directive (WFD) (The European Parliament and the council of the European union 2000) and the Marine Strategy Framework Directive (MSFD) (The European Parliament and the council of the European union 2008). While the WFD and MSFD-implementations are matters between the EU commission and the member stated (i.e. not Russia), the BSAP are negotiated between all the riparian countries around the Baltic Sea, facilitated by HELCOM.

A non-linear cost-minimisation model for the Baltic Sea BALTCOST (Konrad et al. 2010), embracing all 7 sea regions of the Baltic Sea and the riparian countries around the sea. The model is used to prescribe abatement measures to obtain different reduction targets in all 9 countries around the sea as well as targets for the different sea regions. The BALTCOST-model extends former models for the Baltic Sea (Schou et al 2006; Gren 2008) by updating the cost-functions and data behind these, as well as the model structure. The model integrates cost modelling, land-use modelling and marine models, and as part of the model development a distinction is made between groundwater/soil retention and surface water retention. The change from an overall applied retention coefficient (as in Schou et al 2006) to two different sets of retention coefficients changes the comparative advantages of the measures applied by changing land-use, to measures which have a direct effect on the surface water system. Also, the surface water retention differs across drainage basins contributing to differentiation of the relative effect of location of measures.

Modelling scenarios and spatial heterogeneity

In the present application the effects of including ground- and surface water retention are evaluated together with scenarios of different targeting approaches where differences in the total costs, distribution of costs between countries and environmental quality are examined in scenarios where the environmental quality targets are measured at the coastline of each country versus environmental targets for the sea-region. These scenarios take into account the spatial transfer of pollutants in soil, ground- and freshwater as well as between sea regions.

The research illustrates the importance of accounting for both economic and environmental heterogeneity in policy evaluations, and this type of integrated research and modelling has important implications for policy evaluations related to the Water Framework Directive and the Marine Strategy Directive.

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Vulnerability Assessment Model for Local Tourism in Terms of Climate Change Challenges

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Introduction

The Vulnerability Assessment of Ecosystem Services for Climate Change Impacts and Adaptation (VACCIA, LIFE07ENV/FIN/000141) -project 2009–2011 is accomplished by the Finnish Long-Term Socio-Ecological Research Network (FinLTSER). The VACCIA–project is based on the Millennium Ecosystem Assessment Reports 2001–2005 and builds forward from the basic assumption that climate change cannot be avoided, but the emphasis should be put on developing methodologies for vulnerability assessment, knowledge transfer and the overall building of adaptation capabilities (cf. IPCC 2007). VACCIA-project aims to develop adaptation measures that are based on the understanding of (i) the likelihood of change, (ii) the vulnerability of specific sectors to predicted change, and (iii) the knowledge production of local scale possibilities for adaptation.

The University of Oulu is responsible for two Actions in the VACCIA-project. This paper is part of the VACCIA Action 12 (short name: Tourism), which aims at the assessment of ecological, social and health impacts of climate change and developing potential adaptation measures for nature based tourism related communities in two northern towns in Finland; the town of Kuusamo and the municipality of Sotkamo.

Participatory future studies

The aim of this paper is to outline and critically review the vulnerability assessment model developed and applied for the case study of Action 12: Tourism. The paper begins by framing the starting points and the research setting of VACCIA project and particularly the Action 12: Tourism. Then the primary theoretical and methodological concepts considered will be presented with the emphasis on applied methodologies of participatory future studies, such as the narrative future scenario development (cf. story lines) and their further developing in a set of arranged future workshops. The paper will end to the lessons learned discussion and suggestions for further developing of vulnerability assessment methodologies and enhancing of local adaptation measures (Heikkinen et al. 2010).

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The Interactive Use of Multicriteria Decision Analysis to Support the Evaluation of Restoration Alternatives – the Case Study Related to the Enhancement of Migratory Fish Stocks in the River Iijoki

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Restoration of rivers and streams is nowadays a trend that reflects a growing awareness of river degradation; river and stream restoration has become a world-wide phenomenon as well as a booming enterprise (see Palmer et al. 2007). However, restoration planning often suffers from poorly defined objectives, the confusion of objectives and means, and lack of consideration of the impacts of suggested alternatives and measures. Decision making in restoration projects can be complex and seemingly intractable, mostly because of the inherent trade-offs between sociopolitical, ecological, and economic factors. For example, there are concurrently policy initiatives (such as the EU Water Framework Directive) to restore the multi-functionality of riverine ecosystems and landscapes (Pahl-Wostl, 2006; Sigel et al., 2010), and elaborate plans aiming to increase the use of European and northern rivers for hydro-electric power production to meet the obligations of international climate agreements and to gain profit thereof (Karjalainen & Järvikoski 2010).

The lower course of the River Iijoki was constructed for hydropower production in 1961–1971. Five hydropower dams in the lower course have blocked the passage of migratory fish to their reproduction areas for several decades. There are hundreds of hectares of areas suitable for salmonids upstream of the dammed river section. Most of these areas have been restored after the ceasing of the timber floating.

The main objective of the project migratory fish return into the River Iijoki (2008-2010) is to create a concrete program for restoring migratory fish. In order to support this objective, we applied interactive multicriteria decision analysis (MCDA) in a collaborative process which aimed at finding to an ecologically, socially, and economically sustainable way to return migratory fish stocks into the River Iijoki. Four different restoration alternatives were assessed. In the paper we also evaluate the general applicability of the method in multi-stakeholder processes.

Multicriteria Decision Analysis helps the structuring of decision situations by expressing and analysing systematically stakeholders' preferences, comparing alternatives having incommensurable impacts and identifying key trade-offs. Key tasks for all MCDA methods are the identification of key objectives and attributes, assessing their performances and importance in the decision situation, calculating priority values for the alternatives and reaching a consensus within a group of decision makers for these elements. In this project MCDA also provided a framework and tool to collect, organize and analyze information from stakeholders, experts and scientists.

We used decision analysis interview approach (Marttunen and Hämäläinen 2008) which means that key stakeholder groups, e.g. a hydropower company, fishermen, fisheries and environmental authorities and municipalities, are actively involved in the different phases of the work and the weight elicitation and analysis of the results are realized face-to-face between the analyst and the participants. The main advantages of MCDA in this project were enhanced individual and social learning among stakeholders, reframing the planning situation and shared understanding about the decision situation. MCDA also helped to identify issues of agreement and disagreement and to evaluate alternatives from different perspectives. The results can be utilized in the Iijoki project to identify the most acceptable and feasible alternatives for restoring migratory fish runs.

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Participatory River Basin Management Supported with the Complementary Use of Models

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The European Water Framework Directive prescribes a series of tasks for properly assessing and managing river basins with the ultimate aim of protecting and restoring the overall quality status of European surface waters. There is a great need to provide water managers and decision makers tools which enable integration of environmental and socioeconomic factors, systematic comparison of management alternatives, and improving stakeholder involvement, and to communicate and visualise results in a transparent and simple way. However, due to the tight time schedule and lack of appropriate tools, the use of different kind of models was fairly limited in the first planning period, and the Programmes of Measures as well as evaluation of the development of water courses' status were often based on expert judgments in Finland.

In this presentation we show how different models have been used in a complementary way to support participatory river basin planning. We used different models in a continuum to assess the current nutrient load to water course, to identify cost-efficient measures to achieve good ecological status, and to evaluate the monetary and other benefits to recreational use. Different future scenarios with different land use assumptions and climate change hypothesis were developed and their impacts were assessed. The scenarios were developed and the results discussed and evaluated in a multi-stakeholder group. We analyse the challenges and benefits of multi-model approach and discuss the applicability of multi-model approach in the second planning period of the Water Framework Directive. The results and experiences are based on the project carried out in the Karvianjoki water shed (area 3 400 km²) in Western Finland.

Poster Session

Towards Plural and Conditional Water Management – a Challenge for Knowledge Production

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River basin management concerns a wide spectrum of actors and crosses strict sectoral boundaries. Different actors have divergent commitments towards water, its utilisation and management. Recognising and acknowledging these commitments requires plural and conditional water management (Stirling 2008).

In this poster we present a framework for analysing one experiment, where plural and conditional knowledge for water management was seeked for (Kaljonen & Varjopuro submitted). In the experiment a comprehensive set of scenarios for Europe's fresh waters up to 2050 were built using highly participatory scenario-making methods (SCENES) (Kämäri et al. 2008). In this poster we argue that we need to take a dynamic view on knowledge production if we are to understand how participatory scenario-making methods can assist in forming social choices for more responsive water management. We present and discuss criteria composed of social, cognitive and mobilization linkages.

We believe that comparative analysis of the participatory scenario-making experiments, as they were conducted in SCENES, can provide meaningful empirical insights on the tensions that arise when plural and conditional policy advice for water management is seeked for. Developing more responsive water management entails engaging in experiments as well as mechanisms which enable others to learn from those experiments.

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Density Functional Studies of the initial Stage of Aluminium Oxide Dissociation in Clean Water

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Aluminium is the most abundant metal in the Earth´s crust, and the third most abundant element, after oxygen and silicon. It is too reactive chemically to occur in nature as a free metal. Instead, it is found combined in over 270 different minerals [1]. Despite this considerable natural abundance, aluminium may negatively affect terrestrial and aquatic life in different ways. Regular aluminium concentrations in groundwater are about 0.2 ppm [2], but at pH values below 4.5 the solubility rapidly increases, causing aluminium concentrations to rise above 5 ppm [2]. This may also occur at very high pH values. Dissolved Al^{3+}-ions are toxic to plants; these affect roots and decrease phosphate intake [3]. Traditionally so called labile monomeric aluminium including Al^{3+}, $[Al(OH)]^{2+}$ and $[Al(OH)2]^{+}$ is considered the most toxic, however the oligomeric forms may stiften cell membranes and cross link biomolecules in toxic way for the plant metabolism. After dissolution of the minerals in soils, the flow originated from the precipitations, transports these to water sources. This may cause its concentrations in rivers and lakes to rise [4]. Aluminium naturally occurs in waters in very low concentrations. Higher concentrations derived from mining waste and other human activities may negatively affect aquatic biocoenosis. It is toxic to fish in acidic, low alkalinity waters starting at concentrations of 0.1 mg/l. Terrestrial organisms also contain some aluminium. The mechanism of toxicity is mainly based on enzyme inhibition. Large aluminium intake may negatively influence human health [5,6].

The chemistry of aluminium in solutions is quite uncharted even it is widely used in several applications like a coagulation agent in water purification processes. Establishing the complete speciation of aluminium in water is difficult due to the dynamic equilibrium between complexes and versatility of the polynuclear complexes. In the study here presented, several state-of-the-art methods are integrated in a novel way to investigate the aquatic chemistry of aluminium clusters, in order to give additional insights useful to the understanding of the dissolution mechanism of aluminium oxide. In general, the prevailing view of aqueous aluminium chemistry is far from revealed. Here in, computational methods based on quantum mechanics have been combined with electrospray mass spectrometry (ESI MS) and potentiometric techniques, to investigate directly the hydrolysis products of aluminium in aquatic environments. The major goal of this study is to elucidate the progress of hydrolysis and polymerisation of aluminium complexes and study the kinetics of these reactions. Computational study can provide additional information on the structures, stability and chemistry of aluminium compounds in aquatic environments [7,8]. Car-Parrinello molecular dynamics (CP2K [9]) has been used, together with static quantum chemical calculations, to investigate the aqueous structures and chemistry of trimeric and pentameric aluminium complexes originated from the dissolution of similar fragments of aluminium oxide. The validity of the results obtained computationally has been verified comparing structural information to the results of the ESI MS experiments.

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Climate Variability Effects on the Groundwater Table Fluctuations and Nitrate Nitrogen Concentrations in Agricultural Lands

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Introduction

One of the most important ground resources in Latvia is groundwater. Intensive agriculture and inappropriate animal husbandry are the main concerns for decreased water quality. High rates of mineral and organic fertilizers use could lead to increased concentrations of nitrogen and phosphorus into headwaters and shallow groundwater.

The objective of the presented study is to investigate the impacts of climate change on the groundwater table and fluctuations of nitrate nitrogen concentrations caused by the nutrients from agricultural areas.

In order to monitor the agricultural runoff the Department of Environmental Engineering and Water Management has set three monitoring stations Auce, Berze, Mellupite. Necessary data are observed groundwater table, water quality, and subsurface drainage runoff.

Groundwater table modelling

According to meteorological data (air temperature, vapour pressure deficit and precipitation) it is possible to model the groundwater table. Using the mathematical model METUL [1] it is done. Model is calibrated for 2006–2009 time period. Correlation between observed and modelled groundwater tables are – for the Berze $R^2 = 0.88$, Auce $R^2 = 0.65$ and Mellupite $R^2 = 0.63$. By using 11 future climate scenarios from the regional Ensembles models [2] groundwater table is modeled for the reference period (1961–1990) and for the future time period (2071–2100). For modeling purposes data sets from Latvian Environment, Geology and Meteorology Centre (LEGMC), Ensembles [2] and Climate Change Impact on Water Environment in Latvia (KALME) [3] were used.

Results

There are differences in changes of groundwater table fluctuations for the future time period compared to reference period. To estimate the differences between groundwater tables in reference and future time periods the statistical (t-test, F-test) method was applied. All observation wells show similar characteristics for the changes of groundwater table fluctuations within seasons (winters and summers etc.). However, there are differences how relevant the changes are. The most significant statistical ($P(T<=t)$ two-tail <0.05) changes are expected in winter season. In the future during the winter and spring season groundwater table could increase, but in autumn season might be an opposite situation. During summer climate change may increase groundwater table fluctuation amplitudes, but the average water table could decrease.

Trends of the groundwater table fluctuation over 30 years for both reference and future periods show the similar characteristics for most of the wells.

Regarding climate changes water table could reach the level closer to earth surface (minimum depth) with a positive trend as well as water table could be so deep like never before furthermore with rather negative trend (for the maximum depth). However main changes could be expected for minimum depth.

The drainage system runoff depends on groundwater table. It starts after the groundwater table reaches depth of the tile drain pipe. In the future expected high groundwater table could prolong subsurface drainage runoff and possibly fasten nutrient leaching. Drainage runoff for the entire drainage field is estimated according to groundwater depth. In monitoring station Berze correlation between groundwater table and subsurface drainage runoff is $R^2 = 0.83$. Subsurface drainage runoff from drainage field starts if the groundwater table is above ≈ 2.15 m below earth surface.

According to climate changes probability of groundwater depth above 2.15 m the drainage runoff could increase from 62 % (226 days/year) in reference period to 65 % (237 days/year) in future time period. In the monitoring station Mellupite increasing of groundwater table could prolong drainage runoff with probability from 40 % (146 days/year) to 48 % (175 days/year).

Possible changes of nitrate nitrogen concentrations (observed data for 2006–2009) regarding groundwater table fluctuations in a climate variability conditions are considered. To classify water sampling depth (0.7–7.5 m) average value between bottom mark of observation well perforation and groundwater table was determined. It is estimated that variability of nitrate nitrogen concentrations is higher if the groundwater sample is taken closer to earth surface and nitrate nitrogen concentrations can reach higher values. One of the highest nitrate nitrogen concentrations from all the analysed data, are observed in subsurface drainage runoff. For example average nitrate nitrogen concentration is ≈ 0.1 mg/l in a depth 7 m and ≈ 12.5 mg/l in a depth 1.2 m (drainage depth) below earth surface.

Conclusion

The changes of groundwater fluctuation seasonality could affect the leaching of nitrate nitrogen because of retention processes. As the consequence of groundwater table high fluctuation amplitude in the summer, it will cause possible leaching of the nutrients from the soil located closer to earth surface as well as increase of water depth will cause the water deficit for the root zone. Increase of the groundwater depth in autumn could be a positive aspect for the leaching of nitrate nitrogen (it could decrease) and also the field condition will be suitable for the harvest and land cultivation.

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Comparison of Climate Change Scenarios and GCM Models for Kashafrood Basin of Iran

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Increasing in greenhouse gases such as carbon dioxide in the atmosphere could cause global warming and changes in air temperature and temporal and spatial scatter of precipitation (McCabe and Wolock, 2002; Moula, 2006). Mean air temperature of the earth was increasing since the 1850s by about 0.5 °C (Nicholls et al., 1996). These changes of precipitation and temperature can have significant effects on various sections such as agriculture, energy utilization, and human welfare (Watson et al., 1996). According to the IPCC climate change scenarios showed that the temperature is often increased and precipitation totals have increased in high northern latitudes and decreased in lower mid-latitude regions (IPCC, 2001). These changes impact the growth and development of crops in a number of ways. Temperature is a key element of evaporative and transpirative demand, particularly for tropical regions (Challinor et al., 2007). Water demand in agriculture and urban sectors may change in future due to climate change, so climate prediction in coming years will provide an insight of water requirement in various sectors. The large-scale General Circulation Models (GCMs) are appropriate and primary tool for predicting and investigating the changes of climatic parameters. These models are not applicable in the studies of spatial and temporal changes for climatic parameters at regional and local scales because of their coarse resolution. Iran is located in arid and semiarid region of the world. Due to low rainfall and high potential evapotranspiration, Iran has an average annual precipitation of 242 mm, which is less than one third of the world average. This precipitation is under conditions in which 179 mm of rainfall is directly evaporated. In other words, 71 % of the precipitation is lost due to evaporation, while annual potential evaporation of the country is between 1500 and 2000 mm (Shoaei and Heidari, 2006). Precipitation in Iran is occurred mostly from October to March (Nazemosadat et al., 2006). The main goal of this research was to estimate the change of precipitation and temperature for Kashafrood basin under possible future global warming. The future monthly precipitation, maximum and minimum temperatures were estimated from the output of CGCM2 and HAdCM3 for two socio-economic scenarios (A2 and B2) using statistical downscaling method (ASD model). This procedure was repeated for three future time periods including 2010–2039, 2040–2069, and 2070–2099. The usefulness of downscaling method depends on the ability of capturing the impacts of climate variability. It was found that the ASD model is a useful tool for downscaling large-scale climate model into the regional climatic parameters. The ASD model performed the most similar scenarios that varied with seasons. On the average difference between two scenarios (A2 and B2), was the same, while the differences among four seasons were significant. The comparison of downscaled data set under B2 scenario for minimum and maximum temperatures for basin showed that the downscaling model produced less warming over the nearly 100-year simulation than A2 by using both GCMs models. The downscaled minimum and maximum temperatures from both GCMs models indicated the global warming for all cases was consistent with the recent observation and increased with concentration of greenhouse gases. Through increasing the temperature and changing precipitation pattern, and subsequently evapotranspiration, the climate change will influence the agricultural section. The reliability of precipitation at critical phases of crop development, counts for variation agricultural potential. Interannual or interseasonal precipitation was major challenge to rain fed agricultural procedures (Feddema and Freire, 2001; Nicholson, 2001). The ASD model was capable of simulating current climate to study the future climate change due to the atmospheric projections.

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Assessment of Impacts and Adaptation Measures of Climate Change for Water Quality in Agricultural Area

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Introduction

In Southern Finland the climate change models predict 10–24% increase in annual precipitation and 2.8–4.9 °C increase in mean temperature for 2070–2100. In this area climate change will also mean warmer and wetter winters which are likely to increase nutrient loading to surface waters. In the VACCIA (Vulnerability Assessment of ecosystem services for Climate Change Impacts and Adaptation) project one aim is to demonstrate how climate change may affect agricultural production and environment, including impacts on nutrient loading to the waterways. The idea here is of the stakeholders for bottom-up action to mitigate and adapt to the change. The action aims to bring state-of-the-art results and simulation model scenarios of these impacts at reach of layman, public servants, private entrepreneurs, and politicians at local municipal scale. There is thus the need for developing the methodology and tools for connecting the global/regional scale climate/global change scenarios to the local/regional scale where the realistic adaptation measures are planned and conducted.

Effectivenes of adaptation measures

The case demonstration area Lepsämänjoki agroecosystem is a medium-sized agricultural watershed with a drainage area of 213 km². The area belongs to the southern boreal zone, and is ecologically as well as socio-culturally representative of an agroecological zone reaching across Fenno-Scandia. Nitrogen and sediment loads from the catchment are simulated by the INCA-family models INCA-N (Wade et al., 2002) and INCA-SED (Jarritt and Lawrence, 2006). The effect of climate change in discharges is modeled with the hydrological model Watershed Simulation and Forecasting System (WSFS), which is used to produce the input data for the nutrient model. As possible mitigation options we studied the effect of new methods (gypsum), cultivation methods (no-till) and effective nutrient use (nitrogen balance). Results of the use of gypsum are derived from the TraP (Novel gypsum-based products for farm scale phosphorus trapping) project.

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Water Scarcity and the Management of Water Resources in Syria and Lebanon

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In Syria, water resources vary a great deal spatially: from less than 200 mm per year in the dry Badia region to over 1000 mm per year on the mountains. The figures they all speak volumes about water scarcity (Barnes 2009). In recent years, as a result of a negative water balance, groundwater levels have receded, several springs have dried up and a large number of rivers have become seasonal or converted to wastewater canals. In many areas, especially near Damascus, the groundwater is polluted, and fields lie abandoned as a consequence of water shortages. It is estimated that due to climate change, water requirements for agriculture will further increase while productivity decreases (Meslmani & Wardeh 2010).

Lebanon is rich in water when compared to Syria. The mean annual rainfall varies significantly, from 200–600 mm in the northern part of the Bekaa Valley to 1000–1400 mm in the mountains (Sene et al. 2001). Lebanese water resources are under increasing stress, and in most cases already polluted (Jaber 2010). Climate change is expected to increase temperatures and reduce rainfall. A reduction in the amount of water and increased exploitation would have an influence on the groundwater in particular. Undesirable metals and contaminants in springs would become more concentrated and an increase in salinity would spoil the coastal groundwaters.

In both Syria and Lebanon, population growth and rising standards of living are already major factors influencing water scarcity and security. The mismanagement of water resources, namely illegal pumping and lack of proper wastewater disposal and recycling, not to mention the threat of climate change, are likely to worsen the situation (Krogerus 2010).

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Assessing the Effects of Agricultural Contaminants on Fontanili Ecosystems in North Italy

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Introduction

The research is realized in the scope of GENESIS project work package – Groundwater Dependent Ecosystems (GDE). The general objective of this work package is to better understand how groundwater (GW) flow and water quality affect GDE. The generated knowledge will serve to develop tools and methods to assess the vulnerability of GDE to anthropogenic factors. The studies are performed at selected GDE called fontanili which are semi-natural springs localized in the Lombardy region in North Italy. Fontanili are historical man-made installations, where GW is pushed to the surface forming artificial springs. They were created for the purpose of agricultural field irrigations and over the ages became an integral part of the regional landscape forming ecosystems typical for Northern Italian agricultural land. In this region the numerous semi-natural springs create habitats that sustain local biodiversity. As most of the anthropogenic pressure in the studied region comes from agriculture, the research is focused on the agricultural contaminants such as pesticides and nitrates and their impact on the GDE. The planned work includes identification, application and development of bioindicators as pollution indicators in GDE.

The bioindicator applied in the presented study was an in situ Gammarus sp. feeding bioassay. The Gammaridae family comprises the majority of known marine and freshwater amphipods. The Gammarus genus are among the most frequently used organisms in ecotoxicological testing because of their high abundance, wide distribution, very important role in the food chains and proved sensitivity to a variety of pollutants.

Results

The feeding bioassay was applied to selected fontanili localized in the vicinity of maize cultivation fields to see the effects of contaminants arriving from the surrounding fields with surface run-off. The results obtained from the bioassay and parallel chemical analysis of water, sediment and soil samples suggest that run-off from the fields causes a temporary contamination that affects the test animals in the fontanili waters and therefore has an effect on the studied GDE.

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