



Research Programme on Climate  
Change (FICCA)  
2011 – 2014

Project Descriptions and Highlights



ACADEMY OF FINLAND

## FICCA research programme on climate change supports multidisciplinary scientific research

The Academy of Finland's Research Programme on Climate Change (FICCA, 2011–2014) was launched to respond to the scientific challenges posed by climate change on a broad front. One of the principles underlying the FICCA research programme is to support the type of multidisciplinary research that addresses the social and environmental spheres side by side, the objective being a systemic approach to research problems.

The FICCA research programme includes eleven large national research projects composed of 44 sub-projects, six international research projects (with the Chinese Academy of Sciences (CAS), the Russian Foundation for the Humanities (RFH) and the Chinese Academy of Social Sciences (CASS)) and seven development research projects funded by Ministry for Foreign Affairs of Finland and the Academy of Finland. The FICCA projects were funded with a total of 17.1 million euros.

The funded projects cover several different research fields including geosciences; environmental policy, economics and law; economics; other research into the environment and natural resources; ecology, evolution and systematics; environmental technology; ecotoxicology, state of environment, environmental effects; geography; law; physics; education; sociology, social psychology, social work; anthropology, ethnology, folklore, comparative religion; forest sciences; and construction and municipal engineering.

## FICCA consortium projects 2011–2014

**A-LA-CARTE: Assessing limits of adaptation to climate change and opportunities for resilience to be enhanced.** *Timothy Carter, Finnish Environment Institute SYKE; Marja Järvelä, University of Jyväskylä; Helena Kahiluoto, MTT Agrifood Research Finland; Reijo Miettinen, University of Helsinki; and Tapio Määttä, University of Eastern Finland*

The A-LA-CARTE consortium has studied the implications of high-end climate change for agrifood systems and biodiversity in Finland. It sought to examine the limits of adaptation to anticipated climate change, to investigate the extent to which present-day systems are resilient to changes in climate and to explore the options for enhancing this resilience.

Some key messages emerging for agrifood systems:

- Inter-comparison of crop models revealed that accurate predictions of phenology did not necessarily imply reliable estimates of grain yields, and analysis of impact response surfaces showed large differences in model behaviour under high-end climate change.
- The concept of response diversity, by spreading risk, can be used as a means of increasing the resilience of barley cultivars in Finland.
- Plant breeders are receptive to the idea of a possible redirection of breeding programmes to enhance the resilience of cereal production in Finland.
- Farms and small and medium-sized food enterprises appear to be more vulnerable to climate change than larger businesses, inadequately prepared for future impacts and only vaguely aware of the appropriate adaptation activities that might be required.

Key findings on the biodiversity and conservation of birds under a changing climate:

- Densities of southern bird species increased by 29% in protected areas between 1981–1999 and 2000–2009, while for northern species it declined (by 21%) over the same period.
- The probability of occurrence of all species of conservation concern (except marshland birds) is estimated to decrease by 2051–2080 relative to 1971–2000 under all scenarios. The projected decline is greatest in southern boreal and smallest in northern boreal zones.
- The national protected area network in the southern and middle boreal zones will be insufficient to account for climate-induced changes in distributions.

## FICCA consortium projects 2011–2014 (cont.)

- Finnish legal and regulatory systems lack adequate mechanisms to enhance ecosystem connectivity and restoration, while possibilities to use assisted migration are constrained by legislation on invasive alien species. New, flexible mechanisms to enhance ecosystem restoration and to protect the environment at the broader landscape level are needed.
- Interactions between agriculture and biodiversity were also explored by analysing grassland management and butterfly conservation under a changing climate. Cost-effectiveness analysis was used to evaluate alternative adaptation measures based on existing agri-environmental schemes (AES) as well as new measures (species translocation and dispersal corridors).
- 20 peer-reviewed articles attributed to A-LA-CARTE have been published or are in press, and an edited book on climate change adaptation and the food supply chain will be published in 2015.

**CLICHE: Impacts of climate change on the Arctic environment, ecosystem services and society.** *Atte Korhola, University of Helsinki; Hannu I. Heikkinen, University of Oulu; Kimmo Kahilainen, University of Helsinki; Matti Leppäranta, University of Helsinki; Miska Luoto, University of Helsinki; Jarkko Saarinen, University of Oulu; Heikki Seppä, University of Helsinki; and Eeva-Stiina Tuittila, University of Eastern Finland*

The objective of the project is to improve our understanding of the impacts of climate change on Arctic ecosystems and the services that they provide through detailed ecosystem studies, synthesis activities and societal and economic impact assessments. Various elements of the Arctic environment are considered.

The project has been highly successful in terms of scientific innovation and postdoctoral and PhD training. We have produced more than 80 publications in high-ranking international journals and there have also been numerous show-ups in popular arenas. Our work has improved the quality and quantity of climate change impact models on biota, particularly the methodological and theoretical basis of bioclimatic modelling. Our study highlighted the importance of snow cover and snow properties for multiple environmental aspects and societal activities. We found strong indication of regime shifts and northward movement of the raised bog zone while studying peat profiles and peatland vegetation in the border region between raised bog and aapa mire zones. The project provided new knowledge on the distributional patterns of fish communities along climatic gradients. The benefits of upfront adaptation measures were highlighted in particular in relation to the tourism industry and reindeer herding.

## FICCA consortium projects 2011–2014 (cont.)

Overall, our results show that Arctic environments have been stressed by multiple factors (e.g. land use, atmospheric pollution, nitrogen fallout and fish stockings) on different time scales, and it is not always easy to disentangle the relative role of various drivers of environmental change.

### Key findings:

1. There is an increased risk of regional extinction due to Arctic warming, with a projection of disappearance up to 35 per cent of presently existing subarctic plants in Finnish Lapland in the 2xCO<sub>2</sub> situation.
2. Sporadic permafrost (palsas, pounus) will disappear from Lapland with a climate warming of 1.5–2 degrees Celsius.
3. The role of northern peatlands as carbon sinks may increase in future, hence partially diminishing global warming.
4. There has been an invasion of new salmonid and percid fish in the Arctic Fennoscandia due to global warming.
5. Ecological reorganisations in Arctic freshwaters have not been as dramatic during recent times as previously suggested.
6. Climate change has both negative and positive impacts on tourism and local livelihoods.

**ClimWater: Climate change and water cycle: effect on water resources and their utilisation in Finland.** *Jouni Pulliainen, Finnish Meteorological Institute; and Bertel Vehviläinen, Finnish Meteorological Institute SYKE*

The project investigates how climate change will affect water resources in Finland and how the adaptation to climate change requires altering current water regulation practices. The planned work is relevant to different sectors of society, including hydropower production, land use planning and construction in flood-risk areas, and flood prevention.

The results of the project include the further development of climate model predictions in order to facilitate their use as input to hydrological simulations. Additionally, satellite data retrieval methods and data products were developed to characterise the performance of both climate model and hydrological model predictions (using historical simulations). The analyses indicated weaknesses in climate models (ECHAM5) related to the timing of snow clearance. The main effort in the project was selecting a set of suitable climate model predictions and using them as input for hydrological model predictions (up to the year 2090), applying bias correction techniques verified with the analysis of historical data. The obtained simulated discharges were used to estimate changes due to climate change in annual and seasonal discharges and in floods in different parts of Finland.

## FICCA consortium projects 2011–2014 (cont.)

Also changes in flood areas and damages caused by floods were assessed in a few case study locations. The results demonstrate that the bias correction is necessary to successfully assess climate change impacts on hydrology with daily regional climate model (RCM) data. The results also show that floods will change differently in different parts of Finland with decreasing floods in snowmelt flood-dominated areas and increasing floods in large outflow rivers of the lake-district.

Based on these predictions, an exceptional flood event was simulated in the River Kokemäenjoki watershed and in the City of Pori, which is the most significant flood-risk area in Finland. An optimisation model was developed and run based on imperfect information on forthcoming weather conditions in order to mimic the situation that the real decision-makers are faced with. Flood damages were estimated in the different parts of the watercourse applying different regulation strategies. The results were presented and discussed in a stakeholder workshop in May 2013. One of the key findings was that the storage capacity in the regulated lakes upstream is not adequate in extreme flood events, and that there is a need to make hard trade-offs as to where to store flood water in order to minimise total flood damage. The results have been used in a flood event exercise in winter 2014 and in the preparation of a flood-risk management plan for the Kokemäenjoki watershed. The planning process of ClimWater, and the stakeholder workshop in particular, benefited from nine stakeholder interviews that were carried out between December 2012 and February 2013.

The aim of the interviews was to study how the key stakeholders (incl. the municipalities of Pori, Huittinen and Tampere, the two regional Centres for Economic Development, Transport and the Environment, two lake regulators, fishing and fisheries, and boating) perceive flood-risk management, the main challenges and solution possibilities, and the ways in which climate change will affect floods in the area.

**COOL: Aerosol intervention technologies to cool the climate: costs, benefits, side effects and governance.** *Ari Laaksonen, Finnish Meteorological Institute; Mikael Hildén, Finnish Environment Institute SYKE; Hannele Korhonen, Finnish Meteorological Institute; Markku Kulmala, university of Helsinki; Tapio Määttä, University of Eastern Finland; and Sami Romakkaniemi, University of Eastern Finland*

The highly interdisciplinary research project studies methods to cool the climate in order to combat climate change. The methods that are explored are a reduction of black carbon (soot) emissions and two aerosol technologies: injection of sulfur compounds into the stratosphere and spraying of seawater.

## FICCA consortium projects 2011–2014 (cont.)

### Key findings:

- Black carbon (soot) is a significant factor from the perspective of both health and climate change. Small-scale burning of wood in particular is highly questionable as a climate measure and cannot be recommended for densely populated areas. At Northern latitudes, wintertime black carbon emissions have more climate impact than summertime emissions, due to the snow and ice melting effect of black carbon in spring. Globally, targeted black carbon emission reductions are more beneficial to the climate than technologically maximum aerosol emission reductions.
- Completely new factors influencing the feasibility and efficiency of stratospheric and marine brightening methods were discovered. Harnessing either commercial shipping or airline traffic for climate engineering purposes could be a possible but not a very effective measure.
- Geoengineering, if applied, would not exist in a legal vacuum as international law does not currently provide comprehensive regulation of geoengineering, leaving many governance and regulatory gaps. At the same time, developing a new international legal instrument for geoengineering is not feasible for a number of political and other reasons. Therefore, the research proposes that the most appropriate way forward would be to continue with the current approach where geoengineering is addressed in several multilateral treaties in parallel while enhancing inter-regime cooperation and interaction.
- There are very different ways to interpret what geoengineering is about both in media and among researchers. Tensions arise between those who see it as an option to reduce climate change impacts possibly at a relatively low cost; those who consider it as something that should be explored as a “last resort” if acute measures are needed to reduce serious impacts of climate change; and those who reject it completely on ethical grounds. These tensions preclude a consensus on geoengineering for a foreseeable future both among researchers and among the public.
- In considering governance for climate engineering, it is necessary to take into account that a pure technical risk assessment cannot address all key concerns that have been expressed by different actors. Thus, it is necessary to consider how else to deal with, for example, ethical concerns in developing governance mechanisms.
- The analysis of policy documents from different countries revealed that the policy discussion on geoengineering is still at an early stage. The general attitude towards geoengineering is more positive in the US and the UK than, for example, in Germany and in those international organisations that have dealt with it so far. This suggests that any efforts to develop international rules for dealing will face important challenges, and should also recognise the different tensions and the aspects they include.



## FICCA consortium projects 2011–2014 (cont.)

**DECADE: Decadal climate prediction in adaptation to climate change.** *Heikki Järvinen, Finnish Meteorological Institute; Matti Liski, Aalto University; and Eero Nikinmaa, University of Helsinki*

The project aims to optimise adaptation decisions in the energy sector. The hypothesis is that next-generation decadal climate prediction facilities will outperform the current state-of-the-art climate simulations and generate a predictable climate change signal that allows inference of cost-effective adaptation pathways.

Main outcome of the project: Decadal climate prediction of the ocean-atmosphere-land system using Earth observations in model initialisation has become a mainstream activity in climate prediction centres. For the Nordic region, the predictable signal is weak and related to the multi-annual-to-multi-decadal variations of deep oceans. This signal is a factor affecting forest growth in the Nordic region. There is a model- and observation-based indication that forest growth is more affected by short-term weather-type variability and extremes, especially droughts, than the relatively weak decadal-scale climate variations in the mean conditions. Further research on extremes in the future climate and their interaction with biosphere should be welcome to better understand the potential for bioenergy production in the Nordic region.

Specifically, the DECADE project has enabled building a comprehensive modelling chain from instantaneous photosynthetic production to slow ecosystem responses due to large-scale climate forcing, as well applications to climate-economy modelling relevant to carbon price determination, and novel statistical methods, especially so-called random projections, to diagnose massive volumes of climate simulation and prediction data.

**ECONADA: Economically optimal adaptation of forest management in changing climate.** *Raisa Mäkipää, Finnish Forest Research Institute Metla; and Olli Tahvonen, University of Helsinki*

The overall objective of the project was to develop stand management schemes that are economically optimal under current and changed climate as a basis for future adaptation and mitigation strategies for the Finnish forest sector.

The results show that the optimal adaptation for Scots pine differs from that of Norway spruce in terms of optimal initial stand density, forest thinning and rotation periods.



## FICCA consortium projects 2011–2014 (cont.)

Additionally, the results show that earlier economic results that neglect forest thinning or that include thinning but neglect economically optimal adaptation cannot be taken as reliable. During the course of the project, it also turned out that uneven-aged management has interesting potential in adaptation to climate change. We have developed uneven-aged models for Norway spruce, Scots pine and birch separately and for mixed-species forests including all these tree species simultaneously. The results are completely new for Nordic countries and had direct impact on the Finnish forest legislation amendments in 2014.

Our economy-wide analysis shows that the cost of carbon sequestration into forests is lower than reported in earlier studies and cheaper than in competing methods (in the energy sector) to decrease net carbon emissions in Finland. The results show how the economic profitability of bioenergy production depends on bioenergy and carbon permit prices. In addition, they show that forest biomass is not a carbon-neutral energy source, since the use of forest residues for energy production leads to a net increase in carbon emissions.

Predicted climate change may cause major changes in forest growth, carbon sequestration and in economically optimal thinning, rotation periods and profitability of forestry. The highest average carbon stock in standing biomass was observed in mixed stands with three species and in spruce-dominated coniferous stands. Climate change increased stand productivity, and the increase in coniferous stands was more remarkable than in birch-dominated stands. However, experimental studies indicated that birch has high potential for enhanced growth in a changed climate, since both warmer spring and elevated carbon dioxide concentration advanced bud burst and net carbon assimilation.

Another experimental study showed that there is a clear difference in the variation of the photosynthetic activity of spruce and pine, the latter being more conservative during winter months in downgrading its photosynthetic activity. This means that in a changing climate, spruce shows a higher potential for increased photosynthesis in spring months but also a greater risk of frost damage as well as potentially increased respiratory losses during warm spells in winter.

We conclude that carbon sequestration in forests is a cost-efficient option (compared to emission reduction in other sectors) for the mitigation of climate change. Our results underline that the economic profitability of bioenergy production depends on bioenergy and carbon permit prices, whereas the ecological sustainability of bioenergy harvesting depends on the timing and intensity of biomass removals. Predicted climate change will cause major changes in forest growth, the carbon sequestration potential of soil and vegetation as well as in economically optimal thinning, rotation periods and profitability of forestry.

## FICCA consortium projects 2011–2014 (cont.)

**LAICA: Local adaptation and innovation-in-practice in energy efficiency and carbon neutrality.** *Raimo Lovio, Aalto University; Sampsa Hyysalo, Aalto University; Mikko Jalas, Aalto University; and Ari Nissinen, Finnish Environment Institute SYKE*

The project examines the innovative potential that users display in fostering low-carbon solutions in detached houses, the actions of mainstream users as well as the real-life impediments to innovation. The research also quantifies the broader impacts of user innovations.

The LAICA project has focused on citizens as active participants in climate policy implementation. In particular, we have analysed how owners and users of detached houses adopt and adapt technologies to local conditions and diffuse them to other users. First, the project found more than 200 innovations by Finnish consumers in heat pumps, pellet burning systems, solar collectors and solar photovoltaic systems in citizen-run discussion forums. In addition to supporting user-made technical innovations, the forums facilitate the adoption of renewable heating solutions, assisting in what we came to conceptualise as domestication pathways of new technologies. Second, the project investigated sources of and stimuli for low-carbon innovations in everyday life, including diverse constraints such as crises and weather events. The findings of the project indicate that the practices of heating are highly resilient: abrupt crises spur behavioural responses, but appear not to engender innovations. Ownership changes provide a more feasible window of opportunity for the adoption of energy efficiency and renewable energy solutions. Third, the project developed methods to assess the reductions in greenhouse gas emissions due to user innovations and innovative practices. The results show that wide application of the measures is feasible and, if realised, can contribute to significant reductions in carbon dioxide emissions via peak load management, for instance. Fourth, the experiments in the active dissemination of innovative user practices and the building of trust around new energy solutions proved highly successful and have been replicated in several instances.

Preliminary results also indicate significant learning effects related to these interventions. As a synthesis of the findings, the project continues to work on the alignment of climate policy with local and everyday citizen action. Based on the findings, citizens have multiple ways of becoming active participants in climate policy. A synthesis paper is underway and a policy brief with practical implications of the research findings will be published at [www.laica.fi](http://www.laica.fi).

## FICCA consortium projects 2011–2014 (cont.)

**MARISPLAN: Marine spatial planning in a changing climate.** *Markku Viitasalo, Finnish Environment Institute SYKE; Jari Haapala, Finnish Meteorological Institute; Mikael Hildén, Finnish Environment Institute SYKE; Heikki Lehtonen, MTT Agrifood Research Finland; Lauri Urho, Finnish Game and Fisheries Research Institute; and Bertel Vehviläinen, Finnish Environment Institute SYKE*

With the aid of hydrodynamic, ecological, watershed and economic models, the project investigates how climate change will influence the ecosystem of the Baltic Sea and its uses. It assesses how society can adapt its policies for and uses of the marine ecosystem in a changing climate and create GIS-based tools for marine spatial planning.

A “climate-wise” maritime spatial planning process takes into account the possible spatial changes that climate change can cause. We have tested a pressure index method to study the cumulative impacts of human activities and climate change on a coastal ecosystem. Our watershed modelling results also show that climate change influences the amounts of nutrients flowing to the sea and that agricultural adaptation in the different watersheds affects these nutrient flows. This needs to be taken into account when tailoring cost-efficient eutrophication mitigation methods. Furthermore, oceanographic and species modelling shows that climate change will induce changes in the geographical distribution of key species. This needs to be taken into account when making decisions on spatial uses and conservation of sea areas.

**RECAST: Reviewing climate change simulations for enhanced adaptation in sectors and technical infrastructure.** *Adriaan Perrels, Finnish Meteorological Institute; Lasse Makkonen, VTT Technical Research Centre of Finland; and Jouni Räisänen, University of Helsinki*

The project aims at an integrated assessment of the uncertainty of future climate and expected larger variability of many parameters in weather conditions and their economic implications for the building stock and weather-sensitive infrastructure, such as for energy. The project is cross-cutting in its involved disciplines and expected application areas.

A new approach was developed and demonstrated (Makkonen team, VTT) to estimate and validate extrapolations of observed extreme weather events and related consequences under changing climate conditions. As a consequence, the uncertainty of extrapolations can be reduced, which in turn can help the appropriate sizing of adaptation measures.

## FICCA consortium projects 2011–2014 (cont.)

The Räisänen team at the University of Helsinki (UH) showed that its earlier developed cross-validation method for reducing biases in climate model output is generally effective. Notably bias-correction type quantile mapping methods tend to perform better than other bias-correction methods.

However, as the performance of bias-correction methods varies by region, season and distribution segment, the use of portfolios of bias-correction methods is often recommendable, notably in the case of extreme values (tails of distributions). These insights have been used in a joint research effort of the Räisänen (UH) and Perrels (FMI) teams to evaluate the changes induced by climate change in the variability of hydropower reservoir inflow patterns. Preliminary results hint at a possible reduction in the variability of inflow patterns in future climate.

Others in the Perrels (FMI) team assessed the sensitivity of urban real estate prices towards the quality of various ecosystem services, and the interaction of this sensitivity with other economic, spatial and technical features. This lays the groundwork for more elaborate inclusion of ecosystem services and risk in urban economic modelling. The insights were also used to evaluate the effects of public disclosure of flood risks by means of public – internet-accessible e sens-resolution flood maps. The publication of such maps appears to correct, or reduce, prices of flood-prone homes so as to reflect the hitherto unaccounted risk, while not affecting prices of nearby comparable homes.

**RICCS: Risk governance of carbon dioxide capture and storage.** *Janne Hukkinen, University of Helsinki; and Carl-Johan Fogelholm, Aalto University*

The aim of the project is to enhance the reliability, adaptiveness and acceptability of carbon dioxide capture and storage (CCS) technologies by engaging the general public, technology developers and policy-makers in an early-stage appraisal of risks related to the further development of CCS.

We have mapped CCS-related risks at the level of experts, decision-makers and the general public in selected European countries. We have identified the process by which the mental models among Finnish experts and decision-makers concerning CCS technologies reinforce each other, to an extent that an institutional lock-in emerges that prevents the implementation of new CCS technologies. We present legal and regulatory recommendations for breaking this institutional lock-in.

We have also identified characteristics of national cultures and patterns of public perception across European Union nations that influence the acceptability of CCS.

## FICCA consortium projects 2011–2014 (cont.)

We have developed novel methodologies for determining cognitive-institutional lock-ins in the development and implementation of contested new technologies. Furthermore, we have developed new methodologies for mapping the characteristics of the national culture and patterns of public perception that influence the acceptability of contested new technologies.

**STARSHIP: Synergy and trade-off analysis of reduction strategies for climate and health impacts from particulate matter and greenhouse gases.** *Ilkka Savolainen, VTT Technical Research Centre of Finland; Jorma Jokiniemi, University of Eastern Finland; and Kari Lehtinen, Finnish Meteorological Institute*

The aim of the project is to identify and analyse cost-effective strategies and technological possibilities to simultaneously mitigate both climate change and health effects from greenhouse gases, particulate matter and black carbon. It is considered possible to influence climate change and public health through energy system decisions.

The results from the project have been wide-ranging and highly relevant for the development of climate and air pollution policies. Compared to greenhouse gas emissions from fuel combustion, air pollutant emissions are known only with limited accuracy. To address this, the researchers at UEF have measured particulate matter emissions and collected all existing data on residential wood combustion emissions (Leskinen et al. 2014; Nuutinen et al. 2014; Lamberg et al. 2013; Kaivosoja et al. 2013). The database has also been extended for elemental carbon, PAHs, elements and ions.

A policy-relevant study from a Finnish perspective (Ekholm et al. 2014) indicated that although residential wood heating could lower greenhouse gas emissions when substituting oil heating, it would be associated with a trade-off in health impacts due to increased particulate matter emissions. Also, another study with high policy relevance (Partanen et al. 2013) analysed the climatic and health impacts of the sulphur directive for shipping. The study indicated that although there is a trade-off between the cooling and health impact of sulphur emissions, an overall better outcome for the society could also be reached with appropriate measures.

In addition, the project has addressed long-term mitigation pathways under uncertainty (Ekholm 2014), the measurement of climate impacts from short-lived forcers such as methane or air pollutants (Ekholm et al. 2013), the potential role of deliberate aerosol cooling in mitigation scenarios (Ekholm and Korhonen 2014), and the development of a general air quality modelling platform for local-scale purposes (Kauhaniemi et al. 2014). The research in the project has contributed significantly to three PhD theses (Ekholm 2013, Lamberg 2014 and Partanen 2014).

## International joint projects 2012–2014

**China and EU in the context of global climate change** **An analysis of changing economic structures and related policies (co-funded by the Academy of Finland and the Chinese Academy of Social Sciences).** *Jyrki Luukkanen, University of Turku; and Ying Chen, CASS Research Center for Sustainable Development*

The project focuses on a crucial issue in the future development of humankind: climate change and its impacts on economic structures of the world economy. The futures analyses (global trend and scenario analyses) are performed from the point of view of China and the EU.

The research confirms that the fast growth of GDP per capita remains the most important driver of increased energy consumption and greenhouse gas emissions in China. From the point of view of global climate emissions, China's role is extremely significant. While the efficiency improvements in China have been huge, they have not kept up with the growth of affluence and consumption. Economic development, the rise of the middle class, the urbanisation process and government policies are driving the country towards a more service-oriented economic structure, which will reduce energy use and emissions in China in the future.

However, even with very ambitious plans for the development of renewable energy capacity, the changing economic structure can only be expected to limit the growth of carbon dioxide emissions by less than one-third of what the growth would be with an economic structure dominated by heavy industry. The findings suggest that the planned investments in renewable energy production, while massive in scale, will not make it possible for China to curb the growth in emissions by 2030. More efficient interventions in consumption are required to meet the goals.

**Economic effects of climate change across Russian regions (co-funded by the Academy of Finland and the Russian Foundation for the Humanities).** *Riitta Kosonen, Aalto University; and Pavel Druzhinin, Karelian Research Centre*

The project has studied various aspects of potential economic effects resulting from climate change in Russia. We have used methodologies that account for mid-term adaptation and possible nonlinear temperature effects. Global climate scenarios predict increases in both temperature and precipitation for Russia and, thus, it is often suggested that as a relatively cold and arid country it will initially benefit from climate change. One general tendency suggested by our results is that limited warming (< 2C) is beneficial for Russia but further warming will not bring more benefits and could be harmful.



## International joint projects 2012–2014 (cont.)

Furthermore, the benefits are clearer in colder regions, while the benefits from warming are smaller in warmer regions and could be harmful in the warmest regions.

More specifically, firstly, we find that in a mild warming scenario Russia could save roughly 4–9 billion dollars in government expenditure in the 2000–2020s, the benefits accruing mainly from cold regions. Secondly, we find that in a no-adaptation scenario, Russia's grain crop yields will drop by 10 per cent by the 2050s due to climate change, but with adaptation there could be a yield increase of 15 per cent. However, warming beyond the mild level is less beneficial and the total effect also depends highly on the seasonal distribution of warming. Thirdly, foreign companies tend to invest in wetter regions in Russia and foreign firms benefit from warm temperature while locals do not. This suggests that coping with local climate or weather is a competitive edge for companies. Finally, Russia has currently excluded itself from global climate negotiations and is setting up its own climate policy. Based on our interviews, there is a serious disconnection between federal climate plans and local Russian officials' ability to carry out them due to budgetary limitations.

**Adaptation of the food sector and socio-economic impacts of climate change in north-east Europe (co-funded by the Academy of Finland and the Russian Foundation for the Humanities).** *Heikki Lehtonen, MTT Agrifood Research Finland; and Vladimir Surovtsev, Russian Academy of Agricultural Sciences*

The project investigates needed dairy sector adaptations to changed production conditions due to climate change and related market changes in different regions. The project also evaluates solutions to observed and expected climate- and market-related problems as well as considers opportunities for increased productivity and possible production expansion.

Surveyed international literature shows that biomass yields of grasslands would increase in moderate climate change scenarios (A1B or equivalent). In southern parts of Finland and in the Leningrad region, an increase of up to 10 per cent in grass yield is expected. In middle parts of Finland, the increase in grass yields may reach 30 per cent by 2050. The productivity of clover grasses will improve thanks to warmer spring time conditions, elevated carbon dioxide levels and a longer growing period in general. However, drought risks are increasing in southern Finland and overwintering risks are likely to increase in all regions. In the very long term, the overwintering risks may decrease. The improvement in the competitive position of the dairy sector in north-east Europe is possible but rather uncertain due to increased production risks and costs as well as uncertain demand and global prices. The results suggest that the current agricultural policy and high land prices hinder enlarging dairy farms from adopting some management options in the future climate and market conditions.



## International joint projects 2012–2014 (cont.)

For example, the potential of clover grasses is currently only partly utilised due to high land prices, use of concentrate feeds and fertilisers, and policy settings.

The project showed that the dairy sector in the Leningrad region has improved in terms milk yields and grass feed production. However, most farms do not utilise the grass yield and quality potential. This is linked to large farm sizes, land shortages and use of feed concentrates. The changes in consumer preferences and maturity of the markets, combined with an economic recession and its unfavourable income effects, have led to intensified competition on dairy product markets. The Finnish dairy industry still lacks competitiveness when compared to many of its close counterparts in the EU. The growing Russian market for dairy products, despite various risks, is important for dairy farming both in Finland and in the Leningrad region. Network analysis was successfully implemented in the ADIOSO project.

**Impacts of climate change on multiple ecosystem services: processes and adaptation options at landscape scales (co-funded by the Academy of Finland and the Chinese Academy of Sciences).** *Martin Forsius, Finnish Environment Institute SYKE; and Bojie Fu, CAS Research Center for Eco-Environmental Sciences*

The joint project of Chinese and Finnish ecosystem researchers has produced new information on two key ecosystem services: carbon sequestration and water-based services (nitrogen retention, water resources). It also evaluates the impact of both climate change and land-use change processes.

The highly integrative project consisted of field studies, statistical analyses of long-term and regional data, modelling, GIS and remote sensing, and ecosystem service accounting. The work was carried out both at highly instrumented research sites belonging to the International Long Term Ecological Research (ILTER) network in China and Finland, and at larger landscape scales, using data and modelling infrastructures of the participating national research institutes. The general achievements of the project have been as follows:

- documentation of new process understanding of the controls, interactions and trade-offs of the targeted key ecosystem services in contrasting landscapes
- development and application of advanced mathematical models and extrapolation tools for simulating impacts of land-use and climate scenarios
- assessment of consequences of different policy measures
- enhanced cooperation and integration of knowledge between ecosystem researchers in China and Finland
- training of students and opportunities for postdoctoral researchers.

## International joint projects 2012–2014 (cont.)

The developed methodologies can now be applied also in other areas. Despite the short project period, the scientific output was significant. A special issue in a recognised international journal was produced as part of the project activities, summarising some of the key results: Fu, B., Forsius, M. and Liu, J. 2013 (eds.). 'Ecosystem services: climate change and policy impacts'. *Current Opinion in Environmental Sustainability* 5/2013 (doi: <http://dx.doi.org/10.1016/j.cosust.2013.02.003>).

A second special issue (Fu, B, Forsius, M. and Lu N. (eds.): 'Ecosystem services modelling in contrasting landscapes') is currently under production and will be published in the journal *Landscape Ecology* in spring 2015. The problems studied in the project are also of high international societal relevance, for instance, for IPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services).

**Lakes in trouble: Understanding the effect of climate change on threatened ecosystem services of eutrophicated aquatic systems (co-funded by the Academy of Finland and the Chinese Academy of Sciences).** *Anne-Mari Ventelä, Pyhäjärvi Institute; Leena Nurminen, University of Helsinki; and Boqiang Qin, CAS Nanjing Institute of Geography and Limnology*

In this project we wanted to understand how eutrophicated lake ecosystems respond to climate change, how their ecosystem services will be affected and how the restoration work will be (or has already been) challenged. We had two study areas (Lake Pyhäjärvi and Lake Taihu) in Finland and China. These two lakes are geographically distinct but functionally relatively similar shallow systems. The project had a comprehensive approach including paleolimnological and long-term monitoring data analysis, field monitoring and modelling approaches.

The results indicated clearly that climate change has already changed the lake ecosystems and their ecosystem services as well as challenged the management of lakes water quality. An analysis of long-term datasets showed that the main drivers differ between China and Finland. Paleolimnological studies of subfossils and an analysis of changes in phytoplankton communities in time showed that changes in China are mostly related to land use and human impact. In Finland, changes were related more to climatic variation. In both lakes, we found that macrophytes have an important stabilising role decreasing the nutrient flow from sediments. Hydrological models were tested and further developed. Thus, more exact estimations of internal loads will be possible in the future.

It is important to notice that the climate change impact can already be seen and that intensive monitoring of these changes is essential in order to understand and model the current changes.

## International joint projects 2012–2014 (cont.)

In Finland, the environmental administration is reducing the resources of aquatic monitoring, so more scientific funding should be made available for aquatic monitoring and research related to climate change.

**Flux measurements of greenhouse gases for agricultural, lake and wetland ecosystems and process modelling of wetland methane production systems (co-funded by the Academy of Finland and the Chinese Academy of Sciences).** *Timo Vesala, University of Helsinki; and Xunhua Zheng, CAS Institute of Atmospheric Physics*

The project's objective is to improve the fundamental understanding of biosphere-atmosphere interactions based on available long-term field observations and process studies. The project uses the field data from Finnish and Chinese agriculture, lake and wetland measurement sites and international databases together with theoretical process modelling.

The project has shown that the difference in the estimated nitrous oxide fluxes based on the two measurement techniques, chambers and eddy covariance, may vary greatly with changing environmental conditions and management practices. The model developed in the project can provide methane emissions from wetlands and quantify the influence of the *Carex* (sedge) and *Sphagnum* (moss) on methane production and oxidation. The flux measurements have continued at Lake Kuivajärvi in Finland and at Lake Erhai in China. The data from the lakes is planned to be involved in the synthesis analysis and article on about 20 other lakes in the world.

The broader significance of the findings: ICOS (Integrated Carbon Observation System) is developing protocols for standardised measurements of fluxes by chamber and eddy covariance techniques. The intercomparisons done in the project bring valuable information on the performance and capabilities of the measurement techniques. The inversion method based on the tall tower concentrations provides large/regional-scale estimates on greenhouse gas sources/sinks. The method requires the initial model estimate for fluxes. The methane model developed in the project can be utilised in this context. The long-term flux records on lakes are still scarce and the project has brought two long-term lake sites for the research community. The chamber-based estimate for agricultural nitrous oxide emissions were very close to the default value recommended by the Intergovernmental Panel on Climate Change.

## Development research projects 2013–2014

(funded by Ministry of Foreign Affairs of Finland and Academy of Finland)

### **Black and brown carbon influence on climate and climate change in India – from local to regional scale.** *Antti Arola, Finnish Meteorological Institute*

The aim of the project is to better understand and quantify the effects of carbonaceous aerosols on Indian climate and climate change. These aerosols are a major driver of local and regional climate change, and they also have detrimental health effects. Aerosols form the largest uncertainty in current climate change predictions.

The main emphasis in the project has been on achieving an improved chemical speciation of the absorbing carbonaceous aerosol species (black carbon, BC, and brown carbon, BrC) in the Indo-Gangetic Plain (IGP) and Himalayan foothills based on combined use of remote sensing, aerosol-climate modelling and in-situ measurements. We have conducted several intensive in-situ measurement campaigns at two sites in India: Gual Pahari, close to New Delhi, and Mukteshwar, in the foothills of Himalaya. Although the knowledge of the radiative impact of BC has increased recently, still relatively little quantitative information is available particularly regarding the mixing state of BC-containing aerosols. Moreover, there are currently no previous publications about BC mixing state in India. Therefore, our measurements in this project, using a single-particle soot photometer, for the first time offer real measurement-based information about the BC mixing state in India. Our results show that a relatively large fraction of particles (> 30%) contain BC and that those particles are thickly coated, with clear differences between the sites and seasons.

We have also applied arguably a more sophisticated approach, if compared to any previous approach, to estimate the radiative effect of BrC aerosols in the IGP. For this purpose, we exploited the measurements from several Indian sites of the AERONET (Aerosol RObotic NETwork) programme and the extended approach of Arola et al. 2011. Moreover, we have investigated the long-term changes in the outgoing short-wave fluxes at top of the atmosphere (TOA) focusing on India and over a period of about ten years, longest available from satellite measurements.

This is also the first time that this type of analysis has been carried out. During spring and winter seasons, aerosol loading has increased over large parts of India, while it has resulted in clear changes in TOA fluxes only in the winter season. The most significant is the aerosol-related cooling effect over the Bay of Bengal.

## Development research projects 2013–2014 (cont.)

(funded by Ministry for Foreign Affairs of Finland and Academy of Finland)

### **Private agricultural and forest investments and land-use change impact on the adaptive capacity of local communities to climate change in Mozambique (PAIMO)**

*Eshetu Yirdaw, University of Helsinki; Paula Horne, Pellervo Economic Research (PTT)*

The adaptive capacity of local communities to land-use changes in Mozambique was studied by mapping private agricultural and forest investments, investigating changes in ecosystem services at investment sites, evaluating the socioeconomic impacts of private forest investments, and estimating changes in carbon stocks. The results showed that forest investments are mainly located to the northern and central parts of Mozambique, while agricultural investments are concentrated in the southern and central parts of the country.

The land-use change impacts of private forest investments in the form of forest plantations were investigated in Niassa, which is the northernmost province of the country. In general, most of the villagers considered plantations to have either positive impact or no impact on their welfare. Local communities in close proximity to forest plantations experienced decreased availability of natural resources, especially agricultural land, firewood and non-wood forest products. At the same time, local livelihoods benefited from a diversification of livelihood strategies through new employment opportunities and increased cash flows, which has a positive effect on the local communities' adaptive capacity to climate change. Local communities identified changing rain patterns, severe dry spells, strong winds and cold weather as the main climate-related hazards. The availability of firewood and water plays a key role in supporting local livelihoods; future plantations should support the sustainable supply of these pertinent assets alongside livelihood diversification. The strategic location of windbreaks, the introduction of multipurpose trees to the villages, the management of water sources, and the creation of woodlots for firewood are some of the activities that could enhance the adaptive capacity of communities with the support of forest investments. The predicted above-ground carbon stocks of forest plantations were found to be of the same order of magnitude as the carbon stocks of the natural miombo forest. An unexpected result of soil organic carbon stocks appearing independent of the land-use changes was also observed. Otherwise, the carbon stocks found in this study were mostly in line with earlier findings.

On the basis of the results, the project has formulated recommendations for private forest investments in Mozambique directed mainly at investors, but also useful for the Mozambican Government for setting investment regulations and monitoring of their implementation.

## Development research projects 2013–2014 (cont.)

(funded by Ministry for Foreign Affairs of Finland and Academy of Finland)

### **Towards responsive governance in climate change adaptation and mitigation? A comparative case study in Tanzania and Nepal.** *Irmeli Mustalahti, Celeste Richman, Maija Hyle, Bishnu Devkota University of Eastern Finland*

The Nepal and Tanzania case studies show that external actors such as national governments and donor organisations significantly influence the design of locally implemented climate adaptation and mitigation initiatives. Thus, such interventions also impact local democracy and citizenship instead of staying as economic development incentives.

The case study in Tanzania concentrated on the participatory land use planning (PLUP) process. PLUP has positively enhanced the implementation of laws, rules and guidelines emphasising people's participation, but donor funding has also compromised genuine participation despite its intention to make governance more responsive and to engage local people into village-level decision-making, which is important for the sustainability of any action for climate change adaptation and mitigation. In principle, the PLUP process is responsive, participatory and inclusive, and promotes citizenship as a social practice. In practice, this study shows that people's participation and engagement in PLUP is often minimal.

The reality at the grassroots is complex, and national policies do not reflect this complexity. In particular, the strong donor presence makes meaningful participation of citizens difficult as the incentive to participate is mainly financial and therefore tied to a specific moment and not to long-term development of the village or area.

The case study in Nepal shows that the community forest plays an important role in the potential institutionalisation of the climate change agenda, especially in the absence of a stable national government. A comparative study carried out in two community forests with and without Reducing Emissions from Deforestation and Forest Degradation (REDD+) piloted interventions reveals that these interventions have the potential to increase the participation of users in community forestry but that coordination with local government is lacking in the implementation of such measures. Top-down approaches are criticised by the users of the community forest, and alternatives are available. The community forest user committee is encouraged to act as a facilitator of local citizens' priorities, which are often based on class status. The terms of these alternatives are further analysed.



## Development research projects 2013–2014 (cont.)

(funded by Ministry for Foreign Affairs of Finland and Academy of Finland)

In both countries, local citizens' awareness and understanding of climate change adaptation and mitigation actions are very limited. This study argues that in order to influence decisions over these actions, local citizens need to clearly understand the costs, benefits and potential risks of interventions and have the opportunity to discuss these actions internally before making decisions or taking action. Local representatives and authorities need to have legitimate legislative, executive and judiciary powers in order to be able to represent their constituents' interests.

More importantly, mechanisms to include public domain and vulnerable groups are needed to ensure that the design of land use planning or benefit distribution schemes does not exclude vulnerable citizens or impact them unfavourably. Such mechanisms can include:

- careful consideration of the scale and timing of activities and for payments
- use of reliable methods of monitoring carried out by disadvantaged actors
- assessment of the opportunity costs of different actions
- greater weight given to local priorities over external agendas.

**Impact of climate change on water quality: a Himalayan case study.** *Mika Sillanpää, Lappeenranta University of Technology*

The project investigates the impact of climate change on water quality of the headwaters of three major Asian rivers draining the Tibetan Plateau and the lake sediments from respective watershed areas. The objective is to contribute to defining the present chemical quality of surface freshwaters and to increasing knowledge of its environmental and human impacts.

Key findings:

1) The climate change on the Tibetan Plateau has been studied via ice cores. It was proved that an increasing temperature is a general trend over the last 500 years with a strong warming in the 20th century on the plateau and that the regional climate in the central plateau had a more warming trend in the last century than in other regions.

2) Trace elements, especially those that are significant to health (e.g. As, Hg, Cd and Pb), in precipitation and in rivers and lakes have been investigated on the Tibetan Plateau. The research showed that precipitation in the region was highly neutralised, which may be affected by atmospheric pollution transported to the Himalayas from South Asia during the monsoon season.



## Development research projects 2013–2014 (cont.)

(funded by Ministry for Foreign Affairs of Finland and Academy of Finland)

Concentrations of Hg, Cd and Pb in the high-altitude lake (with less anthropogenic activities) were significantly higher compared to the low-altitude lake (with high anthropogenic activities), indicating that atmospheric long-range transportation of pollutants in remote areas of the Himalayas might deposit at high altitudes. Water chemistry studies of rivers in the Himalayan area found that water compositions there were similar to the world average level. However, due to large numbers of As-enriched geothermal springs in the southern Tibetan Plateau, As concentrations in rivers there (Duilong Qu and Lhasa River) were higher than those in the WHO guideline for drinking water.

3) The study of ionic and isotopic characteristics of stream water emanating from one glacier of Tibetan Plateau showed that  $\text{Ca}^{2+}$ ,  $\text{HCO}_3^-$  and  $\text{SO}_4^{2-}$  are the key ions in stream water throughout the ablation season, and the water chemistry is affected by temperature significantly.

**Aquatic ecosystems in a changing climate – introducing a cost-effective tool to guide management options in poorly developed countries.** *Janne Soininen, University of Helsinki*

The project studies the interplay between the abiotic environment, catchment productivity, the aquatic food web and ecosystem services in the Yunnan region, China. It applies various study methods to introduce a simple tool to identify important water sources and to guide how to manage and conserve them via land use.

Our project showed that deterministic processes dominate the assembly of microbial communities in various freshwaters in different regions of China. This suggests that both climate and environmental quality are strong determinants of aquatic biodiversity and it further shows that preventing eutrophication results in distinct biotic communities that may be more efficient in ecosystem processes than communities in human impacted waters. We also revealed that in the Yunnan region, habitat factors such as water quality are even more important for aquatic community composition than geographical factors along elevational gradients. Therefore, retaining water quality at a good level would also be important for biotic communities and thus for ecosystem functions. We further documented that it is important to include land use variables in analyses examining the major determinants for plankton community structure.

Land use thus provides easily definable proxy for aquatic biodiversity even in remote areas that are not easily reached by humans or for which information about water chemistry is not easily available or scarce.

## Development research projects 2013–2014 (cont.)

(funded by Ministry for Foreign Affairs of Finland and Academy of Finland)

Thus, the use of land cover variables for identifying aquatic biodiversity hotspots would a suitable option for developing countries, for example.

Finally, we found out that in China, Spain and Norway species richness of diatoms and bacteria showed widely variable patterns along elevation. This would suggest that these aquatic communities are likely to respond to climatic changes relatively unpredictably. Thus, it seems that climate does not solely affect these communities but they are also regulated by the associated changes in local environment such as in water chemistry. However, if climate change results in large changes in land use, water quality may also change substantially. Overall, the project increased the mobility of researchers between Finland, China and Norway, and it is expected that our collaboration will continue to be active in forthcoming years.

### **Redefining energy and climate policies in least developed countries: analysing institutions and initiatives in the Mekong region.** *Jarmo Vehmas, University of Turku*

The project analyses the prospects and challenges in carrying out climate initiatives in the least developed countries. The research addresses these questions through a quantitative analysis of energy-economic systems and development pathways as well as through qualitative research on actors and forces shaping climate policies.

The production of governability in the context of climate change in Cambodia is strongly influenced by certain policy narratives and expert technologies. There are three key findings related to the production of climate governability:

1) Climate change policy narratives are an important product and driver of the shifting rationalities of government with respect to adaptation and mitigation. In the case of Cambodia, policy narratives of donors have dominated, but have also been co-opted by the national government. It seems that in Cambodia climate governance is not principally grounded on country-level realities but the formation of policy measures has been internationally driven and dependent on existing international incentives and structures developed to support low-carbon development.

2) Most responses to climate change are framed in technical terms drawing on expert knowledge, tools and technologies. In Cambodia, mitigation is viewed through the currency of carbon in CDM projects that downplays other ecosystems and values as well as the livelihood dimensions of intervention projects. Adaptation is viewed through lenses of impacts and vulnerability assessments with their simplified and standardised indicators of vulnerability.

## Development research projects 2013–2014 (cont.)

(funded by Ministry for Foreign Affairs of Finland and Academy of Finland)

Climate change arguments also seem to have certain justificatory power that actually is used to temper controversies around certain large-scale projects such as hydropower dams.

3) The combination of donor-driven policy narratives and expert technologies is potent: it strongly depoliticises climate change as an issue rendering it more easily governable through normal bureaucratic planning processes. In Cambodia, opportunities for meaningful public engagement in shaping national responses to climate change remain limited despite significant opportunities for complementarities with sustainable development policies and concerns with adverse impacts and trade-offs associated with large-scale projects.

### **Study on risk management of extreme weather-related disasters and climate change adaptation in Malawi and Zambia.** *Ari Venäläinen, Finnish Meteorological Institute*

The project focuses on the linkages between disaster risk management and climate change adaptation. It will improve Malawi's and Zambia's preparedness for natural disasters by evaluating and improving the current meteorological network and early-warning systems, and study, for instance, climate change adaptation in agriculture.

An essential part of disaster risk management (DRM) and climate change adaptation (CCA) is the information provided by the national meteorological service (NMS). The societal benefit of the meteorological information depends firstly on the accuracy, secondly on the timely and effective dissemination and thirdly on effective use of the information, that is, on the extent to which end-users are able to interpret and act on the basis of the information and create benefits as well as transfer them to other agents.

In Zambia and Malawi, as in most developing countries, NMSs face major challenges in delivering the required services. In line with earlier surveys, our study finds that the funding needed to upgrade the meteorological observation station networks, forecast production systems and human resource capacities to the level needed to provide accurate and timely services is estimated to be relatively small compared with the potential benefits gained by the investments.

Furthermore, the value of seasonal forecasts in Malawi and in Zambia was examined. The study included verification of the skill of seasonal forecasts and semi-structured interviews and document analysis on the use and benefits of the services. The results of the study emphasise the need to further develop the products, potentially leading to high benefits in the future.

## Development research projects 2013–2014 (cont.)

(funded by Ministry for Foreign Affairs of Finland and Academy of Finland)

The humanitarian logistics actors can contribute to the creation and maintenance of early-warning systems and offer opportunities and challenges of foresight-based logistics management supported by the early-warning systems.

At the grass-roots level, disaster risk reduction and climate change adaptation are closely connected, and a community-based early-warning system has been developed, but at a national level the production and use of the early-warning system requires substantial improvements.

The evaluation of the current situation in Zambia with regard to the integration of DRM and CCA policies emphasises the importance of good cooperation between both communities. The lack of such cooperation can lead to an inefficient use of financial, human and natural resources, unnecessary administrative burdens, and missed opportunities for shared assessments, tools and approaches.

## More information

[www.aka.fi/ficca](http://www.aka.fi/ficca)

Project Manager Tuula Aarnio (tuula.aarnio@aka.fi)

