



NIBIO

NORWEGIAN INSTITUTE OF
BIOECONOMY RESEARCH

NIBIO BOOK | 8 (1) 2022

Green knowledge

39 examples from NIBIO's Activities in 2021



Green knowledge

39 examples from NIBIO's Activities in 2021

Editor: Camilla Baumann

Title: Green knowledge – 39 examples from NIBIO's Activities in 2021

Written contributions: Erling Fløistad, Hege Ulfeng, John Olav Oldertrøen, John Schärer, Kathrine Torday Gulden, Kjersti Bakkebø Fjellstad, Kjersti Kildahl, Lars Sandved Dalen, Liv Jorunn Hind, Morten Günther, Siri Elise Dybdal, Georg Mathisen and Tonje Lindrup Robertsen.

Photo Editor: Erling Fløistad

Lead Editor: Ragnar Våga Pedersen

Cover design: Cover photograph: Steinar Johansen/Statskog

NIBIO BOOK 8(1) 2022

ISBN: 978-82-17-03085-0

ISSN: 2464-1189

This is a translation of the original Norwegian publication "Grønn kunnskap – 39 smakebiter fra NIBIOs virksomhet i 2021", NIBIO BOK 8(1) 2022. ISBN 978-82-17-02991-5

Production: 07 Media – 07.no

www.nibio.no



Foreword

NIBIO has an extensive professional portfolio, with close to 1500 ongoing projects at any given time. The projects reflect the great diversity and breadth of NIBIO's professional activities, with regard to goals, market and geographical location.

Many are concerned with sustainability. At the same time, many of our disciplines are subject to increasing polarization in society, which can express itself in both oversimplification and misrepresentation of complex issues. This requires an awareness of the role that research and knowledge institutions like NIBIO play, and a conscious approach to the difference between science and politics.

For NIBIO it is therefore important to be active throughout the entire knowledge value chain. Our knowledge must be useful – it must be put to use and must contribute to insight and smart decisions that lead to good solutions. Our framework *NIBIO – Making Sustainability Meaningful* is about precisely that – contributing to the diversity of knowledge needed to balance different and often opposing considerations in an increasingly complex terrain.

In this document we have collected 39 articles – selected samples of the great diversity of NIBIO's professional activities in 2021. Activities and results that each, in their own way, contribute to important knowledge in industry and management, and in society – locally, nationally, and internationally.

We hope that these samples inspire you to seek out more information – both about what is presented here and the many other exciting results of NIBIO's 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 chains, 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. 680. (December 31, 2021)

Estimated turnover for 2021 was 760 million NOK.

Number of international projects: approx. 100, of which approx. half are EU or EEA

Present in all regions of Norway

Contents

Foreword.....	3	Sheep grazing statistics available online	26
This is NIBIO	4	Climate-smart success story in Africa	27
		Progressively older forests and dead wood.....	28
Norway's food security in an unstable world	8	Combined map data reveals built-down farmland.....	29
Integrated pest management in grain farming.....	9	VIPS on exclusive UN list of IT solutions	30
DNA Reveals Imported Pests	10	Status of forest trees in Norway	31
Establishing a circular wood value chain	11	Norwegian herbs – a new, green value chain?	32
Researchers hope to get more out of biogas	12	Varying fertilizer effect in fish sludge	33
Cows in loose housing: What will it cost?	13	Cultural heritage vs. climate and tourism.....	34
New virus threatens tomato production	14	New model changes erosion risk map	35
Carbon storage in grasslands	15	Increased awareness of local self-sufficiency	36
Ten facts about the Norwegian food industry.....	16	The distinct flavour of Cider from Hardanger	37
The polar bear's destiny when the ice recedes	17	Mapping the spruce bark beetle genome	38
Yellow larvae in potato crops reduce yields	18	Why soil protection is vital	39
Producing more Norwegian plant protein	19	Tributaries affect lake Mjøsa's water quality	40
Hot water to combat strawberry runners	20	SYNOPS WEB Norway – a new environmental tool	41
Tailored measures to improve soil.....	21	Popular technology day at Apelsvoll	42
Excess fertiliser: Resources gone astray	22	Anadromous Arctic charr as climate indicator.....	43
Forests resilience against snow and storms	23	N-filter installed at waste rock landfill	44
More Norwegian onions on the plate	24	Big data from harvesters.....	45
New invasive fungus on pine trees in Norway	25	Create your own wildflower meadow	46





Photo: Erling Fløistad



Photo: Siri Elise Dybdal

Norway's food security in an unstable world

The debate around Norway's food security has primarily focused on the degree of self-sufficiency and government stockpiling of grain. However, vulnerability in the food system is much more complex and requires a broader understanding.

In recent years, it has become more and more clear that we are facing new and growing threats to global food systems as a result of climate change and other factors. The Covid-19 pandemic showed us how unprepared society can be when a crisis occurs, even with advance warning.

In a new report from NIBIO, researchers analyzed what might challenge preparedness relating to the food supply in Norway, what measures and tactics we should prioritize and what kind of strategies are needed to improve the country's food security and preparedness.

Naturally, food security means different things in Norway and in conflict-affected countries where a large proportion of the population is starving. Purchasing power and access to food in rich countries would imply that, for most, food security is not under threat, provided that there are no extraordinary events. Nevertheless, the fact that many people in the world are starving indicates that, from a global

perspective, there is a widespread lack of food security.

"Our assessment is that the challenges facing global food production could also present a serious threat for a country like Norway, which is dependent on continuous imports of food," says Siri Voll Dombu, project manager for the report at NIBIO.

Norwegian food production has its challenges and limitations in natural conditions and a high cost level, but there are opportunities for agriculture relating to the development of knowledge, technology and competition by making use of comparative advantages.

The work to ensure preparedness and maintain food security must focus on securing the production base, production and trade relations, while also working to understand and adapt to risks and ensure that early warning systems are in place.



Goal: Focus on what might challenge preparedness relating to the food supply in Norway, what measures we should prioritize and what kind of strategies are needed to improve the country's food security and preparedness.

Contact: Senior Adviser Siri Voll Dombu. Email: siri.dombu@nibio.no, mobile: +47 416 01 262. Division of Survey and Statistics



Photo: Erling Fløistad



Integrated pest management in grain farming

In 2015, integrated pest management became mandatory in Norwegian grain production. It has been an eye-opener for Norwegian grain farmers.

Knowledge of Integrated Pest Management (IPM) has been increasing since 2015. This is reflected in two surveys concerning Norwegian grain farmers, carried out by NIBIO in 2014 and in 2017/18. While 22 percent responded that they had a good understanding of the concept in 2014, 50 percent had a good understanding in 2017/18.

The emphasis on using alternative methods rather than spraying against weeds and insects has grown. Now, there is increased focus on preventing pesticide resistance and producing grain that does not contain traces of pesticides.

In the survey from 2017/18, 41 percent of the grain farmers responded that they were practicing Integrated Pest Management to a greater degree than before, while 55 percent said they were practicing it to the same degree as they were before it became mandatory. However, according to the 2014-survey, Norwegian grain farmers were already then using many of the IPM-principles in their

practice. The farmers who had increased their use of IPM reported that the measures most frequently adopted were need-based spraying (e.g., monitoring, reduced dosage), preventive measures (e.g., crop rotation, tolerant crop, and soil tillage), and preventing pesticide resistance.

According to the new regulations, farmers are required to record the assessments they make relating to IPM when they spray pesticides. Some are frustrated by the additional paperwork. Others believe it raises more awareness.

Some farmers were uncertain about what is actually required from them regarding IPM and what kind of penalties that could be implemented. The EU is working on revising the regulations concerning use of pesticides to make them more concrete and enforceable.



Goal: To determine how new regulations concerning Integrated Pest Management have affected Norwegian grain production.
Collaboration: Norwegian University of Life Sciences (NMBU)
Funding: Research Council of Norway
Contact: Research Scientist Valborg Kvakkestad. Email: valborg.kvakkestad@nibio.no, mobile: +47 481 32 706. Division of Food Production and Society



Photo: Erling Fløistad



DNA Reveals Imported Pests

At NIBIO, researchers have used DNA analysis in the fight against unwanted organisms that hide in the soil of imported plants. Environmental DNA makes it possible to find all the organisms hiding in the soil.

Plants with roots and lumps of soil that are transported in the plant trade can contain many different microscopic organisms that can cause plant disease. Among these are oomycetes, which are closely related to algae. These organisms can lead to disease outbreaks and pose a threat to ecosystems, biodiversity and food security. Species from the *Phytophthora* family have killed forests along rivers in several parts of Norway and are examples of organisms that are carried in soil.

However, the tools that make it possible to discover such oomycetes are not yet widely included in international plant hygiene testing protocols.

NIBIO is carrying out a soil monitoring program on behalf of the Norwegian Food Safety Authority, but the current methods are time-consuming with relatively limited findings. Now, researchers are testing out *Environmental DNA metabarcoding* to identify and gain a greater and better understanding of what is hiding in the soil of imported plants.

With environmental DNA metabarcoding all the DNA from the soil samples is isolated and sequenced specifically from oomycetes.

The researchers found approximately 1800 different oomycetes in 64 soil samples, while traditional methods led to the identification of barely 20 different species in the same samples, researcher Simeon Rossmann explains. He was responsible for the project's data analysis.

“We believe this method of analysis will provide us with a far greater insight into what importing plants actually means for Norway's nature and agriculture. Now we are able to see how much slips through undetected, despite the plants coming with a certificate of health,” comments senior researcher May Bente Brurberg.



Goal: To use environmental DNA metabarcoding to identify and gain a greater and better understanding of what is hiding in the soil of imported plants.

Contact: Research Professor May Bente Brurberg. Email: may.brurberg@nibio.no, mobile: +47 926 09 364. Division of Biotechnology and Plant Health



Photo: Lone Ross

Establishing a circular wood value chain

sirkTRE will raise the wood and building industries towards the holistic circular, green shift by ensuring that recycled wood is used in construction projects and is included as a raw material in today's wood processing industry.

To increase the use of wood in constructions, local raw materials are needed. Recycled wood will be a crucial input factor through new reuse and material recycling solutions.

In the sirkTRE project, forest owners, the timber industry, architects, consultants, contractors, waste and recycling operators, property owners and developers, research institutions and standardisation bodies will ensure that wood waste is reused. The goal is to reuse 250,000 cubic meters of Norway's wood waste by 2024, and a million cubic meters by 2030.

The project is run by OMTRE, Vill Energi and NIBIO.

In addition to reducing the amount of wood waste, which benefits both climate and environment, sirkTRE will collaborate with companies and industry players to create new business opportunities, products and jobs and increase the value creation in wood and construction industries locally, nationally and in export markets.

sirkTRE represents a shift in perspective – from consumption to reuse – and from waste to raw material and resource. This is an important step towards reducing the collective environmental impact from industries that will play a central role in the bioeconomy of the future.

The research and competence project circWOOD is an integral part of sirkTRE. The research results, especially those related to resource access and material flows, will be linked to the facilitation of a circular flow of goods, as well as the handling of wood waste, environmental impact, design and production of wood products in, and towards, relevant markets in Norway and abroad.

sirkTRE will cut two million metric tons of CO₂ emissions annually by 2030. This includes storage of biogenic carbon in wood, which makes up a full third of the cut in emissions.



Goal: sirkTRE will support increased use of recycled wood in building projects and as a raw material for the wood industry.

Collaboration: Forest owners, the timber industry, architects, consultants, contractors, waste and recycling operators, property owners and developers, research institutions and standardization bodies

Funding: Innovation Norway, Research Council of Norway and SIVA, through the Green Platform initiative.

Contact: Head of Department /Head of Research Lone Ross. Email: lone.ross@nibio.no, mobile: +47 911 97 268.

Contact: Research Scientist Erik Larnøy. Email: erik.larnoy@nibio.no, mobile: +47 922 62 657. Division of Forest and Forest Resources

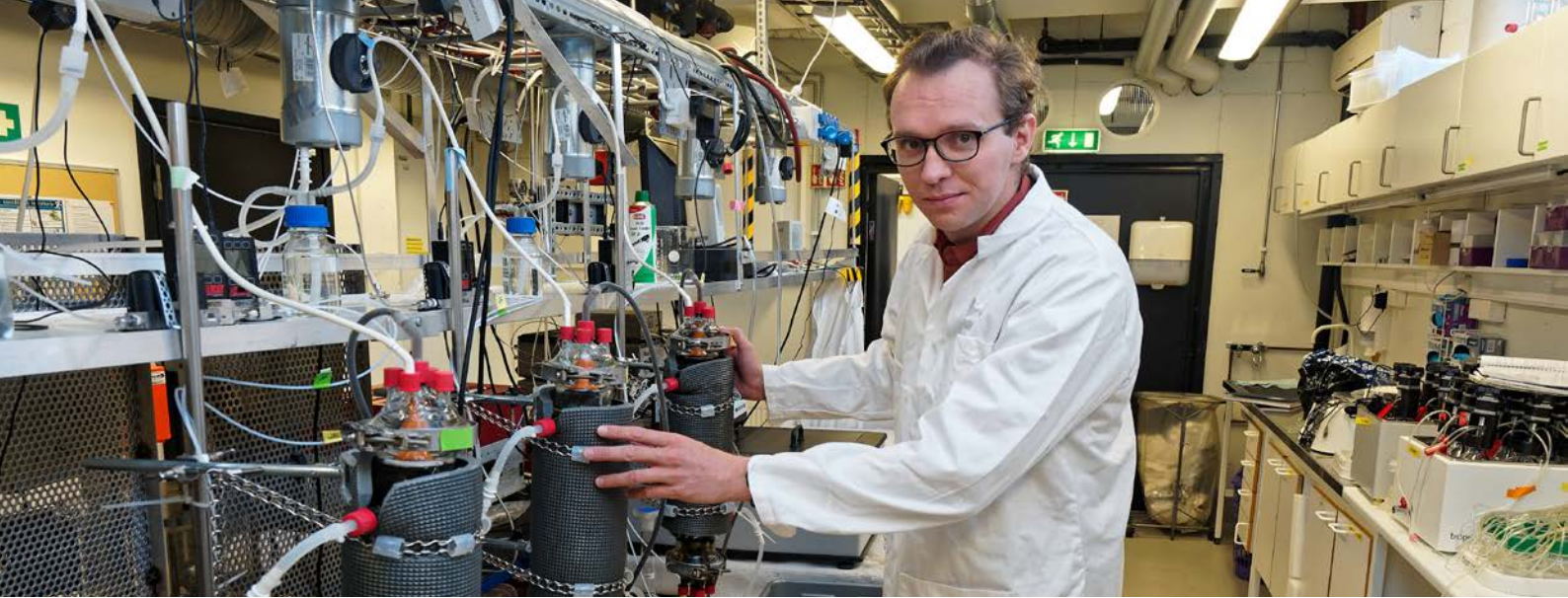


Photo: Georg Mathisen



Researchers hope to get more out of biogas

Increasing biogas use is an important environmental measure in Norway’s transition to a low-emission society. At the biogas lab in Ås, researchers are developing new solutions to make better use of biogas.

Biogas is used for electricity, heat, and as fuel. Plus, it is generated from organic waste.

“We are working with things that are soggy, smell bad and no one else wants. Food waste, sewage and animal manure. Any type of organic material, and everything that is too wet to burn,” says Roald Aasen, researcher at NIBIO.

Together with NMBU professors Svein Jarle Horn and John Morken, Aasen runs the biogas lab in Ås. Among other things, the lab tests how well different combinations of organic waste work as raw materials for generating biogas. They are also looking at how the pretreatment and process can be improved.

In recent years, the researchers at the lab have particularly focused on adding hydrogen into the biogas reactors to upgrade the biogas into pure biomethane. This increases the energy content of the gas produced. The researchers use microorganisms

that convert carbon dioxide and hydrogen into biomethane.

Normally, biogas consists of 50 to 70 percent methane.

“We have got it up to 95 percent when we upgrade the gas further with hydrogen,” says Aasen.

NIBIO researcher Michal Sposób is carrying out trials with different plastic filter materials – what he calls “biofilm carriers” – on which the microorganisms can grow in special reactors. Sposób leads the work with biogas at the research center Bio4Fuels.

“We use biogas together with hydrogen. The microorganisms convert carbon dioxide (from biogas) and hydrogen, into methane and water. Perhaps it will be possible to connect this directly to the biogas reactors so that we get a biogas with a very high concentration of biomethane,” he says.



Goal: To investigate how well different combinations of organic waste work as raw materials for producing biogas.

Collaboration: Norwegian University of Life Sciences (NMBU)

Funding Bio4Fuels: Research Council of Norway

Contact: Research Scientist Michal Sposób. Email: michal.sposob@nibio.no, mobile: +47 458 33 421. Division of Environment and Natural Resources



Photo: Kåre Magnus Oma

Cows in loose housing: What will it cost?

From 2034, all cattle will be in loose housing. The use of stall barns will cease. Starting in 2024, requirements for calving areas will come into force. NIBIO estimates a total investment need of NOK 18–23 billion between now and 2034 due to the new requirements.

The requirement for loose housing means the animals will no longer be tethered to a specific stall but can move around the barn more freely. Modifying barns to meet these conditions requires large investments.

NIBIO has calculated the amount needed to provide the Ministry of Agriculture and Food with a knowledge base for its decisions concerning investment subsidies until 2034.

The calculations assume that milk production will remain around the current level. The number of dairy farms and cows per farm has changed significantly in recent years, but total milk production has been relatively stable around 1500 million liters annually.

From 2007 to 2019, the proportion of stall barns dropped from 89 to 61 percent. Loose housing operations increased in the same period, from 1477 to 2924, while stall barns decreased from 11,698 to 4554.

In 2019, 47 percent of Norwegian dairy cows were housed in stall barns. They supplied 37 percent of the total milk production.

Before 2034, some of the 4554 dairy farmers with stall barns will most likely choose to shut their operation and sell their herds. How many will persevere and how many will give up has been difficult to predict. The expected structural changes and impact of the 2024 requirements have been and will continue to be a challenge.

Different scenarios have been simulated for different herd sizes, how many young animals with calves there should be room for, how often the cows are replaced and whether it will be a matter of new construction or extending or remodeling existing structures etc.

There are substantial regional differences in the investments needed to fulfill the loose housing requirement.



Goal: To calculate the investments needed within milk production to meet loose housing requirements for cattle by 2034.
Funding: Ministry of Agriculture and Food
Contact: Head of Department Lars Johan Rustad. Email: lars-johan.rustad@nibio.no, mobile: +47 911 27 954. Division of Survey and Statistics



Photo: Chamber of Agriculture of North Rhine-Westphalia, Cologne, Germany



New virus threatens tomato production

Each year more than NOK 400 million worth of tomatoes are cultivated in Norway. Just like us humans, tomatoes can be attacked by viruses – the new tomato brown rugose fruit virus is one of them.

In recent years, tomato growers in several countries have had problems with this new tomato virus, which was first discovered in Jordan and Israel in 2014.

“The virus is called tomato brown rugose fruit virus (ToBRFV), but we call it “tomatbrunflekkvirus” in Norwegian,” says Dag-Ragnar Blystad, virologist at NIBIO.

The virus has now spread to the US and several European countries. The virus is highly stable and transmissible, and once it appears in a tomato crop it is difficult to get rid of. It causes reduced quality and yield, thereby resulting in significant loss of income for tomato growers.

NIBIO has determined that the likelihood of outbreaks is very high. The Norwegian Food Safety Authority (NFSA) therefore sponsored a program to monitor and map the virus in Norway in 2021. NFSA will take samples of tomato plants, which NIBIO will analyse.

The new virus belongs to the *Tobamovirus* family and, like other tobamoviruses, ToBRFV spreads easily through contact from plant to plant. The virus also remains transmissible in soil for a long time. Transmission through seeds is also highly likely.

The new virus presents a great potential for damage. The damage appears in the form of yellow and brown spots on the fruit of infected plants. This means that these cannot be sold. Even plants with mild symptoms can lose their vitality. They must therefore be replaced sooner than healthy plants.

“If there is an outbreak in one or more Norwegian tomato crops, the losses – and thereby the replacement costs – could reach between NOK 10 and 100 million, depending on the extent,” says Blystad.

Strict hygiene and preventive measures are the only way we can fight this virus.



Goal: To monitor and map the tomato brown rugose fruit virus in Norway in 2021.
Funding: Norwegian Food Safety Authority
Contact: Research Professor Dag-Ragnar Blystad. Email: dag-ragnar.blystad@nibio.no, mobile: +47 908 72 588. Division of Biotechnology and Plant Health



Photo: Jon Schärer



Carbon storage in grasslands

Grasslands and pastures are efficient for carbon storage, but management practises can affect their storage ability.

Specialised ruminant meat production has been presented by some as a climate problem. At the same time, grasslands hold a lot of carbon in the soil, which is important for the climate and the carbon cycle.

Grasslands, pastures and grazing areas cover more than half of agricultural land in Norway.

“These areas are used in different ways, where operational methods and intensity can affect the soil’s ability to store carbon,” says Teresa G. Bárcena, researcher at NIBIO.

Together with her colleagues, she is researching the soil carbon content of grasslands in several parts of the country. The aim is to identify possible connections between how the land is managed and the soil’s carbon storage capacity. Different management strategies can for example be how much fertiliser is used and how often the grasslands are ploughed.

“Carbon content in soil tends to be measured in the surface layer,” says project manager Levina Sturite.

A central hypothesis of the project, however, is that significant amounts of carbon are also stored in deeper layers of soil in pastures and grazing areas.

“One might think that a long-term grassland that have not been ploughed for several decades would store the most carbon, as the soil remains undisturbed for longer periods protecting the soil organic matter/soil carbon. But this does not coincide with our findings, in which the differences have turned out to be minor,” Bárcena adds.

Several of NIBIO’s stations have long-term experimental fields on grasslands. These go all the way back to around 1970 and are therefore useful for studying differences in carbon storage with different ploughing regimes. Researchers working on the Carbon Storage project have examined these fields with long-term grasslands and quantified soil carbon down to 60 cm depth.



Goal: How to combine grassland productivity and carbon storage in Norwegian permanent grasslands.
Collaboration: Norwegian University of Life Sciences (NMBU), Swedish University of Agricultural Sciences (SLU), Norwegian Agrarian Association, Norwegian Agricultural Extension Service and Agromiljø Agriculture and Food Industry Research Funds
Funding:
Contact: Research Scientist Teresa Gómez de la Bárcena. Email: teresa.barcena@nibio.no, mobile: +47 405 56 025. Division of Environment and Natural Resources



Photo: Øyvind Haug, Nortura

Ten facts about the Norwegian food industry

Norway is exporting and importing more food than ever. Seafood is often exported, while processed foods and agricultural products are often imported. Seafood is the largest single industry.

These are some of the main findings of the 11th NIBIO report *Mat, matindustri og verdikjeder 2020* (Food, Food Industry and Value Chains 2020), published in 2021.

The *food industry* refers to the manufacture of food products and of beverages.

The food industry

- 1 represented 19 percent of the value creation and 26 percent of total operating profits in Norwegian industry in 2018.
- 2 had a combined value creation of approximately NOK 45 billion in 2018. The seafood industry represented more than 25 percent of the value creation.
- 3 employed around 52,000 people in 2018. In the decade from 2008 to 2018, employment increased, with the seafood industry seeing the largest growth.
- 4 creates jobs in every county. In terms of value creation from food industry, the county Viken, is the greatest.

5 more than doubled its investments since 2007. The seafood industry is the largest sector, with 30 percent of total investments.

6 increased operating profits from NOK 10 to 17 billion in eight years. The seafood industry alone represents 30 percent of the total profits.

Norway's trade surplus for food products is NOK 44 billion

7 Exports totalled NOK 117 billion, and imports totalled NOK 73 billion. Raw materials of seafood hold the largest share in export value, while imports are largely driven by agricultural products.

Food products have become relatively cheaper

8 In general, foods are becoming cheaper, compared to other consumer goods.

Food imports have driven inflation

9 Since 2010, import prices have increased more than the Norwegian consumer price index for food.

Large and varied structural changes have occurred in the food sector in the past 20–30 years,

10 particularly within dairy, meat and the fruit and vegetable sector.



Goal: To provide an overview and show the value creation that occurs throughout the value chain for food – from fjord and farm to table.

Funding: Norwegian Agriculture Agency, Ministry of Agriculture and Food, Norwegian Union of Food, Beverage and Allied Workers, Norwegian Seafood Federation and Research Council of Norway

Contact: Senior Adviser Signe Kårstad. Email: signe.kaarstad@nibio.no, mobile: +47 997 60 083. Division of Survey and Statistics



Photo: Morten Günther

The polar bear's destiny when the ice recedes

Over several decades, sea ice has gradually been receding from the areas around Svalbard. New research shows that this has led to loss of genetic diversity and an increasing degree of isolation in the local polar bear population.

Although the polar bear is a good swimmer, it depends on sea ice for hunting, eating and resting.

“The polar bear spends most of its life on sea ice,” says Snorre Hagen, head of research at NIBIO Svanhovd. In collaboration with the Norwegian Polar Institute, NIBIO has investigated how the genetic diversity of the polar bear population around Svalbard has changed in recent years.

Extensive DNA analyses

Researchers have analysed the DNA of 626 polar bears. The samples were collected by the Norwegian Polar Institute in the 1995–2016 period, from four different locations on Svalbard.

The results show that the genetic diversity of the polar bears on Svalbard was reduced by 3–10 percent during the study period. In addition, the researchers found an increase of almost 200 percent in genetic differentiation across regions, as well as an increase in the average genetic relationship between individuals.

“In other words, we can say that the polar bears across the entire area are becoming more and more genetically similar, while the polar bears in each individual area are becoming increasingly genetically isolated from one another,” says Hagen.

Sea ice is receding

These effects are best explained by the fact that the polar bear's habitat is being divided into smaller and smaller fragments, while the ice-free season is growing longer.

“When the sea ice disappears, the polar bears become less mobile. This leads to the bears becoming more similar to one another on a local level, and the local gene pool grows smaller as the polar bears in a given location increasingly mate with polar bears from the same area,” Hagen concludes.



Goal: To predict what will happen to the polar bear population when the climate gets warmer and more of the sea ice disappears.

Collaboration: Norwegian Polar Institute

Funding: World Wildlife Fund (WWF) and Norwegian Polar Institute

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



Photo: Erling Fløistad

Yellow larvae in potato crops reduce yields

Potato crop loss caused by wireworms is on the rise in Norway and abroad. But there are few good strategies to fight the pest. New research will provide more knowledge.

Wireworms are the larvae of the click beetle. They feed on the roots, stems and tubers of potatoes and other root crops. Wireworms reduce yield and quality by creating holes, tunnels, surface damage and scarring. They can also damage grain crops.

In recent years, potato crop loss caused by wireworms has increased in several European countries, including Norway. But how many and what types of species are causing damage here in Norway is not clear. Nor do we have adequate strategies for fighting this problematic pest. Until the 1990s, wireworms were primarily controlled using synthetic insecticides. Most of these are now prohibited.

Annette Folkedal Schjøll, researcher at NIBIO, is now leading a research project to identify and obtain information about wireworms, with the goal of improving monitoring and finding new methods of combating them.

The project collects larvae and mature beetles to show what kinds of species are present and how large their populations are.

“So far, we are seeing that there are more species and different species than we initially thought. We have also shown that they are causing harm,” she explains.

This means that the situation is slightly different from what the researchers thought – there are other species causing damage and whose life cycle they are not familiar with. But they know that there can be substantial variation. This can have a bearing on how the wireworm problem should be handled.

She says that they have also received an increasing number of inquiries about wireworms in grain:

“Damage to grain often goes under the radar; people think it is caused by nematodes or poor germination. But if you dig a little in the soil, you find wireworm larvae” the researcher says.



Goal: To identify and obtain information about wireworms, with the goal of improving monitoring and finding new methods of combating them.

Collaboration: Norwegian University of Life Sciences (NMBU), BAMA, Gartnerhallen, Norwegian Agricultural Extension Service and three potato producers

Funding: “Forskningsmidlene for jordbruk og matindustri” and BAMA, Gartnerhallen SA and potato producers

Contact: Research Scientist Annette Folkedal Schjøll. Email: annette.folkedal.schjoll@nibio.no, mobile: +47 922 43 716. Division of Biotechnology and Plant Health



Photo: Wendy Waalen and Unni Abrahamsen



Producing more Norwegian plant protein

There is an increasing interest in using protein plants for both food and animal feed. Maximizing use of the potential would result in an annual production of about 20,000 metric tons of protein from legumes in Norway. To make the most of this potential, there is a need for adapted varieties and cultivation techniques.

In Norway, the plant protein products are imported or based on imported raw ingredients, particularly from soya, peas, lentils, chickpeas and various types of beans. New technology is making it possible to utilise plant proteins in new ways.

In 2018, cereals, oilseed and protein crops covered about a third of the cultivated land in Norway. Since then, area with oilseed crops has been decreasing, while that of peas and particularly broad beans has been increasing.

Of the protein crops possible to grow in Norway, broad beans are particularly popular, and produce the most protein of all the annual crops. In 2020, approximately 48,000 decares were cultivated with broad beans and peas.

One of the greatest challenges in Norway is the short growing season. Broad beans require a long growing season to reach maturation. This can mean difficult

harvesting conditions, which can in turn affect the quality. Varieties that ripen earlier provide the opportunity to expand the cultivation area for broad beans, thereby increasing the production of Norwegian plant protein.

Access to early varieties from Finland has made a big difference in terms of increasing the cultivation of broad beans in Norway in recent years. The early varieties produce smaller seeds and do not cover as well as the later varieties. Trials indicate that a higher seed sowing density could be used. These varieties also require a different plant protection strategy. Testing different integrated plant protection strategies will therefore also be key going forward.

NIBIO and the Norwegian Agricultural Extension Services established the first trials with broad bean varieties 16 years ago.



Goal: Adapt cultivation techniques and plant protection strategies for broad bean varieties with shorter growing seasons.
Funding: Knowledge development funds from the Ministry of Agriculture and Food
Contact: Research Scientist Chloé Grieu. Email: chloe.grieu@nibio.no, mobile: +47 903 65 883. Division of Food Production and Society



Photo: Siri Elise Dybdal



Hot water to combat strawberry runners

Strawberry plants have runners that quickly fill the fields and provide favorable conditions for fungus if not removed. Reglone is an effective herbicide against runners, but it is no longer approved in the EU and Norway. Now researchers are looking into whether hot water could be an alternative.

The crop protection product Reglone is a contact herbicide that “burns” off the part of the plant it comes into contact with. In 2020, the EU banned diquat – one of the active ingredients in Reglone. This presents a challenge to strawberry growers.

If the runners are not removed, a strawberry field will turn from neat rows into a carpet of vegetation. This provides favorable conditions for gray mold and other fungal diseases. It also makes it very difficult to navigate the field.

As part of the SOLUTIONS project, researchers will investigate new, practical solutions for removing runners and controlling weeds in strawberries grown outdoors.

“This year we set up an experiment in newly established fields with double rows in Ridabu in Hamar. We use hot water to both burn the runners and kill

off vegetation in the double rows and paths,” says Wiktoria Kaczmarek-Derda, researcher at NIBIO.

The researchers are studying the effects of repeated treatments with hot water in combination with mechanical row cleaning. This is compared with chemical spraying, including new unapproved agents in cultivated strawberry crops.

With the hot water treatment, they are testing how close they can get the boiling water to newly planted strawberry plants and what quantities of water can be used without harming the cultivated plants.

The researchers are also looking at how effective the treatment is when different quantities of water are used. This will help to identify the right dose for treating weeds and runners in newly established strawberry fields.



Goal: To find new, practical solutions for weeds and runners in strawberry crops grown outdoors.
Collaboration: Norwegian Agricultural Extension Service Innlandet and Heatweed Technologies AS
Funding: Agriculture and Food Industry Research Funds, Grofondet AS
Contact: Research Scientist Wiktoria Kaczmarek-Derda. Email: wiktoria.kaczmarek@nibio.no, mobile: +47 920 12 897.
Division of Biotechnology and Plant Health



Photo: Till Seehusen



Tailored measures to improve soil

In the SOILCARE research project, scientists have worked to find solutions to the challenges facing Europe’s soil resources.

Many contemporary agricultural practices change the structure and composition of the soil, which results in reduced soil quality.

“By changing soil management practices, we can stop the deterioration of soil quality. This is critical if we are to maintain, and ideally increase, future food production,” says Jannes Stolte, head of the Norwegian side of the SOILCARE project.

In Norway, the trials have focused on investigating how cover crops can help to increase soil quality. Field trials were also carried out to determine whether various plants and their root systems can resolve soil compaction damage.

In the cover crop experiments, the researchers investigated whether cover crops sown in areas with a high quantity of open fields can increase the carbon content of the soil. Cover crops add biomass to the soil, thereby contributing to increased carbon sequestration. The increased addition of plant material can result in an increase in activity of the

microorganisms living in the soil, which, in turn, can result in improved soil structure and a better release of nutrients to the plants.

Preliminary results from the field trials show that the root system of the perennial herb alfalfa can help to resolve soil compaction damage. The root system of the oil crop known as turnip rape, however, did not have the effect the researchers had hoped for.

The establishment of turnip rape did not go as well as was hoped, due to both the weather and the fact that the growing season is thought to be simply too short for turnip rape in the area in which the trials took place. The trials were negatively affected by the dry growing season in 2018, followed by a wet early summer in 2019.

The drought of summer 2018 had a negative impact on the establishment and development of cover crops. Of the cover crops sown, hairy vetch, perennial ryegrass and clover performed best.



Goal: To identify measures that can contribute to improved soil quality across Europe.
Collaboration in Norway: Norwegian Agricultural Extension Service
Funding: EU H2020
Contact: Head of Department/Head of Research Jannes Stolte. Email: jannes.stolte@nibio.no, mobile: +47 974 04 696.
Division of Environment and Natural Resources



Photo: Kjersti Kildahl

Excess fertiliser: Resources gone astray

Fertiliser is like gold to farmers but can be a challenge to society. Nutrients that end up in the wrong place and accumulate in nature create an environmental problem. Therefore, we have fertiliser regulations. Now, these are to be revised.

In their proposal for updated regulations on fertiliser use, the Norwegian Agriculture Agency and the Norwegian Environment Agency put forward different requirements concerning “spreading volume”. Both agencies however want stricter regulations for application of animal manure, which results in an increased need for spreading area.

This will have consequences for many livestock farms. Operations requiring concentrated feeds, such as dairy, pigs and poultry, will feel the effects of changed regulations the most.

NIBIO has calculated that nearly 3600 farms have a surplus of animal manure at an emission limit of 2.5 kilos of phosphorus per decare, as suggested by the Norwegian Agriculture Agency. The Norwegian Environment Agency proposes an upper limit of 2.1 kilograms. This means that approximately 4900 farms will have a surplus.

Rogaland is the only county that will have a net fertiliser surplus based on the new requirements.

NIBIO has assessed the social economics of how to best and most effectively handle the increased fertiliser surplus.

It is important to be able to use animal manure as close to the farm as possible. Therefore, transportation of fertiliser is a key factor in the reporting.

Geographic and agronomic operational differences present different nutrient needs throughout the growing season and affect fertiliser sales. This calls for a differentiated set of regulations.

Restricting the spreading time has also been discussed, with assessments of what time of year and at what point during the season the fertiliser has the greatest nutritional effect and the lowest risk of emissions.

NIBIO has started follow-up work to report on the economic consequences at farm level.



Goal: To evaluate different aspects of the proposal for the new act on fertiliser use.
Funding: Ministry of Agriculture and Food
Contact: Adviser Anna Landrø Hjelt. Email: anna.landro@nibio.no, mobile: +47 958 19 208. Division of Survey and Statistics



Photo: Harald Berger, SB Skog

Forests resilience against snow and storms

Climate change may result in improved forest growth. At the same time, the extent of storm damages and top breakage from heavy snow loads seem to be increasing. To obtain more resilient forests in the future, tailored forest management is needed.

Climate change, with rising temperatures and more precipitation, will result in favourable growing conditions for most of Norway's forests. Increased growth means increased production potential for spruce – the most important tree species in Norwegian forestry.

However, climate change also means more wet snow and fewer days with frozen soil, which exposes the forest to greater risk of storm and snow damage. How vulnerable a spruce forest is, depends on soil conditions, topography and local and regional climate – and how the forest is managed.

A relevant approach to enhance tree stability is to customise, based on location, the regulation of tree density through pre-commercial thinning as well as during thinning at later development stages of a forest stand – and thereby reducing the risk of damage.

“Such measures, however, could lower production and carbon uptake if thinning is done excessively, or is done too late,” says research director and head of the National Forest Inventory Aksel Granhus.

Less soil frost and wetter soils in winter can also make trees less resistant to windthrow. Paradoxically, a warmer climate, with wetter soils and less snow, could therefore result in more damage to trees – even if storms do not become more common in the future.

The international research team collaborating in the project MARCSMAN “Maximizing Resilience and Carbon Sequestration in Managed Norway spruce forests” aims to obtain a better understanding of how management of Norway spruce should be tailored to different conditions with respect to risks of storm and snow damage. It will also develop tools for mapping forests that are vulnerable to such damage.



- Goal:** To produce knowledge of spruce forest management under changed growing conditions and with differing risks of storm and snow damage.
- Collaboration:** Norwegian University of Life Sciences (NMBU), Swedish University of Agricultural Sciences (SLU), Institut Européen de la Forêt Cultivée (IEFC), Norwegian Meteorological Institute, Statskog SF, Fritzøe Skoger and Norconsult
- Funding:** Research Council of Norway and contributions from the participants
- Contact:** Head of Department/Head of Research Aksel Granhus. Email: aksel.granhus@nibio.no, mobile +47 977 14 873. Division of Forest and Forest Resources.



Photo: Morten Günther



More Norwegian onions on the plate

Onions are the third most consumed vegetable in Norway and are also important at a global level. A new research project aims to further increase the quality and status of Norwegian onions.

On average, Norwegians eat 5.66 kg of onions per year, while onion consumption worldwide is 11.9 kg per person. According to the Norwegian Fruit and Vegetable Information Office, onions are one of the healthiest foods we can eat. Norway is largely self-sufficient when it comes to onions, and through the project “More Norwegian Onions,” NIBIO will follow the onion from farm to table.

The aim is to develop new future-oriented and market-adapted onion products for the Norwegian market. Optimising the quality of the raw material will also ensure good product quality and reduced waste from raw material stocks and packaging.

As part of the project, BAMA will carry out market research to find out what onion products consumers want. One of the options may be to introduce some new varieties of onions, perhaps one with a slightly sweeter taste.

NIBIO will take a closer look at the different producers’ cultivation practices, such as strategies for

watering and growth termination, and how these affect the quality and shelf-stability of the onion.

“Most Norwegian onion producers practice curing, which makes the onion more resilient against disease and water evaporation,” says Pia Heltoft, researcher at NIBIO.

With increasingly fluctuating and wetter weather conditions, however, it is beneficial to use methods that reduce the drying time.

“We will for instance examine whether drying with propane torches prior to harvesting could reduce the drying time and improve storage quality. Trimming the tops can also reduce drying time, but the method can lead to the development of fungus and bacteria.”

Heltoft hopes the project will contribute to increased Norwegian onion consumption, new future-oriented onion products and higher quality onions from production warehouses and packagers.



Goal: To contribute to increased Norwegian onion consumption, new future-oriented onion products and higher quality onions from production warehouses and packagers.
Collaboration: Larvik Løk, Mjøsgrønt, Frostaløk, BAMA, Gartnerhallen, Norwegian Agricultural Extension Service, Norgro, 13 onion producers
Funding: Grofondet and Agriculture and Food Industry Research Funds
Contact: Researcher Pia Heltoft. Email: pia.heltoft@nibio.no, mobile: +47 920 80 939. Division of Food Production and Society



Photo: Venche Talgø



New invasive fungus on pine trees in Norway

Diplodia sapinea is an alien, invasive fungus that damage conifers. Pines are particularly vulnerable, and the fungus has caused significant losses for forestry and nurseries in Southern Europe. In August 2020, a serious outbreak caused by this fungus was discovered in Norway.

The fungus spreads locally with rain splash or insect vectors. Across longer distances, the fungus is spread via trade of infected plants or seeds.

The disease caused by this fungus, so-called *Diplodia* shoot blight and canker, can lead to major losses in forestry, and for forest nurseries as it can be transmitted through seeds, and thereby killing seedlings. The fungus is common in Southern Europe, but in recent years it has moved further north, probably because of global warming. In 2013, it was discovered in Sweden, and has since attacked Scots pines in several places in our neighbouring country.

In Norway, a few sporadic discoveries of the fungus were made previously, but the damage was very limited.

“It was in 2020 that we first found a larger outbreak of the fungus in stressed and dying lodgepole pines in Nordskogen in Ås Municipality,” says Venche Talgø, researcher at NIBIO.

“This attack may have been worsened by the drought in 2018,” she says.

To prevent the fungus from spreading to other species of pine and spruce, the entire stock of lodgepole pines was felled in the winter of 2021, and just before Easter the branches and twigs were burned.

Martin Pettersson, researcher at NIBIO, adds that *D. sapinea* is an alien fungal species in Norway and a potential threat to our most important forest trees, which are Scots pine and Norway spruce. But there are also many other vulnerable species of pine, especially in urban landscapes, for instance mountain pine, dwarf pine, ponderosa pine, Siberian pine, and Macedonian pine.

Many of these can be sensitive to infection of *D. sapinea* because they have not fully adapted to the Norwegian climate.



Goal: To gain more knowledge about *Diplodia sapinea* in Norway.
Funding: Norwegian Agriculture Agency through the program “Tilskudd til genressurstiltak – husdyr, planter og skogtrær.”
Contact: Research Scientist Venche Talgø. Email: venche.talگو@nobio.no, mobile: +47 920 69 664. Division of Biotechnology and Plant Health



Photo: Kjersti Kildahl

Sheep grazing statistics available online

As of 2021, statistics provided by Organisert beitebruk on the number of sheep annually released and re-collected from outlying pastures are available at nibio.no. The figures go back 40 years and are sorted by municipality and county.

The grazing statistics are used as a basis for planning, consulting and reporting within central government, municipalities and the grazing industry. Now that the figures are available online, they are much easier to access – for everyone.

Typical situations where these figures are important are the evaluation of applications, subsidies for measures in grazing areas and the development of municipal grazing plans. The statistics are also useful as documentation of loss of sheep and for the general monitoring of predator population goals.

The number of sheep grazing in each area says something about the value of the land. This information is valuable when it comes to land use issues.

About 75 percent of all sheep released to graze freely on Norwegian outlying pastures are included in the grazing statistics. Approximately 1.5 million sheep are registered annually. The statistics show where

the sheep are released and how their number changes over time.

The farmers' grazing groups report annually to the Norwegian Agriculture Agency how many sheep and lambs they released and re-collected every year. Figures from these annual reports make up the core of the grazing statistics. From 1981 to today, this has grown into an extensive collection of statistical material. In total, about 61,400,000 sheep and lambs are registered in the collected data.

The archive of the Norwegian Association of Sheep and Goat Farmers has been key to securing the oldest parts of the material. A lot has been transferred manually from old paper printouts.

More recently, grazing statistics have been updated electronically with the annual figures that the Norwegian Agriculture Agency receives through the benefit program Organisert beitebruk.



Goal: To simplify access to number of sheep released on and lost from outlying pastures
Funding: Ministry of Agriculture and Food
Contact: Lead Engineer Michael Angeloff. Email: michael.angeloff@nibio.no, mobile: +47 975 38 594. Division of Survey and Statistics



Photo: BecA-ILRI

Climate-smart success story in Africa

By taking an innovative and integrative approach, the H2020 InnovAfrica project has succeeded in contributing to improved food and nutrition security for smallholders in six African countries.

Despite much research, food security continues to be a major challenge in many African countries. This is due to inefficient implementation and use of climate smart technologies, inadequate knowledge exchange between scientists and end users, in addition to limited or no market access.

By involving smallholders and ensuring that the entire value chain is addressed, InnovAfrica has contributed to increased food security for thousands of smallholders in six project regions. Milk production has increased by 7–40 percent in the project areas in Kenya and Rwanda as a result of better and higher quantities of feed. More milk has led to higher household milk consumption and increased income for the farmers.

“The goal has been to strengthen African smallholders’ ability to adapt to the climate change. Climate-smart agriculture not only leads to increased productivity, higher income and improved diets, but

is also positive for the environment,” says project coordinator, Dr. Udaya Sekhar Nagothu.

Two Village Knowledge Centers (VKCs) have been established in Kenya and Tanzania through InnovAfrica to network farmers and support them with timely extension services in cooperation with local government agencies. The centers use smartphones and social media like WhatsApp to encourage knowledge transfer and dialog between experts and smallholders.

To date, more than 60,000 smallholders have made use of the services. By May 2021, more than 9000 smallholders had been supplied with brachiaria grass seeds from the Kenyan center alone. To ensure the continued operation of the knowledge centers after the project, contracts have been signed with NGOs and the private sector, who have now taken over and are operating the VKCs after the project completion.



Goal: To contribute to increased food security and improved diet among African smallholders.
Collaboration: BecA-ILRI Hub, KALRO and KENAFF (Kenya), HU (Ethiopia), UoM and SFHC (Malawi), RAB and IAKIB (Rwanda), SUA (Tanzania), TU (Italy), DLO-Alterra (Netherlands), NMBU (Norway), ARC (South Africa), CIMMYT (Zimbabwe), KIAG (Germany)
Funding: EU Horizon 2020, www.innovafrika.eu
Contact: Senior Research Scientist/Director, Centre for International Development (CID) Sekhar Udaya Nagothu. Email: nagothu.udayasekhar@nibio.no, mobile: +47 990 15 621. Division of Environment and Natural Resources



Photo: John Yngvar Larsson

Progressively older forests and dead wood

Measurements from the National Forest Inventory's 22,000 sample plots provide a detailed overview of the Norwegian forest. Recently published data show that the volume of timber is increasing – but slightly less than before.

Norway's forests consist of 10.9 billion trees, or 967 million cubic meters of timber. This is a new record.

The National Forest Inventory has been monitoring Norway's forests for over 100 years. During this time, the volume of timber in the forests has more than tripled. However, growth has been quite stable for the past 20 years with a modest decline in recent years. Every year, just under 25 million cubic meters of timber is added to the forest stock.

To assess the forest situation, 13,000 sample plots all over Norway are visited in field over a five-year period, and a total of 270,000 trees are registered and measured.

In the sample plot, all trees over 5 cm in diameter are measured, and some trees are measured for height. With these measurements, it is possible to calculate how the tree's volume changes over time. Among other variables, tree damage, grazing and the volume of standing and fallen dead wood is also registered.

The report "Skogen i Norge" (The Forest in Norway) shows that most of the environmental assets in forestry are growing, and that the size of protected forest areas has increased to around five percent of the forest area. The Norwegian Storting has set a goal to protect 10 percent of the forest.

The occurrence of habitats where rare or endangered species thrive is also registered. Examples of such habitats are forests with a significant presence of tree species with high bark pH, hanging lichen, old trees, rich ground vegetation and areas with many standing and fallen dead trees – also known as snags and logs.

The volume of dead wood in productive forests rose from 57 million cubic meters in 1996 to 90 million cubic meters in 2017. This is an increase of 58 percent in 21 years.



Goal: The National Forest Inventory provides a detailed overview of forest resources in Norway.
Funding: Commissioned by the Ministry of Agriculture and Food
Contact: Adviser Arvid Svensson. Email: arvid.svensson@nibio.no, mobile +47 465 45 472. Division of Forest and Forest Resources.



Photo: Erling Fløistad

Combined map data reveals built-down farmland

With a clear and intensified soil protection goal, there is a growing need for reliable figures of how much cultivated land is built down every year.

Through the national reporting system KOSTRA, municipalities report how much agricultural land is declared rezoned each year. These figures do not always correspond to how much is actually built down.

NIBIO has tested a method to provide an estimate of how much farmland is built down each year. The model is based on selected map sources, and calculates:

- How much cultivated land was built down the previous year
- What the land is used for, and
- Consequences for food production.

In the current soil protection strategy, the Storting has determined that annual rezoning of cultivated land should remain below 3000 decares. According to Statistics Norway, 3900 decares of cultivated land were rezoned in 2020. An additional 6500 decares of cultivable land were declared rezoned.

Delays are part of the explanation

The statistics from KOSTRA are based on figures of declared *rezoned agricultural land*. However, it can take several years from when cultivated land is declared rezoned until development begins.

Investigations from Statistics Norway show that figures of building on cultivated land in the 2016–2019 period are higher than what was reported through KOSTRA. The differences can likely be explained in part by the delay from when rezoning is planned until building takes place, and partly from rezoning that is not reported.

The work that NIBIO has done on behalf of the Ministry of Agriculture and Food aims to show land that has actually been built down in the previous year and will be a useful supplement to the KOSTRA figures.

The central map sources for NIBIO's measurement method are the National Land Resource Map AR5, which shows existing agricultural land, building points from the national property register and the National Roads Database.



Goal: To obtain a consolidated overview of how much farmland is actually built down, where this happens and what the consequences are for food production.

Funding: Ministry of Agriculture and Food

Contact: Lead Engineer Kjetil Fadnes. Email: kjetil.fadnes@nibio.no, mobile: +47 906 01 894. Division of Survey and Statistics

Digital Public Goods Alliance

Promoting digital public goods

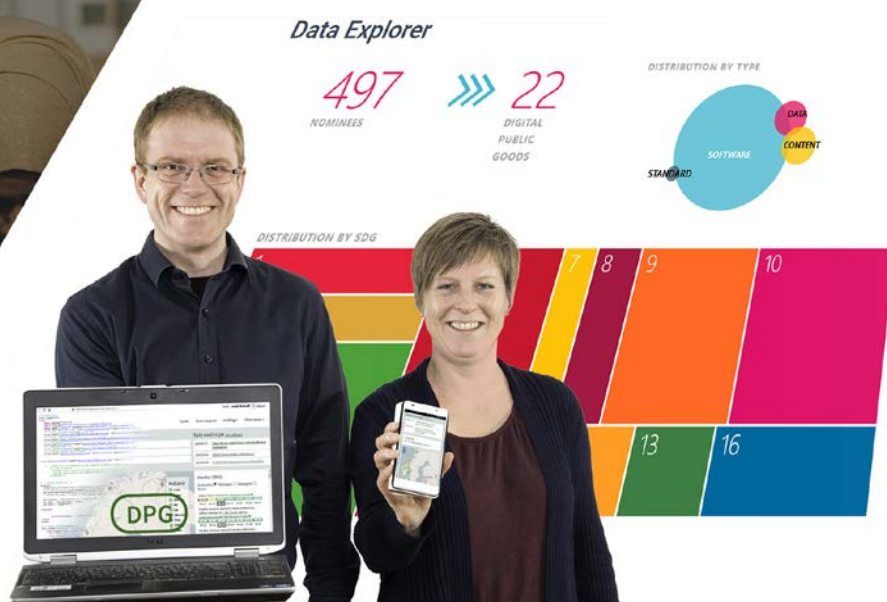


Photo: Erling Fløistad



VIPS on exclusive UN list of IT solutions

NIBIO's online platform to combat pests, weeds and diseases in agriculture, VIPS, has been chosen from among nearly 500 nominees for an exclusive list of innovative open-source IT solutions.

According to the UN, sharing digital innovation is vital if we are to build a fairer world and achieve sustainability goals.

The Digital Public Goods Alliance (DPGA) is a new international initiative led by UNICEF, established to improve access to IT solutions with open-source code in low- and middle-income countries. DPGA has established a register of digital public goods, where everything from data sets and applications to data visualization tools and pedagogical lesson plans with open-source code are freely accessible. So far, 22 platforms have been selected for the register.

Varsling Innen PlanteSkadegjørere (VIPS), or Pest Warning System, is one of the IT solutions to be included on this exclusive list. From Norway, MET Norway Weather API is also included.

"The idea is that this should be like a supermarket for digital public goods," says Tor-Einar Skog, senior adviser at NIBIO.

VIPS has operated as an open-source public good for five years. The software is also offered to plant health partners all over the world, including several projects involving the FAO and IITA, to combat Fall Army-worm.

By using VIPS as a basis, researchers and developers can save time and resources when developing and implementing pest forecasting.

Data from many online weather stations, public weather data networks and weather forecasts can be used, and that way pest and disease models can be tested and validated under local conditions with multiple sources of input data.

"Observations of pests and disease can easily be registered and reported with the help of the online map," says Skog.



Goal: To combat pests, weeds and disease in agriculture.
Funding: Knowledge development funds from the Ministry of Agriculture and Food
Contact: Senior Adviser Tor-Einar Skog. Email: tor-einar.skog@nibio.no, mobile: +47 913 03 819. Division of Biotechnology and Plant Health



Photo: Ragnar Våga Pedersen

Status of forest trees in Norway

Genetic diversity is important for trees' evolution and development as well as adaptation to a changing climate. By safeguarding genetic diversity, we ensure that essential adaptation occurs, and we preserve qualities that could prove useful.

Trees are critical to the biodiversity of everything that makes up a forest. Trees serve as hosts to many species and are important for humans as providers of ecosystem services connected to recreation and outdoor activities. In addition, many trees are part of production forestry, used either as Christmas trees or in parks and gardens. It is therefore vital to have robust forests and sufficient genetic diversity in all tree species, partly because we do not know what qualities we will need in the future.

The report "State of forest genetic resources in Norway 2020" is the Norwegian contribution to the FAO report "State of the World's Forest Genetic Resources" and presents the status of conservation, sustainable use and development of forest genetic resources in Norway.

The recommendations from the status report are that Norway, through holistic collaboration between environmental and agricultural agencies, should

work actively to secure the genetic resources of several tree species.

Several conservation areas for forest genetic resources have been designated in established protected areas, which is a good way to take advantage of the existing infrastructure. Since conservation of genetic resources is not specifically defined as a goal in formal forest protection, it is important to ensure targeted facilitation, management and monitoring.

We currently have some knowledge of genetic diversity for 18 of the tree species in Norway, based on DNA analysis or studies of morphology and production characteristics. Spruce is the only tree we know a lot about. It is therefore important to gain more knowledge, including about tree species' importance for the ecosystem.



Goal: A new report presents the status of conservation, sustainable use and the development of forest genetic resources in Norway.

Collaboration: Norwegian Forest Seed Center, Norwegian Environment Agency, FAO

Funding: Basic allocation from the state budget (LMD)

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



Photo: Mette Thomsen



Norwegian herbs – a new, green value chain?

Plants grown in Nordic regions contain a high level of bioactive compounds. Could these compounds be used as a healthy feed additive or biodegradable packaging?

There is evidence that plants grown in Nordic regions contain a high level of bioactive compounds. Such compounds affect living organisms, tissues, and cells.

By producing bioactive compounds from Norwegian herbs, researchers will extract natural substances with antioxidant, antimicrobial or anti-inflammatory effects. These substances could extend the shelf life of salmon feed, reduce winter ulcers in farmed fish and improve the gut flora and health of chickens. In addition, the researchers want to design biodegradable and antimicrobial packaging products.

The researchers will test a selection of wild Norwegian herbs along with some cultivated herbs that are expected to contain a high level of bioactive compounds: oregano, yarrow, peppermint, hops, roseroot, maral root, sweet wormwood, purslane and rosemary.

The selection of varieties, climatic conditions, fertilization and light will be optimized to promote growth and compound content. The experiments will be carried out in open field, in greenhouses and in growth tunnels in order to find the best conditions for the herbs, in terms of both yield and production of bioactive compounds. The most potent plants will then be scaled up.

The bioactive compounds will be tested for specific qualities. Along the way, they will perform a series of analyses of the herbs' antioxidant, antimicrobial and anti-inflammatory properties.

Extracts and active compounds will be selected with the help of biochemical analyses and laboratory tests. Following this, they will be tested in animal trials with salmon and chicken.

The goal is to create a new, green value chain for plant producers in Norway, based on wild plants from Norwegian nature.



Goal: The project "BioActive," will add value in the Norwegian agricultural sector by producing bioactive compounds to be used in feed supplements and bioactive packaging.

Collaboration: The project is led by Nofima. Other partners are The Norwegian Veterinary Institute, PlantChem AS, Norgesfôr AS, Skretting Arc. Stavanger, Frøvoll Gård, Boheimsmarken AS and Institute of Macromolecular Chemistry in Iasi, Romania

Funding: Research Council of Norway

Contact: Research Scientist Mette Thomsen. Email: mette.thomsen@nibio.no, mobile: +47 406 22 631. Division of Food Production and Society



Photo: Trond Knapp Haraldsen

Varying fertilizer effect in fish sludge

The fertilizer effect of fish sludge varies more than previously thought. In order to make the best possible use of waste resources from the aquaculture industry, it is important to ascertain the quality of the sludge first.

Because fish sludge is rich in the essential nutrients phosphorus and nitrogen, researchers have investigated whether it can replace mineral fertilizer in agricultural applications. The results show that the fertilizer effect of fish sludge from hatcheries varies. Specifically, the nitrogen contained in the sludge is not always in a form that is directly available to plants.

“In order to use fish sludge as a fertilizer, it is important to investigate its nitrogen effect first. When the effect is known, we will have a better understanding of how the resources the sludge contains can best be put to use in agriculture,” says Eva Brod, researcher at NIBIO.

In the project FishBash, Brod analyzed six fish sludge products from onshore facilities that use different processes to treat the sludge. Her results show that up to 70 percent of the nitrogen that is

directly available to the plants is carried off with the water when the sludge is dewatered at the hatchery.

A large proportion of feed residues in relation to fish excrements in the sludge could be one of many factors when it comes to dried fish sludge being more suited as a nitrogen fertilizer. It is, however, best to waste as little feed as possible in the smolt production.

If the sludge has low fertilizer effect, it is better to investigate whether its effectiveness can be increased through alternative treatment processes or be used in combination with mineral fertilizer.

“From a circular economy perspective, we should absolutely make use of fish sludge as a replacement for a smaller or larger proportion of mineral fertilizer, depending on its quality,” says Brod.



Goal: To contribute to the development of recycled fertilizer made from fish sludge, which could replace the use of mineral fertilizer in agriculture.

Collaboration: Norwegian University of Life Sciences, University of Copenhagen, Mowi, Sterner, Helgeland Smolt, Sævareid Fiskeanlegg, Norwegian Farmers Union, Norwegian Agricultural Extension Service and Grønn Gjødning

Funding: Research Council of Norway (HAVBRUK 2)

Contact: Research Scientist Eva Brod. Email: eva.brod@nibio.no, mobile: +47 902 77 760. Division of Environment and Natural Resources



Photo: Morten Günther

Cultural heritage vs. climate and tourism

Due to climate change and increased tourism, wooden cultural heritage sites are degrading more quickly than expected. Researchers are now investigating how tourism and climate affect vulnerable cultural heritage sites in Svalbard and on the Hardanger Plateau.

Although Svalbard is seen as one of Europe's last patches of wilderness, humans have been making their mark there for more than 400 years. Today, the archipelago is rich in cultural heritage sites testifying how whalers, miners, trappers and others exploited the natural resources of this harsh and barren landscape.

Traces of use allow us to understand and interpret the past and can help us to shape our own future. In Svalbard, all cultural sites dating from before 1946 are automatically protected and defined as cultural heritage sites. However, this protected status does not prevent wooden structures and building materials from degrading and breaking down.

The Arctic Alpine Decay project will investigate how climate change and increasing tourism are affecting cultural heritage sites made of wood in alpine and Arctic environments, to help ensure appropriate and

practical site management. The researchers will study cultural heritage sites in selected areas around Longyearbyen and Ny-Ålesund in Svalbard and around Finse, at the very north of the Hardanger Plateau. Sites here include old trapping facilities, mountain farms and cabins, as well as buildings and other structures such as snow fences and snow sheds connected to railroad operation.

NIBIO has unique expertise in wood-decay fungus in wooden buildings, the mechanisms of degradation associated with wood, and on the service life of wood in various applications. In particular, degradation due to the combination of wood-decay fungus and human impact will be studied. The researchers will also make use of knowledge of the attitudes and behaviors of various user groups in this innovative interdisciplinary work.



Goal: How does climate affect vulnerable cultural heritage sites in alpine and Arctic environments?
Collaboration: Norwegian Institute for Cultural Heritage Research, Mycoteam, Royal Danish Academy, Norwegian Directorate for Cultural Heritage, Kings Bay, Store Norske, Vestland County, The Norwegian Trekking Association
Funding: Research Council of Norway
Contact: Head of Department/ Head of Research Lone Ross. Email: lone.ross@nibio.no, mobile: +47 911 97 268. Division of Forest and Forest Resources



Photo: Inga Greipsland

New model changes erosion risk map

In 2021 NIBIO launched two erosion risk maps that show the estimated risk of sheet erosion and ephemeral gully erosion on agricultural land. The maps are based on a new model using local climate data.

Erosion can lead to topsoil losses from land to watercourses, which in turn can result in poor water quality due to accompanying nutrients in soil particles. Two new erosion risk maps divide agricultural land areas into different risk categories, so that farmers can implement measures where they are most needed.

The maps depict two different erosion processes: sheet erosion and ephemeral gully erosion, each with its own map.

When rainwater hits the ground, some of it is absorbed, some is used by plants, some evaporates, and some runs off on the surface. The surface water can carry soil particles with it. When this happens evenly across an entire area of land, it is called sheet erosion. Gully erosion is when the water begins to carve out hollows and depressions.

The model estimates annual soil loss per decare caused by sheet erosion. It also calculates where the risk of gully erosion is the greatest. The model is based on the best data sources available.

Detailed data regarding degree and length of slope is retrieved from a digital terrain model. Detailed information about soil quality is also included. Monthly runoff is simulated using daily local numbers for precipitation, air temperature and evaporation.

The new maps are currently the best basis we have for evaluating erosion risk on Norwegian agricultural land. Local assessment is important in order to consider factors that the model does not take into account.

The previous erosion risk map was the basis for grants through the regional environmental grant program (RMP). Based on the new maps, the Norwegian Agriculture Agency has created a special grant map that will be used for RMP in 2021. Both the grant map and the risk maps for sheet and gully erosion are available through NIBIO's map portal, kilden.nibio.no.



Goal: To update and improve erosion risk maps for planning purposes as well as for the calculation of grant funds.
Funding: Ministry of Agriculture and Food
Contact: Adviser Hege Ulfeng. Email: hege.ulfeng@nibio.no, mobile: +47 468 88 267. Division of Survey and Statistics



Photo: Solveig Kjølberg



Increased awareness of local self-sufficiency

The Competence Networks for Local Food (Kompetansenettverkene for lokalmat) provide food producers around the country with knowledge about local food production and traditional processing methods.

During the pandemic there has been increased interest in gardening, harvesting nature's resources and growing our own food. Frøydis Gillund, who leads the Competence Network in Northern Norway, believes we have become more aware of the importance of national self-sufficiency and food production all over the country.

The Competence Networks are divided into five regions: Eastern, Southern, Western, Central and Northern Norway. The target group is local food producers with less than 10 employees whose goal are to develop, process and sell high-quality products based on local resources.

"The purpose of my job is to strengthen local food production in the Arctic," explains Gillund. This means helping producers who want to learn how to process local resources.

The Network will also help to improve culinary expertise to ensure high quality and safe products within local food production.

It offers courses in subjects such as sausage making, cheese making and butchering. The producers can also receive a visit from a professional for guidance for their business. These are experts with in-depth knowledge of traditional processing methods for local resources.

"Consumer surveys show that people have a lot of confidence in Norwegian-produced food, and particularly Arctic food. Many have extremely high expectations of good quality and food safety as far as Arctic products go," says Gillund.

She believes these expectations may in part be due to the fact that northern farms are often smaller and have less animals. This creates an idea of the farmer having more time for each animal, thus being more able to ensure good quality and animal welfare. From a sustainability perspective, it also makes sense to have the opportunity to buy food produced in the region you live in.



- Goal:** The Competence Network in Northern Norway (Kompetansenettverket for lokalmat i nord) offers courses and guidance to help local food producers produce safe, high-quality food.
- Collaboration:** The other competence networks. See the shared website www.mathåndverk.no
- Funding:** Funds from the national budget (Agricultural Development Fund), commissioned by Troms og Finnmark County.
- Contact:** Senior Adviser Frøydis Gillund. Email: froydis.gillund@nibio.no, mobile: +47 948 62 225. Division of Food Production and Society



Photo: Ida Marie Skeie



The distinct flavour of Cider from Hardanger

Researchers are investigating which characteristics of apples are key to creating the desired flavour of cider from Hardanger. Yeast, sugar and acid – they all work together.

In 2009, “Cider from Hardanger” became a protected geographic designation, like sparkling wine from Champagne. Since then, the cider industry has virtually exploded. Researchers now aim to professionalize the cider industry.

The apples we eat should be crunchy and fresh-tasting, suitably sweet and tart. Some of the same qualities are important for cider production, wherein sugar and acid are the key common denominators.

NIBIO has identified factors that affect the flavour of pressed apples, in both unfermented apple juice and fermented cider. Ripeness is highly important because sugar content plays a large role. The sugar is converted into alcohol in the fermentation process.

Apples that contain a lot of sugar produce the best flavour and result in a rich cider. As the fruit ripens, starch is broken down into sugar. The time of harvesting is therefore crucial to the end product.

During ripening, the sugar content increases while the acid content decreases. There must be a balance between sugar and acid. The combination of sugar and acid in Norwegian apples produces the special flavour that characterizes Cider from Hardanger and other Norwegian ciders.

Phenols, too, have a substantial influence on colour and flavour qualities. Too few phenols produce a bland flavor, while excessive phenols result in too much astringency and bitterness. Phenol content will vary from year to year based on weather, harvest time, ripeness and various forms of stress. In addition, the apple variety and methods of cultivation, storage and pressing will affect the flavour.

Together, these are ingredients that contribute to good cider, but more knowledge is needed about how they work together in order to ensure controlled production and a high-quality end product.



Goal: The aim is to create a standard for cider production at every step, up to the finished cider – in other words, a protocol to ensure the quality of Cider from Hardanger.

Collaboration: University of Nova Gorica

Funding: Regionale forskingsfond Vestland

Contact: Research Scientist Ingunn Øvsthus. Email: ingunn.ovsthus@nibio.no, mobile: +47 482 07 250. Division of Food Production and Society



Photo: Dan Aamlid



Mapping the spruce bark beetle genome

The European spruce bark beetle can kill more than 100 million cubic meters of forest in a year. Now, researchers hope that a complete map of the beetle's genetic material will help limit its destructive potential.

In Norway, the European spruce bark beetle is the only insect that attacks and kills spruce trees on a large scale. Researchers from Norway, Sweden, Germany, and the Czech Republic have now, for the first time, succeeded in mapping the genetic material (the genome) of the European spruce bark beetle. In the long run, this information will help us understand how and why the beetle has become such a serious pest in our forests.

“The European spruce bark beetle has always been a major pest, but in recent years it has become more damaging than ever as it is killing millions of trees in Europe,” explains Paal Krokene, senior researcher at NIBIO and bark beetle expert.

“The fact that we have now succeeded in mapping the species' genetic material is a huge breakthrough, and something I have been dreaming of for years,” he says.

A genome can be likened to a genetic recipe book in which all the genes of a species are described.

Researchers can use this “recipe book” to understand how the European spruce bark beetle functions.

“Do the genes of the European spruce bark beetle conceal any interesting stories? The genome will help us answer that question. It is all a matter of knowing your enemy,” he explains.

The mapping is not only welcome news for the researchers:

“This is exciting and relevant research for forestry, both in terms of the industry and forest management,” says Ingrid Knotten Haugberg, senior adviser for the County Governor of Vestfold and Telemark.

The European spruce bark beetle is a major factor behind the forest damage suffered in Eastern Norway after the warm and dry summer of 2018. Bark beetle populations appear to be growing, and the County Governor's office is concerned that tree killings will increase in the years to come.



Goal: To map the genetic material (genome) of the European spruce bark beetle.

Collaboration: Researchers from several international universities and research institutes

Funding: Lund University, Sweden

Contact: Research Professor Paal Krokene. Email: paal.krokene@nibio.no, mobile: +47 995 16 013. Division of Biotechnology and Plant Health



Photo: Åge Nyborg



Why soil protection is vital

Soil protection is a matter of national food security, microbiology and carbon storage, climate adaptation and much more. Everything must be taken into account to ensure sustainable development.

In 2015 Norway's first soil protection strategy was adopted by the Storting. It was updated in June 2021. NIBIO was commissioned in advance to prepare a new knowledge base for the government's revision of the strategy. Updating facts and discussing connections between soil protection and sustainability were central to the task.

The goal of soil protection is to safeguard food security and the diverse functions of topsoil for the future.

"The UN's sustainability goals cannot be reached without stopping the degradation and loss of land used for food production. We should also produce more of our food in Norway, to improve our self-sufficiency" says Special Adviser Arne Bardalen of NIBIO. He led the work on the report *Reasons for Soil Protection*.

Soil protection entails protecting both land and the many functions of soil. Soil's ability to store water is one such function. It is weakened by the use of heavy

agricultural machinery. If the ground is covered with asphalt, there can be an increased risk of flooding as the water runs off the surface more quickly.

A quarter of the world's species are thought to live in the soil. Land degradation and loss harm biodiversity. Life forms in soil, as well soil's ability to store water and carbon, are of great importance to a soil's productivity and the farmer's yields.

Land degradation and loss impair food security in Norway, both now and in the future. Unfortunately, we are building down the land which has the best topsoil and climate.

By developing a sustainable food system based on optimal use of Norwegian resources to produce food for our own population, we are also in solidarity with people in countries where access to food is limited. This is sustainability at a local, national, and global level.



Goal: To develop a knowledge and decision-making base for Norway's soil protection strategy.
Funding: Ministry of Agriculture and Food
Contact: Special Adviser Arne Bardalen. Email: arne.bardalen@nibio.no, mobile: +47 480 67 328. Department of Research



Photo: Jan-Erik Thrane

Tributaries affect lake Mjøsa's water quality

The water quality of Norway's largest lake has been good for several years, but now action must be taken to prevent the ecological conditions in Lake Mjøsa from declining.

Despite significant improvement in water quality since the implementation of the "Mjøsa Action Plan" in the 1970s and 80s, the concentrations of nutrients in the lower parts of several of the tributaries are still too high. Nevertheless, Lake Mjøsa's ecological status has been good for several years.

In recent years, however, the water quality has declined. In Furnesfjorden, an arm of Lake Mjøsa, conditions are now in the "moderate quality" status.

In collaboration with NIVA, NIBIO prepared the report "Eutrophication of Lake Mjøsa. Investigation of causal relationships and sources of phosphorus in nine sub catchments" (in Norwegian).

"Among other things, we wanted to find out which sources affect Lake Mjøsa," says project manager and research professor at NIBIO, Marianne Bechmann.

The effect of potential measures to mitigate phosphorus loss has also been calculated.

Recommended mitigation measures

The researchers recommend improving unsatisfactory sewage treatment systems for more than 10,000 households, a renewal of old pipelines for sewage, and reducing overflows in municipal sewage treatment plants.

An important agricultural measure is to reduce the application of phosphorus to agricultural land, for example by using phosphorus-free mineral fertilizer and making use of all available areas on which animal manure can be spread.

In grain fields it is important to refrain from autumn ploughing in certain areas, and to establish grass-covered waterways and grass buffer zones. Establishing sedimentation ponds will also help to reduce the contribution of phosphorus into Lake Mjøsa.

NIBIO's calculations show that the sewage-related measures can reduce the contributions of phosphorus into Lake Mjøsa by at least six metric tons. The agricultural measures can result in a phosphorus reduction of approximately five metric tons.



Goal: Investigation of causal relationships and sources of phosphorus in nine sub catchments connected to Lake Mjøsa.
Collaboration: Norwegian Institute for Water Research (NIVA)
Funding: Vassdragsforbundet for Mjøsa med tilløpselver.
Contact: Research Professor Marianne Bechmann. Email: marianne.bechmann@nibio.no, mobile: +47 412 19 506.
Division of Environment and Natural Resources



Photo: Erling Fløistad



SYNOPSIS WEB Norway – a new environmental tool

All farmers must take environmental concerns into account when making pest management plans. SYNOPSIS WEB Norway is a map-based modeling tool for assessing the risk of crop protection strategies. Using this tool, the farmer can also see which measures will be most effective and document their assessments.

Norway's Regulations Concerning Pesticides require users to take into account the risk of unintended environmental effects. In integrated pest management, there is also a general requirement to choose products and methods that present the lowest possible risk to health and the environment. All professional farmers must justify and document the choices they make in a special pest management journal.

In the new tool, SYNOPSIS WEB Norway, these choices are now brought together.

“Here, the environmental impact of protection measures can be assessed along with site-specific information about soil and weather conditions and the characteristics of pest management products, for example degradation, sorption and transport in the soil,” explains Marianne Stenrød, department head at NIBIO.

This way, several different crop protection strategies can be compared, making it possible to choose the strategy with the lowest possible environmental risk.

The tool's model simulations make it possible to assess the effect of different measures to reduce the spread of plant protection products in the environment. Measures for reducing surface runoff, such as reduced tillage and vegetation zones, and measures for reducing drift can be simulated.

Because SYNOPSIS WEB Norway is linked to other data sources, the tool also provides useful information about topography, soil type and soil properties. This is important for identifying areas subject to surface runoff and calculating the distance to open water, which is critical to environmental risk in terms of pesticide drifting.



- Goal:** SYNOPSIS WEB Norway will help the adviser or farmer to make a site-specific risk assessment of a planned or implemented crop protection strategy. This will make it easier to take environmental concerns into account when developing pest management plans and to assess which measures will be most effective.
- Collaboration:** Julius Kühn-Institut (JKI) in Germany.
- Funding:** National Action Plan for sustainable use of pesticides (2016-2020)
- Contact:** Head of Department/Head of Research Marianne Stenrød. Email: marianne.stenrod@nibio.no, mobile: +47 482 97 607. Division of Biotechnology and Plant Health



Photo: Morten Günther



Popular technology day at Apelsvoll

Agriculture has undergone a tremendous technological development in recent decades. New agriculture technology is under continuous advancement, with the aim to increase profitability, ease farmers' daily life and reduce negative environmental and climate impacts.

In September 2021, 200 interested participants made their way to the "Technology Day at NIBIO Center for Precision Agriculture" at NIBIO Apelsvoll in Østre Toten, Norway.

The audience got to hear exciting presentations from researchers, businesses, and end users. After lunch they visited exhibits and stands and were given practical demonstrations of both drones and robots. Close to twenty different companies presented their products and services.

"I have been wanting to arrange this kind of event for several years," said Division Director Audun Korsæth at the opening of the event. "For various reasons, it has not been possible until now, but based on the support it received we hope this can become an annual event".

NIBIO has done research within precision agriculture since 2001, and the Center for Precision Agriculture was established in 2016.

"Our goal is to contribute to resource-efficient and sustainable agriculture by reducing the time it takes from when new technology is developed to when it benefits the farmer," says Kjersti Balke Hveem, the Center's director.

Bjørn Gimming, President of the Norwegian Farmers Union, says that new technology must benefit everyone, regardless of where in the country they operate. A key priority going forward will be targeting the produce industry.

"Our technology needs to be adapted so that it can be used in all villages, all types of production and all regions, while at the same time maintaining profitability. We must manage this in steep mountainside farms in Vestland and smaller farms in Northern Norway, as well as in areas with easier operating conditions," Gimming says.



Goal: To contribute to resource-efficient and sustainable agriculture by reducing the time it takes from when new technology is developed to when it benefits the farmer.

Funding: County Governor of Innlandet

Contact: Head of Department/Head of Research Kjersti Balke Hveem. Email: kjersti.balke.hveem@nibio.no, mobile: +47 976 25 157. Division of Food Production and Society



Photo: Hallvard Jensen

Anadromous Arctic charr as climate indicator

Northern populations of Arctic charr can be anadromous, migrating regularly to the ocean in search of food before it returns to freshwater to spawn. However, the species does not thrive in warm water. Researchers are now studying how the anadromous Arctic charr is adapting to higher water temperatures.

The Arctic charr is the world's northernmost freshwater fish, but part of the population (known as anadromous Arctic charr) migrates into salt water to increase growth. The Arctic charr does not like warmer waters, and when the temperature rises above 15 degrees °C it normally retreats in deeper and colder waters. The researchers at NIBIO, Naturtjenester i Nord and The Arctic University of Norway are studying how the anadromous Arctic charr is adapting to climate change and higher temperatures. Other topics being addressed by the project are infection rates of salmon lice, illegal fishing, habitat requirements, and influx of nutrients.

The anadromous Arctic charr usually migrates to the ocean during May for 20–60 days of feeding before returning to freshwater. During their time in the ocean, some individual fish can double their body-weight.

The life history of the Arctic charr is affected by the choices the individual fish makes throughout its lifetime. One decision is whether it will migrate to the sea or remain in the lake of its youth. While salmon can remain in the ocean for two or three years, the Arctic charr must spend time in freshwater every single year.

Fish researchers are asking themselves whether climate change and higher water temperatures will cause Arctic charr to choose a stationary rather than anadromous lifestyle. And to what extent this is determined by genetic or environmental factors – or perhaps both.

“As researchers of anadromous fish, we often talk about the Shakespeare-inspired and existential question: ‘To sea or not to sea.’ That is the question,” says NIBIO researcher Hallvard Jensen.



- Goal:** Will climate change and higher water temperatures affect the Arctic charr to choose a stationary rather than anadromous lifestyle?
- Collaboration:** The Arctic University of Norway (UiT), Naturtjenester i Nord and Laksvatn fiskelag.
- Funding:** Norwegian Environment Agency and the Tromsø Fram Centre's initiative “Fjord og Kyst” – an investigation into how climate change affects our northern and coastal fish populations.
- Contact:** Research Scientist Hallvard Jensen. Email: hallvard.jensen@nibio.no, mobile +47 406 30 796. Division of Forest and Forest Resources.



Photo: Roger Roseth

N-filter installed at waste rock landfill

As part of the construction of the E16 Bjørum-Skaret road, a pilot nitrogen (N) filter was installed at a waste rock landfill in Nordlandsdalen. The aim is to reduce the serious impact that nitrogen runoff from such landfills can have on the aquatic environment.

The Oslo Fjord is struggling with algal bloom and partial ecological collapse. In the media, agricultural runoff and sewage discharge take the blame. Another significant cause is runoff from landfills containing waste rock from tunnel blasting.

The explosive used to blast tunnels is a pumpable emulsion, which is mostly composed of the nitrogen compound ammonium nitrate, with 5–15 percent sodium nitrate.

“With about 2 million cubic meters of waste rock, there could theoretically be between 42 and 128 metric tons of nitrogen runoff from a landfill. Such large influxes of nitrogen are problematic for the Oslo Fjord, and can have negative effects on freshwater,” says Senior Researcher Roger Roseth.

As part of the ongoing E16 construction, there is now a full-scale treatment facility to remove nitrogen in runoff from a waste rock landfill in Nordlandsdalen.

The filter began operating in the Autumn of 2021, and it is the first and only one of its kind in Norway.

“The filter we constructed is based on a pilot model I had in my garden. It contains woodchips mixed with coarse shell sand to maintain a high pH,” says Roseth.

For the N-removal to work, it is important to have sufficient quantities of organic matter to create an oxygen-free environment. The bacteria will then use the oxygen from the nitrate to break down the organic matter, which will result in most of the nitrogen being released into the air as ordinary nitrogen gas instead of being carried along in the runoff.

“It remains to be seen if this will work on a large scale. The results from the pilot project are good, and preliminary results from the nitrogen filter are also promising,” says Roseth.



Goal: To reduce nitrogen runoff from landfills containing waste rock from tunnel construction.
Collaboration: Norwegian Public Roads Administration, Skanska and ViaNova
Funding: Norwegian Public Roads Administration
Contact: Senior Research Scientist Roger Roseth. Email: roger.roseth@nibio.no, mobile: +47 926 16 344. Division of Environment and Natural Resources



Photo: Komatsu Forest

Big data from harvesters

NIBIO's forest researchers are often told that the old volume models for calculating timber volume of standing trees are out of date. However, new measurements from modern harvesters show that the models are still reliable.

Today's volume functions are more than fifty years old, but after analyzing over 100,000 new measurements of stem volume retrieved from harvesters, NIBIO researchers have concluded that the old models still align with the actual timber volume – even in Trøndelag.

“This is good news for the forestry industry and means that the work done by forest researchers in the 1960s is still useful today,” says Research Professor Johannes Breidenbach.

The volume functions are used when people need estimates of how large Norway's timber resources are today, how large they will be in the future, where they should build wood processing mills, docks, roads etc. It is therefore critical that volume calculations used for inventory and harvesting plans are accurate – both for individual regions and for different types of forests.

The assumption that the volume functions are not adapted to mid-Norway has been an unconfirmed “truth” in forestry for a long time. NIBIO has therefore had a long-standing interest in examining the volume functions more closely.

However, it would require extensive manual labour to fell and measure all the trees needed to be able to provide a good estimate of the various tree species' growth and development. The solution was closer than one might have thought. Modern harvesters automatically measure the logs' length and diameter. In the past, this would have been a nearly impossible task, but now the automatic collection of volume data from harvesters makes it possible.

And even if the harvester's volume calculations are not always completely accurate, the large number of data points provides ample opportunity to discover regional variations in the trees' average form.



Goal: To validate the stem volume models of the 1960s with timber volume from 109,705 spruce stems measured by harvesters.

Collaboration: Forest owners' associations and machinery contractors

Funding: Utviklingsfondet, Skogtiltaksfondet and Research Council of Norway

Contact: Research Professor Johannes Breidenbach. Email: johannes.breidenbach@nibio.no, mobile +47 974 77 985. Division of Forest and Forest Resources.



Photo: Elise Krey Pedersen



Create your own wildflower meadow

Do you want to establish your own insect-friendly wildflower meadow with seeds from your neighborhood? NIBIO's new "Frøboka" (The Seed Book) will provide you with all the help you need.

Late summer to autumn is the time to collect seed from wildflowers. The Seed Book presents approximately 50 different wildflowers that all play an important role for pollinators.

The Seed Book gives a fascinating insight into the plants' biology, when they bloom and produce seeds, how they spread and which insects pollinate them. You can read about semi-natural grasslands and how to collect and dry different seeds. You will also get to know our most important groups of pollinators: bumblebees, wasps, flies, butterflies and bees. In addition, the book provides practical advice on how to establish and maintain your own wildflower meadow.

"In order to protect biodiversity, we must encourage denser networks of living and feeding stations for bumblebees and other insects that perform the important work of pollination," says researcher and editor Ellen Johanne Svalheim.

For the past three years, NIBIO Landvik has been selling wildflower seeds from southeastern Norway. The seeds are collected from various hayfields in the region, and later propagated at the research station in Grimstad. Now, seed blends from other regions have come onto the market or are on their way. However, demand for regional flower seeds is far greater than what NIBIO Landvik can provide. Thus, the idea was born for the Seed Book, which will allow people to create their own wildflower meadows.

Establishing a wildflower meadow is a long-term project that must be allowed to develop over time. You can transplant roadside wildflowers into the meadow, or find seeds from new species that you sow or grow plug plants from. Soon enough, butterflies, bumblebees and many other insects will appear.

"It is exciting, and everyone can contribute," Svalheim says.



- Goal:** To share practical knowledge that contributes to the restoration and creation of diverse wildflower meadows with good habitats for pollinators. This is part of the National Pollinator Strategy.
- Funding:** Sparebankstiftelsen, the Norwegian Agriculture Agency and the Ministry of Agriculture and Food
- Contact:** Research Scientist Ellen Johanne Svalheim. Email: ellen.svalheim@nibio.no, mobile: +47 452 10 350. Division of Food Production and Society



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.

www.nibio.no

Twitter: @NIBIO-no / Facebook: @Nibio.no / Instagram: @nibio_no
Search for NIBIO on LinkedIn and YouTube

