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Green Knowledge

37 Examples from NIBIO's Activities in 2019

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Editor: Camilla Baumann
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Written Contributions: Anette Tjomsland, Erling Fløistad, Hege Ulfeng,
John Olav Oldertrøen, John Schärer, Kathrine Torday Gulden,
Kjersti Kildahl, Liv Jorunn Hind, Lars Sandved Dalen, Morten Günther,
Ragnar Våga Pedersen and Siri Elise Dybdal

Photo Editor: Erling Fløistad
Lead Editor: Ragnar Våga Pedersen
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Foreword

The United Nation's 17 Sustainable Development Goals (SDGs) form an important framework for social development nationally and globally. However, it can sometimes feel as if the concept of 'sustainability' is simply being bandied about with no thought for what it actually involves. To NIBIO, the concept means a lot, and we are committed to making it tangible by using the knowledge we develop and manage, both in Norway and through our activities abroad. Our diverse and specialized activities have made it possible for NIBIO to meet many of the 17 SDGs.

The wide range and huge diversity of our specialist expertise, projects, types of assignments, relationships, people, presence and geography make NIBIO unique. Our focus is on ensuring that our knowledge will be of benefit and can be used to meet the needs of public administration and industry. In an institute with over 1,000 ongoing specialist projects, it is impossible to present a comprehensive and complete picture. Yet we can convey representative aspects. This is the purpose of this edition of Green Knowledge. It provides a selection of 37 individual issues, which represent a cross section of the varied activities at our institute. We hope that it sparks your interest and spurs you to find out more about NIBIO and our specialized activities.

Enjoy!

Nils Vagstad,
Director General

This is NIBIO

Division of Food Production and Society

This division is a leader in core research areas, such as agronomy, plant production, cultural landscapes, agricultural technology and social research. Its researchers contribute to innovation and value creation throughout the agriculture and food production value chain, producing applied knowledge for public governance, businesses and the general public.

Division of Forestry and Forest Resources

This division is Norway's largest supplier of research-based knowledge in forestry and forest resources. It includes sustainable use of resources, optimum forest production, forest inventory, efficient value chains, innovative use of timber products, climate impact of forest and other land use, and the development of rural industries.

Division of Biotechnology and Plant Health

This division manages Norway's most comprehensive knowledge based on plant health and plant protection. It carries out research on diagnostics, biology, and mapping, as well as on combating organisms that lead to plant disease, pests, and weeds. Other key focus areas include biotechnology, algae, pesticides, and organic chemistry.

Division of Environment and Natural Resources

An innovative R&D institute focusing on soil, water, bioresources, and environmental technology. Climate and environmental measures are core elements of the division's work, alongside its efforts to develop sustainable and holistic solutions and services. This division is also involved in numerous international projects.

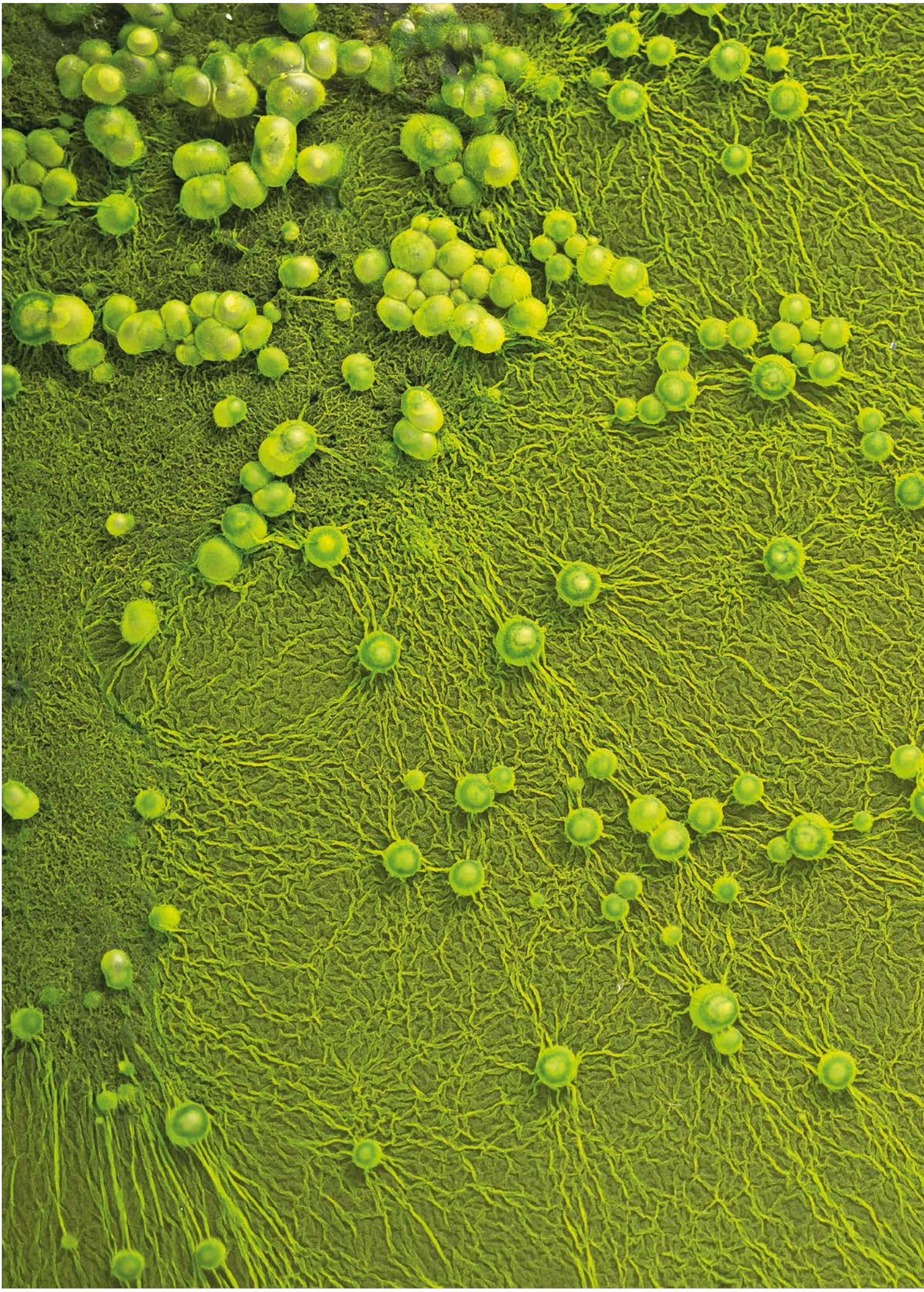
Division of Survey and Statistics

The core competence of this division lies within economic statistics and analysis, resource mapping, and geomatics. The division is responsible for capturing, managing, comprehensively analyzing and presenting data. It includes the Norwegian Genetic Resource Centre and the Budget Committee for Agriculture. Its target audiences are public authorities, industry, and political leaders.

Key Figures:

Number of employees: approx. 700. (689 as of July 1, 2019)
Estimated turnover for 2019 is 750 million.
Number of international projects: approx. 80, of which approx. half are EU or EEA
Present in all regions of Norway

Content



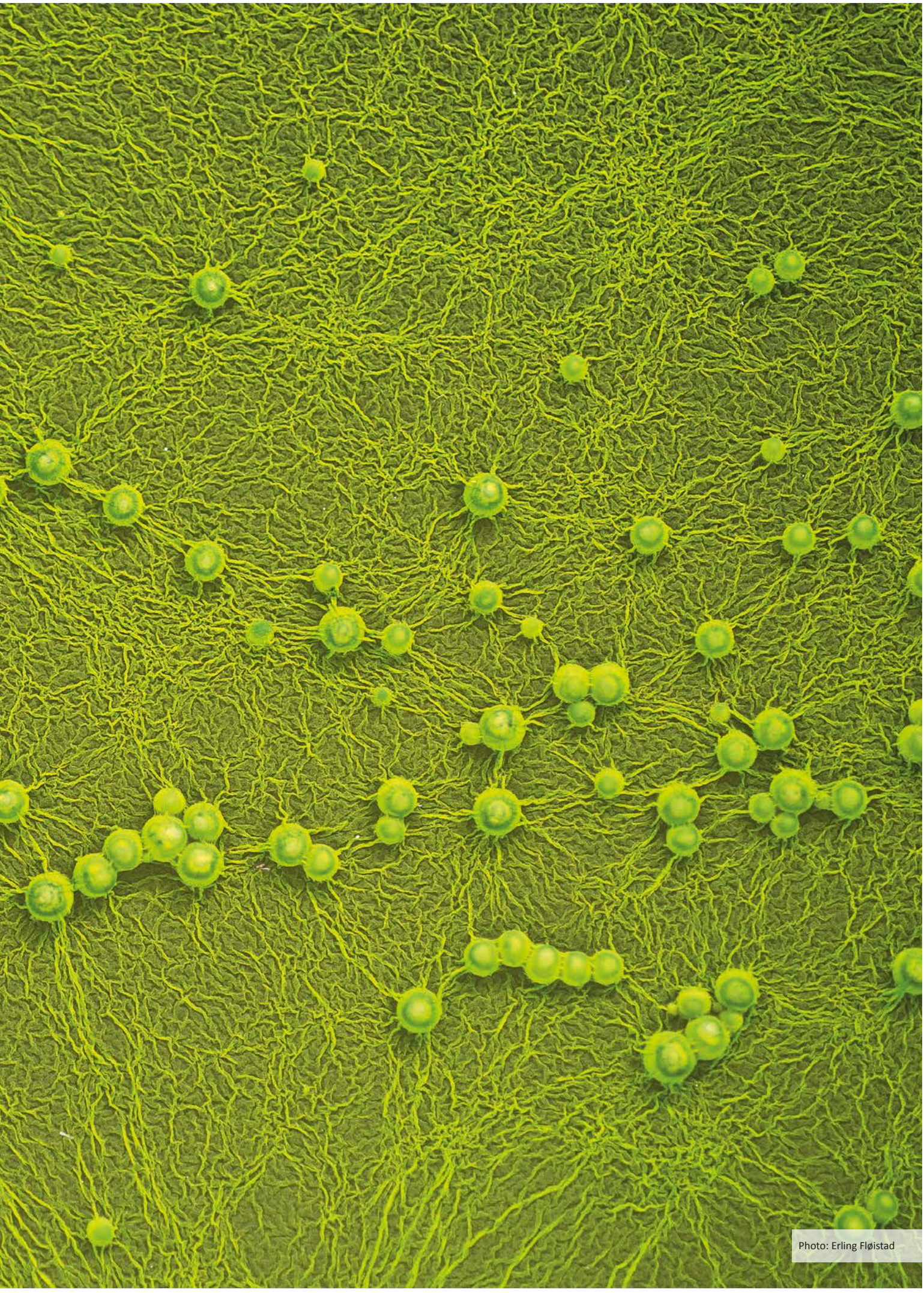


Photo: Erling Fløistad

Data from "Kilden", NIBIO's map service. Montage Photograph: Erling Fløistad

Climate change and land use

In its Special Report on Climate Change and Land, the United Nation's Intergovernmental Panel on Climate Change (IPCC) addresses the connections between land use, food security and climate. NIBIO's research and resource mapping contributes toward Norwegian solutions to the challenges described in the report.

The IPCC report shows the importance of land use in terms of the emission and capture of greenhouse gases; carbon stocks and climate measures in natural and managed ecosystems; ecosystem services; food security; desertification and land degradation; and the effect on natural environments.

Land use and climate change are discussed in a global perspective. The report does not provide specific answers to how individual countries' climate, land use and agriculture policies should be developed. When global reports are taken further in Norwegian politics, they must be interpreted based on our location-specific criteria.

The IPCC highlights the significance of knowledge for better land management. Knowledge of land is one of NIBIO's core activities. For more than a century, the institute has been developing methods and continuously improving its knowledge base on forest resources, land use and land-use change.

The IPCC demonstrates the significance of the "global food system," in which the climate, land degradation, biodiversity and food security must be balanced. The solutions in each country must be based on in-depth knowledge of the particular conditions and advantages of local food systems.

NIBIO is present in in all Norwegian regions and has in-depth knowledge of soil, forests, plants and ecosystems. This knowledge is fundamental to understanding and developing Norwegian land use. Our research looks for answers to how forestry and food production can be developed based on Norwegian location-specific criteria while helping to solve global challenges.

To balance the various considerations, land productivity must be increased, land-use changes curbed, cultivation methods improved, and soil and carbon stocks protected. These challenges are just as relevant in Norway as in the rest of the world and are at the heart of NIBIO's scientific activities.

Contact: Special Adviser Arne Bardalen. Email: arne.bardalen@nibio.no, mobile: +47 480 67 328.
Research staff

Photo: Karl Thunes

VIPS to be adopted in developing countries

India and several African countries would like to start using NIBIO's VIPS system, which alerts farmers of agricultural pest risks.

VIPS (Agricultural Pest and Disease Decision Support Service) is an Open Source, online forecast and information service for decision support in integrated management of pests, diseases and weeds. It provides easy access to all the information that advisers and producers need to assess whether plant protection measures are necessary. The VIPS platform is listed as a nominee in UNs list of digital public goods.

NIBIO researchers are now implementing VIPS as an alert service adapted to local conditions in several developing countries. The purpose is to limit the extent of damage and use of pesticides.

The projects are in the start-up phase in India (Resilience), Mali, Niger and Malawi, in collaboration with organizations that include the UN's Food and Agriculture Organization (FAO) and the International Institute of Tropical Agriculture (IITA).

To implement VIPS in other countries, the researchers need ecological and phenological models adapted to local crop species and pests, and weather data, preferably through collaboration with national meteorological services. Data from yr.no can also be used in countries in Africa and Asia.

"NIBIO will obtain existing models of plants and pests and develop new ones, if necessary, entering them into VIPS. We work closely with biologists and software developers in these countries, enabling us to refine the tools that are already available locally," explains Berit Nordskog, researcher at NIBIO.

The fall armyworm is one of the pests threatening food security in Africa and India. VIPS will be a tool in the battle against this pest.

Karl Thunes, researcher at NIBIO, emphasizes that the sustainability element is important:

"In the projects in which we are involved, the authorities are aware and supportive in various ways. We focus on enhancing local skills and passing on the technology and opportunities that enable the countries we work in to operate the tools themselves."

Goal: Adopt NIBIO's VIPS innovation (Agricultural Pest and Disease Decision Service) to alert producers of agricultural pests in Africa, India and China.

Collaboration: The UN's Food and Agriculture Organization (FAO) and International Institute of Tropical Agriculture (IITA).

Funding: NORAD and the Norwegian Ministry of Foreign Affairs (UD)

Contact: Research Scientist Karl Thunes. Email: karl.thunes@nibio.no, mobile: +47 456 00 856.
Division of Biotechnology and Plant Health

Photo: Unni Abrahamsen

Can we produce more plant protein for food?

Norway is a grassland with huge wilderness resources, but we also have significant land areas on which we can produce grains and vegetables. Is it possible to increase the production of plant protein nationally, or do we have to rely on imports?

"Norwegian agriculture should aim to displace some of the current imports of plant products for food, either in the form of raw materials or finished products. Demand for plant products is increasing, and it would be a shame if Norwegian agriculture misses out on this value creation," argues researcher Unni Abrahamsen.

We also import large volumes of plant protein for feed concentrate. There is a strong desire to reduce these volumes. Pork producers and organic milk producers have signaled that they would like to see a target of 100 percent Norwegian feed. However, with current requirements for feed concentrate volumes and protein content, we cannot achieve this, even if we could fully harvest our potential.

"Some imports will continue in the future," says Abrahamsen. For example, soy and chickpeas will continue to be important. However, we should be able to produce greater quantities of grain legumes ourselves, such as peas and faba beans.

Cultivating more oilseed crops and grain legumes would also be positive in terms of cereal production. Better crop rotation results in higher yields and protein content in cereals, as well as generally better grain quality. Disease severity is also reduced.

By using a range of processing techniques, the use of the cereals can be expanded and used for products other than bread. A combination of oats and grain legumes can also create products with a good protein composition in meat-replacement products.

"We should be producing as much plant protein as possible, both for feed concentrate and food. Wheat suited to bread baking is currently an important part of our production. In the same way, plant protein for food could become an important element of production in the next few years," Abrahamsen concludes.

Goal: Develop a knowledge platform to optimize the production and utilization of protein-rich Norwegian crops.
Collaboration: Norwegian University of Life Sciences (NMBU), Nofima
Funding: The Research Council of Norway, BIONÆR program

Contact: Head of Department/Research Scientist Wendy Waalen. Email: wendy.waalen@nibio.no, mobile: +47 412 62 361.
Division of Food Production and Society

Photo: Lars Dalen

More accurate climate policy

NIBIO is part of a massive project that could result in more accurate climate policy

PLATON is the name of the biggest social science climate research project in Norwegian history. Working alongside CICERO, Statistics Norway, the Institute of Transport Economics, Fridtjof Nansen Institute, Frisch Centre and NIBIO, PLATON collects knowledge to ensure that Norwegian climate policy is more effective and easier to implement, thereby helping Norway achieve its climate targets for 2030 and 2050.

In 2019, the PLATON consortium was awarded NOK 48.5 million from the Research Council of Norway and, in additional to contribution of time and money by the participants own, the total budget amounts to NOK 72.5 million.

The purpose of the PLATON project is to gain knowledge on how Norway can achieve its greenhouse gas emission targets and comply with the regulations in the Climate Change Act. Questions to answer include what instruments are the most effective when it comes to reducing greenhouse gas emissions while increasing uptake – both individually and together.

"Interdisciplinary cooperation is essential if we are to achieve the climate targets," says NIBIO researcher Klaus Mittenzwei.

Mittenzwei leads the work in regard to finding climate policy instruments for the agriculture and forestry sector, in addition to land use and land use change – meaning land converted for different use, such as from forest to car park or shopping mall. He explains that there are many instruments suitable for climate work. They include economic and financial instruments, those related to acts and regulations, along with information work.

"Climate change is caused by the effects humans have on natural processes, and it goes without saying that a combined approach involving the social and natural sciences is needed to obtain a knowledge base for decision-making," Mittenzwei explains.

Goal:	A broad consortium of researchers and partners from public authorities, the business community, the environmental movement and stakeholder organizations will work together to collect and improve knowledge of climate policy and how it should be decided.
Collaboration:	CICERO, Statistics Norway, Institute of Transport Economics, Fridtjof Nansen Institute, Frisch Centre, 16 universities and research institutes, and 28 partners from the business community, public administration and civil society.
Funding:	The Research Council of Norway
Contact:	Research Scientist Klaus Mittenzwei. Email: klaus.mittenzwei@nibio.no, mobile +47 941 43 954. Division of Food Production and Society

Photo: Anette Tjomsland

Soils can store large amounts of carbon

In one of the reports that formed the basis of the agricultural policy negotiations in 2019, 10 methods to increase carbon sequestration in soil were evaluated. Cover crops is the climate measure that emerges as best overall, however biochar has the highest carbon sequestration potential.

Soil stores a lot of carbon, around 2,300 billion metric tons, in the form of more or less decomposed plant and animal residues. In 2019, the carbon emissions from fossil fuels amounted to around 4 thousandths of this, the equivalent to 9 billion metric tons.

What many people now want to know is whether it is possible to compensate for these fossil CO_2 emissions by increasing the carbon content in soil.

"Globally, soil has lost a great deal of carbon through reckless forms of agriculture. By using new and climate-friendly methods of cultivation, in the '4 per 1000' initiative, which was launched at the climate conference in Paris in 2015, we could potentially achieve a reversal. In other words, increasing the amount of carbon stored in soils of the world can largely contribute to compensate for other emissions," says Department Head Daniel Rasse at NIBIO.

To find out exactly which climate measures are most suited to Norwegian conditions, Rasse and his colleagues have authored a report describing various methods of sequestering carbon in soil. The report describes 10 methods which were evaluated for their carbon sequestration potential.

"The climate measures in the report are those most relevant in a Norwegian context. As well as providing a thorough description of the measures, we evaluated them based on a number of criteria, including effect and feasibility of implementation for farmers," says Rasse.

"In short, the use of cover crops is the measure that emerges best overall, while biochar is the climate measure with the highest carbon sequestration potential," he adds.

Goal: Investigate the opportunities and challenges involved in increased carbon sequestration in agricultural soil in Norway.
Collaboration: Norwegian University of Life Sciences (NMBU) and Inland Norway University of Applied Sciences
Funding: Board for the Agricultural Agreement Research Fund

Contact: Head of Department Daniel Rasse. Email: daniel.rasse@nibio.no, mobile: +47 922 63 608.
Division of Environment and Natural Resources

Photo: Kjersti Kildahl

Big data + new technology = new knowledge

In the future, big datasets and high-resolution satellite images will be important tools for monitoring developments in forests and agricultural land

Climate change and pressure on land will change the conditions for sustainable food production and business development. With new technologies and large data resources in agriculture, analyses can reveal changes, new contexts or the state of the growing season. Changes that could be due to the climate or other factors can be detected earlier by seeing new patterns and contexts that we could not see before. The spread of diseases can be recognized more quickly, and measures can be implemented in forests or fields.

In the Stordata project, NIBIO is enhancing its skills in handling large amounts of data to find answers to complex questions and acquire new knowledge. Ingvild Nystuen is Head of the Geomatics Department, which is responsible for the project.

“Big data is characterized by the fact that the volume, complexity and frequent updates of information generate data volumes that cannot be handled with traditional data capacity. Supercomputers are needed”, says Nystuen. Big data also requires special methods for development and management, a dedicated infrastructure.

Nystuen says that we must ask the relevant questions. Powerful computers and big data will help us find the answers. Weather data, elevation and other remotely measured data of soil and forests will be central in helping NIBIO perform its core tasks in areal mapping.

With automated image recognition of land, crops and borders and with new algorithms and machine learning, we gain new knowledge more efficiently. New working methods will provide added value.

“We do not know all the challenges that we will face, but we must be prepared to solve them. NIBIO must be ready for this,” says Nystuen. Being capable of handling large amounts of data is therefore essential in the future.

Goal: Make large amounts of data available for NIBIO’s social mission.

Contact: Head of Department Ingvild Nystuen. Email: ingvild.nystuen@nibio.no, mobile: +47 902 49 768. Division of Survey and Statistics

Photo: Dan Aamlid

Precision forestry could reduce rot damage

By the time of final harvest, every 5th spruce tree is affected by a wood decay fungus that causes root and stem rot. This results in enormous losses for the forest owner. Digital data from felling machinery, satellites, planes and drones could help forest management planning control this problem.

The fungus *Heterobasidion parviporum* that causes rot in spruce invades the tree via the root system and eventually creeps 10 to 15 meters up the trunk. Looking at it, an infected spruce tree may seem perfectly healthy and remain alive for decades. When the forest is felled, after a rotation time of 80–100 years, roughly every fifth spruce tree turns out to be rotten. Timber affected by rot is used as pulpwood or for energy production, selling for less than sawlogs. The fungus can survive in old stumps and stump root systems for up to 50 years and spread to the next spruce generation.

Currently, combined losses to Europe's forest owners amount to NOK 7.5 billion a year. In Norway, the annual value lost is over NOK 100 million. Based on the spread biology of the fungus and the predicted future climate, the damage will increase if the industry and forest owners do not invest more in preventive measures.

A collaboration involving NIBIO's forestry researchers, forest owners, the forestry industry, technology companies and NMBU aims to find solutions to spruce decay problems by using precision forestry. Precision forestry makes use of high technology sensing and analytical tools to support tailoring of forest management practices. For example, new technology makes it possible to use the felling machinery to register whether or not a tree is rotten, its spatial location, and the height of the stem rot column.

Combined with pre-felling data obtained from sensors on drones, planes and satellites, it is possible to predict the amount of rot to consider an optimal rotation time. It may be possible to say how far away from a rot-infected tree a new spruce plant should be planted to reduce the risk of rot in the next generation.

Goal: Prevent the spread of the pathogenic root and stem rot fungus using digital data from felling machinery, drones, planes and satellites to support decision making in forestry.

Collaboration: Norwegian Forest Owners Association Nordafjells Branch, AT Skog, Glommen Skog, Gundersen & Løken AS, Mjøsenskog, Norwegian University of Life Sciences (NMBU), NORSKOG, Norwegian Forest Owners' Association, Terratec, Forestry Extension Institute, Vitenskog

Funding: The Research Council of Norway

Contact: Research Professor Ari Hietala. Email: ari.hietala@nibio.no, mobile: +47 480 28 268.
Division of Biotechnology and Plant Health

Photo: Kathrine Torday Gulden

Varying effects of heatwaves

Countries of the global South may be more vulnerable to the increase in heatwaves caused by climate change.

Researchers from organizations including NIBIO and CICERO have calculated an illustrative heatwave risk index with temperature increases of 1.5°C and 2°C for two future socioeconomic scenarios. The scenarios are intended to illustrate societal vulnerability to extreme heatwaves.

Sebastian Sippel is an ecosystem researcher at NIBIO and has been studying the effects of global climate change on extreme weather events like heatwaves. He points out that even an apparently small, half degree difference between a 1.5 and 2.0 °C increase in global warming could have severe consequences in terms of the number and intensity of extreme heatwaves in the future.

“Our calculations show that the frequency of extreme heatwaves will increase in many areas of the globe with a temperature increase of 2 degrees,” Sippel explains.

“By comparison, a temperature increase of 1.5 degrees will result in markedly fewer heatwaves.”

The social consequences generated by heatwaves further amplify the differences between countries.

“It is not only the frequency, meaning how often heatwaves occur, that determine the consequences of extreme heatwaves; the population density also plays an important role in this conceptual example laid out in our paper,” Sippel points out.

In particular, it is disparities between economic development and population growth that cause extreme heatwaves to have such varying effects.

“Our findings show that even for a more moderate 1.5-degree temperature rise, heatwaves will affect a large number of people in countries with high population growth and low economic development.”

These results illustrate that the effect of extreme events differ depending on the country—regardless of which climate goal will be reached—and that the differences increase dramatically with a higher temperature increase.

Goal: Look into the social consequences of extreme heatwaves.
Collaboration: CICERO
Funding: The Research Council of Norway

Contact: Research Scientist Sebastian Sippel. Email: sebastian.sippel@nibio.no, mobile: +49 1517 432 2476.
Division of Environment and Natural Resources

Photo: Fernanda Canassa

Fungus as bodyguard in strawberry plants

Researchers have found a beneficial fungus that acts as a bodyguard in strawberry plants.

Researchers affiliated with NIBIO, Copenhagen University and the agriculture faculty at Luiz de Queiroz College of Agriculture (ESALQ-USP) in Brazil have performed a number of trials on strawberries and the use of beneficial fungi, developing innovative methods, techniques and tools for integrated plant protection (IPV) that could increase sustainable food production.

By dipping the roots of strawberry plants in a solution of selected isolates from the beneficial fungi *Metarhizium robertsii* and *Beauveria bassiana*, belonging to the order Hypocreales, they learned that the plants became more resistant to attacks by pests and possibly to diseases. The plants also grew more vigorously. The trials were performed in the laboratory, in greenhouses and in the field.

The beneficial fungi belong to an order known as Hypocreales.

"These fungi were first believed to live primarily in soil but newer research discovered that the fungi can also live endophytically, meaning that it can live in the plant without harming it. It even appears that hypocrealean fungi can act as a plant's "bodyguard," says Ingeborg Klingen, Head of Research at the Invertebrate Pests and Weeds in Forestry, Agriculture and Horticulture Department at NIBIO.

In controlled trials with beans in Denmark, it was discovered that the fungi prevent attacks by pests like spider mites and increase the growth of bean plants.

Similar results were found when the fungi were tested on strawberries in greenhouses and in the field in Brazil.

The Brazilian researchers work closely with biocontrol companies in Brazil and will be testing the beneficial fungi on a range of pests in different plant cultures.

Goal: Develop innovative methods, techniques and tools for integrated plant protection (IPV) that can increase sustainable food production.

Collaboration: Copenhagen University and the Agricultural Faculty at São Paulo University (ESALQ-USP) in Brazil as part of the SMARTCROP project.

Funding: The Research Council of Norway.

Contact: Head of Department Ingeborg Klingen. Email: ingeborg.klingen@nibio.no, mobile: +47 930 92 211. Division of Biotechnology and Plant Health

Photo: Erling Fløistad

Norway's National Forest Inventory 100 years

Norway was the first country in the world to have a national forest inventory (NFI). The Norwegian NFI, established in 1919, has provided valuable information about our forest resources for a century.

"Long-term forest research and monitoring is vital to the sustainable management of forest resources," explains forest researcher and Head of the NFI Department, Aksel Granhus.

In the early 20th century, there was widespread concern about the state of the forests. Much of Norway's forests had subjected to high-grading for centuries and it was important to implement measures to restore the forests. It was assumed that felling was not sustainable and that the Norwegian forests "... were on the brink of disaster," as Professor of Forest Management Agnar Barth warned in an article in the *Tidskrift for Skogbruk* forestry periodical in 1916. As a result, the Norwegian Parliament allocated funds for the establishment of a national forest inventory. This allowed planning to start, and the first county was surveyed in 1919.

During the 1920's, only a few years after the Norwegian NFI had been established, similar national forest inventories were set up in Finland, Sweden and the United States. Most developed countries now have similar national forest inventory schemes.

Topics other than just timber growth, such as forest health, biodiversity, deforestation and a forest's ability to capture and store carbon, have become important to the national forest inventories, including how climate change will affect our forests locally and globally. Climate change and initiatives to reduce the rate of deforestation, such as REDD+, have also helped many countries in the Third World to establish national forest inventory programs.

"The most significant technological changes have been in the interaction between measurements on the ground and remote measurements using satellites, planes and drones," Granhus concludes.

Goal: The National Forest Inventory provides an overview of forest resources in Norway.
Funding: Ministry of Agriculture and Food

Contact: Head of Department Aksel Granhus. Email: aksel.granhus@nibio.no, mobile: +47 977 14 873.
Division of Forestry and Forest Resources

Photo: Jon Schärer

Focus on agriculture with a high solar factor

Agriculture must reduce the greenhouse gas emissions associated with food and feed production. This has prompted researchers to investigate the possibility of expanding the use of solar energy in agriculture. At NIBIO Apelsvoll, Norway's first electric tractor is being tested, powered by electricity produced on a barn roof.

"Two measures can be regarded as the 'low hanging fruit' of reducing greenhouse gas emissions in agriculture," says Head of Research at NIBIO Apelsvoll, Audun Korsæth. "The aim is to reduce emissions from tractor operation and emissions generated by the inefficient use of nitrogen fertilizer."

The SolarFarm project is described as a cautious start toward changing agriculture from being dependent on fossil energy sources like diesel to being able to adopt more sustainable solutions. This involves using solar power and hydrogen as energy carriers.

The tractor is and will continue to be the farmer's most important tool.

"All the world's improvements in wheeled equipment have not prevented soil compaction from being one of the biggest crop limitation factors that we face in agriculture," says Korsæth. "While we are looking for environmentally friendly alternatives to diesel, we should also make the most of the opportunity to do something about the size and weight of machinery."

Soil compaction results in increased soil density, lower yields and a greater risk of greenhouse gas emissions. Norway's first electric tractor is at Apelsvoll; it has a three-point hitch with lifting arms and power takeoff (PTO) connection to operate the equipment to which it is connected. The project also purchased a self-propelled, electrically operated robotic tractor with a three-point hitch.

The small tractor is lightweight at 2,000 kg and 50 electric horsepower. It would hardly impress your average farmer, who probably needs four times that power for some operations. The idea is for several robots to work in parallel. Together, they could be as effective as one diesel-powered tractor, but with a significantly reduced load on the soil.

Goal: The main purpose of SolarFarm is to develop an innovative, farm-based system in which the use of technological solutions and methods make it possible to practice solar-powered precision agriculture to improve sustainability and reduce the environmental footprint of the agricultural sector.
Collaboration: Institute of Energy Technology (IFE)
Funding: The Research Council of Norway through the "Lavutslipp 2030" project

Contact: Head of Department /Head of Research Audun Korsæth. Email: audun.korsaeth@nibio.no, mobile: +47 404 82 560.
Division of Food Production and Society

Photo: Erling Fløistad

Milk farmers with microalgae in tubes

Can microalgae cultivated in glass tubes represent a financially sustainable supplement to milk production?

Rolf Olav Gjørven (27) has taken over the family farm with its 25 dairy cows at Folven in Stryn. Running the farm will require investment if it is to remain viable. How can he ensure the best possible return on a major cash injection?

The neighboring farms have worked together for generations. For some time, Gjørven's neighbor Dag Hjelle has been considering how his property could be developed to make better use of local resources.

The two neighboring farms joined forces and set up the company Folvengaard AS. The first tube-based photobioreactors have been installed at the farm. A continuous supply of light and CO_2 will allow 750 liters of microalgae culture to be cultivated in the glass tube photobioreactors.

Folvengaard AS is a partner in NIBIO's A2F research project, Algae to Future.

"In the A2F project, we will develop three value chains for the production of microalgae approved for food or feed, based on contents of starch, proteins and omega-3 fatty acids," says Project Manager Stig A. Borgvang from NIBIO.

"The social benefits are considerable. The cultivation of microalgae starts at the lowest possible level in the food chain where we can increase primary production without using any agricultural land."

Microalgae grow when they have access to CO_2, water, light and nutrients. In the next development stage at Folvengaard, heat and CO_2 will flow from Gjørven's manure cellar via a biogas plant and into the photobioreactors at Hjelle's farm. Several species of microalgae can be cultivated in the photobioreactors. Depending on the species and the growth conditions, different contents of starch, proteins and beneficial fatty acids can be produced. Folvengaard AS has not yet decided on which final microalgae-based products they will aim for.

"The microalgae can be used in animal feed or as food," says Gjørven.

Goal: Develop three value chains for the production of microalgae approved for food or feed, based on starch, proteins and omega-3 fatty acids.

Collaboration: Norwegian Research Centre AS – NORCE, University of Bergen (UiB), Norwegian University of Life Sciences (NMBU), Nofima AS, Nord University, Institute of Marine Research, Centre for Applied Research (SNF) at the Norwegian School of Economics (NHH), Volda University College, Folvengaard AS, Nøgne Ø brewery, Råde Bakeri og Konditori Nærbakst AS, Europhama AS, Vital Seafood AS, County Governor of Sogn og Fjordane, Wageningen University, University of Lisbon, Tokyo University of Marine Science and Technology, Fitoplancton Marino S.L., LGem b.v.

Funding: Research Council of Norway

Contact: Head of Department Stig A. Borgvang. Email: stig.borgvang@nibio.no, mobile: +47 458 67 258. Division of Biotechnology and Plant Health

Drone photo: Jostein Thorvaldsen/Asplan Viak.

Norway's first blue-green roof

A slice of Norwegian nature has been recreated on the roof of Vega Scene in Oslo. The aim of the blue-green roof is to contribute to stormwater management along with increased biodiversity. It will also be an important place to learn about the role green roofs can play in urban ecology.

The Oslo region has biotopes that are home to species rare to find elsewhere in the country, notably systems on shallow calcareous soil. Urbanization, vegetation encroachment and wear and tear from recreational use have fragmented and reduced the sizes of these biotopes seriously affecting the plants and animals that live there.

NIBIO researchers Trond Knapp Haraldsen and Hans Martin Hanslin have been involved in recreating elements of an open calcareous biotope with shallow soil on the roof of Vega Scene in Oslo. This green roof has a species composition and soil structure that provides information about how different species of plants function in growing media constructed on roofs. The roof is also designed to delay greater volumes of precipitation than ordinary sedum roofs.

Growing trials were performed at NIBIO Særheim to develop growing media that provide adequate nutrition and water management, while not becoming too heavy. The researchers controlled water supply to observe how episodes of drought affect the plants and how their roots develop. The growing media that performed best in the trials can now be found at Vega Scene supporting a small set of species from the target biotope.

"The knowledge we are obtaining from Vega Scene is extremely valuable in creating similar blue-green roof projects in the future. There is an increasing demand for this type of green roof. They can help to increase or improve biodiversity in cities, supplementing the important work of conserving and restoring what is left of the original natural environment in cities," Hans Martin Hanslin explains.

Goal: Select and collect plants and develop growth media for green roofs.
Collaboration: Asplan Viak, Bergknapp AS, Protan and Ljono Stauder
Funding: Urbanium AS and Bergknapp AS

Contact: Research Scientist Hans Martin Hanslin. Email: hans.martin.hanslin@nibio.no, mobile: +47 404 75 239.
Division of Environment and Natural Resources

Photo: Åge A. Nyborg

New knowledge about cultivable peatland

A map-based method is generating better knowledge about cultivable land in Norway and how much of it is mire and peatland.

In the analysis, various data sources are linked to show the resource base of current and potential agricultural land.

Based on the new data set, it is possible to show cultivated and cultivable land and selected soil properties, distributed by county, municipality or individual agricultural property.

“The composition of cultivable land is essential knowledge when discussing the climate consequences of cultivating new land. For some farmers, peatland is the only kind of land available for cultivation, while, for others, it is less important,” comments Geir Harald Strand, who has been leading the work.

“There are major differences between the various parts of the country. There can also be variations in local agriculture,” he adds.

The new map provides the public administration and landowners with a tool for assessing which new land can be used for cultivation. Information about factors such as property characteristics and nature conservation areas has been included. The project has also checked whether the land is operated as owned or rented.

Land cover statistics report Cultivable mire and peatland shows that Norway has 1.3 million hectares of cultivable land. Of this, around a third is mire or peatland, or 37 percent. Cultivated land amounts to about 0.9 million hectares.

Model with room for alternatives

Strand emphasizes that different preconditions can generate different results when the data is analyzed:

“The advantage of using a documented, national data set as a basis is that it is relatively easy to perform new calculations. The results are transparent and easy to compare. The information provides a foundation for a fact-based discussion,” adds Strand.

The data set contains 22 million polygons, an expression of how many sub-areas are processed. New technology makes it possible to obtain new knowledge by linking large volumes of data.

Goal: Develop documentation that can be used to assess what new land can be cultivated locally, regionally and nationally.

Funding: Ministry of Agriculture and Food

Contact: Head of Research Geir Harald Strand. Email: geir.harald.strand@nibio.no, mobile: +47 415 01 640. Division of Survey and Statistics

Photo: Geir Harald Strand

DNA detects sources of water contamination

Feces that end up in water sources can be a health hazard. NIBIO researchers have developed a method that reveals from the source of contamination, i.e. whether the fecal matter is human or stems from various types of animals.

One of the most common reasons we fall ill is that human or animal feces are released into the water we drink or swim in. This is known as fecal contamination.

NIBIO has developed a DNA-based method that can identify the source of contamination. The method primarily consists of three steps, the first being the detection of *E. coli* and coliform bacteria in water. Intestinal bacteria *E. coli* is a reliable indicator to signify that the water has been contaminated by feces.

In the next step, DNA tests are used to identify genetic markers specific to a particular host, making it possible to differentiate between different animal groups. In the final step, a so-called contribution profile is developed, indicating which animals the contamination in a water source derives from and to what extent they contribute respectively.

"Using this advanced method enables us to find out whether the source of contamination is human, ruminant, horse, pig or a group we describe as 'other animal species,' such as birds or other warm-blooded animals," explains NIBIO researcher Adam Paruch. He has developed the method together with colleague Lisa Paruch, a molecular biologist at NIBIO.

"Fecal contamination in water can spread microorganisms that pose a health risk. To decide what kind of measures should be taken, it is important to find out where the contamination comes from and what the dominant source is," he continues.

"By detecting and quantifying the host-specific genetic markers from humans, cows or horses, we can point out exactly where the contamination comes from and implement the remediations accordingly," Lisa Paruch adds.

Goal: Detect sources of fecal contamination in water using a DNA-based method.

Contact: Research Scientist Lisa Paruch and Research Professor Adam Paruch.
Email: lisa.paruch@nibio.no, mobile +47 920 10 567 and adam.paruch@nibio.no, mobile +47 924 58 374.
Division of Environment and Natural Resources

Photo: Erling Fløistad

Increased resistance to pesticides

Resistance and reduced sensitivity to several pesticides has been observed in strawberry, raspberry and oilseed rape in Norway.

In 2018, NIBIO surveyed and monitored pesticide resistance in Norwegian agriculture and horticulture. The results indicated that the problem of resistance is increasing.

NIBIO has monitored resistance in pollen beetles in oilseed crops since 2007. The beetles have developed resistance to insecticides in the most important cultivation areas for oilseed crops, with local differences in resistance levels.

"The situation now is that in many areas pollen beetle populations are resistant to two out of the three groups of insecticides available to control them. So far, the insecticides with reduced efficacy still have a partial effect, but if we continue using them, it is likely that the beetles' resistance will build up even more," NIBIO researcher Nina Svae Johansen explains.

Over the recent years, resistance to some of the acaricides used to control the two-spotted spider mites in strawberries and raspberries has been suspected. Preliminary studies indicate that the mites in some areas now are at a starting point for developing resistance to the two active ingredients spirodiclofen (product: Envidor) and bifenazat (product: Floramite), which are approved for use in both crops, and fenpyroximat (Danitron) which is approved for use in raspberries. None of the two-spotted spider-mite populations were resistant to abamektin (Vertimec). Development of an effective anti-resistance strategy is crucial to avoid resistance problems.

"Fungicide resistance in the pathogen causing grey mold (Botrytis) in strawberries and raspberries is a widespread problem. Many of the Botrytis isolates are resistant to several fungicides, which makes control of this disease very difficult," says Svae Johansen.

Goal: New surveys and monitoring of resistance to pesticides in Norwegian agriculture and horticulture in 2018 indicate that the problem of resistance is increasing.

Funding: Norwegian Agriculture Agency.

Contact: Research Scientist Nina Svae Johansen. Email: nina.johansen@nibio.no, mobile: +47 922 56 004.
Division of Biotechnology and Plant Health

Photo: Roger Holten

Pesticides leach from frozen soil

Pesticide leaching from soil increases significantly during freeze-thaw episodes, new research shows.

There is little knowledge about how the freezing and thawing of soil affects water transport and pesticide leaching. In some field trials in Norway and other Nordic countries, however, high concentrations of pesticides have been observed in leachate, drainage water and surface runoff from soil during freeze-thaw periods in late winter or early spring.

A three-year doctoral project at NIBIO (which formed part of the SMARTCROP project) has investigated the transport of pesticides through intact frozen soil columns in the laboratory. The results confirm that, when soil freezes, there is a considerable increase in pesticide leaching during a subsequent period of precipitation and soil thawing.

According to Roger Holten, researcher at NIBIO, intact soil columns of topsoil and subsurface soil were collected from two types of agricultural soil (silt and loam) in southeast Norway. Tracers and pesticides were applied to the surface of all the columns. Half of the columns were frozen, while the rest were kept refrigerated. The columns were then subjected to repeated irrigation, which was followed by freezing or cooling.

The results of the column tests showed that up to 5,000 times more pesticides were transported out of the frozen columns than from the unfrozen columns.

“We measured high concentrations of pesticides from frozen soil columns soon after the start of an episode of irrigation and thawing. This indicates that the preferred transport route is through open macropores, such as cracks and root channels in the soil,” explains Holten.

In the future, climate change could result in more frequent freezing and thawing during a winter, as well as longer growing seasons.

“Longer spraying seasons and more frequent treatments are probable in the future. In theory, this may result in more contamination of surface water and groundwater,” Holten says.

Goal: Investigate how freezing and thawing of soil affects water transport and pesticide leaching.
Collaboration: The doctoral thesis was part of the SMARTCROP project
Funding: The Research Council of Norway

Contact: Research Scientist Roger Holten. Email: roger.holten@nibio.no, mobile: +47 915 92 762.
Division of Biotechnology and Plant Health

Photo: Anette Tjomsland

New growing medium gives us greener fingers

Many years of research lie behind the growing medium that utilizes nutrients from garden and park compost, rock powder and poultry manure fertilizer.

NIBIO was commissioned by Nordic Garden to develop the growing medium, which has been on sale at agricultural cooperatives and independent garden centers since January 2019.

“The growing medium that we have developed can be used for growing almost all types of plants without restrictions. We want everyone to experience the pleasure of having beautiful plants,” says senior researcher Trond Knapp Haraldsen.

Before the growing medium went on sale in stores, it was tested. Various crops were cultivated in a number of test mixtures to find the optimum composition of ingredients.

The mixtures in the test were compared with plant crops cultivated in five commercial products on the market. Trials with cucumbers, tomatoes and petunias achieved better growth in what has now been named Premium Flower soil (Green Viking/Plantasjen). Carrots achieved relatively similar growth as those in the best of the mixtures on sale in garden centers.

The trials to develop the mixture started in 2018, but it takes much longer than a year to develop good growing media.

“It started in 2001 when we were performing research on recycled waste and environmentally friendly compost. We replaced some peat with compost and replaced mineral fertilizer with organic fertilizer. Since then, we have systematically researched how various types of organic material perform in soil and fertilizer mixtures,” Haraldsen says.

He explains that this is the reason they know so much about the ingredients used in the mixture.

“We know something about every single component because we have already tested them individually. We studied what happens when we put them together, and then we optimized their effect,” Haraldsen explains.

Goal: Develop a low-peat growing medium of good quality.
Funding: Nordic Garden AS

Contact: Research Professor Trond Knapp Haraldsen. Email: trond.haraldsen@nibio.no, mobile: +47 928 04 196.
Division of Environment and Natural Resources

Photo: John Schärer

Strawberry revolution in Northern Norway

Strawberry cultivation in Northern Norway no longer takes a lot of effort and gives little reward. A combination of production-ready plants and cultivation in tunnels has resulted in much higher yields, better quality and less spraying.

In 2015, farmers were allowed to buy production-ready plants from abroad. That created new opportunities in the north. Tunnels and new cultivation techniques were also adopted, creating new optimism for berry production in Northern Norway.

Marianne and Frode Vik from Vik Farm in Kvæfjord have been part of the 'strawberry revolution,' from outdoor growing to imported plants in tunnels. They use what is known as the table-top method in which plants are at table height and grown in growing medium. Fertilizing and watering are performed automatically 24 hours a day.

"The project started with 6 producers. Now there are more than 20 of us, all over Northern Norway," says Frode Vik.

Overall, production has increased from 7,000 plants in 2016 to 75,000 in 2019. That is still not enough in a region that would like to have fresh, locally produced berries.

The climate of Northern Norway is ideal for strawberry production in tunnels. The tunnels extend the growing season and ensure that the plants get the necessary warmth in spring. Ventilation regulates the temperature as they mature. And long, bright days give the berries great taste.

Also, the plants are less vulnerable to pests and diseases in the cooler climate.

However, the midnight sun also brings its challenges. The red light results in more legginess, and the flower stalks become long and snap easily. Special support strips are commonly used to prevent stalks from breaking, but wider strips are needed here than farther south.

Norway is a long country, which means that knowledge cannot be transferred directly from south to north. The light and climate conditions are vastly different. So, we need to develop our own knowledge of conditions in Northern Norway.

Goal: A project that provides expert advice to strawberry farmers from Northern Norway who want to try new production methods in greenhouses and tunnels.
Collaboration: Norwegian Agricultural Counseling (NLR)
Funding: Grofondet, BAMA Eiendom AS and NorgesGruppen ASA

Contact: Adviser Åge Jørgensen. Email: age.jorgensen@nibio.no, mobile: +47 452 29 234.
Division of Food Production and Society

Photo: Erling Fløistad

With an aim to improve the farmer's gold

Using livestock feces for fertilizer is nothing new. We are familiar with the whiff of the 'farmer's gold' every spring in the countryside. Now researchers believe that there is also enormous unused potential in fish sludge and food waste, which contain nutrients that can be harvested.

Norway imports huge quantities of nutrients through feed and food. Yet we also waste enormous volumes of nutrients that could be recycled.

The aquaculture industry produces a steadily increasing amount of fish sludge from both offshore and land-based aquaculture facilities. For land-based aquaculture, the industry has a duty to dispose of the byproducts and waste material generated by production. So, the best solution is to produce something that can benefit industries, for example plant production.

But how can plants benefit from food and fish waste? And how can livestock fertilizer be utilized better?

"We are currently studying the properties of the various components to see what we need to do to make better use of the nutrients," says project manager Arne Sæbø.

The materials will be mixed and, in some cases, also enriched with nutrients to form granulated or pelleted fertilizers with a balanced nutrient content according to plants' needs. The use of the rest products as soil amendments and as substitute of peat in growing media are also investigated.

The optimization also consists of knowledge regarding timely application. Some nutrients are highly soluble and can be absorbed by the plants immediately. Others are bound to the organic material and must be mineralized by microbes before they are available to the plants.

In other words, the challenges are multiple. After a four-year project period, the researchers will perform a broad assessment of how the organic materials can be used in a good way. Can we make use of the waste materials and generate financial and product values at the same time as we decrease the climate footprint?

Goal: MAFIGOLD – Develop solutions to recycle nutrients and reduce the geographically imbalanced distribution of nutrients through efficient and sustainable methods.

Collaboration: Felleskjøpet Rogaland Agder SA agricultural cooperative, Scanship AS, Jæren Biogass AS, HØST – verdien i avfall AS, IVAR IKS, Fister Smolt AS, Blue Planet AS, Norwegian Agricultural Counseling Rogaland and Inland Norway, AGRI-E AS, Norwegian Agrarian Association Rogaland, Skretting AS, Tine SA, Rogaland County Governor, Helmholz Zentrum München – German Research Institute and Hasselt University

Funding: Agriculture and Food Industry Research Funds

Contact: Research Station Manager Arne Sæbø. Email: arne.sabo@nibio.no, mobile: +47 404 74 349. Division of Food Production and Society

Photo: Erling Fløistad

Timber imports break Norwegian law

Norway imports significant volumes of illegal timber and wood products. This practice increases the risk of alien pests traveling in consignments spreading into Norwegian forests.

The alarming volume of illegal wood product imports was pointed out in a study as early as 2012. A report from NIBIO from 2019 shows that the situation has not changed.

The import statistics show that illegal timber and wood products are being imported into Norway from North America and Asia. Research Professor Bjørn Økland at NIBO explains that it should in fact be possible to detect and stop these illegal wood products, seeing as their identities are shown by product numbers and countries of origin during import into Norway.

However, the customs statistics in the new report indicate that this existing information is not used to stop illegal products and that there are no procedures to ensure this.

According to Økland it is also difficult to check an import using individual samples from portions of the wood products in the port alone:

"Traditionally, officials believe that samples must only be taken once the product has arrived in port, but this is a rather hopeless task when large volumes are involved," he says.

Potentially, the products could be carrying alien species of insects, fungi, nematodes or plants that could be harmful to Norwegian forests. It is extremely difficult to eradicate an alien species once it has arrived and become established in the natural environment.

The report also shows that, in some cases, Norway could be contributing to the trade in timber and wood products based on tropical tree species and felling that are otherwise illegal.

"This is something that must be studied more closely if we are to identify whether these export commodities from the countries in question constitute a breach of timber regulations or not," says the NIBIO researcher.

Goal: The import statistics show that illegal timber and wood products are being imported into Norway from North America and Asia.

Funding: Norwegian Environment Agency

Contact: Research Professor Bjørn Økland. Email: bjorn.okland@nibio.no, mobile: +47 916 28 225.
Division of Biotechnology and Plant Health

Photo: Kathrine Torday Gulden

From ashes to ashes, dust to dust

Norwegian graveyards are filling up, and many need to expand. Researchers are currently investigating the soil conditions in these new areas to ensure that the contents of the coffins will decompose naturally, something which is not the case everywhere.

Inghild Økland is a paleontologist and soil scientist. She says that the problem regarding inadequate decomposition most often occurs when the soil retains water and uses up oxygen.

"Without oxygen, there is no bacterial life in the soil to ensure the decomposition of organic material," she explains.

A grave in soil that does not facilitate decomposition, can entail that the contents potentially can remain unchanged for an extremely long time, much longer than the 20 years indicated by the preservation period.

When Økland and her colleagues go about to find out whether the soil conditions are ideal for a graveyard or not, they first excavate soil profiles in the study areas. They then describe all the layers in the soil profile and look at a number of properties associated with preservation or decomposition, seen in relation to the most likely penetration of water through the soil.

"If we find very stiff and dense clay soil with residual plant roots and other organic matter, it's a sure sign that decomposition is not taking place to any great degree, which means that the soil is unfit for a graveyard. Similarly, if the soil profile is very wet after precipitation, drainage conditions may be inferior," Økland explains.

Once the soil layers have been studied and the soil profiles analyzed, the researchers recommend measures.

"These can include everything from mixing sand into the compact soil to increase its drainage capacity, to raising the ground level, basically leaving the unsuitable soil where it is and spreading new soil over the top," says Økland.

Goal: Study whether the soil in graveyards is suitable and propose soil improvement measures.
Collaboration: Joint Parish Councils and municipalities, KA Church employers' Association and National Graveyard Adviser.

Contact: Research Scientist Inghild Økland. Email: inghild.okland@nibio.no, mobile: +47 907 23 378.
Division of Environment and Natural Resources

Photo: Kjersti Kildahl

Basis for agricultural policy negotiations

The dry summer of 2018 had enormous consequences for many farmers. However, the underlying figures for the agricultural policy negotiations show an increase in Norwegian farmers' income.

This was the introduction when in April 2019 the Budget Committee for Agriculture (BFJ) submitted the figures that mark the start of the annual agricultural policy negotiations between the state and farmers.

The analysis was conducted by NIBIO's Department of Agricultural Economics, which acts as the secretariat of the committee.

"The underlying figures both illustrate how the industry actually performed in the previous financial year, and reflect the normal situation, which is development evened out over time," says Department Head Lars Johan Rustad.

The normal situation is based on results from several years in which economic variations linked to weather or extraordinary events gradually become evened out. These normalized figures form the basis for the negotiations.

The BFJ consists of representatives from parties involved in the agricultural policy negotiations, the state and farmers, as well as neutral members from Statistics Norway and a chair, who, in 2019, came from the Ministry of Education and Research.

The three elements of the background information for the negotiations:

Aggregated agriculture account – shows the level of income, income development and overall value creation in Norwegian agriculture. Also used to compare farmers' income development with that of other social groups.

Reference farms – presents the financial results for reference farms that represent different types of operations, sizes and locations. During the negotiations, these are used to calculate the impact of the requirements and proposals in different scenarios. The figures are based on approx. 700 agricultural enterprises which take part in the operations survey for agriculture.

Results control – illustrates the development and achievement of goals in agriculture. The impact of agricultural policy is shown through selected measurement parameters and changes in them.

Goal: Submit the material that forms the basis of the agricultural policy negotiations
Funding: Ministry of Agriculture and Food

Contact: Head of Department Lars-Johan Rustad. E-post: lars-johan.rustad, mobile: +47 911 27 954.
Division of Survey and Statistics

Photo: Donald Njarui.

South-south cooperation increases food security

By using smartphones and social media, local knowledge centers provide smallholders and marginal farmers in Tanzania and Kenya with quick and timely information, hence supporting them in adapting their farming practice to a steadily changing climate.

Based on positive experiences in India, where Village Knowledge Centers ensure that essential information about weather conditions to plant diseases is communicated to farmers, the InnovAfrica research project recently set up similar centers in Kenya and Tanzania. The knowledge centers are the first of their kind on the African continent.

"By establishing connectivity with farmers using modern information technology tools and mobile phones, we ensure that timely and essential information about sustainable and climate-smart farming practices reaches the people who need it," says Research Professor, Dr. Udaya Sekhar Nagothu.

Due to the use of new technology, the knowledge centers established by the RESILIENCE project in India, connect approx. 25,000 smallholders in two states (Assam and Odisha) with relevant information and training in climate smart farming practices.

Thus, several thousand smallholders benefit from the information, which is disseminated via the digital systems.

The knowledge centers in Kenya and Tanzania were established relatively recently. Feedback from the staff, authorities and the several hundred smallholders associated with them have been positive so far.

"In the next few years, we plan to establish similar centers in other African countries," Dr. Nagothu says. He adds that more will also be established in India.
"The goal of these ICT-based centers is to revolutionize the way knowledge is exchanged between smallholders and researchers in countries particularly vulnerable to climate-related challenges. This will help to ensure that they can continue to produce food, despite climate change."

Goal: Set up knowledge centers for timely and fast information transfer to smallholders in India and several African countries.

Collaboration: IWMI, MSSRF with several in India (Resilience - www.resilienceindida.org), BecA-ILRI Hub with several in Kenya, and a number of other R&D institutions in Ethiopia, Malawi, Rwanda, Tanzania, Italy, Netherlands, Norway, South Africa, Zimbabwe and Germany (InnovAfrica).

Funding: Ministry of Foreign Affairs/Embassy of Norway in New Delhi (Resilience) and EU Horizon 2020 (InnovAfrica - innovafrica.eu)

Contact: Research Prof./Director Centre for International Development-CID Udaya Sekhar Nagothu.
Email: nagothu.udayasekhar@nibio.no, mobile: +47 990 15 621.
Division of Environment and Natural Resources

Photo: Erling Fløistad

Cooperation to conserve spruce genes

Eight conservation stands for genetic resources in Norway spruce have been established in Eastern Norway. These could be of great importance.

Climate change, disease outbreak or other unforeseen events could create a need for trees with properties that differ from those that they are currently being bred for.

“That is why we must conserve spruce trees with a range of genes we may have a use for in the future,” explains project leader Kjersti Bakkebø Fjellstad.

The eight areas are based on seed sources and a genetic variation for which data and information are available.

Up to now, conservation has been undertaken as part of the tree breeding activities, in the collections of ‘plus trees’ in the Norwegian Forest Seed Center’s clonal archives.

“The ‘plus tree’ archives are now being phased out, in accordance with new priorities. This means that we will need other practical ways of conserving the important genetic variation represented by the ‘plus trees.” Fjellstad says.

“We have interested forest owners on board who care about what they grow in their forests. They will help to ensure that there is increased quality and growth in the next generation. They are now helping to conserve variation in their existing stands.”

Long-term agreements with forest owners will ensure dynamic conservation of trees for future use. The term dynamic means that the trees will continuously be subject to potential selection through climate change, environment or pathogens.

In addition to the actual conservation agreements, it is of general importance that information about all the forest genetic material being planted in Norwegian forests is retained.

Seedlings from Norwegian nurseries are labeled with a reference number indicating the origin.

“If information like that is readily available, it makes it easy to decide which trees should be conserved, studied or used for other applications” says Fjellstad.

Goal: Conserve genetic variation for the future.
Funding: Norwegian Agriculture Agency

Contact: Senior Scientific Adviser Kjersti Bakkebø Fjellstad. Email: kjersti.bakkebo.fjellstad@nibio.no, mobile: +47 905 06 661.
Division of Survey and Statistics, Norwegian Genetic Resource Center

Photo: Erling Fløistad

Cereal cyst nematodes are a growing problem

Thorild Haga Brødholt and her husband Bjørn grow oats for seed grain production on 60 hectares in Kråkstad, in the Municipality of Ski. Analyses revealed that their fields are infested with cereal cyst nematodes.

Nematodes have damaged the roots of the oat plants within an oval-shaped area of 4–500 square meters, causing them to be stunted and less vigorous. Weeds have flourished between them.

The oat variety grown in this field was selected because it is resistant to cereal cyst nematodes.

“And it is,” says NIBIO researcher Marit Skuterud Vennatrø. “However, when there are a lot of nematodes in the soil, the variety can be damaged anyway. This soil is clearly heavily infested with these pests.”

In 2019, conditions for nematodes were ideal, with a cool and wet early summer. Several farmers in the district saw clear symptoms of nematode damage this year. More up-to-date knowledge about grain varieties and their resistance to nematodes is therefore needed.

Marte Persdatter Tangvik is working on a doctoral degree on free-living nematodes in soil. By counting and identifying the species of nematodes in soil samples and combining this with drone photos of the field, she will study the extent of damage in relation to the number of nematodes in the soil.

Farmers who see suspicious patches in their fields are encouraged to take soil samples and send them to the Plant Clinic at NIBIO for nematode analysis. NIBIO has recently developed instructions for sampling that can be downloaded from NIBIO’s website.

“There are resistant grain varieties available”, assures Marit. “It is, however, important to know which species and races of nematodes are present in the field before choosing one.”, it is, however,

If a nematode problem has become established, it is important to avoid the nematodes’ host plants. Well-planned crop rotation with non-host plants will reduce the nematode population and help the farmer control the problem.

Goal: Inform grain farmers of the problem associated with the increase in cereal cyst nematodes.

Contact: Research Scientist Marit Skuterud Vennatrø. Email: marit.vennatro@nibio.no,
mobile: +47 918 16 986.
Division of Biotechnology and Plant Health

Photo: Arne Steffenrem

Forests affect climate and vice versa

New research into how the climate affects forests and how forests affect the climate aims to give us more knowledge about the future climate and how we can best adapt to the changes expected.

Trees absorb CO_2 from the atmosphere through photosynthesis and carbon storage in their roots, trunks and branches. Coniferous boreal forests in the north form an almost continuous belt across the northern hemisphere, constituting 30 percent of the world's forests. The way we protect these enormous forest areas is tremendously important to the planet's climate system, now and in the future. But trees and forests affect the climate in many more ways than just carbon capture. In addition to CO_2, forests have a major impact on the local and regional climate.

"In fact, particularly in winter, coniferous trees like spruce and pine capture a great deal of solar radiation and generate more warming than non-forested land," explains Project Manager Stephanie Eisner.

"Forests are also more irregular, with a more uneven surface than other types of vegetation. Forests create more turbulence, which means that there is more energy and moisture exchange between the ground and atmosphere," Eisner explains.

Stephanie Eisner and her colleagues study how forest management over the last 60 years has affected these flows and exchanges of moisture and energy between the ground and atmosphere. Why 60 years, specifically? Because we have such good weather data for temperature and precipitation (including snowfall) back to the 1960s.

"For the first time, we have the opportunity to quantify the exact extent to which forest management affects the water and energy fluxes between the ground and atmosphere. And by using new satellite images, we can get a much higher resolution (1 x 1 kilometer) than we have ever had before. That is particularly important here in Norway, where the landscape and geography are so varied," concludes Eisner.

Goal: We need more knowledge to adapt to and counteract changes in the future climate.
Collaboration: Norwegian Water Resources and Energy Directorate (NVE), University of Edinburgh, Clark University in the United States and Swedish University of Agricultural Sciences (SLU).
Funding: Research Council of Norway

Contact: Research Scientist Stephanie Eisner. Email: stephanie.eisner@nibio.no, mobile: +47 904 13 678.
Division of Forestry and Forest Resources

Photo: Kathrine Torday Gulden

Cow dung, fish sludge and food waste as fuel

Biogas is produced when animal manure, food waste and fish sludge break down. The main ingredient is the much-discussed greenhouse gas, methane. By recycling this kind of biological waste in a biogas reactor, the highly flammable properties of methane can be used to replace fossil energy.

Biogas is produced from biological waste products which largely tend to go unused. Through a biogas reactor, waste from the aquaculture industry can be converted into a carbon-neutral product that can be used for electricity, heat or fuel. This is a "win-win" situation where a problem turns into a resource.

The microbial process in the biogas reactor can be compared to the rumen function of a ruminant. The microorganisms are fed with a combination of intestinal content, septic matter, animal manure and waste from the aquaculture industry. This enables the organisms to grow, break down the raw material and produce gas. The conditions in the reactor must be adjusted precisely for the natural processes to occur and the material to break down at an optimum rate.

However, producing biogas is expensive, and getting these plants to run at a profit is challenging.

Researcher Vibeke Lind and her colleagues have been working on a feasibility study for biogas plants in Helgeland. They have analyzed three different types of plants with access to a variety of local materials from the waste, agriculture and aquaculture industries.

Profitability depends on good logistics and proximity to raw materials. This makes Helgeland a particularly suitable location for biogas plants.

"Helgeland is a 'Norway in miniature,' with relatively short distances to livestock and plant production, forestry, agriculture, slaughterhouses, dairies and private and industrial food waste," says Lind.

"In the future, we hope to see buses, trains and boats powered by recovered biogas, as an alternative to oil and fossil energy."

Goal: Study the potential of biogas plants based on local resources from livestock and the blue-green sector in the Helgeland region, with a focus on regional use and the circular economy.

Collaboration: Alstahaug Municipality, Nordland Farmers' Union, LetSea AS, Biomiljø AS, SHMIL IKS, Nordland Forest Industry Forum, Østfold Research

Funding: Norwegian Agriculture Agency, Nordland County Authority, Alstahaug municipality, Nordland Farmers' Union, LetSea AS, Biomiljø AS, SHMIL IKS, Nordland Forest Industry Forum

Contact: Research Scientist Vibeke Lind. Email: vibeke.lind@nibio.no, mobile: +47 934 99 436.
Division of Food Production and Society

Photo: Erling Fløistad

Learning from decay fungi

Logs could soon be turned into pig feed, food stabilizers and much more.

"Brown rot fungi are the most common wood decaying organism in our northern, boreal forest areas. They do a priceless job of breaking down dead trees in the forest. Without them, there would be mountains of trees and twigs," explains biologist and Research Professor Gry Alfredsen.

What if we could learn from the brown rot fungi's unique ability to break down trees?

"What makes brown rot fungi unique is their ability to break down cellulose and hemicellulose efficiently," explains Alfredsen.

Cellulose and hemicellulose are fibers constructed from carbohydrates. Together with lignin, they form the wood of a tree. The depolymerization by the brown rot fungi result in short-chain sugar compounds, which are carbohydrates that, in theory, can be used in other contexts, such as animal feed, food preparation and fuel production.

The discovery of a new group of enzymes called lytic polysaccharide monooxygenases (LPMOs) is an interesting example. This group of enzymes was discovered at NMBU in 2010 and contributes to more efficient biorefinery processes, when timber is broken down and converted into new products.

Another example is wood protection. Knowledge about how the brown rot fungi breaks down timber teaches us how to best protect timber buildings and wood structures from fungi attacks, helping to extend lifespans and increase carbon storage.

Hemicellulose, one of the main components in timber like spruce, is also interesting.

The carbohydrates in hemicellulose are similar to components used in foodstuffs. Interesting work is done by Norwegian University of Life Sciences on this topic.

"It may sound strange to use trees for food, but it is actually very practical to do so. There is a lot of forest in Norway. If we are successful in extracting useful carbohydrates from these trees, the potential is enormous," Alfredsen concludes.

Goal: With a little help from researchers, logs could soon be turned into added value products
Collaboration: Norwegian University of Life Sciences (NMBU)
Funding: The Research Council of Norway

Contact: Research Professor Gry Alfredsen. Email: gry.alfredsen@nibio.no, mobile: +47 918 76 568.
Division of Forestry and Forest Resources

Photo: Yngve Rekdal

Is there enough wilderness for everyone?

Tourists, sheep, predators, cabin owners and farmers. All of them want a piece of wilderness. But the level of conflict is increasing, and grazing land tends to be the loser. This is the opinion of Researcher Bjørn Egil Flø, who is investigating why some types of partnerships succeed, while others clash.

Cabin construction, power production, commercialization of hunting and other leisure activities have increased the pressure on wilderness areas. With increasing competition for land and structural changes in agriculture, the management of grazing land has become more complicated.

Rural Sociologist Bjørn Egil Flø studies how our current use of wilderness works. The objective is to ensure that we make better use of grazing resources.

"The new users are resourceful," Flø says. "They feel strongly about what wilderness should be and how it should be used, and they have big organizations behind them. In some grazing areas, this has resulted in a level of conflict so fierce that many farmers cannot cope with the social stress involved in being part of the industry."

By studying different grazing areas with different structures and types of ownership, the aim of the researchers is to devise alternative methods of structuring, operating and managing grazing areas.

Farmers tell of a gradual weakening of cooperation, both between the various users of grazing land and between these users and other wilderness users. In some areas, this has resulted in development that has also gradually reduced the number of grazing livestock. This means that the grazing resources are not being utilized properly, hence they become overgrown with reduced grazing quality and a consequent loss of biodiversity.

"In other areas, farmers say that there is far too much grazing pressure in relation to the resource base. Small farms have grown large and consequently have herds many times larger than the average for the area.

"The aim is to identify what works well and what does not work in the various locations, and then be able to provide a list of measures, although obviously these would have to be adapted to local conditions," Flø says.

Goal: How are formal and informal institutions adapting to environmental, political and financial changes over time?

Collaboration: Norwegian University of Life Sciences (NMBU), University of Oslo et al.

Funding: The Research Council of Norway, Norwegian Mountain Board, Animalia, Norwegian Farmers' Union, Norwegian Farmers and Smallholders Union, Norwegian Association of Sheep and Goat Farmers, Norwegian Beef-Breeders Association, County Governors of Hedmark, Oppland, Trøndelag, Møre og Romsdal, Nordland and Aust og Vest Agder

Contact: Research Scientist Bjørn Egil Flø. Email: bjorn.flo@nibio.no, mobile: +47 951 15 617.
Division of Food Production and Society

Photo: Erling Fløistad

Changing potato blight gives new challenges

EU_41, a new, more aggressive genetic variant of potato blight, has now established itself in Norway. This makes it even more important to issue timely blight warnings to treat fields.

NIBIO researcher Håvard Eikemo just finished working on a European project to identify genetic variations in potato blight in Norway and four other European countries.

They have studied whether a range of potato blight variants belong to a particular genotype, how serious the symptoms can be, the potato blight's ability to break down resistance in potato varieties, and potential resistance to chemical potato blight treatments.

Up to now, it has not been possible to find evidence in Norway of the establishment of genotypes with, for example, increased aggressivity or reduced sensitivity to chemical treatment. There are several such clones in various places across the continent.

If a new type of potato blight spreads to an area, the result of this can be that a previously resistant potato variety becomes susceptible or that a pesticide can no longer be used. In the last few years, data has revealed that new genotypes are spreading in several parts of Europe. EU_41 has now reached Norway.

Testing shows that there are major differences between EU_41 and the common potato blight in Norway. Its spore production is extremely high and can attack numerous potato varieties with resistant genes against potato blight.

"Although the clone is not resistant to chemical treatment, an attack of this genotype can be more serious than we are used to," says Eikemo.

The potato coordinator of the Norwegian Agricultural Advisory Service, Borghild Glorvigen, says that it is important to have several pesticides to alternate between to prevent the development of resistance.

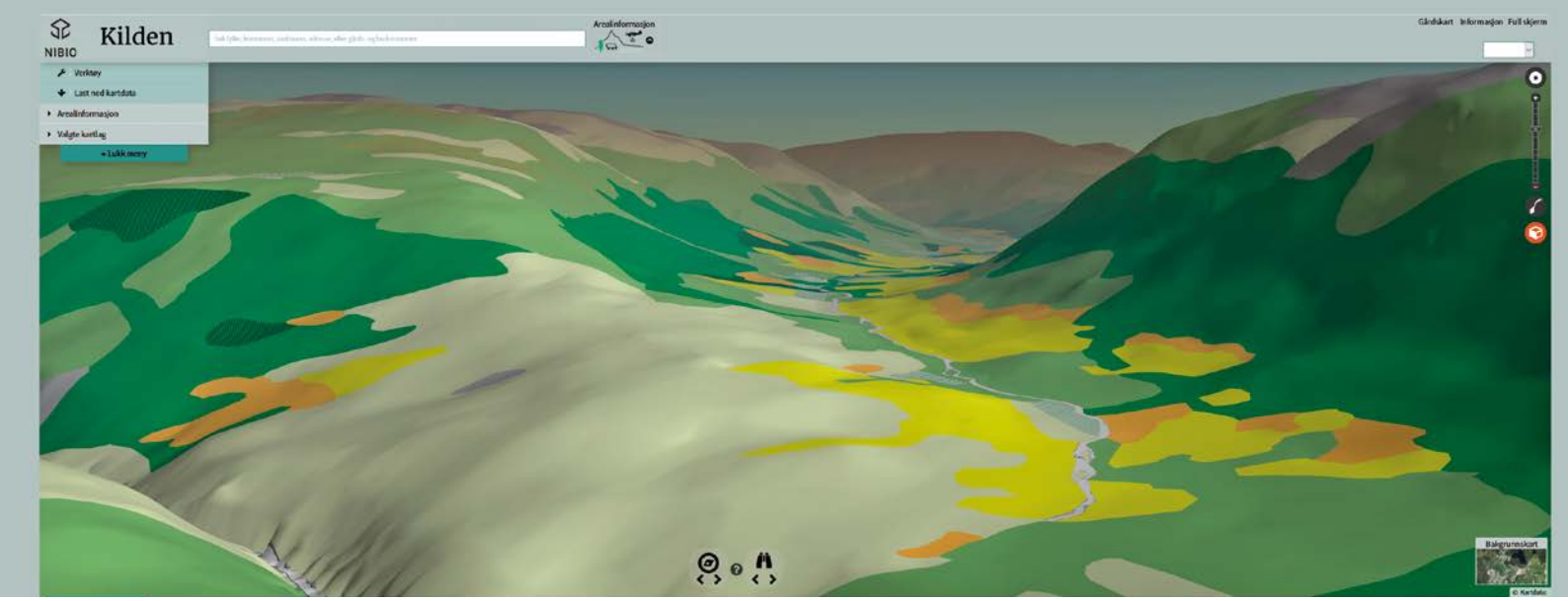
"With the ban on the pesticide Reglone from 2020, we can expect to use more measures to combat potato blight before harvesting," she says.

Goal: Provide information about a new and more aggressive potato blight that has become established in Norway.

Collaboration: Part of the EU EuroBlight project, a research collaboration between several European research institutes.

Funding: EU

Contact: Research Scientist Håvard Eikemo. Email: haavard.eikemo@nibio.no, mobile: +47 916 95 954.
Division of Biotechnology and Plant Health



Kilden maps show 3D and receive GPS data

In the latest version of Kilden, we can see map data in three dimensions, which gives us better visualization of the landscape. We can also upload GPS data and see it alongside other maps.

"One of the aims of the new development was the desire to make it easier to understand the maps. We know that around half of 'average people' find it challenging to understand maps," says Project Manager Tove Vaaje-Kolstad.

"Aerial images improve the way we convey the information, while 'tilting' the ground and showing features like valleys, hills and mountain ranges, as we do in 3-D, improves our understanding even further."

The other element of the innovation is the ability to import GPS tracking. Whether it is a farmer who needs to document newly cultivated land or a hunting society that wishes to enter the location of a hide in its area, it is now possible to transfer a GPS file into Kilden.

"The only technology needed is a smartphone," says the enthusiastic project manager.

"We noticed that the service can be used for a range of purposes. For example, updating the map for control purposes in regard to area-based subsidies can be accomplished faster if the farmer himself contributes with new data."

Make your own acreage report

In the new Kilden, it is possible for people to draw in an area on the map to obtain information about the land resources within that area: For example, to find out how much is forest or cultivated land, the quality of agricultural land, how much can be brought under cultivation and turned into fully cultivated land, or whether marshland is shallow or deep. Agricultural properties on which agricultural land may be disused is one of the menu options.

The acreage report makes it easier for regional and municipal agricultural administrations to attend to their responsibility under national guidelines governing the protection of land resources, or as the Ministry of Agriculture and Food puts it: 'land of national or significant value.' Protecting the soil and cultural landscape is part of this responsibility.

Goal: Improve the way we convey and manage information about land resources.
Funding: Ministry of Agriculture and Food

Contact: Lead Engineer Tove Vaaje-Kolstad. Email: tove.vaaje-kolstad@nibio.no, mobile: +47 930 08 377.
Division of Survey and Statistics

Photo: Tommi Nyman

Mapping the trout in the Pasvik River

As part of Norwegian-Russian collaboration in the border region, researchers are mapping the trout stocks in the Pasvik River.

The construction of hydropower plants between 1956 and 1978 along the Pasvik River, which stretches 140 kilometers north from Lake Inari to Kirkenes, turned the river into a fully regulated watercourse. Most of the waterfalls and rapids disappeared, and many of the natural trout spawning and nursing areas were destroyed. However, there is still a lot of trout in the river.

"Ever since the hydropower plants were built, the local energy company has had a duty to stock the Pasvik River with trout. They focus on ensuring that the tasks of cultivation and release are performed appropriately and sustainably in a long-term perspective," explains Head of Department Snorre Hagen at NIBIO Svanhovd. He leads the Norwegian-Russian collaboration mapping the trout stocks and wild trout populations in the Pasvik River.

The goal of the project is to find out more about the genetic diversity of the trout stocks and the effect of the current methods of cultivating and releasing the fish. Another goal is to determine how many trout populations are present in the watercourse, to what degree they have contact with each other and how they spread. The researchers will also be looking at whether the cultivation program ensures stocks that are viable in the long-term and what can be improved to strengthen the wild trout population in the river.

"We have been taking genetic samples from every single brood stock of trout used for breeding since 2015, as well as from some offspring from every combination of parents. We are therefore starting to get a fairly large genetic database of the fish used in Pasvik Kraft's aquaculture facility, which will later be released into the river," explains Hagen.

The hope is that the trout project becomes a springboard for wider studies of the ecosystems in the Pasvik Valley – both in water and on land.

Goal: Map trout stocks in the Pasvik River.
Collaboration: Pasvik Zapovednik, Pasvik Kraft AS, INEP, University of Tromsø, Norwegian University of Life Sciences (NMBU), Akvaplan-niva, Municipality of South Varanger, County Governors of Troms and Finnmark and local anglers.
Funding: Ministry of Climate and Environment

Contact: Head of Department Snorre Hagen. Email: snorre.hagen@nibio.no, mobile: +47 932 40 197.
Division of Environment and Natural Resources

Photo: Marton Berntsen [CC BY-SA 4.0 (https://creativecommons.org/licenses/by-sa/4.0)]

Are we facing the age of skylark silence?

Although migratory birds return and the skylark warbles joyously over the fields, things are still not as they should be. Many bird species in the agricultural landscape struggle with declining populations. Fortunately, this trend can be reversed.

Europe has lost more than 420 million breeding birds in the last 30 years. Things are particularly difficult for species in the agricultural landscape.

“Our monitoring programme on the Norwegian agricultural landscape, 3Q, shows the same trends,” says researcher Christian Pedersen. In a few decades, the number of lapwings in Norway has declined by 75 percent. And in some places, the populations of other species such as Eurasian curlews, Eurasian skylarks, yellowhammers and whinchats are severely declining.

“For 20 years, we have monitored changes in land use and how these changes affect biodiversity. The decline in farmland bird populations and distribution indicates that agriculture is not sustainable.”

The connection between a heterogeneous agricultural landscape and the number of breeding bird species is clear. The spatial variation in land use in Norway’s landscape is important for many species.

The agricultural landscape provides habitat for a number of migratory birds. Although we have little agricultural land, we have a landscape that provides a buffer against the challenges encountered by birds elsewhere in Europe.

The EU is now introducing massive measures to strengthen its bird populations. While we wait for these to take effect, Norway and its Nordic neighbors have an important role to play.

Norway must make it easier for farmers to do the right thing, Pedersen believes. Considerate haymaking, unsown areas in fields and farm ponds are examples of good measures.

“Many measures have a positive effect on multiple species at the same time. This means that good planning can benefit a variety of species and biodiversity in general,” the researcher says.

Goal: Document populations and change in the Norwegian agricultural landscape.
Funding: Ministry of Agriculture and Food

Contact: Research Scientist Christian Pedersen. Email: christian.pedersen@nibio.no, mobile: +47 974 34 123.
Division of Survey and Statistics

Photo: Roar Linjord

Hay meadows save lives – if we save them

Our insects are starving. As one of the most biodiverse natural environments we have, blooming hay meadows could help save them. A new guide for restoration and management of hay meadows are published. The objective is to preserve the tradition of managing this critically endangered nature type and to increase the biodiversity that provides habitats for insects.

A third of all food production depends on pollinating insects. They are also an important food source for many birds and reptiles. This means that there is every reason for concern in regard to the reduction in insect biodiversity.

But how can we reverse the trend? In short, we have to increase insects' access to food and give them somewhere to live. Hay meadows are one of the most biodiverse natural environments in Norway, ideal for a huge variety of insects. But this nature type is disappearing.

A hay meadow contains wild, indigenous plant species and has been subject to minimum ground disturbance or fertilizers. Researcher Ellen Svalheim describes hay meadows as full of buzzing insects and a variety of grass species and colorful herbs, forming elements of living cultural history.

"They developed through an interplay between people and nature over generations. For centuries, hay meadows were one of the most common nature types in Norway—they were everywhere"!

After World War II new and more intensive cultivation methods became more common. The most easily run farmland was turned into productive and fertilized pastures. This provided a lot of fodder but most of the hay meadows disappeared, along with the biodiversity within them. There are now only remnants of the wildflower meadows on which generations before us had depended.

In recent years, many people have seen the need to conserve traditional hay meadows. NIBIO's guide to the restoration and management of hay meadows provides increasing knowledge about how we can conserve this culturally historic natural environment and the insects that live there.

Goal: National coordinator for monitoring the action plan for hayfields.
Funding: Norwegian Environment Agency

Contact: Research Scientist Ellen Johanne Svalheim. Email: ellen.svalheim@nibio.no, mobile: +47 452 10 350.
Division of Food Production and Society

Photo: Anette Tjomsland

How many trees can Norway cut down?

In a collaboration with the Norwegian Environment Agency, NIBIO has performed extensive calculations as a basis for how to incorporate forestry in the climate agreement between Norway and the EU.

The calculations describe how many trees can be felled in Norwegian forests in the coming years. The EU regulations for the forestry and land use sector indicate how emissions and sequestration from the categories of managed forests, newly afforested land, deforested land, pastureland, cultivated land and wetlands must be calculated and counted toward the commitment. The overall goal for the forestry and land use sector is for emissions and sequestration to achieve net zero.

Emissions and sequestration from managed forests—which means forests that are felled and regenerated—are to be measured up against a reference trajectory. The level of felling is the most important individual factor affecting this reference trajectory. Felling that is higher than the reference trajectory could take our calculated emissions from forests above net zero. If felling is lower, our calculated sequestration could count toward a reduction in emissions.

NIBIO and the Norwegian Environment Agency have submitted six scenarios for the reference trajectory for managed forests based on two approaches. The government concluded that Norway's reference trajectory should be the 'Finland 9' scenario. The average annual felling level for the 2021–2030 period at the selected reference trajectory is around 16 billion cubic meters. The felling level in the reference trajectory must be reduced by around 8 percent—including deductions for crowns and wood that cannot be sold—to be comparable with Statistics Norway's felling statistics. This makes the comparable felling level in the reference trajectory approximately 14.5 million cubic meters.

According to Statistics Norway, the felling level in 2017 was 12.5 million cubic meters, including wood. To compare the felling level in Statistics Norway's statistics with the reference trajectory, timber from deforestation must be deducted. This means that, in 2017, felling in the managed forest category was 11.8 million cubic meters.

Goal: Calculate the annual felling level for the 2021–2030 period as part of the climate agreement between Norway and the EU.

Funding: Norwegian Environment Agency

Contact: Director Bjørn Håvard Evjen. Email: bjorn.havard.evjen@nibio.no, mobile: +47 901 28 872.
Division of Forestry and Forest Resources

Photo: Morten Günther

Food or housing – an old unresolved conflict

Soil protection is a challenge that humans have been facing for millennia. Chieftains and kings established towns in the middle of their food sources. Then towns started to grow.

It is no coincidence that our cities are situated where they are. They flourished in areas where fertile soil, seas and rivers provided food and opportunities.

Towns and populations grew slowly until the end of the 19th century. Occasionally, land had to make way for buildings. Then industrialization arrived. Factories and homes were built. The towns grew. Food production in close proximity to cities became less important. Modern agriculture resulted in cheaper food production using less land. More food was imported.

Only a fraction of the fertile land of the past can still be found in cities. However, the percentage of cultivated land close to populated areas is 10 times higher than in the rest of the country. This is a challenge.

The high percentage of agricultural land close to towns and cities leads to conflicts about whether the land should be used for food production or other social purposes. Since the 1950s, approximately 100,000 hectars of cultivated and cultivable land have been converted to land use for homes, roads and industrial areas in Norway.

Researcher Linda Aune-Lundberg has been studying agricultural areas surrounding towns and cities:

“Between 2004 and 2015, 12 percent of agricultural land in the surroundings of populated areas was built up in Norway. Half of that agricultural land was within one kilometer of a populated area.”

Around densely populated areas, 34 percent of the land is agricultural, while, in Norway in total, that figure is only 3 percent.

“In this country, we only have 3 percent agricultural land and not a lot of cultivable soil. In addition, this cultivable soil is often less favorable for food production than the soil we are already cultivating. Our analyses of land conversion demonstrate how agricultural land close to densely populated areas is particularly vulnerable.”

Goal: Communicating information and raising awareness about soil protection.
Funding: Ministry of Agriculture and Food

Contact: Research Scientist Linda Aune-Lundberg.Research Scientist Linda Aune-Lundberg.
Email: linda.aune-lundberg@nibio.no, mobile: +47 995 78 533.
Division of Survey and Statistics

NIBIO
NORWEGIAN INSTITUTE OF
BIOECONOMY RESEARCH

Bioeconomy is based on the utilization and management of biological resources from land and sea. The institute aims to contribute to food security and safety, sustainable resource management, innovation, and value creation through research and knowledge production within food, forestry, and other biobased industries. The institute aims to deliver research, management support and knowledge for application in national emergency preparedness, businesses and society at large. NIBIO aims to be the national leader in the development of knowledge about the bioeconomy.

NIBIO is subject to the Ministry of Agriculture and Food as an administrative agency with special authority and its own board. The head office is in Ås, just outside Oslo. The Institute has several regional units and a branch office in Oslo.

The Norwegian Institute of Bioeconomy Research (NIBIO) was founded on July 1, 2015, as a merger of the Norwegian Institute for Agricultural and Environmental Research (Bioforsk), Norsk institutt for landbruksøkonomisk forskning (NILF), and the Norwegian Forest and Landscape Institute.

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