“Into the future through research and new solutions”

Danish agriculture, horticulture and aquaculture manage the living: the land, nature and animals. Our production is visible in the landscape and many of our products are served at mealtimes. It is quite natural, therefore, that the world around us makes great demands on us, and that we also place great demands on ourselves: we want to leave the land and its resources in good shape for the next generation and run profitable and economically viable farms in the meantime.

Agriculture is one of Denmark’s most important industries, both in relation to jobs and export revenue. It is also an industry where competitiveness is constantly under pressure and consumer preferences are always changing. Through research and development of new products, solutions and methods, we can strengthen agricultural production, so that in future, it meets the demands that the surrounding world puts upon us and the demands we place on ourselves.

Danish agriculture is based on a tradition of innovation and investment in the development, research and dissemination of new knowledge. This has brought us to where we are today: a high-tech and productive industry recognised throughout the world as delivering healthy and safe raw materials of high and traceable quality produced sustainably.

It is essential for Denmark to build on this position and this means that research and innovation in agriculture and food production need to be boosted significantly in the years to come.

In this research strategy, we highlight the key research requirements that the agriculture industry faces up to 2030 in relation to creating new solutions within climate, resource utilisation, sustainability, organic production, the environment, nature, quality, animal welfare, etc, which together will strengthen our competitiveness.

The strategy takes in the entire primary production; agriculture, horticulture and aquaculture and adheres closely to the food research strategy »World-class food innovation towards 2030«, launched in September 2017 by the Danish Agriculture & Food Council and the Confederation of Danish Industry: Food. The food research strategy mainly covers the value chain from the time the raw materials leave the farm and provides answers to how research can help resolve some of the corresponding challenges in the food and ingredients sectors.

This strategy has been prepared with input from the agricultural sectors and the industry’s major companies, and it is a significant point that the greatest challenges and potentials of agricultural production should be solved jointly, and neither can nor should be borne by one sector alone. Major cross-sectoral research projects are needed to achieve solid, sustainable solutions that work both for the individual farm and for the industry as a whole.
The figure summarises agriculture’s challenges and the research that needs investment in order to improve both a green and a black bottom line.

Through the independent advisory system and a skilled workforce in primary production, we in Denmark are good at exploiting new knowledge, but we can become much better. Research work should be conducted in close collaboration throughout the entire innovation chain from universities and GTS institutions to advisory systems, primary producers and manufacturers of equipment, as well as other inputs to agriculture, so that the best possible results are achieved.
The main challenges

Danish agriculture faces several challenges and dilemmas, which need to be solved continually to create a broad legitimacy for the continued positive development of the industry. The research requirements highlighted in this strategy will, as a starting point, aim to have a double bottom line, where new knowledge will provide increased earnings for Danish agriculture while, at the same time, benefiting the environment, climate, animal welfare, nature, etc.

The current research strategy identifies the most significant research requirements and potentials within five main challenges. This is the key to a strong agricultural industry that meets society’s expectations.

We find these five main challenges in, for example, the UN sustainable development goals, the new research programme within the EU, Horizon Europe and the Danish research programme, FORSK2025. All the challenges involve significant research requirements, which will develop new solutions and methods that can strengthen the competitiveness and sustainability of agricultural production. At the Danish Agriculture & Food Council we are particularly focused on contributing to world objectives 2, 12 and 13, but this strategy will contribute solutions to several of the UN sustainable development goals.

1 Resource utilisation and sustainability

Rapid global population growth and a growing middle class mean increased demand for food. This creates additional pressure on the Earth’s resources. Therefore, there is both a need for and an expectation that Danish farmers, who supply to both local and global consumers, will continue to improve resource utilisation and increase sustainability, so that agriculture produces »more with less«. The development from a fossil-based to a bio-based society should take place at the same time as pressure on the land’s resources is reduced. This requires new solutions that can only be found through a massive research and development programmes.

2 Climate and the environment

Danish and international wishes and obligations for agriculture to reduce its climate and environmental footprint is placing new demands on the industry, which itself has set ambitious targets for a climate-neutral agriculture. Focusing om climate, we must now translate research results into practical solutions for primary producers. This applies, for example, in relation to carbon sequestration and to housing technologies, including feeding systems. The
challenges of climate and environmental footprint from agriculture give rise to discussions about data, measurement and inventory methods, calculations, certification and labelling schemes. They place demands on validated methods and calculations, including testing in practice, and it is essential that they can be compared across countries. The surrounding society, including consumers and companies that process agricultural raw materials, also expects agriculture to continue to minimise the impact on the environment to ensure that our land is delivered to future generations in good condition.

**Healthy, safe raw materials of a high quality**

The highest quality raw materials are essential for the food industry to supply high quality food. The perception of quality is individual and extends from soft parameters such as ethics and animal welfare to physiological characteristics such as taste and texture. In addition, there is strong focus on the raw materials’ nutritional properties and the development of raw materials with improved health properties. New consumer trends also mean that raw material production is constantly having to meet new requirements. Transparency and documentation in relation to production methods and conditions are becoming a crucial competitive parameter towards consumers. New diseases in plants and in animals are increasing the requirements for a high level of food safety which is paramount for the export from the Danish food industry.

**Animal welfare and animal health**

There is an increased demand from consumers, retailers and the food service sector for products produced according to different animal welfare criteria and standards. There is therefore a need for new, innovative solutions that ensure that Denmark is also at the forefront in terms of ensuring high animal welfare and health within the framework of economically and environmentally sustainable production. A growing concern about antibiotic resistance means that there is also a need to find solutions that can further reduce the use of antibiotics.

**Biodiversity and nature**

Around 60 per cent of the Danish land area is agricultural and the agricultural sector is therefore a central player in the management of nature and biodiversity. There is a perception that nature and agriculture are in conflict but, with a targeted and professionally based approach to the management of nature and biodiversity, it is possible to protect valuable nature and strengthen biodiversity, as well as ensure a competitive agricultural industry. In this context, it is important to have a common starting point for assessing both the present state of nature and the effects of the initiatives that are undertaken to promote nature and biodiversity. There is an ongoing need to implement a more precise mapping of nature, as well as to ensure knowledge about how the challenges for nature and biodiversity are best resolved in interaction with the agricultural industry.
Research platforms

The five main challenges cause a range of research needs and create several opportunities to increase Danish agricultural earnings and strengthen competitiveness. Globally, there is a great demand for solutions in relation to the climate, the environment, organic production, sustainability and health etc. This means that research efforts in the agricultural sector will contribute to continued growth in the Danish food cluster and hence Danish society. Seven research platforms have been identified based on these five main challenges; and they need to contribute to translating the challenges into opportunities and solutions.

Production systems and management

Research that creates robust and resource-efficient production systems in livestock farming and plant production with a low environmental and climate impact and where animal welfare and health are the focus. The research must be translated into specific tools and management concepts.

Circular bioeconomy

Circular bioeconomic research has enormous potential in terms of improving resource utilisation and sustainable production.

Genetics

Research into genetics is about developing breeding and breeding improvement. New tools need to make the work quicker and easier, and genetic technologies must identify robust plant varieties and develop robust animals.
Bioenergy and biorefining
Research into more efficient use of biomass for energy purposes as well as research into biorefining and resource-efficient extraction of protein from crops, residual products and sidestreams.

Quality and health
Research into improved food safety and quality in relation to both plant- and animal-based raw materials. Identification and research to optimise the health value of the raw material. A range of research requirements also relate to the interaction between people, animals, the environment and microbiology also called »One Health«.

Organic production
Research into effective organic systems that comply with the organic regulations including improved animal welfare and health for livestock and a production with minimal environmental and climate impact.

Digitalisation
There is great potential in increased research and development into digitalisation. Technology, data, artificial intelligence, robots, sensors, drones, image recognition, etc. are tools that can strengthen the development in several areas within primary production.
Production systems and management

If Danish agriculture is to solve the five main challenges, it requires research into new production systems. This research involves developing a knowledge base and creating solutions in relation to robust and resource-efficient production systems in livestock farming and plant production. That is, systems where environmental and climate impact is low, where animal welfare and health are in focus and where production takes nature and biodiversity into account.

Management is a vital part of the continued development of agriculture. Therefore, an important focus area is to ensure that the research is translated into specific tools and management concepts that help the individual farmer to both improve production methods and document the effect in relation to greenhouse gas emissions, animal welfare, environmental impact, biodiversity, etc. The latter is crucial to increasing motivation and ensuring higher earnings for the farmer for his effort.

Livestock

Research and development of new technologies, digital solutions and better real-time monitoring capabilities will improve existing production systems so that greater knowledge is created on the individual farm. This will give the farmer the opportunity to optimise animal welfare, as well as climate and environmental impact.

Feed is the most important input factor in livestock production. New knowledge about the nutritional value and disease-preventing effects of the feed, as well as the development of new protein sources and of new feeding systems are essential for agriculture to be able to continue to produce more with less, reduce the impact of the surroundings and supply high-quality raw materials. Furthermore, the development of feed with pre- and probiotic effects is key to reducing disease outbreaks.

Research into animal behaviour, disease control, infection protection, vaccines and One Health must be translated into specific tools and solutions for the individual farm, so that the production systems support the focus on animal welfare and health.

Plants and soil

Research and development of robust crops and cultivation systems within both conventional and organic cultivation will ensure a high stable yield under varying climate conditions and soil types, where the environment, the nature and sustainability are taken into account. There is a need for research and knowledge into improved crop
New protein value chains will help reduce climate and environmental impact.

Rotation, optimised nutrient allocation, management of livestock fertiliser, recirculated fertiliser testing, soil fertility development, selection of crops and crop cultivation.

Research into new protein value chains will help reduce the dependence of imported soy and reduce the climate and environmental impact in the production of animal products.

There is potential in research and development of concepts and solutions that consider plants as biological production units that can be targeted and designed to be included in food and non-food products with special properties. The research needs to optimise the biomass yield and promote the fact that agriculture develops products that can be used in broader contexts and focusing on raising the value of side streams.

Research into cultivation systems should take production conditions into account in both organic and conventional production, as well as in greenhouse production. The focus areas include the prevention of soil fatigue and fungal attack, as well as ensuring water supply for plants and land drainage. Agricultural use of pesticides is an issue of public concern, in particular about the environment, including groundwater.

It is therefore important that research into pesticides, including new pesticides and alternatives, is increased. It is also important to research new spraying technologies, including the handling of the spraying process. Research in this area should also focus on biologically-based plant protection.

There is also a need for research into grazing systems that focus as much as possible on biodiversity, nature and animal welfare in nature conservation.

Digitalisation

Digital tools and solutions can support the creation of agricultural knowledge, management and production, thereby increasing farmers opportunities to reduce environmental and climate impact and produce ‘more with less.’ Digitalisation can provide better decision-making tools that optimise both the green and the black bottom line. It is about exploiting the possibilities of technology, data, artificial intelligence, robotics, sensors, drones, image recognition, etc. New big data solutions that link existing and new data, e.g. from satellites and equipment in fields and housing units, will ensure that management and resource utilisation are optimised.

The research requirements in digitalisation are directed towards digital warning systems in relation to the outbreak of disease in animals and attacks by pests in plant production so as to ensure...
that the use of antibiotics, pesticides, etc. is reduced. At the same time, optimised use of image analysis software, including camera-managed weed control, sensors and precision technologies, will reduce and optimise the use of pesticides. Real-time monitoring in housing units will ensure better management in terms of health and productivity.

Similarly, research into camera, sensor and GPS technology will continue to monitor and measure the development of biodiversity and nature and will be used to develop tools that can work even better with nature and promote biodiversity.

Research and development of digital tools, data value chains and blockchain technology will ensure transparency and documentation of the individual producer’s production methods.

**Genetics**

Developments in agriculture are largely based on the ability to run efficient breeding work. Research into new techniques and the development of digital tools will boost developments in this area.

**Animal breeding**

Data collection via sensors and cameras on farms, as well as large amounts of DNA data that can be related to individual animals and contain information on productivity, disease and animal welfare, will be used to research breeding progress. Genomic selection and use of digital solutions in the work with large amounts of data will ensure that research focuses on finding methods for breeding robust and more climate-friendly animals, as well as animals with better feed utilisation who are less prone to disease. At the same time, research into breeding should also find tools for selecting animals with a particularly good meat quality.

Knowledge and development of breeding solutions make it possible to select the genetic properties that will enhance the animals’ robustness and production capacity.
There is a need for separate research into breeding methods and systems that can create organic production animals adapted to the organic production framework.

**Plant breeding**

An important research area is aimed at the development of robust plant varieties with better nutritional qualities and increased nutrient uptake. Mapping the genetic resources of plants will make future varieties more robust and increase their profitability. Moreover, the development of new crops and varieties will focus on the fact that they will be able to grow with less water consumption and that they are resilient to weather fluctuations and climate change. In relation to organic production, development work should ensure that the chosen techniques are approved in relation to the organic regulatory framework.

Plant breeding research should also focus on the fact that crops should utilise the periods when plant growth is possible in Denmark better. This may involve crops with a longer growing season or the ability to fit more crops into the crop rotation of each growing season.

There is also a need for research that can enhance Danish expertise in the development of protein plants and algae, including perennial grasses, clover and broad beans as well as micro and macro-algae. This is in order to ensure a higher proportion of domestically produced sustainable protein for feed and food.

**Quality and health**

Research into quality runs across several disciplines of research and which, individually or together, is needed to support the development of new quality foods and good communication and information for consumers.

A current trend in society is to eat smaller quantities of a better quality with people willing to pay a higher price. Agriculture must therefore be innovative in terms of being able to produce products with specific characteristics targeted at the market – for example by breeding animals that produce meat with a better eating quality and milk with a favourable nutritional fatty acid composition.

There is a need for research into improved food safety and quality with regard to vegetable as well as animal-based raw materials. The need for research will be targeted at livestock diseases, the spread of which is linked to climate change, increased globalisation and the design of production systems. There is also a need for research into the development of effective contingency plans and disease control strategies.
Another requirement is the identification of and research into the health potential that lies in »optimising« the health of organic as well as conventional raw materials. This includes illustrating to what extent raw materials affect human health and which parameters have a decisive effect on human health and lifestyle diseases. In addition, there is a need for the development of cultivation systems that address the health parameter in the raw materials.

One Health
A range of research needs are targeted at the interface between people, animals, the environment and microbiology. A comprehensive, cross-cutting focus on these issues is termed »One Health«, and there is, among other things, a need for a more harmonised »One Health« monitoring of antibiotic consumption and resistance with a higher degree of comparability of resistance occurrence in animals, humans and the environment. There is a need for research into the mechanisms by which new pathogenic organisms emerge and spread, and how resistant bacteria spreads between animals (including livestock), between humans, and between animals and humans, – and how resistance genes spread between the different bacterial species.

Circular bioeconomy
Circular bioeconomy offers enormous potential in terms of improving resource utilisation and more sustainable production. Some raw materials and natural resources essential to agriculture, especially fresh water and phosphorus, could be in short supply in the long term. Therefore, it is of utmost importance to take care of and re-use these limited resources in a better way.

A desire to recycle more sludge and other recycled products cannot be allowed to compromise the quality of the raw materials that are produced. Therefore, studies on the presence of undesirable substances in food products and the importance for soil fertility and soil purity are needed – including the effect of plastic and other environmentally hazardous substances as the rate of recycling increases. Research should also focus on biogas, safe urban recycling, upcycling of plant and animal by-products and finding solutions for recycling phosphorus and other nutrients.

In addition, it is important to research into residual products from crop production. These have great potential for use in biomaterials or packaging.

The research should also focus on the cascade utilisation of bioresidual products for high value products or energy.
grade products from waste to resource. It is important that the research in the circular bioeconomy involves the entire value chain.

**Bioenergy and biorefining**

There is great potential for further use of biomass from Danish agriculture for energy purposes. This applies to straw, energy crops and livestock manure. Biomass for energy can make an important contribution to meeting the Danish renewable energy targets and in relation to greenhouse gas reductions. It is therefore important to research how to ensure a more efficient use of biomass, and how biomass for energy can play effectively with other energy technologies, including sun and wind.

Biorefining is one of the areas that offers great new potential for Danish agriculture. It can be used to produce energy and other products including feed, food products, biochemicals and biomaterials. Biorefining also has an advantage in that it can create improvements for the environment, climate and biodiversity.

If the potential of biorefining is to be fully exploited, it requires research into the green, yellow and blue biomass. Focus should be on refining new crops using both classic and new processing techniques. The development of sustainable, efficient protein production should be achieved through optimising processes and interaction from the cultivation of crops in the field to the development of the refining process and knowledge about the marketing of the products. It requires research into the development of resource-efficient extraction of protein from crops, residual products and sidestreams and the development of new value chains based on aquatic biomass. There is also a need to document the nutritional and environmental value of the products.

Biorefining in organic production offers a particular potential with focus on clover grass, including new grass and clover varieties with high protein yields.
Organic production

Organic production is a focus area because the organic regulatory framework presents special challenges in the production of organic raw materials.

It is essential to research and develop efficient organic systems that allow animals access to outdoor areas while maintaining a high standard of health and welfare with minimal environmental and climate impact, where the focus is on animal health and welfare without the use of antibiotics. At the same time, focus should be put on developing the farm as an integrated climate system, including documentation of the farmer’s specific actions on his own farm. The documentation also applies to how digital possibilities can showcase production and document the farmer’s work, as well as create transparency and dialogue with consumers, e.g. show development in soil fertility and nature initiatives.

Regarding organic plant production, there is a need for research and development of optimal systems for the cultivation of organic protein, as well as knowledge about optimising crop rotations, including intercropping. Other areas where research and development are needed include variety selection, development of soil fertility and new types of fertiliser in organic production, including recycled fertiliser sources. Similarly, there is a need for research into the optimal arrangement of organic grazing systems in relation to supporting increased biodiversity and the natural behaviour of animals.
Research and innovation infrastructure

Research requirements must be addressed in both longer-term strategic research and in more application-oriented research and innovation. The objective of improving the double bottom line in Danish agriculture by 2030 not only requires investments in the research requirements described, it also requires that Denmark has the right facilities, infrastructure and cooperation culture to conduct the research and implement the outcomes. Ground-breaking results require the availability of the right equipment, databases, resources, laboratory facilities, and so on. Agriculture, universities, GTS institutions and other knowledge institutions should be able to use and collaborate on facilities across the board to achieve the best possible results.

The following points set out the critical infrastructure that must be available to ensure the full benefit of the research platforms:

- Unique Danish research and innovation infrastructure in Danish primary production.
- Infrastructure for emergency preparedness in case of animal disease outbreaks.
- Facilities for testing intelligent digital solutions for agriculture.
- Further development of existing omics platforms.
- Danish ESS lighthouse project in agriculture and food.

The two strategies »Research strategy 2030 for Danish agriculture« and »World-class food innovation towards 2030« cover the full extent of the research needs for the entire food cluster in the coming decade. The strategies contain several common factors, such as digitalisation, food safety and sustainability, which must be addressed across agriculture and industry.
The Danish Agriculture & Food Council is a trade association representing agriculture, the food and agro industries. With annual exports in excess of DKK 166 billion and with 186,000 employees, we represent one of Denmark’s most important business sectors. Through innovation and promotion of the industry’s contribution to society, we work to ensure a strong position for our members in Denmark as well as in international markets.

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