



NIBIO

NORWEGIAN INSTITUTE OF
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Green knowledge

37 examples from NIBIO's Activities in 2022



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Foreword

With its five specialized divisions, NIBIO possesses a distinctive expertise and specialist profile that aligns perfectly with the core principles of sustainability: knowledge about value creation, environmental science and resource management, as well as economics and social development. NIBIO also has a solid regional base with departments and specialists all over Norway. What is more, we are an important international player in what is defined as “the global grand challenges”.

Due to its comprehensive understanding of sustainability, NIBIO is exceptionally well-equipped to provide tangible and specific contributions to the concept. NIBIO’s readiness stems from its ability to incorporate and harmonize all three dimensions that constitute sustainability, giving it profound significance. Sustainability is increasingly about effectively managing a dynamic and long-term dilemma, where the main challenge lies in considering and balancing frequently conflicting considerations.

At any one time, NIBIO has around 1,500 projects on the go which contribute to the diversity of knowledge that is needed to manage this dilemma, give substance to sustainability, and identify solutions to specific specialist questions. The activities, each in their unique way, make significant contributions to knowledge in industry, management, and society at local, national, and international levels.

Of this huge multitude of projects, we have gathered 37 examples that provide insight into some of the many activities that take place at our 15 different premises located throughout Norway. We hope this serves as inspiration for you to explore further information regarding the exciting opportunities and significant challenges that we at NIBIO work with.

Enjoy your reading!

Nils Vagstad
CEO

This is NIBIO



Division of Food Production and Society

The division is the country's leading and largest research environment in the primary sector of Norwegian land-based food production, encompassing both natural and social science disciplines. Here, knowledge is developed on input factors, farming practices, environmental impacts, and yields in crop and livestock production for the benefit of management, industry, and society. Additionally, research and development at the intersection of the green and blue sectors, which is an area of growth within the division, are also conducted.



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. 711 (December 31, 2022)

Estimated turnover for 2022 was 865 mill.

Number of international projects: approx. 100, of which approx. half are EU or EEA (H2020, EØS, Era-net).

Present in all regions of Norway

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Photo: Erling Fløistad



Photo: Erling Fløistad

No great increase in forest harvesting

Several forest researchers reacted when the journal Nature published very surprising figures showing a dramatic and sudden increase in forest harvesting in Europe in 2016 – not least in Sweden and Finland. A new scientific study shows how the figures in Nature could be so wrong.

“We were very surprised. That such a big and sudden change could happen without anyone noticing was totally unexpected,” says Johannes Breidenbach, who was the lead author of the study.

“The EU’s forest policy should be based on accurate and reliable figures. I don’t think one should harvest more than is necessary, but one shouldn’t refer to figures that aren’t correct either.”

The article in Nature is based on satellite-based forest maps. Researchers from Norway, Sweden, Finland and Switzerland, combined the satellite-based maps with observations from the Swedish and Finnish national forest inventories. The national forest inventories are measurements of forests across the country and have been carried out for more than 100 years in Norway, Sweden and Finland.

Their results showed that the results in the Nature article could not be correct.

“The huge increase was quite simply a side effect caused by the method of identifying harvesting areas having improved since 2015,” explains Breidenbach.

The researchers compared the satellite maps with more than 120,000 forest observations, and the results showed that it was not the harvest rate that had increased, but rather the ability to detect harvests in satellite data. The measurements on the ground, in the forest, carried out by field workers of the Finnish and Swedish national forest inventories in the years before and after 2015 showed the actual harvesting, and it had not increased dramatically after 2015.

“Satellite images are a useful tool, but it’s always important to calibrate the satellite images with thorough reference data, ideally from the ground, in the forests where the trees grow,” concludes Breidenbach.



Purpose: An international research group with researchers from Norway, Sweden, Finland and Switzerland have combined satellite-based maps with observations from the Swedish and Finnish national forest inventories to investigate the claims of increased forest harvesting in Europe.

Collaboration: An international research group of researchers from Norway, Sweden, Finland and Switzerland

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Division of Forest and Forest Resources



Photo: Morten Günther



Resistance – also a challenge in Norway

Research shows that the level of resistance to pesticides in Norwegian agriculture is higher than previously assumed. This requires farmers to rely on alternative and integrated plant protection strategies to a greater extent to prevent resistance.

So far, pesticide resistance has been detected in around 30 important plant diseases, pests and weeds in Norway. The industry is continually reporting new suspected incidences of resistance, and there are fewer approved pesticides due to harmful side effects to the environment and humans. Furthermore, very few new chemical agents are being developed. Therefore, it is crucial to ensure that the chemical agents that are still available and remain effective when others are ineffective.

In the RESISTOPP project, researchers at NIBIO have looked at pesticide resistance under Norwegian climatic conditions. The results of the project show, that Norwegian agriculture has a bigger problem with resistance than previously assumed.

“It’s not just about resistance to individual compounds, but we have examples of fungi that are resistant to up to five or six different chemical groups,” explains Arne Stensvand, Head of RESISTOPP.

Other aims in the project have been to obtain more knowledge about good anti-resistance strategies, and knowledge about survival and adaptation of the resistant fungal strains, pests and weeds.

NIBIO has collaborated with the Norwegian Agricultural Extension Service, amongst other things to examine the prevalence of resistance in the grey mould fungus in Norwegian and foreign strawberry transplants. They discovered grey mould resistance in both, and some samples had 100 per cent resistance to several pesticides.

The researchers have also detected resistance to several so-called low-dose agents against eight different species of weeds.

Stensvand says that researchers, advisers and farmers stand united in their desire for a new development. Using pesticides is the final straw.



Purpose: Survey pesticide resistance under Norwegian climatic conditions, obtain information about survivability and adaptation of resistant plant pathogens, pests and weeds, and develop good anti-resistance strategies.

Collaboration: The Norwegian Agricultural Extension Service, farmers, pesticide companies and foreign research institutions

Funding: The Research Council of Norway

Contact: Research Professor Arne Stensvand. E-mail arne.stensvand@nibio.no, phone: +47 911 83 430. Division of Biotechnology and Plant Health



Photo: Stefano Puliti

SmartForest with AI in the cloud

Cloud technology provides new opportunities to process large amounts of data. Through the ForestSens cloud solution, artificial intelligence is being used to analyse large amounts of data throughout the forestry value chain – from planting and silviculture to harvesting and sawmills.

In the SmartForest project, researchers will use cloud technology from the IT company Oracle to make available an analysis tool for sensor data from the forest. Insights from collected data can help to provide better services and make it possible to resolve forestry tasks more efficiently with a higher level of quality than today.

“The results could be increased profitability in the forestry sector, reduced costs and less environmental impact,” explains Rasmus Astrup, head of SmartForest – centre for research-based innovation (SFI).

“In the SmartForest project we want to bring about a digital transformation in the forestry industry.”

The basis for such a transformation is the desire for more sustainable operations, increased competitiveness, and better efficiency in forestry operations. Large datasets and high-resolution images from drones and harvesting machines, among others, are

important tools in following the development in the forest. But analysing large datasets requires smart algorithms and powerful computer capacity.

The idea is to have a system that can receive images for example from different sensors mounted on drones, harvesting machines, vehicles and whatever is out in the forest. This information is sent to the cloud service and machine learning algorithms will then process the data and produce information that can be used in various forestry services.

This could be data that provides information for example about forest damage, forest road maintenance requirements, use of different forest processes, certification information, valuation, and environmental information.

“Overall, it’s about how we can manage our forests well,” concludes Astrup.



- Purpose:** Provide the forestry industry with knowledge on how new technology such as drones, remote sensing, machine data, robotics, blockchain and digital twin can be used to increase value creation and the environmental work in the Norwegian forestry sector.
- Collaboration:** The Norwegian University of Life Sciences, University of Oslo, three foreign research partners and several business partners from the Norwegian forestry industry
- Funding:** The Research Council of Norway
- Contact:** Head of Research Rasmus Astrup. E-mail: rasmus.astrup@nibio.no, phone: +47 941 51 660. Division of Forest and Forest Resources



Photo: Erling Fløistad



Smarter fertilising results in lower costs

In recent years fertiliser prices have risen dramatically. Each farmer must make use of good agronomy to keep the costs down and production up.

To take advantage of the yield potential in grain fields, it is important to make good use of mineral fertiliser and organic fertiliser in addition to crop rotation, integrated plant protection, good soil structure, the right pH, and the composition of topsoil.

NIBIO has investigated the effect of nitrogen on oats and barley by adding the entire amount of nitrogen in spring versus split application where some nitrogen is given in the spring and the rest as partial fertilising. The researchers recommend 8–9 kg of nitrogen per acres in the spring and the rest as partial fertilising. This makes it possible to adapt fertilising to the growing conditions beyond the season.

The results show a yield increase up to 12 kg of nitrogen per acres, but no noticeable yield increase when fertiliser amount increased to 16 kg nitrogen per acres. This means that 12 kg was enough, even at a yield level of over 600 kg of grain per acres. This

matches well with the fertiliser standards in NIBIO's fertilising handbook.

There are big savings to be made by taking advantage of the soil's stored phosphorus resources. If the soil is rich in nutrients and loamy, you can under-fertilise with phosphorus for a year. This is positive in terms of economy and the environment. At the same time, you should aim for a high humus content in the soil which provides good conditions for root growth and nutrient uptake.

NIBIO has also investigated organic waste to see how the nitrogen becomes available for the plants. The studies show that in solid waste the nitrogen was present in organic compounds, while as ammonia in liquid waste. The amount of nitrogen that is released from different types of waste varies considerably, but they all have in common that the rapidly available nitrogen fraction is released after 10–20 days.



- Purpose:** Prepare fertilising strategies to take advantage of the yield potential and achieve good quality in the products while also keeping the impact on the climate and environment as low as possible.
- Collaboration:** Several of the surveys were performed in collaboration with the Norwegian Agricultural Extension Service
- Funding:** The projects were funded by the Research Council of Norway (the Optikorn project), SIS funds, KU funds (Adapted fertilising) and Yara
- Contact:** Research Scientist Annbjørg Øverli Kristoffersen. E-mail: annbjorg.kristoffersen@nibio.no, phone: +47 406 30 331. Division of Food Production and Society

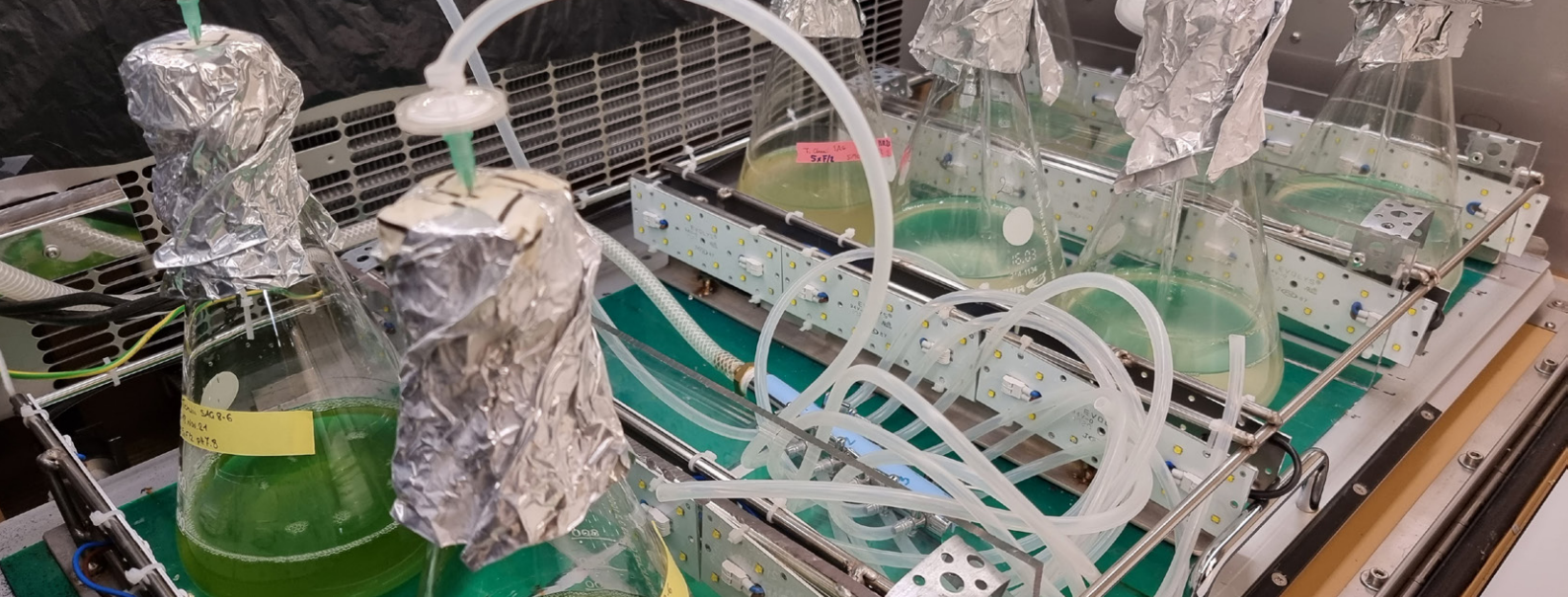


Photo: John Olav Oldertrøen

Green recycling of resources in wastewater

A combination of microalgae and bacteria can function as natural purifying agents for greywater. The resources from the organic material could also be recycled to be used as food and animal feed products in the future.

Untreated greywater contains nutrients such as nitrogen and phosphorous. This must be removed before the wastewater is released into circulation again to avoid eutrophication and disruption to watercourse and marine ecosystems. One way to do this is to employ nature's own mechanisms by letting microalgae do the work for us.

In the GRAALrecovery project, NIBIO and other institutions are studying the treatment of wastewater based on a patented system using algae granules. This results in more effective purification of greywater, costs are reduced, and resources are recycled.

“We initially identified the best algae for taking up nitrogen and phosphorous from greywater. We are now focusing on recycling bioresidue products, the other content of the biomass produced by microalgae and which are retrieved from the greywater,” explains Michal Sposób.

Sposób and colleague Ikumi Umetani have experimented with several different microalgae in various standardised wastewater samples and under different living and environmental conditions. They have also tested various concentrations and take ups of nutrients such as nitrogen and phosphorous, and looked at the composition of lipids, carbohydrates and proteins measured in the biomass.

Until now the researchers have discovered two species of microalgae that produce a lot of proteins in greywater. Over 70 per cent of the cells in these are proteins.

“Microalgae can produce chemical compounds that can be used in medicine, fertiliser and food. Nowadays using products created from greywater is prohibited, but in the future, algae could become a source of protein, carbohydrates, and lipids,” says Sposób.



Purpose: Treatment of wastewater based on a patented system using algae granules, and to investigate the potential for recycling resources.

Collaboration: ECOIND, The Norwegian University of Life Sciences, Valahia University Targoviste

Funding: EEA Grants/Norwegian Financial Mechanism 2014–2021

Contact: Research Scientist Ikumi Umetani. E-mail: ikumi.umetani@nibio.no, phone: +47 959 78 056. Division of Environment and Natural Resources



Photo: Morten Günther

National monitoring programme for soil health

Norway is finally following the EU in establishing a national monitoring programme for soil health.

The implementation of a monitoring programme for soil health in Norway was adopted by the parties in the Agricultural Settlement in 2022. The soil monitoring system will represent Norwegian arable land, i.e., cultivated soil, surface cultivated soil and infield pastureland. The EU has for some time had a monitoring programme for changes in the soil, Lucas Soil, which is a European system for monitoring soil health. Until now, we have not had any programme to regularly monitor the soil in Norway.

The main aim of establishing a soil monitoring system in Norway is to obtain information about the condition of Norwegian soil and its development for domestic use. Such updated information is a prerequisite for implementing measures and giving advice on agronomic practice in order to deal with the challenges as described by the IPCC.

“Information about the condition of the soil and its development is necessary for sustainable manage-

ment of the soil, and for sustainable agriculture,” explains Head of Department Siri Svendgård-Stokke.

“The soil is the basis for life on Earth and our food security. We’re almost the last in Europe to put in place a system, but this will be more comprehensive than the monitoring systems of our neighbours and will give Norway an international position in soil monitoring,” continues Svendgård-Stokke.

Most of our food comes from soil. That is why it is both important and timely that we set up a national programme for monitoring soil health. We will differentiate between natural conditions and those related to industrial processes and will focus on erosion, loss of organic material, loss of biodiversity, soil compaction and contamination. Within each of these areas there are many indicators, some of which require annual investigation, while many indicators only require investigating every nine years.



Purpose: The main aim of establishing a soil monitoring system in Norway is to obtain information about the condition of Norwegian soil and its development for domestic use.

Collaboration: LUCAS Soil

Funding: The Agricultural Settlement

Contact: Head of Department Siri Svendgård-Stokke. E-mail: siri.svendgard-stokke@nibio.no, phone: +47 478 14 011. Division of Survey and Statistics

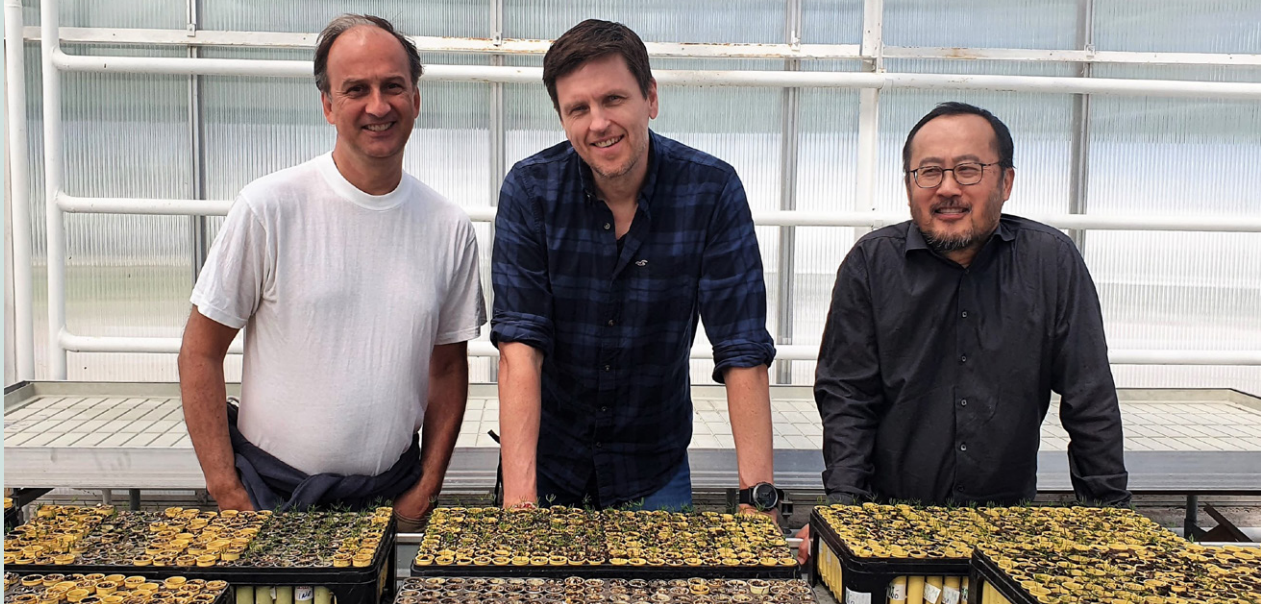


Photo: Siri Elise Dybdal



Natural bacteria against plant disease

Researchers from NIBIO and The Norwegian University of Life Sciences will use knowledge about natural bacterial to fight antibiotic-resistant bacterial and plant diseases in a new innovation company.

There is a great need for new alternative biological pesticides that do not develop resistance to chemical pesticides. Biological alternatives may also be important for animal and human health. Incorrect use of antibiotics has caused many bacteria to become resistant to the medicines that we rely on today.

Now biotech company, Agribiotix AS, will use many years of research in natural bacterial substances to develop alternative products to antibiotics and chemical pesticides in agriculture. The company's idea owners are researcher Tage Thorstensen, senior researcher Paal Krokene from NIBIO, and Professor Dzung B. Diep from The Norwegian University of Life Sciences.

The plan is to identify natural bacteria and peptides in lactic acid bacteria, soil bacteria and bacteria that lives naturally on plants. These will be used to develop new sustainable medicines for animals, and

prophylactic preparations and vaccines in animal and plant health.

“We know for example that probiotics are good for the gut and general health of people. This is also the case for plants and animals. In plants they live on and in the roots and help facilitate the take up of nutrients. They also make the plants able to withstand infections,” explains Thorstensen.

One focus area will be combating fungal and bacterial disease in plants biologically using bacteria and plant vaccines.

“We already have promising results against black rot and Rhizoctonia in potatoes and against grey mould on lettuce,” explains Thorstensen.

The researchers aim to reduce the need for chemical sprays and increase production capacity.



- Purpose:** To use many years of research to develop alternative products to antibiotics and chemical pesticides in agriculture.
- Collaboration:** Norwegian University of Life Sciences and Ard Innovation. The company has also been granted incubator status in Aggrator, the incubator company at Campus Ås
- Funding:** Commercialisation funding from the Research Council of Norway
- Contact:** Research Scientist Tage Thorstensen. E-mail: tage.thorstensen@nibio.no, phone: +47 402 00 909. Division of Biotechnology and Plant Health



Photo: Ragnar Våga Pedersen



Increased focus on Arctic agriculture

In this year's Agricultural Settlement, there was particular emphasis on the importance of sustainable agriculture in the north. The Centre for Arctic Agriculture has been given an important role in coordinating NIBIO's contribution to the investment in sustainable food production and value creation in the north.

Agriculture in northern Norway is a small, but important industry that contributes to housing, employment, value creation and an open cultural landscape in the region. An active agricultural industry throughout Norway is also an important foundation for national supply security.

In northern Norway we have the northernmost agriculture in the world. It takes place under special conditions with a lot of light and little heat. These conditions impose restrictions on what can be grown and the size of yields. However, it also allows for less use of chemical pesticides and provide a unique Arctic quality.

"Agriculture in the north is particularly vulnerable regarding competence and producer environments that are few and far between and vast transport distances. This makes it difficult to maintain agricultural activity in several areas," explains Head of the Centre for Arctic Agriculture at NIBIO, Marianne Vileid Uleberg.

The Centre was established at NIBIO in 2021. The aim is to provide knowledge and activities to support North Norwegian farmers.

This year's Agricultural Settlement emphasised the importance of strengthening the agricultural industry in the north. It will help to strengthen vulnerable producer environments in Nordland, Troms and Finnmark.

"The aim is to counteract decline, increase land use, increase competence in the agricultural industry and food value chain, and take advantage of regional assets and opportunities in Arctic agriculture," explains Uleberg.

The activities will be carried out in close collaboration with the agricultural industry, management and research institutions in northern Norway.



Purpose:	The Centre for Arctic Agriculture will provide knowledge and activities to support North Norwegian farmers. The centre will coordinate NIBIO's contribution to achieve the aims of the targeted initiative for agriculture in the north in the 2022 Agricultural Agreement.
Collaboration:	North Norway Agricultural Council, the county municipalities of Troms and Finnmark and Nordland, the County Governors, and other supporters of the agricultural industry in northern Norway
Funding:	The Centre for Arctic Agriculture is funded through NIBIO's basic grant. The targeted initiative for sustainable food production and value creation in the north is funded by the Agricultural Agreement
Contact:	Senior Adviser Marianne Vileid Uleberg. E-mail: marianne.uleberg@nibio.no , phone: +47 414 33 744. Division of Food Production and Society



Photo: Kathrine Torday Gulden

Waste wood into new products

With the help of Ragn-Sells, NIBIO and the Norwegian Institute of Wood Technology are investigating the quality and volume of that arrives at recycling stations. The aim is to find out how much of the waste wood could be reused to make new products.

At Ragn-Sells waste disposal and recycling plant in Moss, there is much activity underway. Enormous containerloads of waste wood are emptied into a gigantic heap which wheel loaders divide into several smaller piles. Plant workers, researchers, students and advisers are hurrying back and forth, picking up bits of wood, sorting, analysing and weighing before the majority of it is eventually made into chips for energy.

According to Lone Ross, Head of the CircWOOD project, around ninety per cent of the wood waste was used for energy in 2020.

In light of the huge volumes of wood that are used and thrown away here in Norway, the researchers want to find out how much of it could be reused, i.e., included in new products.

CircWOOD will study different aspects of wood use in the Norwegian economy. The project will have a particular emphasis on the use of reclaimed wood from building projects, and recycled wood as raw materials in today's timber industry. The environmental and climatic impact of the timber industry's value chain will be analysed based on strategies and new technologies that will contribute to circularity. In addition, the project will follow the life cycle of Norwegian wood material and find new ways to use this resource efficiently.

The research results, related to resource access and material flows, will be linked to the facilitation of circular and digital flow of goods, handling, environmental impact, design and production of wood in, and towards, relevant markets nationally and abroad.



Purpose: Increase reuse of waste wood into new products.

Collaboration: NTNU, The Norwegian University of Life Sciences, Inland Norway University of Applied Sciences, Norwegian Institute of Wood Technology, Trefokus, Ragn-Sells, Oslo tre, Norwegian Wood Cluster, Omtre, Norwegian Forest Owners Association, Veidekke Entreprenør, the Norwegian Directorate of Public Construction and Property and Construction Products Norway. The CircWOOD research project is part of the SirkTre Green Platform project

Funding: The Research Council of Norway

Contact: Head of Division/Head of Research Lone Ross. E-mail: lone.ross@nibio.no, phone: +47 911 97 268. Division of Forest and Forest Resources



Photo: Malin Larsen Græsdahl



Precision fertilisation and battery tractor

In the SolarFarm project, researchers have looked at how we can make better use of nitrogen fertiliser and reduce diesel consumption in Norwegian farming. Solar energy can power electric and partly autonomous vehicles in precision agriculture with reduced greenhouse gas emissions.

Fertilisation is currently performed mostly uniformly in a field, regardless of the nutritional requirements of the individual plant. By using drones equipped with hyperspectral cameras, it is possible to collect detailed information about the plants' nitrogen uptake during the growth season. Based on this, you can create a split fertilisation recommendation that is translated to the tractor and fertiliser spreader.

The researchers of SolarFarm have tested the split fertilisation concept with variable rate fertiliser distribution with high precision down to the square metre level. They have developed a fertiliser spreader for liquid mineral fertiliser and carried out a series of field tests on wheat and barley. The aim is to provide each plant with precisely as much nitrogen as it needs, and for the technology to make it possible to distribute fertiliser more efficiently.

Starting with 16 different farms in different locations nationwide, the researchers have also investigated how diesel consumption can be reduced.

Today's modern tractors are too big and energy-intensive to replace a large diesel engine with an equivalent electric tractor using current technology. The researchers have therefore looked at the possibility of using several smaller electric tractors. The idea is to have a manned tractor and two self-driving ones that work in tandem.

In the project the researchers have shown that it is possible to change the energy source, and that it results in reduced greenhouse gas emissions. However, the practical application of this is a little way off. The major challenges are the lack of powerful, small autonomous electric tractors, and storage capacities for self-produced energy. .



Purpose: Investigate how solar energy produced on the farm can operate electric and partly autonomous vehicles in precision agriculture with reduced greenhouse gas emissions.

Collaboration: Institute of Energy Technology (IFE), University of LeHavre, University of Stuttgart and Adigo AS

Funding: The Research Council of Norway

Contact: Research Scientist Jakob Geipel. E-mail: jakob.geipel@nibio.no, phone: +47 915 66 289. Division of Food Production and Society



Photo: Erling Fløistad



Eelgrass disease along the Norwegian coast

Eelgrasses are very important ecosystems for many marine species including coastal cod. When the eelgrass is damaged, cod and many other species are affected. Eelgrass is damaged by coastal zone expansion and pollution but is also vulnerable to disease.

Eelgrasses (*Zostera* spp.) are perennial, flowering plants that grow on the soft seabed along the coast. They form large meadows which are important ecosystems and habitats for many marine species. Eelgrass is common along the entire Norwegian coastline but unfortunately, we are seeing a global trend of reduced eel grass populations.

Since 2018 Venche Talgø and colleagues have detected several possible pathogenic species of *Phytophthora* and *Halophytophthora* in eelgrass along the Norwegian coast. It is uncertain how many of these species contribute to the decline of eelgrass, and further research is needed.

Because *Phytophthora* and related species often cause severe diseases in terrestrial plants, there is reason to suspect that these species are causing the diseases we are seeing in eelgrass along the Norwegian coast. The diseases manifest as dark spots with dead tissue on the foliage and decay of the roots.

Isolates from diseased eelgrass have been cultivated and the species identified using DNA analyses at NIBIO. Two *Halophytophthora* species and three *Phytophthora* species have now been found, and four of these species were previously not detected in Norway.

To prove that the isolated species are harmful to eelgrass, infection tests must be performed on healthy plants. In the Netherlands, Sweden and Denmark, where similar *Phytophthora* species have been detected, it has not been possible to find healthy eelgrass for such tests to be carried out.

“We know a location in Vestlandet with an apparently healthy eelgrass population,” Talgø explains. We are hoping that we can use seeds or plants from there in infection tests. Extended mapping to establish the disease status of eelgrass in Norway should also be performed.



Purpose: Investigate the plant health status of eelgrass as a possible reason for the destruction of marine environments.

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



Photo: Ragnar Våga Pedersen



New digital plant health service in Malawi

NIBIO will lead an international project in Malawi worth NOK 50 million. The project will establish a digital plant health service which will give farmers a tool for targeted and effective management of pests and disease, increased yields and reduce the need for pesticides.

Various digital systems have been developed to identify, monitor, administer, control and predict the outbreak of pests and diseases. These provide useful information that can help in making decisions and adapting integrated strategies for combating pests.

An international collaborative effort led by NIBIO, *Malawi Digital Plant Health Service with National Public Ownership (MaDiPHS)*, will now build on the development and data from such systems. The aim is to create a joint international platform that will be able to provide data to national digital services. The VIPS technology platform, developed by NIBIO, is one such system that will be integrated into the service.

Malawi, in south-eastern Africa, is greatly dependent on natural irrigated farming – 80 per cent of the population is involved in smallholdings or subsistence farming.

The country is periodically affected by food shortages due, among other things, to drought, floods, limited access to modern technology, poor infrastructure, diseases and, recently, infestations from pests such as the Fall Armyworm (FAW).

“In 2020, a FAW infestation resulted in the loss of more than 150,000 hectares of maize fields, and because maize is the main crop, thousands of families were in danger of starvation,” explains Karl Thunes, researcher at NIBIO, and project lead.

FAW and maize have been chosen as the first pest and product. The service will also be expanded to include information and tools related to other destructive pests and diseases that affect products relevant to Malawi farming.

The locally adapted service will be owned and administered by Malawi authorities.



- Purpose:** To establish a digital plant health service for farming in Malawi, which will give farmers a tool for targeted and effective management of pests and diseases, increase yields and reduce the need for pesticides.
- Collaboration:** The Norwegian Meteorological Institute, several international research institutions and Malawi authorities
- Funding:** NORAD
- Contact:** Research Scientist Karl Thunes. E-mail: karl.thunes@nibio.no, phone: + 47 456 00 856. Division of Biotechnology and Plant Health



Photo: Anette Tjomsland Spilling



Targeted use of biochar is essential

Biochar has many positive qualities that make it a potentially important tool for carbon neutral farming systems. However, according to one researcher, it is important to target the application to achieve the desired effect.

Charred biomass in the form of Biochar can help to improve the soil quality and reduce greenhouse gas emissions when added to the soil. Unlike untreated organic material such as leaves or compost, Biochar remains largely in the soil. This is because the biochar has a chemical structure that makes it hard for micro-organisms to break it down.

The carbon, of which the biochar is made, is therefore not released as carbon dioxide into the atmosphere, but instead helps to increase the carbon content of the soil.

In his doctorate (PhD), Simon Weldon investigated how biochar might be used to improve nitrogen use by retaining more mineral nitrogen and reducing nitrous oxide (N₂O) emissions in compost and soil.

He discovered, among other things, that biochar that is produced at high temperatures contributes the most to reducing N₂O emissions.

He also discovered that the ability of fresh biochar to store nitrogen is limited, something that may have significance for the production of biochar-enriched fertiliser.

“Our results both confirm and challenge existing knowledge on biochar function. We argued that production and application of Biochar needs to be targeted to maximise the potential benefits across a range of soil types, climates and applications,” explains Weldon.

Nevertheless, he is clear that biochar is a valuable technology for the future bioeconomy.

“Biochar clearly has the potential to reduce greenhouse gas emissions from both compost and soil. It is also one of the few effective measures we have to increase soil carbon while also reducing N₂O emissions.” he says.

It is important to be realistic about biochar so that the technology finds the most economic and effective use.



Purpose: Investigate to what extent Biochar can help to reduce nitrous oxide emissions while also maintaining the content of mineral nitrogen in soil and compost (PhD).
Collaboration: Norwegian University of Life Sciences
Funding: Foundation Fund for Soil and Peat Research and The Research Council of Norway
Contact: Research Scientist Simon Weldon. E-mail: simon.weldon@nibio.no, phone: +47 407 69 197. Division of Environment and Natural Resources



Photo: Lars Sandved Dalen



Climate advice as a tool in agriculture

Climate advice by the Norwegian agricultural extension service has been introduced to make climate-relevant knowledge available to Norwegian farmers. The pilot scheme will also encourage them to take climate measures. But what exactly do the farmers think about the advice?

On the initiative of parties to the agricultural settlement, the Norwegian Agricultural Extension Service and TINE have developed a special offering on climate advice aimed at farmers. They have also trained climate advisers throughout Norway. The idea behind the pilot scheme, which lasts until 2024, is that it should be possible for Norwegian farmers to apply for environmental subsidies on the back of receiving climate advice and an action plan from an approved adviser.

But one question remains: How widely will this service reach in practice, in its current form?

The project *Climate advice as a reorganisation tool in agriculture* aims to provide the most accurate climate advice offering possible that will reach as many farmers as possible. Some of what the project will investigate is which farmers use the advice, and what are their motivation for applying for climate advice and implementing climate measures in their

own farming systems. The advisers' strategies for successful climate advice will also be investigated.

– “Owing to the acute nature of the climate issue, it is necessary to perform a prompt assessment of how the climate advice is received and used by Norwegian farmers,” says project manager Kamilla Skaalsveen.

By coordinating this initiative with relevant projects and actors, such as Climate Smart Agriculture, the hope is to be able to contribute to optimising the climate advice as a reorganisation tool in agriculture.

The results from the project will help raise awareness of the measures that can be taken to increase the impact area of the work associated with climate advice and climate planning. This will provide more knowledge of the climate challenges facing agriculture and will be useful in relation to revising the pilot scheme in 2024.



Purpose: Revising the climate advice pilot scheme as a reorganisation tool in agriculture.
Collaboration: Ruralis
Funding: The Norwegian Agriculture Agency
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Photo: Yngve Rekdal

Room for more grazing animals in outfields

Norway has limited topsoil, but large areas with little used outfield grazing land of good quality. If the resources are not used, the quality will be reduced. It will have direct consequences for food security.

“We must have agriculture that takes advantage of the local resource basis, and we have to eat what the land can produce. Outfield grazing land can be converted to human food and fibre by ruminants, but the grazing pressure is too low. This leads to overgrowth and loss of productivity, cultural landscape and biodiversity associated with outfields,” explains Yngve Rekdal of NIBIO.

In the report entitled “Land audit of outfields and outfield grazing land – resource basis and grazing” you can read that the total use of outfield grazing in Norway is 45 per cent. There are therefore plenty of resources for more livestock in outfields in most counties.

A hundred years ago there was a flow of energy and protein from outfields to farms. In modern industrial agriculture, it is possible to cultivate in a concentrated way on less land. A consequence of this is that producing feed from outfields has reduced consider-

ably, but outfields are still an important resource as summer pastures.

In the last 30 years, the total number of animals in outfields has remained somewhat stable. Around 46 per cent of Norwegian farming businesses release animals into outfields. The highest percentage-wise is the former Hordaland council with 73 per cent, Sogn and Fjordane and Troms both with 72 per cent, while Østfold is the lowest with just seven per cent of farming businesses. It shows that outfields are much more important in councils with the most livestock and more grass production.

“Outfield grazing can be achieved with good results on most Norwegian outfield land. The challenge is to adapt the operation to the resources that are available. In fairly lean areas it is especially important to adapt the number of livestock and find the best areas,” concludes Yngve Rekdal.



Purpose: The established land audit of outfields (AR18x18) is based on a national sample survey of land cover. Data is presented for the whole country and in reports by country.

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Photo: Ragnar Våga Pedersen

Nobody knows how much farmers earn

If you are employed, it's not difficult to find out how much you earn. But if you are a farmer, the “salary” is not easy to work out. So how can we manage to compare the income of farmers and salaried employees?

This is what the so-called “Income Calculation Committee”, or Grytten committee, is trying to uncover. Ola Honningdal Grytten chaired the Committee, and its report was published October 2022: NOU 2022:14 “Income measurement in agriculture”, or the “Grytten report”.

The Committee was established because the Norwegian Parliament and Government wanted to increase food production at a time of both political unrest and unstable climate. In which case we must have farmers with an income that means they can and want to continue working.

Calculating an average net income for Norwegian farmers has proved to be easier said than done. That is because there is a lot of variety among Norway's more than 38,000 farmers.

The Grytten report shows that almost half of Norwegian farmers receive less than 10 per cent of their total income from farming. A third have negative or no net income from farming. Just a

quarter of Norwegian farmers receive more than half of their income from farming.

If you look at different productions, major horticultural crop producers do well, while many of those who farm with sheep, suckling cows and corn have lower incomes.

Lars Johan Rustad is head of NIBIO's division of agricultural economics. He has been involved in the Committee Secretary. He has also been the link between the Committee and NIBIO's expertise in agricultural economics.

Rustad explains that the Committee is proposing a model for calculating net income that they call the Hybrid Model. According to this model, the average income for the upper half to a third of Norwegian farmers is NOK 518,000. The final decision on how farmers' incomes will be measured will be taken by the Norwegian Parliament following a consultation period.



Purpose: Calculation of farmers' incomes as a basis for comparing with salary income of other social groups.

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Photo: Line Johansen



Will restore threatened habitats

Many habitats in the agricultural landscape have high levels of biodiversity and are important for the world's food production. Several such semi-natural habitats are now threatened across large parts of Europe, and NIBIO will find new restoration solutions.

Semi-natural habitats have been formed through extensive management such as making hay, grazing and burning heather. We have now lost so many of these species-rich habitats that it is no longer enough to take care of the land that is left. The destruction must now be reversed, and the land restored.

Ecological restoration means recreating an ecosystem that has been changed, damaged or destroyed, and to help return it to its original condition. Restoring an entire ecosystem is very complicated and involves more than just bringing back plants. However, through proper management, researchers think that habitats can be given a second chance.

In the RESTORE project, the researchers are developing tools to assess the potential for and the effect of restoring selected habitats including semi-natural meadow, semi-natural marsh and coastal heathland.

– “We will tailor measures for each area to restore the desired habitat,” explains project lead Line Johansen.

For example, this could be recreating coastal heathland on a wind farm. This is an extensive restoration where it may be necessary to change the soil and sow different types of seeds. In other places the challenge could be encroachment, and an appropriate measure there would be to remove forest.

The researchers will identify the extent to which a habitat can be destroyed and yet still be restored. The hypothesis is that the potential for restoration is great. Even severely degraded areas can regain their original ecosystems. But it relies on the restoration being followed up with extensive management.

– “The aim is to make it possible for anyone to use the tool who wants to help restore semi-natural ecosystems,” says Johansen.



Purpose: In the RESTORE project, the researchers will develop a tool that assesses the potential for restoring selected habitats, as well as the effect of the restoration.

Collaboration: Møreforskning, Ruralis, NTNU, Multiconsult, the Norwegian Environment Agency, SNO, Country Governor of Trøndelag and University of Tartu

Funding: The Research Council of Norway

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Photo: Oskar Puschmann



Low concentrations of glyphosate in streams

Results from monitoring of the pesticide glyphosate in agricultural streams performed by NIBIO, show no basis to say that drainage from glyphosate to the surface water will result in negative environmental effects in Norway

Potential negative environmental consequences from widespread use of glyphosate have been a talking point in recent years. The EU is now assessing whether to phase out the pesticide.

A report from NIBIO highlights connections between environmental concentrations of glyphosate in areas' agricultural streams and factors that affect the concentrations, such as weather conditions and operational and spraying practices. The study is focused on two agricultural catchments dominated by cereal production included in the national monitoring programme JOVA in the periods 1997–2000/2001 and 2016–2018. Glyphosate is used annually in these areas to control weeds.

“Through JOVA we now have over 25 years of monitoring data from the field. This means that we have the data which show the pesticide levels in agricultural streams over long periods,” explains Marianne Stenrød, Director of Division of Biotechnology and Plant Health at NIBIO.

“The monitoring data for glyphosate show low concentrations in relation to the environmental toxicity of this substance, and we do not expect these levels to cause any negative environmental effects,” says Stenrød.

The main findings were that glyphosate persists longer in the Norwegian environment than previously assumed, and that the substance has been detected in most water samples that have been analysed in agricultural areas where the agent is used regularly over larger areas. But these also showed that the concentrations are mainly low.

“The current practice therefore does not pose a hazard to the water environment,” concludes Stenrød.



Purpose: Understanding and knowledge of which factors affect detected concentrations of glyphosate in the water environment in order to provide recommendations for sustainable agricultural activity.

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Photo: Ragnar Våga Pedersen



Nordic freshwaters and bioeconomy

How will the green transition change the land use in rural districts in the Nordic countries? And what consequences will this have for our water systems and the benefits we enjoy from clean water?

Biowater is a Nordic centre of excellence within bioeconomy that aims to find solutions to the management of land, the environment and water resources when Nordic countries implement the green shift.

Together with partners in agriculture, forestry, non-profit organisations and public administration, the researchers have mapped how the bioeconomy will develop in five scenarios. The scenarios are possible main directions for the future and build on what is known internationally as “Shared Socioeconomic Pathways”, translated into Nordic Bioeconomy Pathways.

“Our results show that if the bioeconomy does not develop in a sustainable manner, the impact of the bioeconomy on the rural landscape, in combination with expected climate change, will have serious negative consequences for our freshwater resources and society,” explains Biowater’s Project Lead Eva Skarbøvik.

It is a stated aim that food production in Norway must increase at the same rate as the population trend. This must either happen by intensifying production, or by cultivating new land.

Both will have an impact on the water environment. Agriculture must have nutrients for growing crops, but nutrients that end up in the water systems can lead to toxic algal blooms.

If there will also be increased deforestation followed by soil erosion and loss of nutrients, it could be very challenging for the water systems.

“That is why it is tremendously important to make increased efforts concerning environmental measures,” says Skarbøvik. “The advantage of working with these issues across the Nordic countries is that we learn from each other, including experiences on the effects on water quality and biology of different agricultural and forestry management practices, and environmental mitigation measures.”



Purpose: Integration of land and water management for a sustainable Nordic bioeconomy.

Collaboration: Biowater (2017–2022) is managed by NIBIO and the Norwegian University of Life Sciences and consists of a total of eight Nordic and three non-Nordic R&D institutions. Stakeholders in relevant business and management are also affiliated with the centre.

Funding: NordForsk

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Photo: Wendy Fjellstad

Do you live in an edible city?

Two hundred years ago, it was common in Christiania (now: Oslo) to grow your own vegetables and keep a few animals. Cows, horses, pigs and chickens were commonplace in backyards in the city centre. These days, agriculture is returning to the capital, but in a slightly different way.

All over the world it is becoming more and more common (again) to grow food in towns and cities. This is often referred to as “urban agriculture”. A major EU Innovation Action, the Edible Cities Network (EdiCitNet), connects initiatives from different cities. Front runner cities pave the way for follower cities. They can learn from each other and spread their knowledge and experiences.

Urban agriculture has much to offer towns and cities that face major societal challenges. It is not just about producing your own food but also about community, integration, work training, biodiversity, flood prevention and much more. The project will help to put into use and spread existing knowledge.

Oslo is a front runner city in EdiCitNet, with a “Living Lab” where various kinds of urban agriculture are tested and monitored. Work training and social integration are central.

The Living Lab was established on an area of former farmland at Linderud Manor, made available by Museums in Akershus. After major investments and joint efforts from different actors, Linderud neighbourhood and community garden was opened in 2020.

Here, you can learn about entrepreneurship by starting a market garden, take part in community supported agriculture, learn about soil improvement, regenerative farming, and how to attract pollinators like bumblebees to the garden. Communal meals are arranged, and locally grown food is sold on market days.

NIBIO is helping the front runner cities to document and monitor their projects using selected indicators, as well as developing an online platform where urban farmers and gardeners from “edible cities” all over the world can share knowledge and inspiration.



- Purpose:** Share knowledge about urban agriculture across national borders and continents.
- Collaboration:** The project is coordinated by the Humboldt University of Berlin. Other Norwegian partners are: The City of Oslo (Agency for Urban Environment), Nabolagshager AS and OsloMet (Work Research Institute)
- Funding:** The project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No. 776665.
- Contact:** Research Professor Sebastian Eiter. E-mail: sebastian.eiter@nibio.no, phone: +47 974 81 109. Division of Survey and Statistics



Photo: Erling Fløistad / OrtoPhoto: © Geovekst

Drawing the boundaries of agricultural land

The boundaries of Norwegian agricultural land resources are regularly updated by twelve geodata workers at NIBIO. The work they do is hugely important for both individuals, agricultural management and for national soil preservation.

NIBIO is the responsible authority for Norway's land resource map for agriculture and forestry (AR5).

In maintaining the AR5 map NIBIO work closely with the municipal agricultural offices. The municipalities update the map *continuously*, while NIBIO is responsible for *periodic updating*, which is performed every five to eight years.

It is difficult for the municipalities to keep track of all the changes that take place. In addition, it is very important that a neutral authority has overall responsibility. NIBIO uses the same criteria for the whole country and therefore local preferences and considerations will not affect the map.

There are many reasons why it is important that the map is as accurate as possible. Most importantly, the AR5 map is the basis for controlling the allocation of land subsidies that farmers receive from the authorities. That is why it is critical that the map matches the terrain.

The map is also the basis for national statistics. AR5 makes it possible for us to know that 3.5 per cent, or approx. 1,135,000 hectares, of Norway consists of agricultural land. The total agricultural area has been quite stable for several decades, but AR5 shows that the proportion of pasture is increasing while the proportion of cultivated land is decreasing.

Finally, the AR5 map is hugely important for soil preservation. The land that is classified as agricultural land in AR5 is protected by the Norwegian Land Act. The Norwegian Land Act states that it is prohibited to use agricultural land for purposes other than agricultural production.

Work is constantly being done to develop effective and safe methods to make the map even better. Updating AR5 is one of the tools society can use to take good care of Norway's agricultural land.



Purpose: NIBIO has the professional responsibility for updating the AR5 map. It is very important for the management of agricultural land that AR5 is kept updated in a standardised way and in accordance with the classification system.

Collaboration: Geovekst partnership

Funding: Geovekst

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Photo: Yngve Rekdal



Will make European milk more sustainable

It is estimated that greenhouse gas emissions from beef and dairy farming represents around 14.5 per cent of global greenhouse gas emissions. In a new international research project, European milk production will be made more sustainable.

The Norwegian dairy industry is already very sustainable, especially as farmyard manure and feed resources from cultivated land as well as rangeland are used optimally. Nevertheless, there is a desire from a business management point of view to reduce greenhouse gas emissions. Utilising less imported concentrate feed and mineral fertiliser, will not only save money but also CO₂ equivalents.

In the DairyMix project, the researchers are collecting large amounts of data from dairy producers across Europe. This is mainly information about environmental, economic and social input factors gathered through interviews and farm visits. Data from sensors that measure greenhouse gases in cowsheds, will add to the complete database that shows how specific measures work on livestock of various sizes in different regions.

European milk production covers a wide range of climates and weather conditions as well as many different farm sizes and production systems, not to

mention a range of different traditions. In Norway the researchers have selected six representative focus farms. Production data, soil and crop data, finances and data of a more sociological nature are collected from here. Calculations and modelling are then performed. After a comprehensive life cycle analysis, the so-called decision support tool will finally see the light of day.

This decision support tool will enable the producers to make sustainable decisions for their dairy enterprises. If such a tool is to work in practice, it must have a good foundation in the practical day-to-day work of the industry.

For example, we will be able to see how changing the cows' feed additives might result in more sustainable production. The differences in European milk production are too great to generate a one-size-fits-all formula. But the larger the dataset, the more variation in production system the database will cover.



Purpose: DairyMix aims to develop a large database that will become a decision support tool for sustainable milk production in Europe, and with a particular emphasis on greenhouse gas emissions.

Collaboration: A total of 10 countries are participating in the project: Germany (ATB), Ireland (TEAGASC + UCD), Italy (UMIL), Poland (UZ), France (INRAE), Norway (NIBIO + RURALIS), Belgium (ILVO) and Argentina (INTA).

Funding: The project is funded in a joint announcement through ERA-NET's SusAn (Sustainable Animal Production Systems), FACCE ERA-GAS (Monitoring and Mitigation of Greenhouse Gases from Agriculture and Silviculture) and ICT-AGRI-FOOD and SusCrop (Sustainable Crop Production). The Norwegian funds are administered through the Research Council of Norway

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Photo: Morten Günther



Increased yield from farming's factor inputs

The global population is increasing, meanwhile political instability and ongoing climate change is negatively affecting many of the major agricultural areas. There is a need to double global food production by 2050. The problem is that farmers find themselves at the top of the cost chain but at the bottom of the value chain.

In Norway we have a target to increase food production by 20 per cent by 2030. However, there is currently major economic pressure and high prices in the world market. This is a challenge, as all cost changes we are seeing in society terminate with farmers.

The prices of factor inputs such as mineral fertiliser, plastic, diesel and power are going up, while the income from production is staying the same. This is not sustainable for Norwegian food production. When the price of factor inputs is higher than the value of yields, the factor inputs must be better utilised to achieve higher yields.

A yield gap is the difference between the yield potential and the yield that is actually harvested. An achievable yield potential is generally approx. 80 per cent of the theoretical yield potential.

Research shows that it is possible to increase Norwegian yields on existing land by up to 30 per cent. This means that our farming is currently not managing to utilise the factor inputs as well as we should. To achieve increased yields, we can expand the farming land or increase the yields on existing land. The challenge will be to make better use of fertiliser, diesel and pesticides.

Optimal fertilising is about adapting the nutritional supply to the needs of the crops. Optimally, you should then perform variable fertilising in shifts. Ideally this means that each individual crop receives the exact amount of fertiliser that it needs.

Technological tools that will help to improve the use of farming factor inputs for more sustainable precision farming are constantly being developed.



Purpose: Better use of the farming factor inputs to increase the yields and save both money and the environment.

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Photo: Steinar Johansen/Statskog

More timber and less damage to nature

New research from the Horizon 2020 project TECH4EFFECT, led by NIBIO, has made European forestry operations more productive, and with less damage to terrain from logging machines.

Together with Norskog and Statskog in Norway, researchers from NIBIO and 21 other institutions have developed new knowledge and technology that will revolutionise the way logging is operated in Europe. Unlike oil and gas, timber is a renewable resource; 70–100 years after felling, the tree is back in the same place and has taken up CO₂ from the atmosphere again. At the same time, it is important that logging and forest planting after logging take place so that the natural values and biodiversity are looked after in the best way possible.

“Climate change is causing milder winters which in turn is resulting in less ground frost. This complicates forestry operations because the logging machines sink into the terrain where there was previously frost underneath,” explains Head of Research, Rasmus Astrup at NIBIO.

In some years, you have to suspend forestry work for weeks at a time because of mild weather, resulting in major losses for the forest owners.

New and world-leading technology, developed through the EU project TECH4EFFECT, provides machine operators with access to digital terrain models that calculate how forestry machines should operate to reduce potential damage they may cause.

In addition, dedicated databases have been developed that collect information about fuel consumption and efficiency from forestry machines across Europe. This allows the log harvester operator to compare themselves with the most efficient and environmentally friendly logging contractors across Europe.

“If a Norwegian log harvester operator sees for example that a German contractor is producing more timber with the same resources as us, we can go in and see exactly how they are working and learn from their experiences,” says Rasmus Astrup, who has led the four-year Horizon 2020 project.



Purpose: Develop new knowledge and technology that will revolutionise the way logging is carried out in Europe.

Collaboration: Norskog and Statskog and 21 other institutions in Europe

Funding: Horizon 2020 and the Research Council of Norway

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Photo: Gunda Thöming



More pests in broad beans and peas

The production of legumes such as broad beans and peas has increased in Norway. But so too has the extent of pest insects with negative impact on crop yields.

There is a rising demand for Norwegian-produced protein crops for both food and animal feed, which has resulted in increased production of broad beans and peas in recent years.

At the same time as production has expanded, the number of incidents of crops being lost due to damage by pest insects, among other things, has also increased. Ten years ago, researchers would receive two to three questions about pests in protein crops during the whole season, now they are receiving two to three a day.

Part of the reason is that climate change is providing better conditions for the pest species to develop, while at the same time fewer insecticides are becoming available each year. Norway is slightly behind when it comes to knowledge about growing protein crops, but in Europe, research on alternative measures to combat the pests are ongoing. As part of a larger research project, NIBIO has now started to

test alternatives to insecticides under Norwegian conditions.

One of the biggest problems for producers of both broad beans and peas is the pea-leaf weevil (*Sitona lineatus*). The adult beetle lives on the leaves and lays eggs in the soil. The larvae are feeding on the roots and nitrogen-fixing nodules, which might reduce the crop yield. This beetle has always been present in Norway but has now become a major problem. There have been local infestations so extensive that entire crops have failed due to feeding on the root system. It is possible to use insecticides against the adult beetles, but if you find an adult, there will already be eggs in the soil.

It is considered wise to sow broad beans a little later and deeper than usual, but this can be difficult because of the short growing season in Norway. Therefore, NIBIO is testing an early variety combined with later and deeper sowing. So far, the results are promising.



Purpose: Assessment of the risk from plant toxins for human health

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Photo: Anne-Grete Buseth Blankenberg

Europe's best water environment measures

Which environmental measures are best suited to retain water and nutrients in small agriculture-dominated catchments, and how can the measures be combined so that they become more cost effective where they are introduced? This is what European researchers are currently trying to find out.

“To achieve the major targets on a global level, we have to find good and effective solutions locally,” says Senior Researcher Attila Nemes, who is leading the EU project OPTAIN from NIBIO's side. The European researchers are working together with farmers and advisers to identify and refine nature-based and location-adapted environmental measures for 14 small catchment areas in several countries. One of these is the Kråkstadelva catchment in Norway.

By using simulation models, researchers are investigating where the best places are to introduce measures in catchment areas, which measures have the greatest impact, which measures work well together and which are the most likely to be implemented with regard to the farmers' willingness and needs.

“Soil conditions, type of production and not least the country's laws, regulations and financial support

schemes are also important for how farming is carried out,” explains Nemes.

It is not enough to simply identify a problem and propose measures to resolve it. If they are to achieve good results, for the future as well, it is important that researchers maintain a dialogue with those who are active in the area.

It is not just about finding solutions that will have an effect in countries and areas with widely varying conditions.

“We also hope to achieve increased understanding of the connections between agriculture, the different characteristics of a landscape, and very specific environmental measures,” says Nemes.

Hopefully it will be easier for various agricultural players to make well-informed choices in the future.



Purpose: Identify Europe's best water environment measures for small agriculture-dominated catchment areas, either alone or in combination.

Collaboration: OPTAIN is ongoing until 2025 and is coordinated by UFZ Helmholtz Centre in Germany. The Norwegian partners are NIBIO and NIVA.

Funding: EU Horizon 2020

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Photo: Erling Fløistad



Detected plant toxins in herbal tea

NIBIO is performing an annual monitoring programme of plant toxins in food commissioned by the Norwegian Food Safety Authority. In 2021, certain plant toxins were detected in 13 herbal tea products. To reduce the possible health risk, the Norwegian Food Safety Authority recommends limiting your intake of herbal tea.

Many plants produce plant toxins which are a natural protection against insects and other herbivores. The natural toxin content in plants used for food is generally low, but certain weeds can contain many strong toxins. If weeds are included in the harvesting of food plants, the harmful plant toxins can end up in our food. In 2021 NIBIO analysed 30 samples to survey selected plant toxins on behalf of the Norwegian Food Safety Authority.

20 different types of herbal tea were analysed for a group of plant toxins called pyrrolizidine alkaloids. These can be harmful to the liver and carcinogenic when ingested over time. Varying levels of pyrrolizidine alkaloids were detected in 13 of the products of nursing tea, rooibos tea, chamomile tea and peppermint tea.

To reduce the potential health risk, the Norwegian Food Safety Authority recommend limiting the

consumption of these types of teas and varying between different products. This applies particularly to pregnant and breastfeeding women.

The results from the Norwegian Food Safety Authority's monitoring programme are used to assess the risk to human health from ingesting food. Updated data is important to be able to manage this risk through regulation, warnings and information for consumers.

“Further monitoring is important to see whether the new maximum levels of the plant toxins lead to fewer detections and lower levels of such plant toxins in food products,” explains researcher Marit Almvik at NIBIO. Tea grown and harvested in accordance with good agricultural practice and constituted from certified herbs with high purity could help reduce contamination with plant toxins from weeds.



Purpose: Assessment of the exposure of plant toxins in food and feed.
Funding: The Norwegian Food Safety Authority
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Photo: Morten Günther

In-between spaces in agricultural landscapes

The Norwegian agricultural landscape is very important for food production and security. However, in between the fields there are small areas with great significance for the entirety of the landscape.

“We’re referring to roadside verges, stream banks, field islets, fallow meadows, field margins, vegetation lines and solitary trees. These small spaces are important for the ecosystems and the species that live there,” explains NIBIO researcher Christian Pedersen.

However, years of monitoring the agricultural landscape show that these spaces are disappearing as well as plant species important for pollinators. Bumblebees and wild bees compete for a constantly diminishing resource.

Managing the spaces

NIBIO has recently completed the three-year project “Status and change of in-between spaces in agricultural landscapes”. The researchers have been concerned with finding out how to manage the in-between spaces to avoid getting more of what is already found everywhere else.

“One question has been whether these areas should be mowed, and they probably should,” explains Head

of Department Wenche Dramstad. In the past few decades, we have had increasingly fewer areas that are mowed without being in intensive agricultural production. However, there are many areas that are abandoned and experiencing secondary succession.

It is important not to mow too early. The insects must have access to nutrients throughout the summer months and not all areas should be mowed at the same time.

Increased focus on spaces desirable

The Norwegian Public Roads Administration has done a good job with roadside verges, but there is generally little knowledge about what exists in other in-between spaces.

The management of in-between spaces is mainly focused on preventing spread of undesirable organisms into arable land or secondary succession. In the future we should also focus on management promoting biodiversity and how in-between areas can contribute positively to the landscape.



Purpose: To identify changes in the diversity of vascular plants since 2002 and provide advice on how the diversity of plants and pollinating insects can be sustained by using “in-between spaces” in the agricultural landscape.

Funding: Norwegian Agriculture Agency

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Photo: Morten Günther



Norwegian potatoes all year round

Optimal storage involves temperature, lighting, humidity and air quality. Researcher Pia Heltoft Thomsen is leading two projects that will contribute to better potato quality, profitability and less food waste. The aim is to guarantee the industry access to good, Norwegian potatoes throughout the year.

Good year-round potato quality requires the potatoes that arrive for storage to be of good quality. This requires careful harvest that reduces the risk of damage, and that the harvesting takes place in dry and breezy weather, and not when it is too cold and wet.

The first weeks in storage are important. The potatoes must be ventilated well and go through a wound healing process to cure damages and wounded tissue. It is then important that the temperature is lowered gradually. Drying and wound healing requires a temperature of approx. 12 degrees and good ventilation to remove excess heat, water and CO₂. How quickly potatoes need to be cooled depends on what they will be used for. Potatoes for cooking which must have a nice skin, should be dried and cooled quickly to avoid silver scurf and black spots.

Potatoes for crisps must not be stored below 7 degrees. This is to prevent the starch being converted into sugar. Too much sugar content can result in carcinogenic acrylamide in crisps and french fries. On the other hand, potatoes for cooking can be stored at approx. 4 degrees. The low temperature provides a longer shelf life and prevents sprouting. However, when storing below 3–4 degrees the potato can take on a slightly sweet taste. Because potatoes used for deep frying must not be stored too cold, it can be difficult to prevent them from sprouting.

In the Antigro project, researchers are testing various anti-sprouting agents, including mint and orange oils. They see good effects from the new agents on the market, but it is important to learn how to use them correctly. Under Norwegian conditions we need fewer treatments and lower doses than other countries in Europe.



Purpose: Secure the potato industry's access to good, Norwegian potatoes throughout the year.
Collaboration: HOFF SA, Maarud AS, Orkla/KiMs, Findus, PTG, Inagro, Dormfresh, Nordisk Alkali, Biocontrol Andermatt, UPL and potato producers
Funding: "Forskningsmidlene for jordbruk og matindustri" [Research funds for agriculture and the food industry] + industry
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Photo: Tom Lifjell

New guide on feeding reindeer

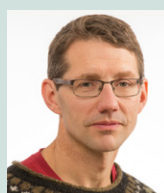
From nature's perspective, reindeer are adapted to seasonal changes in food quality and quantity. In recent years, reindeer winter pastures has been covered by ice and large amounts of snow due to climate change. To prevent potential starvation, ensure animal welfare and survival reindeer must be supplementary fed during such periods. In collaboration, NIBIO and the Norwegian Veterinary Institute in Tromsø have published the guide "Feeding of reindeer – and food related diseases".

If reindeer are exposed to periods of long-term reduction in food intake or starvation, their ability to adapt and benefit from the new feed they are given is reduced. This is due to a reduced number of micro-organisms in the rumen. When feeding is initiated, it is therefore important to proceed carefully so that the reindeer can gradually get used to the new feed. To prevent a situation like this, it is most important to start feeding before the reindeer start to starve.

The guide also discusses different types of feed (hay, silage, lichen and concentrates) and the properties of these. According to NIBIO researchers Svein Morten Eilertsen and Erlend Winje, it is important that the

reindeer owners know how to assess the quality before buying the feed.

The new feeding guide has also been published in a Northern Sami version and has been prepared and updated based on experienced-based knowledge from reindeer owners – supplemented with research-based knowledge of reindeer digestion and their ability to utilise different types of feed. The feeding guide include a section on feeding related diseases in reindeer. In addition, there is also a section on health, safety and environment (HSE).



Purpose: Increase knowledge in the reindeer husbandry about feeding reindeer.
Collaboration: Reindeer owners with experience on feeding of their animals, Norwegian Veterinary Institute and reindeer researchers from Norway, Sweden and Finland
Contact: Researcher Svein Eilertsen. E-mail: svein.eilertsen@nibio.no, phone: +47 934 99 412. Division of Forest and Forest Resources.
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Photo: Erling Fløistad

SR16 now covers all of Norway

Information about forests is important for a forest management that considers the values of biodiversity and bioeconomy. The recently updated forest resource map SR16 will be a great benefit to a sustainable forest management.

SR16 is a comprehensive digital forest resource map that provides an overview of the extent of the forest and properties of Norway's land resources, including for example tree species, average tree height and timber volume. The map service is available from NIBIO's Kilden map solution, under the Forest Portal.

To map forest attributes in Norway, researchers at NIBIO have used a combination of forest recordings on the ground (Norway's National Forest Inventory), remotely sensed data from satellite images (Sentinel-2), laser scans from aircraft and image matching from the Norwegian Mapping Authority.

One who has taken part in the development of the new forest resource maps, is Johannes Breidenbach, Research Professor at NIBIO. He explains that up until to now, around 80 per cent of forest land has been included in the map solution. The new version of SR16 achieves 100 per cent coverage.

"This means that the maps not only can reveal information about the whole country, but also about very local conditions," explains Breidenbach.

According to NIBIO-colleague Bjørn Tobias Borchsenius, the forest resource maps make it easier for forest owners to know where logging has taken place and to plan future logging. Many request information about the forest to obtain an overview of the stock in the forest, and to plan logging, thinning and to make other operational decisions.

"And if a municipality for example wants to develop its own climate policy, it can use SR16 to decide how to formulate local decisions. The county governors also need this information," says Borchsenius.

Forest information is also important in relation to avalanches or landslides, and data from SR16 can be used to prepare due diligence maps.



Purpose: SR16 is a comprehensive digital forest resource map that provides an overview of the extent of the forest and properties of Norway's land resources, trees species, average height and timber volume.

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Division of Forest and Forest Resources



Photo: Isabella Børja



Canker disease could wipe out aspen in the north

Many aspen trees in Troms and Finnmark have been left almost without leaves, and the damage is so extensive that aspen is close to being wiped out in the north. After several years of searching, researchers have now discovered the cause.

Aspen canker disease has been occurring over a fifteen-year period in Northern Norway, but in recent years the damage has increased significantly, according to the annual Forest Health Report from NIBIO.

Until now the cause was unknown, but recently a research group at NIBIO has confirmed that the damage is related to a fungus called *Cytospora chrysosperma*.

Isabella Børja, Research Professor at NIBIO, describes how in the spring in Troms and Finnmark you can see many aspen groves with dead branches. The condition is also common in northern parts of Finland, and probably in neighbouring parts of Sweden and Russia as well. NIBIO researcher Venche Talgø has also discovered similar damage to aspen in elevated areas in Jotunheimen and along Gudbrandsdalen.

In the crown many of the branches are dead, and the leaves develop only sporadically on some branches. Upon closer inspection, you can see many small

black balls sticking out through the bark on the dead or dying branches.

These black balls, which are smaller than pinheads, are the asexual stage of the canker-causing fungus, *Cytospora chrysosperma*. Finding the sexual stage (*Valsa*) is rarer.

The researchers have isolated several fungi from cankered aspen trees.

“We have been able to confirm that *Cytospora* has been isolated from several of our aspen samples,” says Børja. “Our observations indicate that the fungus can probably live in healthy branches and buds. It doesn’t cause damage until the trees become weakened or stressed.”

Because the damage is so prominent and extensive that it threatens to wipe out aspen trees in the north, the researchers have started working on several systematic collections and analyses of plant materials.



Purpose: Discover and confirm the cause of aspen canker disease in the north.

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Photo: Josefine Bergs

Pink salmon – resource or scourge?

Stocks of pink salmon in Norway have practically exploded and in 2021 the species was caught in rivers from north to south. Now NIBIO will obtain new information for sustainable management and possible exploitation of the blacklisted species.

Stocks of pink salmon in Norwegian rivers have received attention in recent years for being alien, invasive and undesirable. A lot of resources are used on a local level to suppress the species, but for the moment it is unknown whether the measures are effective.

– “The major expansion is possibly due to climate change and means that the pink salmon is an example of an invasive species that can pose major challenges for us, but also opportunities as it is an excellent edible fish if caught at sea,” explains Snorre Hagen, Head of Research at NIBIO Svanhovd.

Much of the current understanding of pink salmon is based on foreign studies, and several observations in Norway differ from this established knowledge. There is also a lot that is unknown, or rather uncertain, including what impact pink salmon has on Norwegian species and ecosystems.

In a new venture, NIBIO in partnership with authorities, research, management, voluntary organisations,

business, and the public, will obtain knowledge about the species from a Norwegian point of view.

The problem of pink salmon is complicated and socially relevant where the long-term creation of knowledge and competence are at the very centre.

– “Among the things we want to find out is how the stocks develop and shift. We also want to study the biology of the species, what impact it has on ecosystems, what measures work best and at what time, as well as questions relating to the development of knowledge-based management strategies,” says Hagen.

The work involved in building a genetic database on pink salmon as a tool for research and management, as well as developing methods for genetic studies, is ongoing and will continue throughout the project period.



Purpose: Obtain new knowledge about pink salmon for sustainable management and possible exploitation.

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Division of Environment and Natural Resources



Example of green areas in cities

Photo: Anette Tjomsland Spilling

New maps help with climate considerations

How can we develop towns and cities in a way that takes the best possible care of nature, produces the least possible greenhouse gas emissions, preserves natural diversity, and improves the conditions for managing climate change? NIBIO has developed maps that will help Oslo, Drammen and Tønsberg with just this.

The maps will make it easier for the municipalities to assess greenhouse gas emissions through changed land use, as well as how best to adapt to climate change and take care of species diversity. For example, green areas and vegetation are important for taking up rain and for helping cool towns and cities on warm days.

“The thematic maps provide information on where you should preserve nature or change land use practices in order to avoid large amounts of greenhouse gas emissions from land use and land use change,” explains Head of Project and Senior Adviser at NIBIO, Henrik Forsberg Mathiesen.

The feedback from the municipalities has been very positive. The municipalities of Tønsberg and Drammen have recently started using the maps when assessing plans and applications for developing and redeveloping areas for residential or commercial activities.

“We didn’t have any methods for ranking greenhouse emissions before. This gives us some indication whether there will be more or less emissions as a result of an intervention involving nature during land degradation,” says Kristine Molkersrød, Climate Adviser at Tønsberg municipality.

New national regulations instruct all municipalities to survey ecosystems and land use that are important for climate adaptation, and to consider climate emissions reduction and climate adaptation in local area planning processes. More municipalities have contacted NIBIO to have similar maps developed for their municipality.

During the Zero Conference in November 2022, Tønsberg and Drammen municipalities achieved second place in the “Local climate measure of the year” award for their work involving the new climate maps.



Purpose: New climate maps make it easier for municipalities to take care of natural diversity, limit their own greenhouse gas emissions, and adapt to climate change.

Funding: The report for Drammen and Tønsberg is funded through ‘Klimasats’ funds from the Norwegian Environmental Agency. The report for Oslo was completed with funding from the Agency for Climate, the Agency for Planning and Building Services, the Agency for Water and Sewerage and the Agency of Urban Environment.

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Photo: Kathrine Torday Gulden



Circular economy in the potato chips industry

With expert help from NIBIO, the potato chips manufacturer Maarud has established a large and modern composting facility for its waste resources. The facility will help keep valuable nutrients in circulation.

NIBIO researcher Ove Bergersen is a compost expert. For many years he has been involved in large and small composting projects, both in the laboratory at Ås and with clients. This has allowed him to gather a great deal of knowledge about what is required for bacteria to thrive in different types of waste resources, so that they break down waste into stable compost as best as possible.

In spring 2020, the snack food manufacturer Maarud got in touch with him. For many years crushed potatoes, starch, and sludge waste from the factory had piled up in a waste disposal site in their factory area, and the factory manager thought that this surely must be a valuable resource going to waste.

He was right about this.

“The sludge from the water treatment plant at Maarud is packed with nutrients that is worth its weight in gold for good plant growth,” Bergersen explains.

“It’s also free of environmental toxins and heavy metals, which is a good basis for compost that will be added to soil.”

Maarud is located in the forest in Sør-Odal and is not connected to the municipal drainage network. That is why it has its own treatment plant in the area to clean the process water that is used to rinse the potatoes before producing chips.

“The advantage of having your own facility is that the sludge from the water treatment has not been in contact with industry waste or other waste streams. This means that the compost produced is very pure,” says Bergersen.

Based on knowledge and advice from Bergersen, Maarud completed its cutting-edge windrow-based composting facility between 2020 and autumn 2021. The aim of the facility is to process all waste from the factory, i.e., sludge, starch and crushed potatoes and turn it into a high value compost product.



Purpose: Contribute with research-based knowledge and advice in establishing an outdoor composting facility for waste resources at Maarud in Disenå, Sør-Odal.

Collaboration: Maarud AS

Funding: Maarud AS

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Photo: Erling Fløistad



How to attain emission free greenhouses

The greenhouse industry has traditionally used natural gas for heating. However, this production method results in high greenhouse gas emissions. By switching to electric lighting in the greenhouses, the industry faces a possibility to a more climate friendly method of operation.

Fruit and vegetables produced in Norway account for around 35–40% of the products on sale in shops. There is potential to increase the Norwegian production significantly, especially in the greenhouse sector.

The traditional use of natural gas for heating result in high CO₂ emission. Researchers at NIBIO have helped to develop new operating methods involving a switch from heat to light, the most effective measure to reduce greenhouse gas emissions in the greenhouse industry.

“A greenhouse is a solar collector that captures twice as much energy as it uses in a year. By closing the air vents and accumulating the heat in a water tank, we collect the heat during the day for use at night. Our calculations have shown that this will reduce the energy consumption of heating by 50 per cent,” explains NIBIO researcher Michel Verheul.

Light, and not heat, is the limiting factor for plant production. A new cultivation system, developed at NIBIO, increased tomato production from 40 kg to 120 kg by using supplemental light. In addition, CO₂ emissions were reduced by 60% and energy consumption by 40% per kg of tomatoes.

Switching to electric lighting is expensive, considering the current high electricity prices. However, calculations performed by NIBIO have shown that investing in LED lighting can pay off.

Recently, NIBIO tested a new system that controls and regulates heat, humidity and CO₂ level in a greenhouse with supplemental lighting. This system increased production while windows were kept closed. Combined with a facility that captures CO₂ from outdoor air, CO₂ emissions from tomato production were reduced to zero.



Purpose: Increase production of plant materials with desired quality, and least possible consumption of energy and CO₂ emissions per unit produced.

Collaboration: Norwegian tomato and cucumber producers, The Norwegian University of Life Sciences, NORSUS, SINTEF, Norwegian Growers Association, GreenCap Solutions AS, BAMA/GH, regional authorities, and international collaboration partners

Funding: The Research Council of Norway, Grofondet, Rogaland County Municipality, Interreg (EU)

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Photo: Ragnar Våga Pedersen

Dried spruce as firewood

After the dry summer of 2018, there has been a lot of dried spruce in the forest. What if this could be used as firewood? NIBIO's wood expert Simen Gjølshjøl has investigated whether there is good fuel economy in taking dried spruce directly from the forest for use in woodburning stoves.

Wood is a renewable and climate neutral energy source and is an important source of heating in Norwegian homes. Normally the trees are cut and chopped in the spring, then the wood is dried over the summer. However, the warm and dry summer of 2018, and subsequent bark beetle infestations, have left many dead trees in the forest, not least so-called dried spruce of which there is a lot. This dried spruce could be a good resource as firewood. But is the natural drying over the past few summers enough so that the dried spruce can be used directly in wood-burning stoves?

Gjølshjøl has led a pilot study where the researchers have investigated the fuel economy of approximately 150 years old spruce trees that had died in the summer of 2019 and 2021 respectively. The researchers took bits from the trunk, so-called trunk slices, at chest height from the middle of the tree. They then measured the moisture content in the heartwood and sapwood.

The heartwood is the most central part of the trunk. This is dead wood and nutrients are not transported in the heartwood. Outside the heartwood we find the sapwood where the nutrients are transported.

The results of the measurements showed that the rootstock, i.e. the lowest part of the trunk, on trees that had dried for a couple of years, had an average moisture content of 23.5 per cent. This shows that rootstocks of dried spruce trees can be sold as firewood.

In accordance with the new Norwegian Standard, the moisture content must be below 25 per cent in what is called class 2 and 3 firewood. This means that the rootstocks can be sold as class 3.



Purpose: Can dried spruce be used as firewood? NIBIO has investigated whether there is good fuel economy in taking dried spruce directly from the forest for use in woodburning stoves.

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NIBIO

NORWEGIAN INSTITUTE OF
BIOECONOMY RESEARCH

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

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

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

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