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DCA - DANISH CENTRE FOR FOOD AND AGRICULTURE

PERSPECTIVE

ANNUAL REPORT 2018

DCA – DANISH CENTRE FOR FOOD AND AGRICULTURE

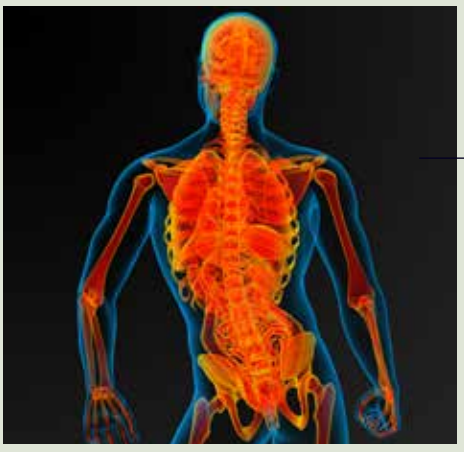
Food and agricultural science
Research-based policy support
Knowledge exchange and industrial collaboration
National and international research alliances

2018

DCA – Danish Centre for Food and Agriculture publishes the annual report **Perspective**. The report contains information about the work that underpins Aarhus University's research-based policy support in food and agriculture.

The publication provides examples of new projects and recent research results including collaborations with commercial companies and organisations.

It is our vision that Perspective will generate interest and understanding – in research as well as policy support – and illustrate how these efforts help strengthen the foundation for important societal decision-making.



About DCA

Climate

Nutrients

IPM

Circular bioeconomy

Technology

Animal Production

Genetics

Food and consumer behaviour

DCA reports

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Cover photo
Researcher Maria Knadel is part of a team who has developed a new and quick method to predict the transport of chemicals through the soil. Read more on page 14.
Photo: Søren Kjeldgaard, AU Photo

Relevant expertise and unique facilities are a requisite for solving problems in food and agriculture

It is exciting to be involved in an industry with huge prospects on the one hand and complex problems to be solved on the other hand. The present might actually be the most exciting time to be a part of food and agricultural science.

There is an increasing need for food, as well as biomass for energy and materials to replace fossil fuels. At the same time, it is necessary to reduce the impact of agriculture on climate, water and nature and – especially in a global context – the use of antibiotics and other input.

One of the obvious challenges regards the climate. Like most other countries, Denmark is committed to reduce emissions; this obligation includes food and agricultural production, which account for approximately 20 per cent of climate gas emissions in Denmark. These emissions stem from the soil, plants and animals, and there are no simple solutions.

In some cases, it will be necessary to develop new, targeted technologies to reduce emissions. In other cases, significant systemic changes, such as cultivation systems that increase soil carbon storage, are required.

It is a true measure of due diligence that the farmer-owned companies Arla and Danish Crown, together with the Danish Agriculture and Food Council, have committed to the goal of being climate-neutral by 2050. Research will play a significant role in developing climate-friendly production systems; and DCA is ready to contribute.

Another challenge relates to the aquatic environment, to which Denmark is committed to reducing nutrient leaching. This area also has a significant need for the development of targeted technologies and new culti-

vation systems that can help reduce pesticide consumption while maintaining profitable crop production.

A third challenge is the use of antibiotics in livestock production. Today, antimicrobial resistance (AMR) is considered one of the most important threats to public health. One of the causes of increasing AMR is incorrect or excessive use of antibiotics in livestock production on a global level. The Danish efforts to reduce the use and minimise the problems have been exemplary.

There is, however, still a need to find alternatives to antibiotics, also in organic farming.

Common to all three examples is the fact that they are multifactorial issues, and the development of solutions should thus involve a broad range of various research disciplines and dedicated facilities.

”Denmark has unique opportunities for carrying out holistic research that can contribute to solving the challenges that the food and agricultural sector faces”

At the international level, the number of research centres dealing with coherent and interdisciplinary research in comprehensive food and agricultural issues is limited.

In this regard, the research facilities at Aarhus University are unique. The facilities at the research centres in Foulum, Flakkebjerg and Aarslev/Agro Food Park allow researchers to carry out advanced experiments and measurements in conventional and organic production systems. It is possible to carry out experiments with different crop rotations, use different soil types, and work with many types of animals, housing systems, and manure management systems. For example, the research can include advanced measurements of nutrient loss and greenhouse gas emissions as well as use of new technologies and precision agriculture.

In other words, Denmark has unique opportunities for carrying out holistic research that can contribute to solving the challenges that the food and agricultural sector faces. The researchers already collaborate with a wide range of companies in relation to research and innovation. This annual report from DCA – Danish Centre for Food and Agriculture provides excellent examples of such collaboration.

However, there is an increasing need to further develop the research infrastructure, e.g. at AU Foulum, which was inaugurated almost 40 years ago.

In the years to come, we will continue to develop and strengthen the research and innovation platforms that can help the food and agricultural sector reduce its climate and environmental impact, and to find alternatives to antibiotics.

We hope you will enjoy reading this report.

Niels Halberg,
Director, DCA – Danish Centre for Food and Agriculture

Research-based policy support

Denmark has a long tradition for basing political and administrative decisions on a knowledge-based foundation. In recent years, it has become increasingly obvious that current, trustworthy and relevant knowledge is the cornerstone in a modern, democratic society.

One of a university's core tasks is to provide research and ensure communication of new knowledge. This is accomplished by publication and dissemination of research results, student education, and research-based policy support to authorities.

Aarhus University (AU) has entered into an agreement with the Ministry of Environment and Food of Denmark (MFVM) on the provision of research-based policy support in areas relating to nature and the aquatic environment, arctic conditions, air, emissions and risk assessment, food quality and consumer behavior, crop production, and livestock production. The agreement comprises a framework agreement ensuring that AU carries out research to support the Ministry's administrative tasks. In addition, the agreement ensures that AU has the necessary knowledge and competence required to provide research-based policy support within the scientific areas comprised by the framework agreement.

About DCA – Danish Centre for Food and Agriculture

Providing policy support in relation to complex questions requires interdisciplinary collaboration. In order to ensure this within the areas of food and agricultural science, Aarhus University has established DCA – Danish Centre for Food and Agriculture. The centre coordinates cooperation with the Ministry within the following areas: Crop production, Livestock production, and Food Quality and Consumer Behaviour.

DCA – Danish Centre for Food and Agriculture comprises AU departments with food and agricultural science activities:

- Department of Agroecology
- Department of Animal Science
- Department of Food Science
- Parts of Department of Molecular Biology and Genetics
- Parts of Department of Engineering
- MAPP Centre, Department of Management

About the DCA Centre Unit

The DCA Centre Unit supports and coordinates DCA activities, which – in addition to policy support – also include industrial and sector collaboration, international collaboration, and communication.

An advisory panel contributes to organising cooperation with national users and collaborative partners. Advisory panel members include the Ministry of Environment and Food of Denmark and organisations and companies related to food and agricultural production.

The panel provides advice on the centre's overarching supervision and strategy, including the relevance of research in relation to society's future needs for advisory services, national and international research topics, communication of knowledge to society and the framework for research-based policy support.

Via its centre unit, DCA is in charge of a number of tasks in relation to international research and policy support. On behalf of the Ministry of Environment and Food of Denmark, DCA attends to responsibilities in e.g. the European Innovation Partnership on Agricultural Sustainability and Productivity (EIP-AGRI), Collaborative Working Group of Sustainable Animal Production, NordGen Council for Farm Animal Genetic Resources and Animal Task Force. The DCA Centre unit also participates in a series of European research programmes and supports collaboration in major applications to European research programmes, primarily Horizon 2020.

A weekly Danish and monthly English newsletter communicate knowledge about policy support tasks and new research from the DCA departments.

The DCA Centre Unit also publishes DCA reports, primarily based on policy support tasks, and arranges meetings with and between researchers, authorities and the public.

What is **research-based** policy support?

Basically, all university core tasks are research-based. In order to provide qualified advice and support to authorities, the university must possess scientific competence within the area as well as observe the authorities' expectations as to relevance, form and punctuality in the support provided.

In order words, research provides the necessary foundation for highly qualified policy support, and the term "research-based policy support" thus comprises both research-based advice and the underlying research.

All public research and policy support should be freely available, and the universities are entitled – and obligated – to publish the results. Researchers' freedom of speech and research are fundamental principles that the universities cherish and protect, including when it applies to research-based policy support.

The agreement with the Ministry respects the arm's length principle, and DCA's policy support is based solely on the scientific contributions provided by the researchers. The authorities are responsible for the subsequent political and administrative considerations.

Financing food and agricultural research

Different sources fund food and agricultural research, and DCA's contract with the Ministry of Environment and Food of Denmark is the main income source. According to the agreement, DCA received 260.7 million DKK in 2018.

The grant from the Ministry of Environment and Food of Denmark allows DCA to attract and carry out research projects in collaboration with organisations and companies. This collaboration, together with grants from national funds and research programmes, was the main reason why the total research and development funding amounted to 680 million DKK in 2018.

Subscribe to newsletters from DCA

The Danish DCA newsletter is published weekly and the English edition monthly. To subscribe, please visit dca.au.dk/en.

Follow DCA on social media

Follow DCA on social media to keep up to date with news, studies and events within the areas of food and agriculture. Just type "DCA - Nationalt Center for Fødevarer og jordbrug" in the search field.

Milk production affects not just **the climate**

When evaluating the effect of food on the environment, it is important to look not only at the climate, but also at the effects on soil carbon, ecotoxicity and biodiversity.

Assessing the effects of food productionon the climate is a hot topic – and with good reason – but it is not enough. Food affects more than just the climate.

The impacts on field biodiversity and soil carbon changes, and effects of nutrients and pesticides on the aquatic environment (eutrophication and ecotoxicity, respectively) should also be included when assessing the environmental footprint of food.

- Soil carbon changes impact the climate, biodiversity is decreasing markedly everywhere, and the effects of pollutants such as pesticides can have a range of effects, says researcher Marie Trydeman Knudsen from the Department of Agroecology. She uses life cycle assessments to calculate the overall environmental impacts of food products.

Take for example something as simple as a glass of milk. Until recently, the environmental effect of milk has mainly been assessed on the basis of its carbon footprint, eutrophication and acidification. These three factors do not, however, show the full picture of how milk production affects the environment.

Organic milk production is more environmentally friendly

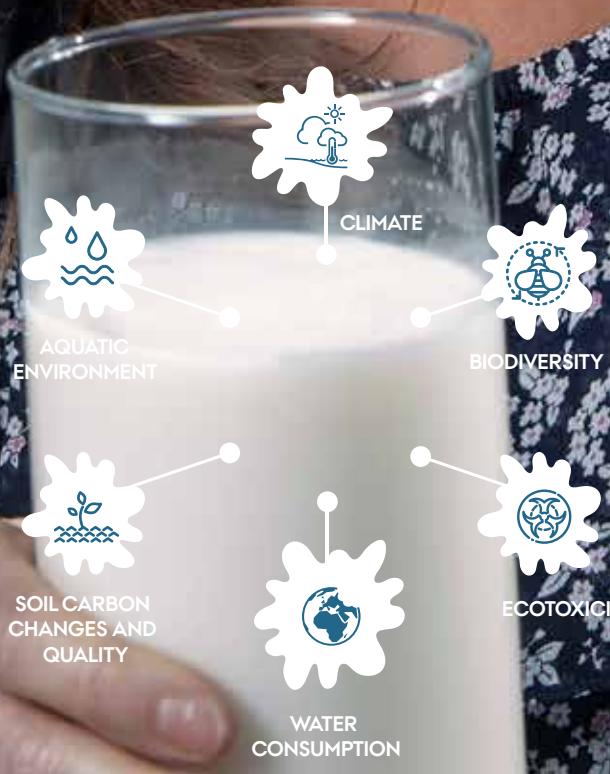
Researchers from Aarhus University have collaborated with European colleagues in a study where they looked at three different types of organic and conventional production systems in Europe: mixed systems with milk production and arable crops, grass-based milk production and milk production in mountainous areas.

Across the three systems, the carbon footprint per kg organic and conventional milk was somewhat the same when the contribution from soil carbon changes was not included.

When the effect of milk production on soil carbon sequestration was included, the carbon footprint of primarily organic milk was reduced by 9-18 per cent. The organic production systems also had a lower environmental impact with regard to ecotoxicity, field biodiversity and use of non-renewable resources.

- On average, the effect of organic milk production on ecotoxicity was only two percent of the effect of conventional milk production, and the organic systems had on average only one third of the effect on field biodiversity compared to the conventional production systems, Marie Trydeman Knudsen says and continues:

- Including more grass in the diet of dairy cows increases soil carbon sequestration and decreases the negative effect on biodiversity.



Methods for reducing agricultural **greenhouse gas emissions**

You can read more about Aarhus University's efforts regarding life cycle assessment of food at dca.au.dk/en/climate

Researcher Marie Trydeman Knudsen from the Department of Agroecology uses life cycle assessments to calculate the overall environmental impacts of food products. Photo: Søren Kjeldgaard, AU Photo.

Agriculture contributes approximately 20 percent of the total Danish greenhouse gas emissions measured in global warming potential. However, it is possible to reduce these emissions. A report from DCA – Danish Centre for Food and Agriculture provides an overview of potentials, effects and barriers for a range of measures for reducing agricultural greenhouse gas emissions by 2030. The measures vary greatly with regard to their effects, side effects and cost efficiency, but there are five measures that the authors of the report find of particular importance. They are:

1. Altered feeding of cattle and young stock with concentrate, fat and easily digestible forage
2. Biogas, with or without frequent emptying of slurry from house to storage or cooling of slurry in the livestock house
3. Acidification of slurry in the livestock house
4. Addition of nitrification inhibitors to mineral fertilisers and animal manure (slurry)
5. Set-aside of organic soils with or without re-wetting of the land

The measures can reduce greenhouse gas emissions from the Danish agricultural sector by 10-12 percent by 2030.

- The measures mentioned and their effects on greenhouse gas emissions reflect a realistic estimate of how widely the selected measures may be implemented, and the evaluations are based on current frameworks for agricultural production, says one of the authors of the report, Section Manager and Professor Jørgen E. Olesen from the Department of Agroecology.

The report was produced in collaboration between the Department of Agroecology and the Department of Animal Science at Aarhus University and the Department of Food and Resources Economics at the University of Copenhagen at the request of the Ministry of Environment and Food of Denmark.

The DCA report "Virkemidler til reduktion af klimagasser i landbruget" (in Danish) can be downloaded from dca.au.dk/en.

Can agricultural soil in Greenland be improved with **glacial flour**?

Researchers from the universities in Aarhus, Aalborg and Copenhagen are investigating if glacial flour can be used to optimise agricultural land in Southern Greenland.

Global warming is creating an opportunity to cultivate more land in the Arctic regions. In the project **NewLand**, researchers from Aarhus University, among others, are investigating the potential for creating new, good agricultural soil with the aid of glacial flour in the area around Igaliku in Southern Greenland.

The preliminary field investigations have revealed certain obstacles to creating healthy and resilient agricultural soil in the area. One is that the soil is water repellent and has a very low level of plant-available water. If the crops cannot access water, they cannot thrive. The other major obstacle is that the soil has a poor structure because it is not good at creating complexes of organic carbon due to the soil's very low content of fine particles, i.e. clay and silt. In addition, the soil cover is very thin in many places.

Researchers are investigating the potential for creating new, good cultivated land with the aid of glacial flour. Photo: Mogens Humlekrog Greve.

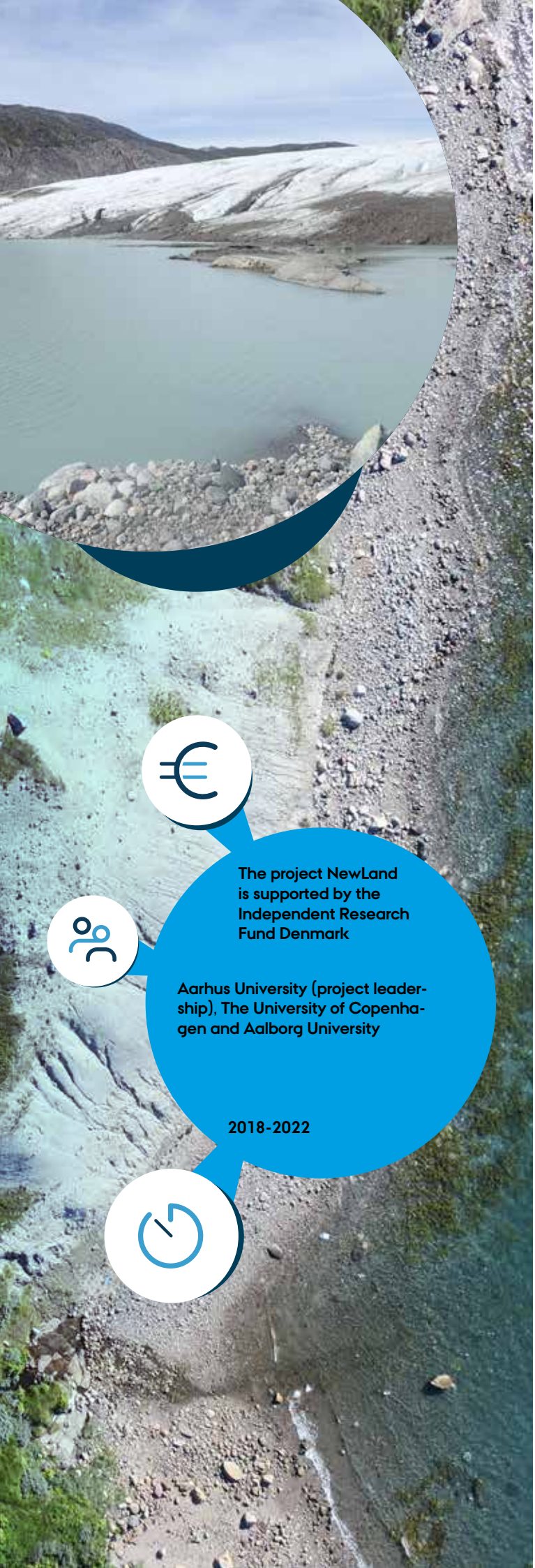
Glacial flour for soil improvement

The solution could be to add fine particles to the soil in the form of glacial flour, which is found in the vicinity of the agricultural lands in Southern Greenland. Glacial flour is formed when glaciers crush underlying rocks and stones. The finely ground material is washed out from under the glacier and deposited.

Glacial flour contains a wide array of minerals and trace elements and can therefore contribute to increasing soil pH, improving soil structure, promoting microbiological activity, and preventing soil depletion.

The researchers will also investigate to what extent soil with added glacial flour can sequester carbon, because this can have a positive effect on climate change.

- At the present, only about 1000 ha are cultivated in South Greenland. Productivity and carbon sequestration of this soil can be improved with glacial flour. Sustainable optimisation of the food production is an obvious alternative to more polluting industries when the goal is to protect the environment and nature, says Professor Lis Wollesen de Jonge from the Department of Agroecology, Aarhus University.



Forest manage-ment cannot save us from climate change

Managing the forests in Europe to maximise carbon sequestration has a minimal effect on the global climate.

If you think that sustainable forest management can be a major contributor to mitigating climate change, then you had better not hold your breath. The effects would be minimal, according to the findings in a recent study published in Nature by an international team of scientists that included postdoc Sylvestre Njakou Djomo from the Department of Agroecology, Aarhus University.

The scientists found that the additional climate benefits through sustainable forest management will be modest and local rather than global. Even if European forests are managed in such a way that their carbon sequestration is maximised, it will not impact the climate significantly. Instead, it seems that the forests themselves will need to be adapted to climate change.

- We suggest that the primary role of forest management in Europe in the coming decades is not to protect the climate, but to adapt the forest cover to future climate in order to sustain the provision of wood and ecological, social and cultural services, while avoiding climate feedbacks from fire, wind, pests and drought disturbances, the authors of the article write.

You can read the full article in Nature vol. 562

The project NewLand is supported by the Independent Research Fund Denmark

Aarhus University (project leadership), The University of Copenhagen and Aalborg University

2018-2022

Measurements from **test bioreactors** are underway

With the establishment of six test facilities with different soil and weather conditions, the research project regarding bioreactors enters a new phase: data collection.

In October 2018, the last of six test bioreactor facilities was inaugurated at Hofmansgave on the island of Funen - this one in full scale. The six bioreactors are the result of a four-year project that the Ministry of Environment and Food of Denmark has granted 15 million DKK to Aarhus University to carry out.

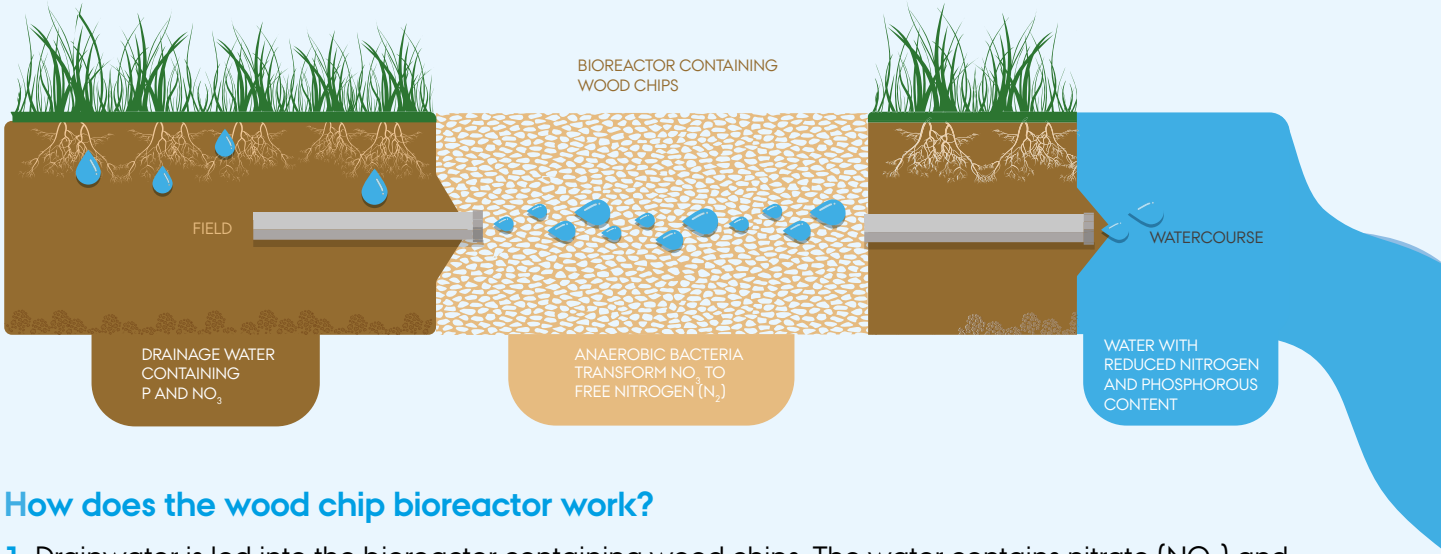
With the beginning of the runoff season, the research project enters a new phase: data collection.

The aim of the project is to generate more knowledge about and evaluate how well this type of measure is at removing nitrogen and phosphorous both in the short and long run – and how cost efficient it is. The test and research units will also be used to investigate how potential negative side effects can be minimised.

The test facilities have been established in various geographical regions with different soil and weather conditions. They have been designed and adapted to local conditions. In the units, several parameters can be varied with the aim of optimising the total nitrogen reduction and minimising potential negative side effects.

The project has a total budget of 31 million DKK, including the special grant of 15 million DKK from the Ministry of Environment and Food, 12 million DKK from the Department of Agroecology's share of the policy support contract, and 4 million DKK from various research projects, including Future Cropping, BufferTech, and iDræn, which are funded by, among others, Innovation Fund Denmark.

The project is headed by Senior Researcher Finn Plauborg from the Department of Agroecology and is a collaboration between the Department of Agroecology and the Department of Bioscience at Aarhus University.



How does the wood chip bioreactor work?

1. Drainwater is led into the bioreactor containing wood chips. The water contains nitrate (NO_3) and phosphorus compounds (P) derived from fertilisers.
2. In the wood chip bioreactor, denitrifying microorganisms transform NO_3 to free nitrogen (N_2) under anaerobic conditions.
3. Water leaving the bioreactor has a reduced nitrogen and phosphorous content, but may also have a lower oxygen content.

Half of the Danish fields **are drained**

A new map shows where in the country agricultural fields are drained. This is important knowledge to have when planning targeted measures.

While agricultural fields in Eastern Jutland, and on the islands of Funen, most of Zealand and Bornholm are drained extensively, the fields in Western Jutland are drained to a much lesser extent. This is obvious on a new map prepared by researchers from the Department of Agroecology in collaboration with Orbicon. According to the map, that was prepared at the request of the Ministry of Environment and Food of Denmark, a total 52 percent of Denmark's agricultural fields are drained.

The need to know whether a given field is drained or not has become relevant in connection with the use of targeted measures to reduce leaching of nutrients to the aquatic environment.

The new map of drained agricultural fields is based on a larger data set and more recent models than previous maps and it is therefore more detailed and accurate. The map is based on a statistical analysis of the relation between drainage and a wide range of geographical data layers, including terrain, soil properties, satellite imagery and land use.

Many of the most important variables in the analysis have a known effect on drainage. For example, the analysis showed that soil clay contents and depth to the groundwater were highly important. Local conditions such as the terrain were also important for the mapping.

The map and background material (in Danish) have been published as a DCA report which can be downloaded from dca.au.dk/en.

Mapping provides a better basis for **targeted regulation**

Researchers are mapping soil quality and the deeper geology in different types of catchment areas with the aim of improving targeted nitrogen regulation and farming practices.

Scientists from Aarhus University are collaborating with the authorities and the agricultural sector in the research and innovation project **MapField** which aims to develop new methods to minimise leaching of nitrogen to the aquatic environment while at the same time creating better production conditions for Danish agriculture.

In the project, which is led by GEUS, the partners will develop new, innovative environmental technologies and tools for agriculture in order for targeted regulation to be translated into practice while taking the environment and farm finances into consideration.

The project will generate knowledge about the characteristics of the soil with precision down to a few metres. This is crucial for making precise predictions of water and nitrogen pathways and the conversion of nitrogen on its way from field to groundwater and waterways. The partners will also investigate how this new knowledge can be implemented in practice, since previous research projects have demonstrated that this aspect can pose significant challenges for farmers.

The project MapField has been granted 18.9 million DKK from Innovation Fund Denmark and has a total budget of 29.7 million DKK.

Geological Survey of Denmark and Greenland (project leader), Aarhus University, The University of Copenhagen, The Danish Environmental Protection Agency, SEGES, Aarhus GeoSoftware, NIRAS, Central Denmark Region, and the Danish Association of Consulting Engineers.

2018-2021

Following the paths of **chemicals through the soil**

A new and quick way to predict the transport of chemicals through the soil has been developed by researchers at Aarhus University.

Where do pesticides and their degradation products go once they enter the soil? And how long does it take for them to reach the groundwater or drainage systems? That depends on a number of factors, but researchers at Aarhus University have come a step closer to finding quick answers.

The ability of soils to transport dissolved chemicals depends on the texture and structure of the soil. Tracking the travel time of these solutes is usually carried out in the laboratory by measuring breakthrough curves. Researchers obtain these curves by applying a solute at the surface of a soil sample and recording when it appears at the bottom of the soil sample.

Obtaining breakthrough curves from laboratory studies is extremely expensive as well as time consuming and labour intensive, so a team of scientists from Aarhus University and Aalborg University decided to think out of the box and use visible/near-infrared (vis-NIR) spectroscopy to predict breakthrough curves – for the first time ever.

Vis-NIR spectroscopy is well recognised for its measurement speed and its low data acquisition cost. The team of scientists used vis-NIR spectroscopy to predict the breakthrough curves of the solutes on a large variety of intact soil columns from six representative fields in Denmark. Averaged across the individual field, the new technology estimated the breakthrough curves with a high degree of accuracy.

- Our findings can pave the way for next-generation measurements and monitoring of dissolved chemical transport by spectroscopy, says one of the scientists on the team, researcher Maria Knadel from the Department of Agroecology.

The results are published in an article in Nature Scientific Reports.

Researcher Maria Knadel is part of the team of researchers who has developed a new and quick method to predict the transport of chemicals through the soil. Photo: Søren Kjeldgaard, AU Photo

How can we combine farming with protection of **drinking water in Europe?**

Researchers from Aarhus University are partners in an EU-funded study that focuses on protecting drinking water from agricultural pollution.

Researchers from 11 countries in Europe, including some from the Department of Agroecology, are investigating agricultural practices and EU policies in relation to drinking water quality and the use of pesticides and nitrogen in agriculture. This is being carried out in the EU-funded project **FAIRWAY**.

Limiting agriculture's emission of pesticides and nutrients is crucial to attaining EU's targets for drinking water quality and the UN's sustainable development goals regarding clean water for all. The aim of FAIRWAY is to develop consistent policies and innovative practices for all member states to enhance sustainable agriculture and respond to the environmental and health challenges related to clean drinking water. Partners include a mix of researchers and consultancy companies who will use their expertise to analyse 13 case studies, some of them located in Denmark.

- With more than 99 percent of the drinking water coming from groundwater, and agriculture as the dominating land use on top of the groundwater magazines, Denmark is a particularly interesting case from which lessons can be learned, says Professor and project partner Tommy Dalgaard from the Department of Agroecology.

The project FAIRWAY has been granted 5 million euro from EU's Horizon 2020 programme

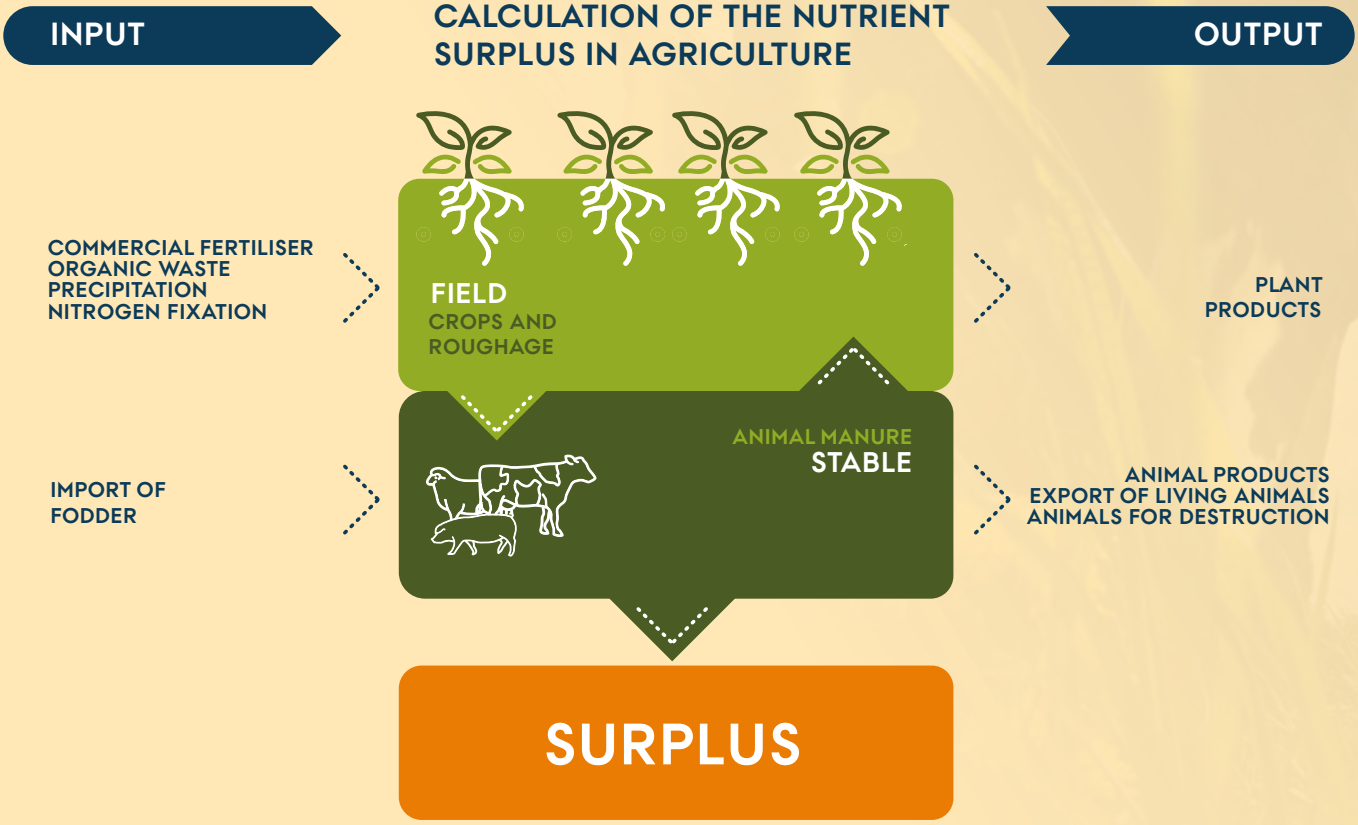
2017-2021

22 partners from 11 EU Member States

fairway-project.eu

Nutrient surplus has increased

The surplus of nutrients from agriculture has been decreasing steadily for the past 20 years, but rose in 2016/2017.



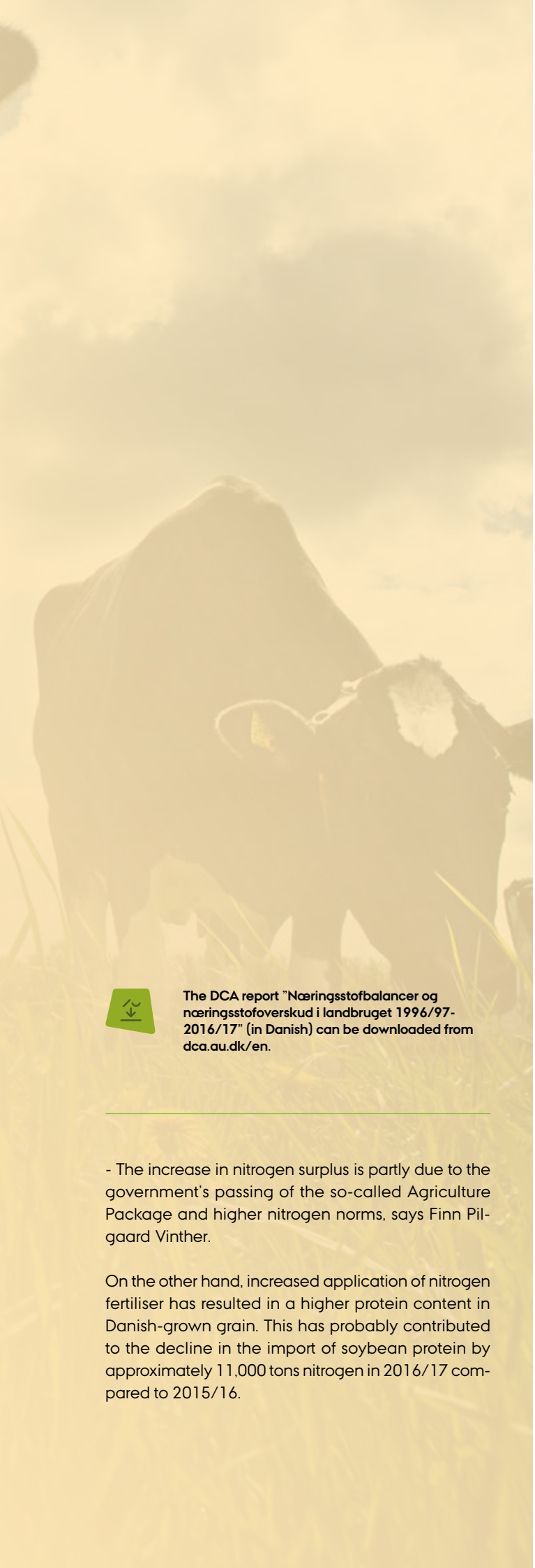
Every year, DCA – Danish Centre for Food and Agriculture publishes an update of the latest 20 years' nutrient balances from agriculture. The report from 2018 shows that the nutrient surplus for the 2016/2017 season increased compared to the years prior to that.

- It must be emphasised that you cannot equate surplus with leaching or emission to the aquatic environment, says Academic Employee Finn Pilgaard Vinther from the Department of Agroecology and one of the authors of the report published by DCA.

The report covers nitrogen, phosphorous and potassium and shows both surplus and use of the three nutrients. Surplus is the difference between agriculture's input and output, while use is output as a percentage of input. The surplus from agriculture in 2016/2017 increased for all three nutrients.

Input includes field applications in the form of commercial fertiliser, organic waste, precipitation and nitrogen fixation via legumes as well as supplies to the farm animals in the form of feed from outside the farm. Output includes cash crops harvested from the field, meat, eggs, and milk from the farm animals, and disposal of live and dead farm animals.

The internal exchanges between field and animal housing in the form of home-produced feed and application of animal manure in the field are not included in the balances.



Saving money and protecting the environment

There are both benefits for the aquatic environment and farmer revenues by improving the basis for calculating nutrient surpluses.

Researchers from Aarhus University and The University of Copenhagen are collaborating with SEGES in a new project that is expected to give annual reductions in agricultural nitrate leaching corresponding to 1,000 tons nitrogen and to save farmers 18 million DKK.

The project **StyrN** will create a basis for field-scale nutrient accounting that can be used by the individual farmer to reduce nutrient surplus and increase nutrient uptake efficiency.

The goal is to prepare accounts for approximately 85 percent of Danish agricultural land, which is already handled through the farm-based decision support system Mark Online, thus quantifying and illustrating how much nitrogen the soil in a given field already contributes to the crop and the size of the nutrient surplus. The tool will also estimate anticipated nitrogen losses.

The system for nutrient budgeting will be designed in a way so there will be no need for extra entries to be made in order for farmers to calculate nutrient surplus, nitrogen loss, and changes in soil nitrogen content.

The project StyrN has been granted 4.9 million DKK from the Green Development and Demonstration Programme (GUDP)

SEGES (project leader), Aarhus University and The University of Copenhagen

2018-2020

The DCA report "Næringsstofbalancer og næringsstofoverskud i landbruget 1996/97-2016/17" (in Danish) can be downloaded from dca.au.dk/en.

- The increase in nitrogen surplus is partly due to the government's passing of the so-called Agriculture Package and higher nitrogen norms, says Finn Pilgaard Vinther.

On the other hand, increased application of nitrogen fertiliser has resulted in a higher protein content in Danish-grown grain. This has probably contributed to the decline in the import of soybean protein by approximately 11,000 tons nitrogen in 2016/17 compared to 2015/16.

In brief

Photo: Jesper Rais, AU Photo

Development of a new fertiliser accounting system in the Baltic Sea Region

The maximum amount of nitrogen application per hectare from animal manure is 170 kg in all environmentally vulnerable areas in the EU. However, the methods used to determine the amount of nutrients in animal manure vary between countries. This means that some countries might actually apply more nutrients than other countries.

The EU has therefore funded the project **Manure Standards** in which nine countries in the Baltic Sea Region will develop joint guidelines on how to determine nutrient contents in animal manure. This can be done either via manure analyses, or by calculating nutrient content based on feed input minus the amount left in animals' production. Animal manure samples will be taken on-farm in all countries. In Denmark, the partners are Aarhus University and SEGES with a total of 11 farms.

The goal is to develop a joint tool that will provide proposals for implementation of the new system. This will hopefully result in improved utilisation of animal manure in the entire region to the benefit of the Baltic Sea environment as well as the many livestock farmers in this area.

Feeding cattle sustainably – here is some help

Steak or salad? Choosing what to eat makes a difference if you want a sustainable lifestyle. The same goes for cattle. Whether to feed them with maize or molasses, barley or beets makes a difference when farmers consider how to feed their animals most sustainably.

Researchers from Aarhus University have published a report that makes it easier to figure out which feedstuffs are most sustainable. The report includes a table that shows calculated values for selected sustainability parameters for the most commonly used feed ingredients in Danish cattle production.

The parameters selected to express the sustainability of a feedstuff are carbon footprint, land use, effect on biodiversity, fossil energy use, and potential eutrophication. The aim is to provide farmers and advisors with a tool to compose a feed ration that is economically optimal, fulfils nutritional recommendations and where production of the feed has had the least impact on the climate, environment and biodiversity.

The table includes homegrown roughage and other feedstuffs produced in Denmark, purchased feed and by-products, and concentrates, and ranges from rye, rapeseed and soya to maize, molasses, beets and grass – a total of 35 different feedstuffs. The report is available from dca.au.dk/en.

Photo: Janne Hansen

Maize cultivation with reduced environmental impact

A maize crop needs nutrients right from the start. This is the reason why many farmers – in addition to slurry – apply phosphorus in mineral fertiliser in the spring. This "starter" fertiliser poses a risk for the environment in the long-term due to extra accumulation of phosphorus in soil.

Previous field trials at Aarhus University have shown that slurry may work at least as well as mineral starter fertiliser if placed at the correct distance from maize, but there is no suitable application equipment on the market. Furthermore, slurry itself may also impact the environment via greenhouse gas emissions and nitrogen loss.

Researchers from Aarhus University are partners in a new project – **SlurryMaize** – that will approach these problems by developing new methods for improved utilisation of slurry as the primary nutrient source. The aim of the project, which is led by SEGES, is to develop a slurry injection system that ensures precise placement of the slurry prior to sowing, so that the maize has faster and better access to the nutrients. Accurate placement is crucial to subsequent placement of the seeds at the right distance from the slurry. The seeds will die if they are in direct contact with the slurry after sowing. And if too far away, they will not be able to utilise the nutrients sufficiently.

In collaboration with the company Samson Agro, the Department of Engineering at Aarhus University will develop the injection technology that is required for correct placement and distribution of the slurry. Researchers from the Department of Agroecology will investigate the effects of the new technology on maize production, nutrient uptake, and development of greenhouse gases.

The project is funded by the Green Development and Demonstration Fund (GUDP).

Photo: Colourbox

Organic greenhouse vegetables can become more sustainable and resilient

How can tomatoes, lettuce and other organic crops be produced in greenhouses in Denmark without consuming a lot of energy for heating? And how can a corresponding organic vegetable production be possible in southern Europe without crops being eaten or attacked by heat-loving insects and diseases? Researchers from, among others, Department of Food Science will investigate these issues in the new project **Greenresilient**, which has partners from eight European countries.

The main goal is to design and demonstrate resilient agroecosystems in greenhouses and tunnels, which allow for a high and stable production with a low environmental impact. The innovative cropping systems will be tested at five locations in Europe. The partners will investigate diseases, pests and weeds in the crops, soil fertility and soil nitrogen content as well as the environmental and economic sustainability.

The principal crop in the project will be tomato, which in the innovative systems will be combined with other crops. One idea is to shorten the tomato season so that the tomatoes are only grown during the summer, possibly together with legumes such as peas or beans contributing with both a salable yield and nitrogen. Then the cooler and darker winter months can be used to grow winter purslane, mizuna and other winter leafy crops and in spring lettuce, which is hardier than tomato.

The project is funded by Core Organic.

Professor Mogens Støvring Hovmøller is in charge of the project which aims to develope a new early warning system to protect wheat against new races of rust. Photo: Søren Kjeldgaard, AU Photo.

Improved protection of European wheat against **rust diseases is underway**

A European research project is developing a new early warning system to protect wheat against new races of rust.

Rust in wheat has become an increasing problem not only in Europe, but in many parts of the world, and it affects both food security and agricultural productivity.

The project **RustWatch** is a unique, international alliance between research, plant breeding, variety testing, and advice within plant protection with the goal to develop a common early warning system for wheat rust.

The main aim of the project is to ensure a quick and accurate diagnosis of new races of rust followed up by investigation of which consequences such races can have for rust susceptibility in the various wheat varieties that are grown in Europe.

The new early warning system will include yellow rust, black rust and brown rust in wheat grown for the production of feed, bread and pasta products.

- Wheat is the most important crop in Europe. Thus, it is urgent to be at the forefront with rapid and precise identification of new races of rust in wheat, says Professor Mogens Støvring Hovmøller from the Department of Agroecology at Aarhus University. He is the leader of RustWatch, which has 24 partners from 13 countries.

The project will develop new diagnostic tools to enable rapid and precise identification of emerging invasive rust races, and detect their potential harmful effects on existing and future wheat varieties.

Thus, the researchers will investigate the importance of virulence, aggressiveness and adaptation of wheat rust to a warmer climate as drivers for the spread and establishment of new rust races in Europe.

The Global Rust Reference Centre at AU Flakkebjerg, Aarhus University, has a key role in the warning system, in that emerging rust races gathered in Europe can be compared with rust races from other parts of the world. In addition, the rust centre will be responsible for the databases which will handle the large amounts of disease data that the project will collect, and which will be the basis for dissemination of the results to the project partners and end users.

- The collaboration between research, commercial plant breeders and advisory services is key. The project has the potential to be a breakthrough for a more efficient and precise phenotyping of resistance in wheat, e.g. by categorising resistance responses on the cellular level. It is important to be able to use the enormous amounts of genomic sequence data that the new plant breeding technnologies generate, says Mogens Støvring Hovmøller.

The project RustWatch has been granted 5 million euro from EU's Horizon 2020 programme

24 partners from13 countries, including Aarhus University, Danish Agriculture and Food Council, Nordic Seed A/S and the Tystofte Foundation from Denmark

2018-2022

agro.au.dk/en

Resistance to fungicide continues to rise

Fungal crop diseases are a significant problem in both Denmark and the rest of the world. In Denmark the fungus septoria causes the greatest losses in wheat and is controlled with azoles, among others. However, an important problem is that the fungi develop resistance to the fungicides.

In order to monitor this development, researchers from the Department of Agroecology have continuously investigated septoria's resistance to azoles. Unfortunately, the results show that resistance continues to rise. This is the case for Rubric (epoxiconazol) and Proline (prothioconazol), among others. In trials in which the azoles were used on their own it was also observed that resistance led to lower additional yield.

The researchers have also shown that better field results are achieved by combining the azoles. The azole mixtures Armure (difenoconazol + propiconazol) and Prosaro (prothioconazol + tebuconazol) had a better effect than products with just one azole. The best solutions were achieved if the azoles were combined with products with other modes of action.

Pyrethroids can be used to control cabbage-stem flea beetles

Pyrethroids can be used against cabbage-stem flea beetles instead of neonicotinoids, which can be harmful to bees.

Upon a request from the Danish Environmental Protection Agency via DCA – Danish Centre for Food and Agriculture, researchers from the Department of Agroecology have taken a closer look at protection against cabbage-stem flea beetles and the use of seed protection products.

Infection with larvae of cabbage-stem flea beetles can be a big problem in winter rapeseed. Since it is difficult to predict precisely when and where the attacks occur, farmers use neonicotinoids to protect seeds against larval attacks. The product is applied to rape seeds before they are sown. This makes the rape plant poisonous to the larvae. The problem is that neonicotinoids can also be poisonous to bees.

In the EU, the use of neonicotinoids is forbidden or limited but exemption can be granted and permission given for limited use in cases where there are no other reasonable options and the neonicotinoids are used safely – e.g. their application does not harm bees. However, there is another solution.

In Denmark it is possible to protect against cabbage-stem flea beetles by using pyrethroids. Pyrethroids affect adult cabbage-stem flea beetles and to a certain extent their larvae. Economically and environmentally their use is only meaningful if a significant attack is expected. It is therefore important to monitor the population of cabbage-stem flea beetles so that a decision to use the pyrethroids can be taken on the basis of a threshold value.

The researchers do not expect that resistance will be a problem in Denmark in the near future – but make clear that care should be taken.

If exclusively pyrethroids are used to control cabbage-stem flea beetles, then it is important to check for resistance regularly. The recommendation from the researchers is to gather samples of adult cabbage-stem flea beetles every two to five years from representative areas in Denmark with the aim of monitoring resistance development.

The DCA report "Udredning om rapsjordlopper som skadedyr i raps" (in Danish) can be downloaded from dca.au.dk/en.

Growing of perennial crops in the Limfjord catchment area shows huge potential

By converting 25-35 percent of the agricultural area surrounding the Limfjord to biomass production, it is possible to achieve the reduction goals for nitrogen leaching in the aquatic environment plans. However, more knowledge about the economics in relation to biorefining is required.

A significant reduction in nitrogen leaching in some of the Limfjord catchment areas is needed in order to fulfil the requirements in the Danish Aquatic Environment Plans, which derive from the implementation of the EU Water Framework Directive. It is not immediately possible to reach the goals using traditional means and it may be necessary to set aside agricultural land.

Experiments carried out at Aarhus University in Foulum show that cultivation of perennial crops may provide a significant reduction in nitrogen losses compared to annual crops even in situations where the crops are fertilised optimally.

Changing crops allows for an increase in biomass production and a reduction of nitrogen loss. The prerequisite for such a conversion is to ensure a stable and profitable biomass market and to be aware of expected impacts on the environment, climate, economy and employment.

It is technically possible to meet the goals

In order to elucidate this topic the Ministry of Environment and Food of Denmark asked researchers from Aarhus University and The University of Copenhagen to examine the potentials of increased biomass production in the catchment areas of Hjarbæk Fjord, Lovns Bredning and Skive Fjord.

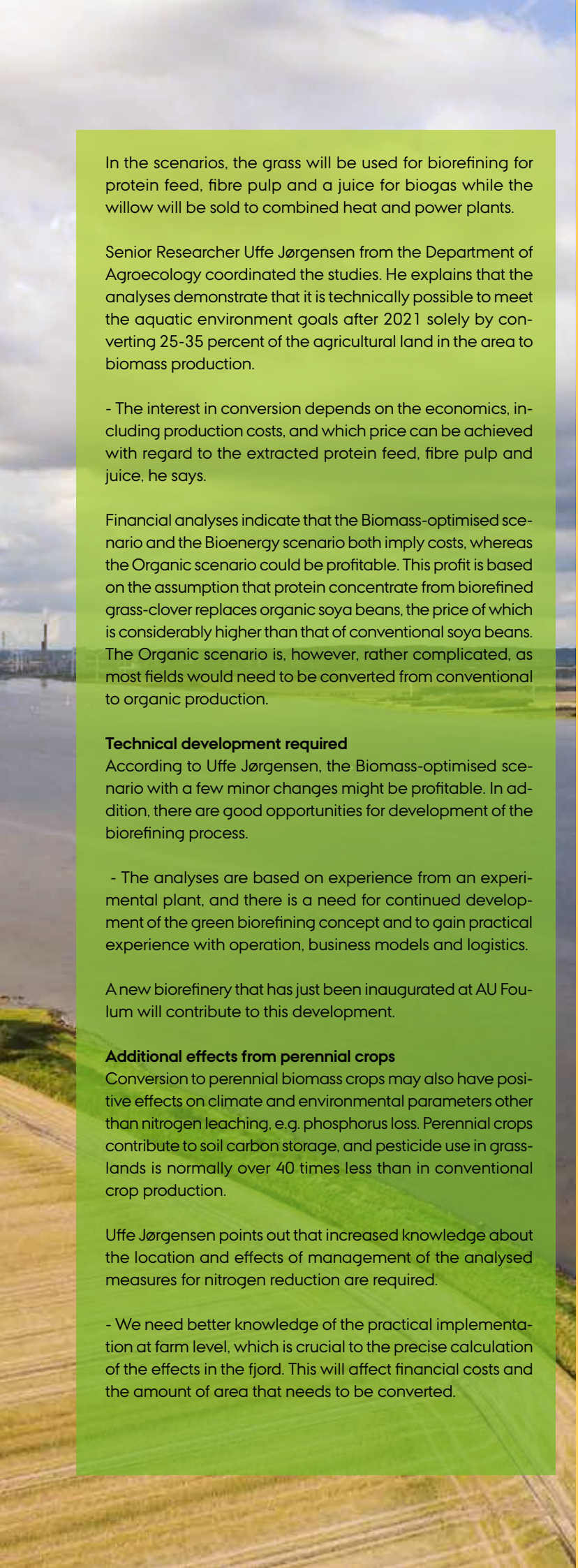
The researchers analysed four possible scenarios to provide an overview:

- **Unchanged scenario** (high share of annual crops – cereals and maize)
- **Biomass-optimised scenario** (conversion to highly-fertilised pure grass)
- **Organic scenario** (conversion to grass-clover with minimum fertiliser)
- **Bioenergy scenario** (conversion to willow for energy production)

The DCA report "Kan reduktionsmålsætninger for nitratudvaskning til Limfjorden opfyldes ved øget dyrkning af biomasse?" (in Danish) can be downloaded from dca.au.dk/en.

According to Senior Researcher Uffe Jørgensen, it is technically possible to achieve the aquatic environment goals solely by converting 25-35 percent of the agricultural land in the area surrounding Limfjorden to biomass production. Photo: Maria Randima, AU Photo.

Photo: Colourbox



In the scenarios, the grass will be used for biorefining for protein feed, fibre pulp and a juice for biogas while the willow will be sold to combined heat and power plants.

Senior Researcher Uffe Jørgensen from the Department of Agroecology coordinated the studies. He explains that the analyses demonstrate that it is technically possible to meet the aquatic environment goals after 2021 solely by converting 25-35 percent of the agricultural land in the area to biomass production.

- The interest in conversion depends on the economics, including production costs, and which price can be achieved with regard to the extracted protein feed, fibre pulp and juice, he says.

Financial analyses indicate that the Biomass-optimised scenario and the Bioenergy scenario both imply costs, whereas the Organic scenario could be profitable. This profit is based on the assumption that protein concentrate from biorefined grass-clover replaces organic soya beans, the price of which is considerably higher than that of conventional soya beans. The Organic scenario is, however, rather complicated, as most fields would need to be converted from conventional to organic production.

Technical development required

According to Uffe Jørgensen, the Biomass-optimised scenario with a few minor changes might be profitable. In addition, there are good opportunities for development of the biorefining process.

- The analyses are based on experience from an experimental plant, and there is a need for continued development of the green biorefining concept and to gain practical experience with operation, business models and logistics.

A new biorefinery that has just been inaugurated at AU Foulum will contribute to this development.

Additional effects from perennial crops

Conversion to perennial biomass crops may also have positive effects on climate and environmental parameters other than nitrogen leaching, e.g. phosphorus loss. Perennial crops contribute to soil carbon storage, and pesticide use in grasslands is normally over 40 times less than in conventional crop production.

Uffe Jørgensen points out that increased knowledge about the location and effects of management of the analysed measures for nitrogen reduction are required.

- We need better knowledge of the practical implementation at farm level, which is crucial to the precise calculation of the effects in the fjord. This will affect financial costs and the amount of area that needs to be converted.

Denmark can grow all the protein needed for feed for its animal production

Denmark is a net importer of protein for feed due to its major animal production for domestic consumption and export. However, Denmark can potentially produce enough protein to cover its demands for animal feed, food and export. This is the conclusion of a report prepared by researchers from Aarhus University and The University of Copenhagen at the request of the Ministry of Environment and Food of Denmark.

The report, which can be downloaded from the Ministry's website, describes new protein sources for feedstuffs and food. The potential new proteins for animal feed are grouped by sources that can be grown on land or in water, and protein sources that are produced with the aid of microorganisms or insects on an industrial scale based on various residual products. With regard to potential new protein sources for food, the researchers looked at the possibilities of using seaweed as well as by-products from the production of potato starch, vegetable oil, and flour, and from slaughterhouses.

For each product, there is a description of the rationale for considering the new protein source, how mature the technology is, the production potential in Denmark, possible applications, export potential, anticipated climate and environmental effects, and barriers for possible implementation.

On the global level, increased production of Danish protein can lead to less pressure on land use change from nature to agriculture, thus reducing greenhouse gas emissions and easing the pressure on biodiversity.

Intelligent spraying and precision technologies reduce pesticide consumption

A single, targeted droplet of herbicide sprayed on a budding weed, or a precise measure of fungicide on a diseased crop can help farmers reduce their pesticide consumption.

The market for spraying and precision technologies, which can target and reduce the use of pesticides in agriculture, is developing rapidly.

The technologies vary as to stage of development. Several GPS-based systems are already in use to achieve a precise pesticide application and can reduce pesticide consumption by 5-10 per cent. Other technologies have demonstrated their potential field experiments but need significant development before becoming commercially marketable products.

There are, however, essential barriers to the implementation of spraying and precision technologies. These include lack of documentation of the financial benefits of investing in new technologies, and considerable difficulties with regard to practical implementation.

A report commissioned by the Danish Environmental Protection Agency and prepared by Aarhus University and SEGES sheds light on this. The authors describe the challenges and barriers related to the individual technologies and suggest how to increase the use of said technologies.

The Partnership for Precision Spraying
Several of the technologies are currently being tested in field trials and there is a growing interest among farmers to invest in new technologies.

In order to establish a framework within which stakeholders can collaborate on a smooth implementation of the technologies in practice, the Danish Environmental Protection Agency has established **The Partnership for Precision Spraying**".

The new partnership, which was launched at a kick-off meeting in April 2018 at AU Foulum, will contribute to reduce pesticide consumption, thus reducing farmers' costs and environmental impact.

The partnership is led by the Danish Environmental Protection Agency. DCA – Danish Centre for Food and Agriculture acts as its secretariat in collaboration with partners from the consulting company LMO, HortiAdvice, and Agro Business Park.

Find more information on The Partnership for Precision Spraying at mst.dk.

Agricultural machines must **speak the same language**

Smart technologies are only really smart when they can interact. Senior researcher Claus Grøn Sørensen is working on just that: getting IoT products from many different manufacturers to be able to talk seamlessly together. Photo: Anders Trærup, AU Photo.

Smart technologies are only really smart when they can communicate with each other. This also applies in agriculture, where internet-connected machines will pave the way for „agriculture 4.0".

The Internet of Things (IoT) has a huge potential to increase agricultural efficiency. However, smart devices from different manufacturers do not currently speak the same language. As a result, they cannot share information. This limits the value of the available information and the smart devices.

For example, a combine harvester could collect valuable data, but if its software cannot communicate with the rest of the farm's management systems, then the data cannot be used for operational or strategic decisions.

The Department of Engineering at Aarhus University has therefore joined forces with a wide range of European universities and companies to tackle the problem of interoperability and design the digital agricultural system of the future. This collaboration is part of the EU-funded smart farming project "Internet of Food & Farm 2020" to promote the use of IoT technologies in the European food and agricultural sectors with a view to improving sustainability and productivity.

Everything needs to be interconnected

The project partners are working on developing an open source software tool, ADAPT, originally developed by the organisation AgGateway. ADAPT allows the exchange of data between farming equipment and various brands of software platforms in a harmonised format. With a simple plug-in, software companies and equipment manufacturers will be able to read data from various sources. This will ease data exchange between the systems and ultimately facilitate more qualified decision-making and much more productive farming.

It will enable farmers to use a wide range of hardware and software which, irrespective of manufacturer, can communicate with each other.

Machine to machine communication (M2M)

Another step in digitilisation of agriculture is about real-time and two-way cloud communication for vehicles. To achieve this, the project will further develop existing standards and collaborate with the Agricultural Industry Electronics Foundation (AEF).

AEF is an independent organisation with more than 200 member companies. The main objective is to improve compatibility between electronic and electrical components in agricultural equipment and ensure transparency regarding compatibility issues.

Internet of Food & Farm 2020 has received 35 million euro from EU's Horizon 2020 programme

100 partners

2017-2020

iof2020.eu

Reduction of greenhouse gas emissions from livestock production

New technologies will help reduce greenhouse gas emissions from livestock production. At a meeting organised by Aarhus University, companies and knowledge institutions brainstormed on the opportunities.

Livestock farming is a major source of climate gas emissions, including methane and nitrous oxide from livestock metabolism, and ammonia from animal barns and storage facilities. In recent years, this area has been researched extensively in Denmark, and Danish food production is among the most climate-efficient in the world when measured per product unit.

Nevertheless, Denmark is faced with major requirements regarding greenhouse gas mitigation, including significant reduction goals in Danish agriculture. This situation requires exploration of the possibilities for further reducing emissions from livestock production.

It is unlikely that any one research area can deliver a total solution. Possible solutions will more likely be found through an interaction between innovative companies and university research environments.

On this background, DCA and iCLIMATE held a networking meeting in December 2018 with the aim of creating new contacts between research environments and companies, and inspiring innovation and collaboration for development of new technologies and solutions for reducing the climate footprint of livestock production.

In the course of the day, short talks provided inspiration for creating networks and sharing knowledge. The emphasis was on group discussions, where the participants presented ideas for mitigating greenhouse gas emissions from livestock production and thereafter discussed proposals for concrete actions.

Important focus areas

A range of specific areas in which research and development could reduce greenhouse gas emissions from livestock production were proposed at the meeting:

- Frequent slurry removal
- Slurry acidification
- Development and testing of slurry additives
- Monitoring, and development of sensors
- Air cleansing in slurry storage facilities
- Development and test of feed additives
- Feeds which promote non-methane producing microorganisms in the rumen
- Reduction of hydrogen in the rumen
- Incentives for farmers and evaluation of management systems
- Breeding, and developing measurement methods and equipment at the individual animal level
- Chain considerations/accumulated effects

You can read more about how Aarhus University works to reduce greenhouse gas emissions from livestock production at dca.au.dk/en/climate.

Photo: Carl-Otto Ottosen

Can certain types of light result in **herbs with more taste?**

Researchers from the Department of Food Science are investigating the possibilities of using specific light spectra from LED to boost the taste of herbs.

Light consists of a whole spectrum of colors which affect plant growth in many different ways. For example, red light results in elongation, which means the plants grow taller, while blue light results in a more compact growth. In a new project, researchers from Aarhus University are investigating the possibilities for using specific light spectra from LED lamps to give herbs more taste when grown in protected cultivation.

- Just think of a forest where the plants stretch towards the sunlight, Professor Carl-Otto Ottosen from the Department of Food Science at Aarhus University says. He explains that this is due to the red spectrum in sunlight and adds that blue or UV light might help plants defend themselves by producing protective pigments.

Carl-Otto Ottosen is the leader of a project, which, in combination with the GUDP funded project Intelligent Light, will shed light on herbs from the island of Funen in particular.

Light colour affects plant growth

The researchers will select certain species of herbs and focus on the plants' reactions to different combinations of light in closed systems during three phases of the plants' production: germination, growth and senescence. Other potted plants are also included in the project, which is a collaboration between Aarhus University, three Danish nurseries, a lamp manufacturer and The University of Copenhagen.

- The aim is to create plants with a more compact growth and more intense leaf and flower color, and herbs with a more intense taste. It might not be necessary to replace all the lamps if you can suffice with providing the right light combination for a shorter period of the production and thus reduce costs, Carl-Otto Ottosen says.

With the aid of advanced equipment, the researchers will measure plant photosynthesis and stomatal regulation. This will be combined with measurements of plant growth, developmental speed, taste and content of relevant substances.

- The results may pave the way for multi-layer production, which in turn can make it easier to grow herbs or other crops in cities, also known as urban farming, Carl-Otto Ottosen says.

The project has received 200.000 DKK from Funen Energy Development Fund. The project is connected to iFOOD - Aarhus University Centre for Innovative Food Research and is a collaboration between the GUDP-funded project Intelligent Light and EU's Interreg project SmartGreen.

Aarhus University, The University of Copenhagen, the nurseries Knud Jepsen, Rosborg, and Graff, and the lamp manufacturer Senmatic.

At Aarhus University, **animal welfare is in the spotlight**

Aarhus University carries out research in just about every aspect of animal welfare and is among the international elite in this area. The research is both basic and applied and enables the university to carry out research-based advice, teaching and technological development which is in demand by businesses and authorities.

Animal welfare is a subject that often occupy the minds of consumers and there is a growing focus on promoting animal welfare. Researchers from Aarhus University provide advice in the area on a daily basis to Danish and European authorities, and are constantly working to ensure that research in animal welfare matches demands from the industry and the authorities with regard to new knowledge, technology and system development.

So says Professor and Section Manager in the Department of Animal Science, Jan Tind Sørensen.

- Animal welfare is a very broad concept, and promoting animal welfare is complicated and has many consequences. It is therefore important that our efforts stretch broadly and cover everything from behaviour, welfare assessment, technology and management to transport and relations between humans and animals. In general, we have a strong focus on developing tools and methods that make it possible for farmers to constantly improve animal welfare.

Both animals and farmers benefit

As part of the policy support services, the researchers must be able to analyse, assess and document the effects of measures for improving animal welfare in conventional and organic production systems.

As is par for the course, in 2018 the researchers carried out a wide range of tasks for the Ministry of Environment and Food of Denmark. They have given recommendations for improving animal welfare in barn egg production, and provided assessments of whether there are alternative, suitable injection methods for local anesthesia of suckling piglets prior to castration than those already approved.

The researchers have also provided advice on ruminants' requirements for access to drinking water, the possible welfare effects of the use of long-term analgesics in calves after dehorning, and the importance of sick pens for dairy cows with mastitis.

One of the problems the researchers have addressed specifically for many years is piglet mortality. Studies from Aarhus University have shown that piglet survival after birth improves if the dams are fed closer to farrowing. The correct feeding strategy results in a shorter farrowing and thereby stronger

newborn piglets. Researchers from Aarhus University are therefore collaborating with the industry to develop new feeding strategies and feed products that can improve piglet survival significantly.

Top-knotch facilities

The numerous trials and research tasks require special facilities. Aarhus University therefore has flexible research facilities for pigs, cattle, poultry, mink and horses. The university also has access to an organic farm animal platform for research in management, technology, nutrition, health and behaviour under organic conditions.

Depending on the purpose, data collection can also be carried out on commercial farms, during transportation of animals, or in situations involving interactions between animals and humans. For example, Aarhus University was responsible for one of the world's first studies of transport fitness of cull sows.

Collaboration in Denmark and internationally

Aarhus University has a leading position within European research in animal behaviour and welfare. In 2018, the Department of Animal Science at Aarhus University was designated to build EU's first Reference Centre for Animal Welfare in collaboration with two research institutions in Germany and The Netherlands. The department won the assignment in competition with a number of other European consortia, and during the next five years, Danish researchers thus contribute to improve animal welfare control in European livestock herds as well as provide advice to authorities in 28 member countries.

- It is crucial, and a prerequisite for achieving excellent results, that the research activities are carried out in close collaboration with others – research environments, the industry, companies and industry associations. Therefore, we continuously work to maintain and further develop our exceptional position via a holistic approach and interdisciplinary research to the benefit of primary production and animal welfare, Jan Tind Sørensen says.

„It is crucial, and a prerequisite for achieving excellent results, that the research activities are carried out in close collaboration with other research environments, the industry, companies and industry associations," Jan Tind Sørensen, Professor and Section manager in the Department of Animal Science says. Photo: Søren Kjeldgaard, AU Photo.

New efforts to reduce antibiotic consumption

How can we reduce the use of antibiotics in Danish pig production and still ensure animal health and welfare? Three research projects aim to find the answer.

During the period from the piglets are weaned and until they weigh 30 kg, a conventional Danish weaner pig receives antibiotic treatments five times on average, primarily because of diarrhoea. Photo: Jesper Rais, AU Photo.

In recent years, the use of antibiotics in Danish livestock production has been a controversial issue – and with good reason. A high antibiotic consumption on Danish farms may result in problems with resistance, which can reduce the possibilities of effectively treating infections in both animals and humans. In December 2017, the Danish Parliament therefore adopted the Veterinary Settlement III that has a strong focus on reducing antibiotic consumption in Danish pig production.

As part of the settlement, targeted research efforts have been initiated in collaboration between Aarhus University, The University of Copenhagen and Statens Serum Institut (SSI) in order to procure knowledge and tools to reduce antibiotic consumption with due consideration to animal welfare and economic sustainability.

Focus on weaner pigs
At the Department of Animal Science, Aarhus University, three projects have been initiated which focus on reducing antibiotic consumption in weaner pigs. Weaners are pigs from weaning at the age of 3-5 weeks (conventional production systems) or older (organic production systems) until they weigh 30 kg at the age of approximately 12 weeks.

During this period, a conventional Danish weaner pig receives an average of five antibiotic treatments, primarily because of diarrhoea. Therefore, researchers aim to improve the pigs' resilience and disease resistance in the suckling period. Professor Charlotte Lauridsen, Department of Animal Science, and head of the project, explains:

- We do not know yet why some pigs manage better than others during the weaning period. Therefore, we will examine whether pig size is important to their ability to access the udder, and if the time of birth is important in relation to their competition for access to the colostrum.

Just like breastmilk, the sow's colostrum is rich in various substances that are important to healthy development of the gastrointestinal tract and a strong immune system. If there are many piglets in a litter, it is necessary to supplement the sow's milk with milk and feed in the suckling period:

- There is a significant difference in the pigs' inclination to eat anything else than sow milk, and we will study this behaviour in more detail to clarify how old the pigs should be in order to reduce the risk of developing diarrhoea at weaning. We will also examine the connection between this and the robustness of the intestine and immunity, Charlotte Lauridsen says.

Feeding strategies to improve intestinal health in piglets
Within the framework of another project, the researchers will develop feeding strategies expected to stimulate feed intake in piglets as early as the suckling period. Increased feed intake during the suckling period may entail increased feed intake after weaning. This is very important in order to maintain intestinal health and productivity, and it further helps reduce the risk of diarrhoea.

In a series of infection experiments, weaner pigs will be fed fermented wet feed, which is a softer transition from milk than dry feed.

When fermenting wet feed, you achieve a very strong growth of lactic acid bacteria, a high concentration of lactic acid and a low pH value, which will kill pathogenic bacteria such as E. coli and salmonella in the feed as well as in the intestine. Subsequently, the researchers will study the effect of this strategy on intestinal health, immune system, productivity, and especially the effect in relation to weaning diarrhoea.

Increased weight and reduced antibiotic consumption
A third project focuses on increasing pig weight; partly by weaning at an older age, and partly by keeping the piglets in stable litters together with the sow during the suckling period. Several studies and practical experience indicate that bigger and more robust pigs at weaning may reduce the occurrence of infections requiring treatment and thus the need for antibiotics.

- Today, the sow will typically have larger litters than she can take care of, and therefore many piglets are moved to another sow who will take care of them until weaning. At Department of Animal Science, we want to study the effect of keeping the litter together from birth to weaning, meaning that the sow will only have her own piglets to take care of. Subsequently, we will follow the piglets as weaners in the weaning barn and examine the prevalence of diseases and antibiotic treatments, Charlotte Lauridsen says.

The three projects described will run until 2021. Results are expected to be available together with those from the other collaboration projects in 2021.

Robust calves are in demand – but how?

Researchers from Aarhus University collaborate with research colleagues and the industry in a major calf project, the aim of which is to reduce calf mortality and antibiotic use by means of targeted health management.

The first months of a calf's life are critical. During these first months, the mortality rate and antibiotic consumption due to diarrhoea and pneumonia are high. At the same time, diseases and inappropriate feeding or care during the first weeks may affect the calf, thus resulting in reduced milk yield and growth as an adult cow or veal calf, respectively.

Based on this, researchers from Aarhus University are part of a major research project, the aim of which is to reduce calf mortality and antibiotic use via targeted health management.

Researchers from the Department of Animal Science will examine diagnostic tools for monitoring calf health status – including test of a method for measuring the immune status of calves. Researchers will also examine how Brix measurements in calf serum can be used as an indicator for the calf's immunization status and thus its robustness.

- We have collected blood samples from calves in dairy herds, and these will be analyzed in the laboratories at AU Foulum. They are supposed to provide an accurate overview of the calf's immunization achieved "from its mother", and whether this will be important for its performance as a veal calf, Senior Researcher Mogens Vestergaard, Department of Animal Science, explains.

Probiotics – an appropriate alternative to antibiotics?

Further, researchers will investigate whether probiotics may constitute a possible alternative to antibiotics, and the importance of this in relation to the development of a robust intestine and immune system. During the autumn and winter of 2018, researchers tested a probiotic product added to the calf milk replacer and also added to the compound feed and then fed to calves in a private veal calf herd.

Within the framework of the project, researchers will examine whether probiotics may be an alternative to antibiotics. Photo: Jesper Rais, AU

- The probiotic product consisted of living yeast. We expect that such products will have positive effects for calves, and we hope this will help stabilize newly shipped veal calves and help us reduce medication, says Mogens Vestergaard, and continues:

- We plan to test the same probiotic product in a dairy cattle herd with diarrhoea problems; newborn calves will be given probiotics from birth and until 4 weeks of age. Subsequently, we will make a general assessment indicating whether this probiotic product has the potential of replacing antibiotics – fully or partly – when treating gastrointestinal diseases in calves.

Development of effective management tools

The project also focuses on the development of efficient management tools to be used in heifer and veal calf production. Post Doc Bodil Højlund Nielsen, Aarhus University, will be responsible for this part. The aim is to provide the farmer with analyses and management tools to support his efforts in relation to strengthening calf robustness; and which may also be used in a dialogue with employees, advisors and purchasers of veal calves and heifers.

The researchers will conduct a comprehensive analysis based on data from approx.100 herds as well as the Danish Cattle database. Data are collected in clusters of herds, each consisting of one veal calf producer and up to five of his suppliers of calves.

Based on this, the researchers will select key parameters that are relevant as management goals – i.e. properties and characteristics in calves, feeding, housing, care etc. that best support the production of robust calves with a low disease frequency and mortality rate and with good growth.

- These efforts will result in a description of tools to be used when communicating with the employees, but also for complex analyses used for identification and quantification of problems as well as for decision support in a dialogue with the advisor, says Bodil Højlund Nielsen.

Keel bone fractures in laying hens affect animal welfare

Many laying hens experience keel bone fractures at some point in their lives in both conventional and organic systems. The fractures can arise when the hens collide with objects or each other during flight, or if they land incorrectly. In 2018, the Ministry of Environment and Food of Denmark asked Aarhus University to account for how the injuries affect welfare of laying hens.

Based on a literature review, researchers from the Department of Animal Science concluded that the fractures constitute a welfare problem, irrespective of whether the animal welfare indicators used are production parameters, affective states (e.g. pain, fear and discomfort) or opportunities to exercise natural behavior.

Layers with keel bone fractures lay fewer eggs and have a reduced mobility. In addition, several studies indicate that the hens are in pain. The underlying cause of keel bone fractures is unknown, but breeding for high yields and feed efficiency is thought to play a major role. Modern hens have small breast muscles and a low body weight, and lay many eggs from an early age.

Further research is needed to elucidate how to prevent keel bone fractures from occurring.

The review has been published in Frontiers in Veterinary Science.

In brief

Photo: Maria Randima, AU Photo

Distinguished recognition of the welfare assessment scheme WelFur

Researchers from the Department of Animal Science at Aarhus University have developed the welfare assessment scheme **WelFur** in collaboration with colleagues in five countries.

WelFur is a tool for objective assessment of animal welfare on fur farms. In 2018, the scheme was recognised at the highest level, in that it was included in the European Commission's database of Self-Regulation and Co-Regulation initiatives. Here WelFur is described as a "science-based, practical and reliable on-farm assessment system that acts as a tool for monitoring and improving animal welfare". Schemes that are accepted often form the basis for binding legislation.

The WelFur protocol was first applied in January 2017. Since then, it has become common practice for all fur farms in Europe to get a visit from a WelFur auditor, who will assess the welfare in three important production seasons. If the animal welfare is satisfactory, and the farmer complies with legislation, the farm will be certified.

From 2020, the world's three auction houses Kopenhagen Fur, Saga Furs and NAFA will only sell European mink and fox pelts that have been WelFur certified. Therefore, almost all European mink farmers have signed up for WelFur. Aarhus University is responsible for training WelFur-Mink auditors.

Smart sow feeding leads to better piglet survival

Studies from Aarhus University have shown that more piglets can survive birth and the time thereafter if their mothers are fed closer to farrowing. The right feeding strategy results in a quicker farrowing and thereby stronger newborn piglets with a good start in life. In other words, appropriate sow feeding the last couple of days prior to farrowing will result in quicker farrowings and higher survival rates.

Researchers from Aarhus University collaborate with the industry to implement this knowledge in practice and to disseminate knowledge on feeding strategies as well as develop new feed products aimed at reducing total pig mortality up to weaning. This will take place in the four-year research project **Born2Live**, which has been granted 7.1 million DKK from the Green Development and Demonstration Programme (GUDP).

In order to zoom in on the best strategy, the project will test various combinations and levels of meal frequency, amount of feed per meal, and new feed compositions.

The partners expect that the project can reduce the proportion of stillborn piglets by 1.5 percentage points and increase survival rates of liveborn piglets by 0.5 percentage points.

Photo: Carsten Kjærulff Christensen, AU

New knowledge about transport of cull sows to slaughter

Every year, about half of the Danish sows are slaughtered – approximately 500,000 animals – and transported to slaughter by truck. Cull sows are vulnerable to transport stress, as they are older than slaughter pigs, and may be weakened or injured.

Researchers from Aarhus University were some of the first to study this particular group of animals, and have carried out several studies. A recent study was based on 47 batches of sows from 12 herds. Before transport, technicians conducted clinical examinations of a total of 522 sows. Next, the sows were loaded onto a commercial pig truck and transported for a period of 0-8 hours, cf. Danish legislation. When the sows were unloaded at the abattoir, the technicians repeated the clinical examination.

The pre-transport examination revealed signs of reduced clinical condition such as wounds, superficial skin lesions, udder lesions and shoulder ulcers in a considerable proportion of the sows. Almost 40 percent of the sows came directly from the farrowing barn and were lactating at the day of slaughter. Arriving at the abattoir, only very few of the sows were in a condition, which would have been considered unfit for transport by the authorities. However, the clinical condition of the sows was deteriorated, as shown by an increase in the number of wounds, superficial skin lesions, signs of dehydration, increased numbers of torn hooves and vulva lesions, compared to the pre-transport clinical examination.

Examination of possible risk factors for this deterioration pointed mainly to characteristics regarding transportation as such. For instance, the researchers discovered that the main risk factors were duration of the transport as well as duration of stops on the way, and waiting time before unloading at the abattoir – often in interaction with the temperature in the truck. In order to point out actual solutions, develop procedures or guidelines for transport of cull sows, ongoing studies are now focusing on identification of individual risk factors for the deterioration of the sows' condition. Such guidelines would be of benefit to animal welfare, the industry and the authorities.

The study was conducted at a request from the Ministry of Environment and Food of Denmark as part of a larger study on fitness for transport. The results have been published in Translational Animal Science and Frontiers in Veterinary Science.

Photo: Ida Marie Jensen, AU Photo

School lessons in animal welfare

Which is better for cows, poultry and pigs – to stay indoors or have access to outdoor facilities? Why does the farmer castrate male piglets? And what is meant by terms such as "animal welfare" and "ethical considerations"?

Children in 4th-6th grade as well as in 7th-9th grade will be asked questions like these – and will be given the answers – by means of new education material targeted at these age groups. At a request from the Ministry of Environment and Food of Denmark, the material has been produced in cooperation between the Danish Agriculture and Food Council, Council on Animal Ethics, Animal Protection Organisation, Danish Association of Veterinarians and DOSO - Animal Protection Cooperation Organisation.

Researchers from Aarhus University and The University of Copenhagen contributed facts. The aim is to help children become conscious consumers and allow informed choices.

The material is targeted at the two age groups and may be ordered free of charge. In addition, a series of films has been produced – Sebastian Klein visiting Danish livestock farms. Read more about the material at the Ministry of Environment and Food of Denmark's website.

Here you can also download the material and order books (in Danish).

The use of precision breeding will be inhibited by new EU legislation

EU's recent legislation can make it difficult for all others than large, multi-national companies to take advantage of modern breeding techniques.

Plant breeding has made significant progress in recent years and a whole range of new precision breeding techniques is now available. However, new EU legislation can make it hard for most Danish breeding companies to take advantage of the new techniques, according to researchers from the Department of Molecular Biology and Genetics. In 2018, EU's Court of Justice ruled that the techniques should be regulated according to full GMO legislation.

Upon the request of The Danish Agricultural Agency to DCA – Danish Centre for Food and Agriculture, the researchers investigated the possibilities and risks of using new plant breeding techniques in Danish agriculture, horticulture and forestry. The report was requested and prepared prior to the EU ruling.

- Mutation breeding with the new precision technologies can support an already very efficient plant breeding industry. Especially precision breeding, where you induce one or a few mutations in precise locations on a DNA molecule has great potential because the number of undesired mutations can be minimised. The old-fashioned techniques typically cause thousands of mutations randomly spread in often unsought and unwanted locations on the genome,

Modern breeding technology can increase Danish market shares

Researchers from the Department of Molecular Biology and Genetics are partners in a project that uses new breeding technologies to improve crop yield and quality. The aim of the project is to develop a tool that helps breeders to find the genes behind a desired trait in a plant more precisely.

This can enable a much more efficient breeding process. Due to collaboration with the industry, the knowledge acquired in the project will be used in practice. More specifically, the project will develop breeding techniques with the aim of improving crop photosynthesis in order to increase crop yield and resistance to fungal diseases and to improve crop feed digestibility.

Project partners expect that with the aid of new breeding techniques Danish plant breeders can increase their global market shares by 5-10 per cent.

30 million DKK from Innovation Fund Denmark

The University of Copenhagen (project leader), Aarhus University, Sejet Plant Breeding, Nordic Seed, DLF and Danespo

2018-2023

explains Professor Henrik Brinch-Pedersen from the Department of Molecular Biology and Genetics and one of the authors of the requested knowledge synthesis on the subject.

If the new techniques were exempted from the GMO legislation, we could, according to Henrik Brinch-Pedersen, expect that even small Danish breeding companies would quickly implement the new methods since the techniques do not require heavy investments.

- Now it will most likely only be the largest international breeding companies that can bear the costs when these technologies are subject to full GMO legislation. In this case, it will be unrealistic for Danish breeding companies and thus also to a great extent for Danish agriculture to take advantage of the new technologies. This means we can end up with a few multinational companies having a monopoly, such as is the case with regard to GMO, says Henrik Brinch-Pedersen.

You can download the DCA report "Videnssyntese om nye planteforædlingsteknikker og deres effekt på dansk landbrug" (in Danish) from dca.au.dk/en.

Mutation breeding with the new precision technologies can support an already very efficient plant breeding industry, says Henrik Brinch-Pedersen. Photo: Søren Kjeldgaard, AU Photo

Breeding for **better piglet survival** is moving in the right direction

More piglets are surviving their first five days of life after the introduction of the breeding goal "live piglets at day five".

Since 2004, Danish pig breeders have had the number of live piglets at day five (LS5) as a breeding goal instead of the number of piglets at birth. The aim has been to reduce piglet mortality the first days postpartum. The question is if the change in breeding goal has had the desired effect. Researchers from the Department of Molecular Biology and Genetics have investigated this question at the request of the 2014 action plan for improved pig welfare follow-up group.

It can be difficult to evaluate the effect of the change, since it takes several years for breeding results to show up in production herds. In addition, there are many other factors besides genetics that affect piglet survival. However, the researchers believe that breeding for LS5 has contributed to reducing piglet mortality in breeding and multiplier herds as well as in production herds.

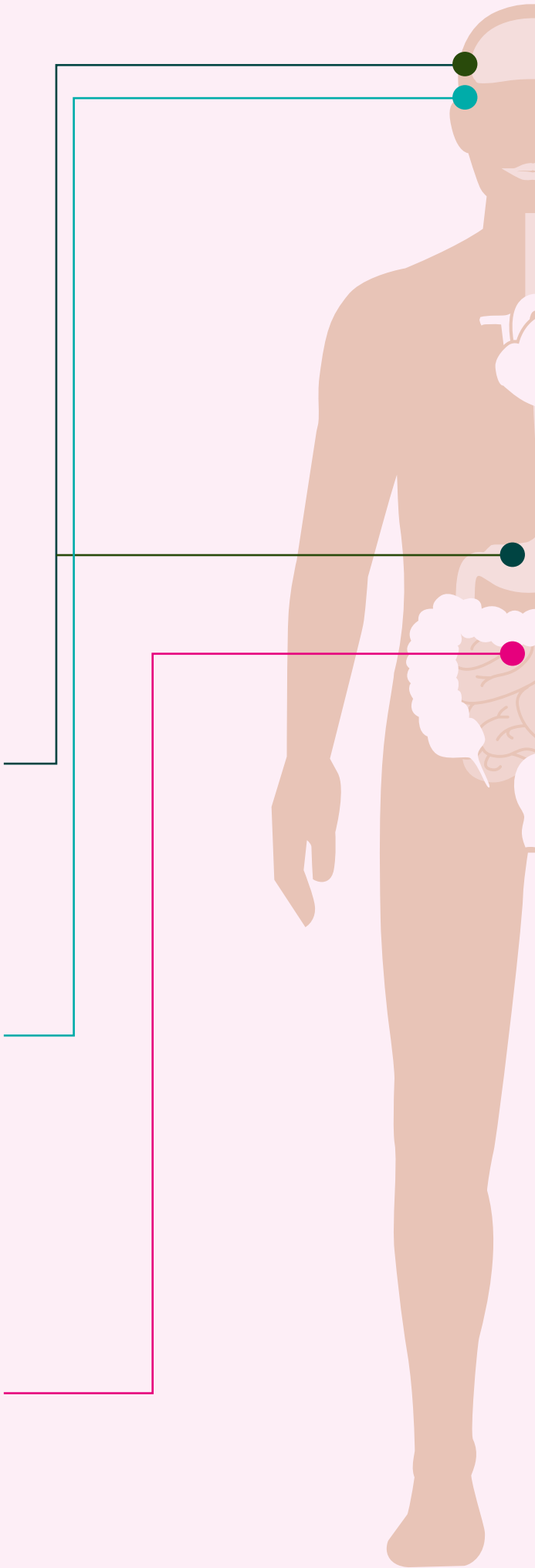
The work has been led by Senior Researcher Ole Fredslund Christensen at the Department of Molecular Biology and Genetics. He points out that part of the improvement in survival rate seen in breeding and multiplier herds has not yet reached production herds.

- From a genetic viewpoint we expect to see improvement in survival rates in production herds by a few percent. By continuing to breed for LS5, we expect that in breeding and multiplier units per cent piglet survival to day five will remain more or less constant in the near future, says Ole Fredslund Christensen and adds that there are alternatives which are expected to lead to better piglet survival than breeding for LS5.

You can download the report "Evaluering af avl for LG5" (in Danish) at dca.au.dk/en.

Food and our body – what happens when we eat?

The interaction between our bodies and food is a key factor in most research within the food area at Aarhus University. Read more about the researchers' efforts to examine the interactions between our bodies and food.



Satiety and hunger are complex issues

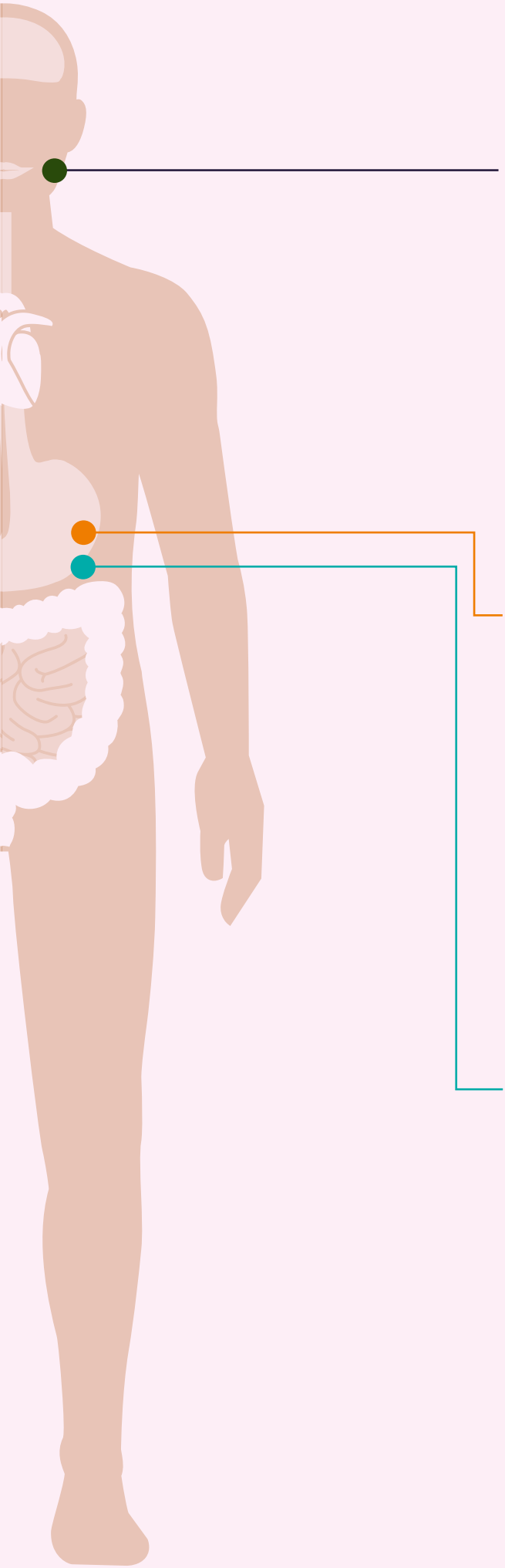
Several factors are at play when it comes to determining whether we feel full or hungry. Within the framework of the **Omnisam** project, researchers from Aarhus University study satiety. The project aims to develop a method to measure the satiating capacity of foods; this will allow the production of foods that make us feel full for longer periods and thus help address the obesity epidemic. In the project the researchers examine behavior, metabolites and appetite hormones in the blood as well as the reward centres in the brain. Read more: food.au.dk/omnisam.

Having a sweet tooth

Within the framework of the **InnoSweet** project, researchers – together with a number of industrial partners – examine methods to reduce the sugar content in sweet beverages and still maintain the sweetness perception. One method is to replace sugar with artificial sweeteners; however, other sensory factors are important to taste perception, relating to both the actual product and your surroundings. Anything, ranging from the colour of the beverage to the font on the label and the music your listen to while drinking, are factors influencing your sensory perception. Read more: innosweet.com.

Milk protein may improve vitamin D uptake

In the Northern parts of the world, vitamin D deficiency is a significant problem. One method of ensuring a sufficient vitamin D intake is to fortify foods with it. However, the fortification of foods with vitamin D is a complex issue, as the vitamin is fat-soluble and prone to degradation. The **DFORT** project aims to investigate the possibilities of improving the availability of vitamin D. Among other approaches, researchers have examined how certain milk proteins may form complexes with vitamin D and thus protect the vitamin from degradation. Researchers are currently examining whether these complexes are able to protect the vitamin long enough for it to be absorbed into our digestive system. Read more: food.au.dk/dfort.



DNA molecules to mimic our sense of taste

The purpose of the **DNA-SHAPES** project is to compare the specific binding characteristics of DNA aptamers to food molecules related to their sensory properties and next correlate them to the human sense of taste. The aim is to develop artificial tasting technologies, similar to our natural sense of taste. Using new high speed DNA sequencing methods and computer analysis, the project partners hope to be able to develop 'artificial tasting machines' that can help not only to determine the sensory characteristics but also to enable assessment of quality, authenticity, and contamination in food in a rapid manner for use in industrial production.

Pig model may help increase knowledge of metabolic syndrome

About 20-25 percent of the adult population in the western part of the world suffer from metabolic syndrome, which significantly increases the risk of cardiovascular disease and type 2 diabetes. Easy access to energy dense, unhealthy foods is a key factor responsible for this development. Department of Animal Science is in charge of the **MERITS** project, within the framework of which researchers – together with the industry – study dietary strategies based on high protein and dietary fibres to mitigate the condition in persons suffering from metabolic syndrome.

As part of the project, a porcine model has been developed, possessing metabolic abnormalities corresponding to those seen in humans. This will partly allow for an examination of the molecular changes that are the consequences of an unhealthy lifestyle; and, in addition, provide the opportunity to examine whether diets are able to change the negative consequences of an unhealthy lifestyle early in life.

Furthermore, a Ph.D. thesis by Mihai Victor Curtasu has been completed and defended in June 2019. It held the title: "Obesity and metabolic syndrome in miniature pigs as models for human disease – metabolic changes in response to ad libitum feeding of high-fat-high-carbohydrate diets".

The connection between the body and food

What happens when you eat soured milk products for breakfast – and what actually takes place in your body, when the milk product is metabolized? A team of researchers at Aarhus University is currently working to map the connection between food intake and health – and they are leaders within this particular field. The researchers apply a method known as metabolomics. When the body burns off nutrients such as carbohydrates, proteins and fat, certain molecules are secreted in the urine or blood. By analyzing and mapping the contents of these molecules, researchers can examine whether certain foods relate to a specific change in the body. Read more at food.au.dk/en.

The perfect packaging for fresh fruit and vegetables must meet many demands

Within the framework of the **Kvalipak** project, Aarhus University collaborates with a series of companies and The Danish Technological Institute in order to develop new types of packaging solutions that may prolong the shelf life of fresh fruit and vegetables. Associate Professor Merete Edelenbos from Department of Food Science at Aarhus University explains:

- In the project, we look at two sides of packaging. We consider alternatives to conventional plastic materials, and we also examine whether we are able to change the conditions within the package to maintain shelf life.

The identification of alternative packaging materials such as bioplastics shows most promise. Bioplastic is based on renewable resources, is biodegradable under proper conditions and has high water vapor transmission rates, and thus seems promising in relation to controlling microbial growth.

- Bioplastics possess promising qualities in relation to the relative humidity inside packages, but the materials need further development. Technological challenges exist as to the strength, how well the materials seal and their transparency, but some of these challenges can be solved, Merete Edelenbos emphasizes.

She further points out that packaging is necessary if consumers want fresh and crisp vegetables. However, we want to avoid insufficient packaging that "reduces" shelf life. Too little packaging or inappropriate use of packaging materials leads to considerable food waste, as dehydrated vegetables or fermented products are thrown out.

Consumers are motivated to **reduce food** waste

Motivation and the opportunity to save money may be the key to reduce food waste in Danish households, according to a recent report from the MAPP Centre at Aarhus University, whom was asked by the Danish Veterinary and Food Administration to shed light on consumer food waste.

The online study used questionnaires that were answered by 508 respondents.

When asked why we throw out food, the most frequent answer was "we buy too much". 85 percent of the respondents said that they had seen or heard something about food waste during the past year. Many of the respondents are aware of the environmental effects of food waste and know how much their household spends on food that is thrown away.

The way we shop can be important with regard to how much food we throw out. More than half of the respondents said they buy more than they need when faced with bulk discounts in the grocery store.

Most of the respondents check the refrigerator and cupboards before grocery shopping, but not very many plan meals ahead, which would otherwise be a good way to avoid buying too much.

A question in the survey was:
How important, if at all, are the following incentives for reducing food waste in the near future?

	Unimportant	Neither/ nor	Important
Saving money	5	29	66
Feeling competent in the kitchen	24	44	32
Keeping order in the kitchen	6	40	54
Avoiding regrets about wasted time	9	38	53
Helping the environment	7	34	59
My values	4	37	59

You can download the DCA report "Consumer Food Waste in Denmark" at dca.au.dk/en.

Food waste is recycled

The Danish food industry is good at using food waste in different ways so the amount that actually goes to waste is limited.

Food production is one of the human activities that contributes most significantly to greenhouse gas emissions in addition to using various limited resources such as water, land and minerals. Keeping this in mind, it is even more of a pity if food products are not eaten but instead wasted. According to the World Health Organization (WHO), more than one third of the food produced globally goes to waste.

How bad is the situation in the Danish primary production and food industry? Researchers from Aarhus University have investigated the facts at a request from the Ministry of Environment and Food of Denmark.

Animal production has the least food waste

The study clarifies that the amount of food waste from the primary production and the food industry is limited. Rather, the waste is recycled for various purposes, including animal feed, biogas or fertiliser.

The study also shows that waste from animal production, in particular, is very small and constant from year to year. The main on-farm causes of waste are sick animals, mortality during transportation, and rejection at the slaughterhouse.

With regard to the primary production of vegetable products, there is more food waste and greater variation from year to year. Here, the main causes of waste are crop diseases and pests. In the food industry, food waste comes mainly from entrails, bones, heads and skin from animals, and from peels, pulp and trimming from fruit and vegetables.

In other words, the study clarifies that the lion's share of food waste from the primary production and the food industry in fact does *not* go to waste and that most of the waste that is not recycled occurs farther out in the chain, i.e. from retail to consumer.

- Compared to the amount that is produced, only a small percentage of food is wasted in both the primary production and the food industry annually in Denmark, says Research Assistant Anna Borum from the Department of Food Science, Aarhus University. Together with her colleagues, she is currently working on a similar study – this time focusing on the Danish service sector.

You can download the DCA report "Food waste in the Danish primary production and food industries" at dca.au.dk/en.

Compared to the amount that is produced, only a small percentage of food is wasted in the Danish primary production and food industry. Photo: Colourbox

Peas as a source of food protein to be explored

Peas and other high-protein crops have long been used as a source of protein for animal feed. Now the potential of peas in food will be investigated. This will take place under the auspices of **P-FOOD**, in which researchers from across Aarhus University will set the framework for a project to investigate peas as a source of food protein. The preproject is funded by iFOOD.

Peas were a common food in Scandinavia a few hundred years ago. At that time, many varieties of peas were grown, while today we are mainly familiar with split peas and fresh or frozen green peas with or without pods.

The aim of P-FOOD, which is based on existing activities at the university, is to explore relevant aspects of peas and other legumes as a source of protein for humans – throughout the whole chain from research in cultivation of peas to studies of their health profile and consumer attitudes to pea-based products.

Meal replacements are not **much of a hit**

Danes are not overly fond of meal replacement products that are primarily used for losing weight. Young people seem to have a more positive attitude to the idea of replacing a meal.

One Meal Low Calorie, Diet Meal Bar, Smart Meal and Diet Milk Shake! The market for meal replacement products is growing rapidly. However, the general public is not overly enthusiastic about this type of product, according to a study from Aarhus University.

- The aim was to elucidate consumption of meal replacements and the frequency and main reasons for their consumption in various age groups. Previously, the products have mainly been investigated in connection with weight control support and regulation of eating behaviour, but we do not have much knowledge about consumer perception of the products or what motivates consumers to use them, says Research Assistant at the MAPP Centre at Aarhus University, Stine Cecilie Mangaard Sarraf.

Most are familiar with at least one product

The study is based on questionnaire surveys carried out among adults (16+) and youth (11-16 years), respectively, with a particular focus on the youth and how attractive they find these products.

Most of the respondents ove the age of 16 are familiar with at least one of the four types of products that were used in the survey, while only 18 per cent answered that they consume them. Consumption is most often limited to one type of product and is characterised by being either occasionally or periodically. As seen in previous studies, weight control is the most important motivation – and only a few consume them as part of their regular diet.

- However, the young group – the 16-35-year olds – seem to consume the meal replacements a bit more often, which can indicate that consumption will increase in the future, explains Stine Cecilie Mangaard Sarraf.

Practical in a busy life – but not suitable for children

According to the study, the general attitude towards the products is neutral, at its best. The products are perceived as practical solutions in a busy life – especially as between-meal snacks – but are generally not considered suitable for children and teenagers.

- However, even those who consume the products are reserved and give neutral rather than positive answers when asked about benefits of the products. At the same time, they also recognise the drawbacks, Stine Cecilie Mangaard Sarraf explains.

The random test among the 11-16-year-olds was relatively small, but the results indicate that the young age group is relatively open to the idea of replacing meals.

Download the DCA report "Forbrugernes holdninger til brug af måltidserstatningersprodukter" (in Danish) at dca.au.dk/en.

We like salt, but are still open to salt reduced food

Consuming too much salt increases the risk of high blood pressure, which can lead to cardiovascular diseases. Since most of the salt that we consume stems from processed food, the industry is encouraged to reduce the amount of salt in these types of products.

The question remains if consumers will actually buy food products with a reduced salt content. PhD researcher Trine Mørk from MAPP Centre at Aarhus University has investigated this via a web-based survey with 1030 respondents and an in-store experiment with 190 participants.

Results show that only a few are willing to change their dietary salt intake. However, at the same time most people are open to trying salt-reduced products. If such products are to be labelled, then the labelling should state that the product fulfills the Food Administration's recommendations regarding salt levels instead of a "Reduced salt" label.

The results from the in-store experiment indicate that such labelling would be able to move some of the sales, although only for products such as crisps, cakes, cookies and cornflakes.

By far most of the salt that we get from our food stems from processed food such as crisps, rye bread or cheese. Photo: Colourbox.

Download the DCA report "Salt og forbrugervalg – om forbrugernes forhold til salt i maden" (in Danish) at dca.au.dk/en.

In brief

Photo: Colourbox

Aarhus University is a new partner in a large European innovation network

Aarhus University has become a partner in EIT Food, one of eight Knowledge and Innovation Communities (KIC) established under the European Institute of Innovation and Technology (EIT).

As one of the largest food-related initiatives in the world, EIT FOOD gathers more than 50 companies, educational institutions and research organisations from 13 European countries. The aim is to promote and strengthen synergy and collaboration between the partners in order to address a range of global challenges and place Europe in the centre of a global revolution within food innovation and production.

EIT Food's partners include research institutions and food giants such as Nestlé, Pepsico and Givaudan. An important part of EIT Food is to involve European consumers in the development of innovative solutions to global challenges.

EIT Food offers a series of services, including support to business start-ups, innovation competitions and pools for entrepreneurs, development of new educational activities such as online teaching, summer schools and seminars, platforms for consumer-driven communication, and regional innovation support for areas in the EU with limited innovation activities.

EIT FOOD is an integrated part of Horizon 2020, which is EU's framework programme for research and innovation. In the course of the first seven years, the partners will invest around 1200 million euro that will be matched with up to 400 million euro from EIT.

The EIT Food headquarter is located in Leuven, Belgium. Four co-location centres in Poland, Spain, Great Britain and Germany will ensure strong regional presence and local co-funding as well as knowledge transfer from one region to another. Director of DCA – Danish Centre for Food and Agriculture Niels Halberg says:

- Aarhus University is the first new Scandinavian partner. We have been invited because of, among other things, our competences in research in all parts of the food value chain. The university is also strong with regard to consumer behaviour and for the same reason Aarhus University is considered an interesting partner that can contribute essential knowledge for solving future important food challenges. We naturally also hope that more Danish companies will soon be invited to the network, which provides unique opportunities for researchers, producers and consumers to think innovatively together and thus ensure future global food production.

Read more at eitfood.eu.

Photo: AU Photo

Photo: AU Photo

New power centre for the Danish food industry in Aarhus

Denmark is internationally recognised for quality food products and leading food science research. When Aarhus University turned the first sod for the Department of Food Science's new building in Agro Food Park in Aarhus in March 2018, it marked the beginning of efforts that will consolidate and expand the department's position.

Research and education at the Department of Food Science comprise the whole chain from field to fork. With its new location, the department will be able to underpin and enter into dynamic collaborations with the more than 75 companies and organisations presently situated in the business park. The new location is therefore an important step towards more collaboration with companies and a jumping off point for consolidated and strengthened food science research and talent development at Aarhus University.

The 140 employees, students and visitors who will have their base in the research and innovation environment from 2019, can all contribute profound professionalism, and with its broad research profile, the Department of Food Science can become the fulcrum for innovations to the benefit of business and society as a whole.

The buildings are expected to be ready at the end of 2019.

Mapping the food science competences and facilities at Aarhus University

In the autumn of 2018, DCA and the Department of Food Science carried out an extensive mapping of facilities and competences within food science across all faculties and departments at Aarhus University. This resulted in the publication „Enabling world-class food innovation and sustainable food production - with interdisciplinary research solutions from Aarhus University," which was presented at a reception in November 2018 at SEGES.

The publication was prepared in response to the research strategy "World Class Food Innovation towards 2030", which was formulated by the Confederation of Danish Industry, Danish Agriculture and Food Council and several large food companies.

The publication is an ambitious attempt to survey and gather all relevant competences and facilities across Aarhus University with regard to the demands for food research identified by the industry – and to illustrate with case stories how the university works across disciplines with the challenges and solutions that are presented in the industry's research strategy. The publication also acts as a guide and lists contact persons in the various academic areas.

You can download the food science survey from food.au.dk/en.

DCA reports about food and agriculture

DCA – Danish Centre for Food and Agriculture publishes reports that mainly contain research and test results aimed at Danish conditions. The reports are often based on policy support answers to the authorities.

In 2018, DCA published 33 reports that can all be downloaded for free at dca.au.dk/en.

AARHUS UNIVERSITY
DCA - DANISH CENTRE FOR FOOD AND AGRICULTURE