Policy Brief No. 1 2020

BIOWATER

How green will a bioeconomy be for our Nordic water resources?

In the future, we may increasingly rely on renewable biomass resources for the provision of food, fodder, fibre and fuel. But do we know how this transition into a bioeconomy will affect Nordic water resources? Biowater is a Nordic Centre of Excellence that is looking into this question.

In a recent special issue of the journal *Ambio* 49(11), we explore how the answer may be found in plausible scenarios, long-term datasets, and modelling. We have also studied how our societies will be affected by these changes, and investigated different environmental mitigation options. A key question is how the land use will change, and how this, in combination with climate change, will affect water quantity, quality and biology, and thereby the ecosystem services provided by water resources. In this policy brief we give a short summary of the twelve papers in the special issue, for the benefit of stakeholders and policy makers. Our main messages include:

- If the bioeconomy does not develop in a sustainable way, the alterations to the rural landscape, in combination with expected climate change, will seriously affect our freshwater resources.
- Such severe impacts on aquatic ecosystems will negatively affect societies and human welfare.
- Long-term monitoring data of water quality, quantity and land use practices are crucial for discovering new trends in our Nordic water resources, as warnings of bioeconomy impacts.
- Systematic monitoring data of catchments dominated by different forestry practices are less available than data from agricultural and pristine catchments.
- Better targeting of mitigation measures (location and dimension) offers clear optimisation opportunities for improving surface water quality. Improved measures can therefore assist in reducing negative environmental side effects of a growing bioeconomy, while at the same time reducing unnecessary occupation of fertile land useful for the production of food, fodder, fibre and fuel.

BIOWATER (2017-2022) is a Nordic Centre of Excellence, funded by Nordforsk. Our main goal is to examine the impacts of a bioeconomy on land use, freshwater quality and quantity, and society.

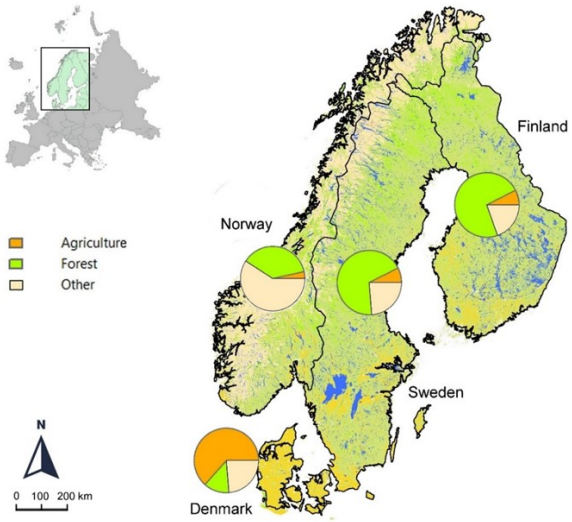
We are eight institutions in four Nordic countries (Denmark, Finland, Norway and Sweden), and with three European collaborating partners.

We cooperate closely with policy makers and stakeholder representatives to ensure calibration of our research questions with current needs.

NordForsk · NIBIO · NMBU Norwegian University of Life Sciences · NIVA Norwegian Institute for Water Research · SLU Swedish University of Agricultural Sciences · AARHUS UNIVERSITY · SYKE · Luke Natural Resources Institute Finland · University of Oulu

Will the landscape change? Scenario development in a bioeconomy

Will an increased need for biomass result in more intensive utilisation of rural areas? And if so, how will the landscape change? These are key questions if we are to understand how water resources will be affected, but we cannot yet know the answer. We have therefore proposed five likely future pathways[(1)] for the development of the Nordic bioeconomy, following the system of the shared socio-economic pathways developed by O'Neill et al. (2013). These scenarios are now being further developed through the assistance of stakeholders and managers, and are being used as inputs in catchment models, which will give feedback on how our water resources will respond. The model results will be presented at a later stage, but one paper has already used the scenarios in research on ecosystem services ([(7)] see below).



Land use differs in the Nordic countries, but how will it change over time, with a bioeconomy?

Different bioeconomy scenarios lead to very different societal benefits

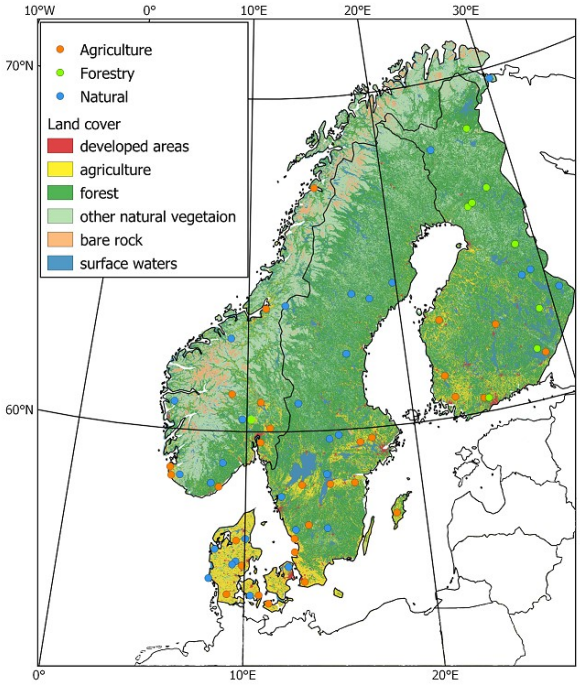
Nature with its ecosystems provide us with a number of services, such as clean water for drinking, swimming and boating. When waters are affected by eutrophication as in this example, the services are also affected.

In BIOWATER, the term "Ecosystem services" is used as a framework to quantify the many different ways society can benefit from the environment. We compared the effects of the different scenarios on ecosystem services delivery, using data from Nordic catchments.[(7)]

We found that a sustainable introduction of a bioeconomy could well lead to an increase in the diversity of the services delivered by ecosystems, and this could also increase the total monetary value of these services. If, on the other hand, the future focus would be on biomass outtake alone, the diversity of the services that the ecosystems provide us would likely not increase. Overall, this would greatly depend on the prevailing land use in a catchment.

Learning from the past: What can long-term data-series tell us?

Long-term data series are a treasure for scientists and managers alike, as they can help us to understand future consequences for the environment of policy decisions. Nordic countries have un-broken series of water quantity and quality in small catchments where land use and land management are also recorded, both for agricultural and near-pristine forested catchments. However, systematic monitoring of catchments dominated by different forestry practices are less accessible.[(2)] Impacts on water quality from intensified forestry seem to be limited when studying shorter-term data, but we have few data to help us understand long-term effects.[(3)]



Overview of the catchments studied in BIOWATER.

In agricultural catchments there are indications that the growing season is increasing in Nordic countries, but we do not yet fully understand how this will affect nutrient losses to waters. Preliminary results indicate that a longer growing season may give reductions in river nitrogen concentrations in catchments with cereal fields, but not in grassland catchments.[4] The processes are complex since long-term data are also affected by reductions of atmospheric nitrogen deposition, and more studies are needed to understand how combined changes in land use and climate will affect the nutrient conditions in our catchments.[5]

In this regard, it is also of importance to compare expected future changes with a relatively 'fixed' benchmark, or reference conditions. Reference conditions of water bodies are defined as a natural or minimal anthropogenically disturbed state. Investigations have revealed that the Nordic countries have used different methods to find these, and that reference conditions in especially lowland catchments are rather uncertain and should be revised.[6]

Mitigating the effects of a bioeconomy

Can we mitigate the impacts that the combined effects of land use and climate change assert on our water bodies? Increasingly, researchers are working towards more targeted mitigation measures, while at the same time acknowledging that measures can have multiple functions:

- Optimisation of the positioning and size of **constructed wetlands** has a great potential for reducing the land needed. Possible positive side effects could be water retention during floods and increased biodiversity.[8]

- **Set-aside land**, i.e., the conversion of arable land to forest or permanent grassland, is a radical measure that needs to be targeted. A method has been developed to optimise the spatial allocation of land, taking into consideration national goals on surface water quality, groundwater quality, nature conservation, and climate plans.[9]

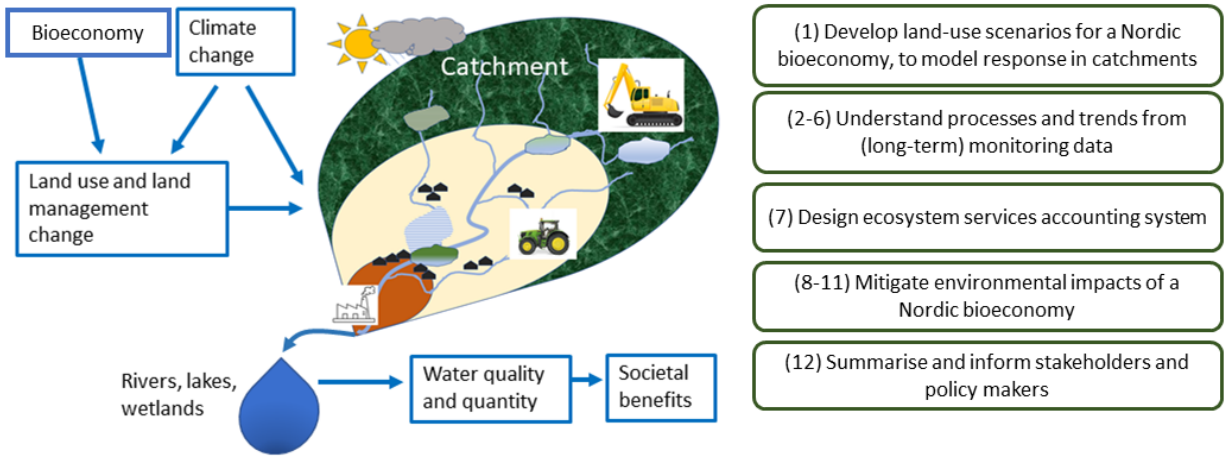
- Increased need for **drainage**, both due to climate change and a possible need for more land for biomass production, increases the need to reduce nutrient losses from drainage pipes. A review has looked into the various options and their effect, including how to avoid negative side-effects.[10]

- **Buffer zones** along streams are usually established to reduce nutrient and soil runoff from fields, but also have many other ecosystem services, including biodiversity, protection against bank erosion and recreation. All these should be considered when establishing and maintaining these zones.[11]

Buffer zones can be more targeted towards reducing pressures on water from agriculture, like this 'intelligent buffer zone' in Denmark.

A methodology to investigate environmental impacts of a bioeconomy

The combined effect of a bioeconomy and climate change is expected to affect land use and land management, and thereby also water quantity and quality. BIOWATER has developed a methodology to assess these impacts on freshwaters.[(12)] A simplified presentation of the methods is given in the figure below, where some of the steps are shown to the right in the figure. The numbers refer to the papers of the special issue, listed below.



The figure illustrates some of the steps in a methodology to better understand how a bioeconomy may affect our water resources, and thereby society. Paper 12 goes more into detail on this. The numbers in the boxes to the right refer to the main topics of the papers listed below.

Environmental effects of a green bioeconomy; AMBIO 49(11) 2020

(1) Rakovic, J. et al. Nordic Bioeconomy Pathways: storylines for assessment of water resource and ecosystem service impacts of alternative agricultural and forestry systems.

(2) Marttila, H., et al. Potential impacts of a future Nordic bioeconomy on surface water quality.

(3) Sundnes, F., et al. Climate mitigation and intensified forest management in Norway: to what extent are surface waters safeguarded?

(4) Wenng, H., et al. Climate effects on land management and stream nitrogen concentrations in small agricultural catchments in Norway.

(5) Kaste, Ø., et al. Streamwater responses to reduced nitrogen deposition at four small upland catchments in Norway.

(6) Skarbøvik, E., et al. Comparing nutrient reference concentrations in Nordic countries with focus on lowland rivers.

(7) Vermaat J.E., et al. Applying ecosystem services as a framework to analyse possible effects of a green bio-economy shift in Nordic catchments.

(8) Djodjic, F., et al. Optimizing placement of constructed wetlands at landscape scale in order to reduce phosphorus losses.

(9) Hashemi, F. and B. Kronvang. Multi-functional benefits from targeted set-aside in a Danish catchment.

(10) Carstensen, M.V., et al. Efficiency of mitigation measures targeting nutrient losses from agricultural drainage systems: A review.

(11) Blankenberg, A.-G.B. and E. Skarbøvik. Phosphorus retention, erosion protection and farmers' perceptions of riparian buffer zones with grass and natural vegetation: Case studies from South-Eastern Norway.

(12) Skarbøvik, E., et al. Catchment effects of a future Nordic bioeconomy: From land use to water resources.

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See also the main BIOWATER contact points.

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