

AgriFoodTure

Roadmap for sustainable transformation of the Danish agri-food system

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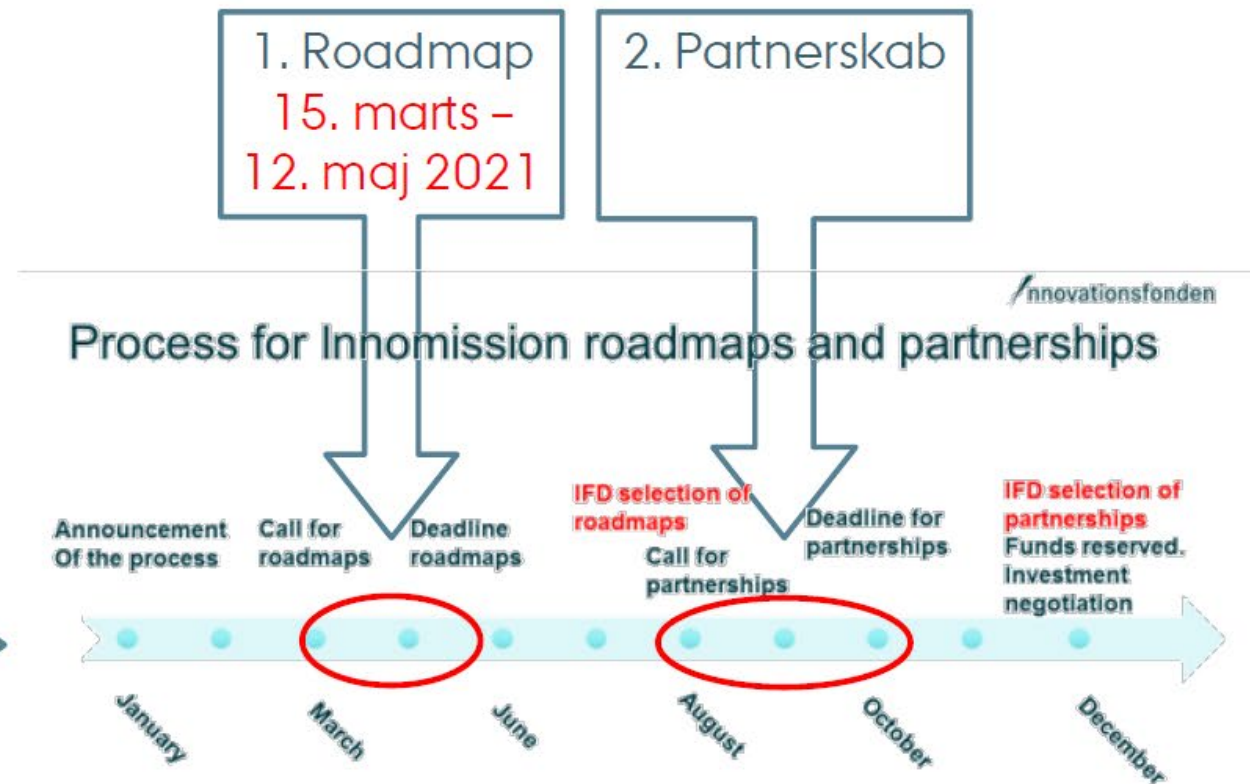
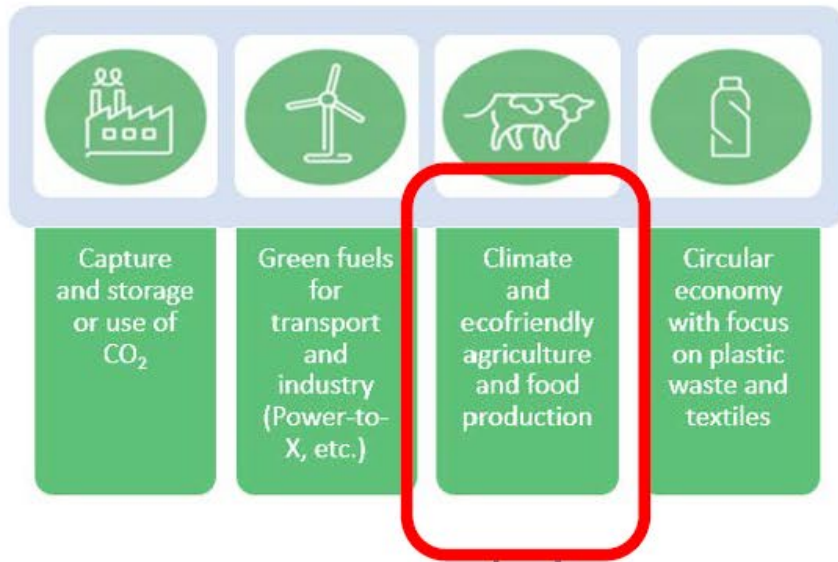
A collaborative effort with contributions from more than 200 researchers from eight Danish universities, sector organisations and industries



Roadmaps for research and innovation

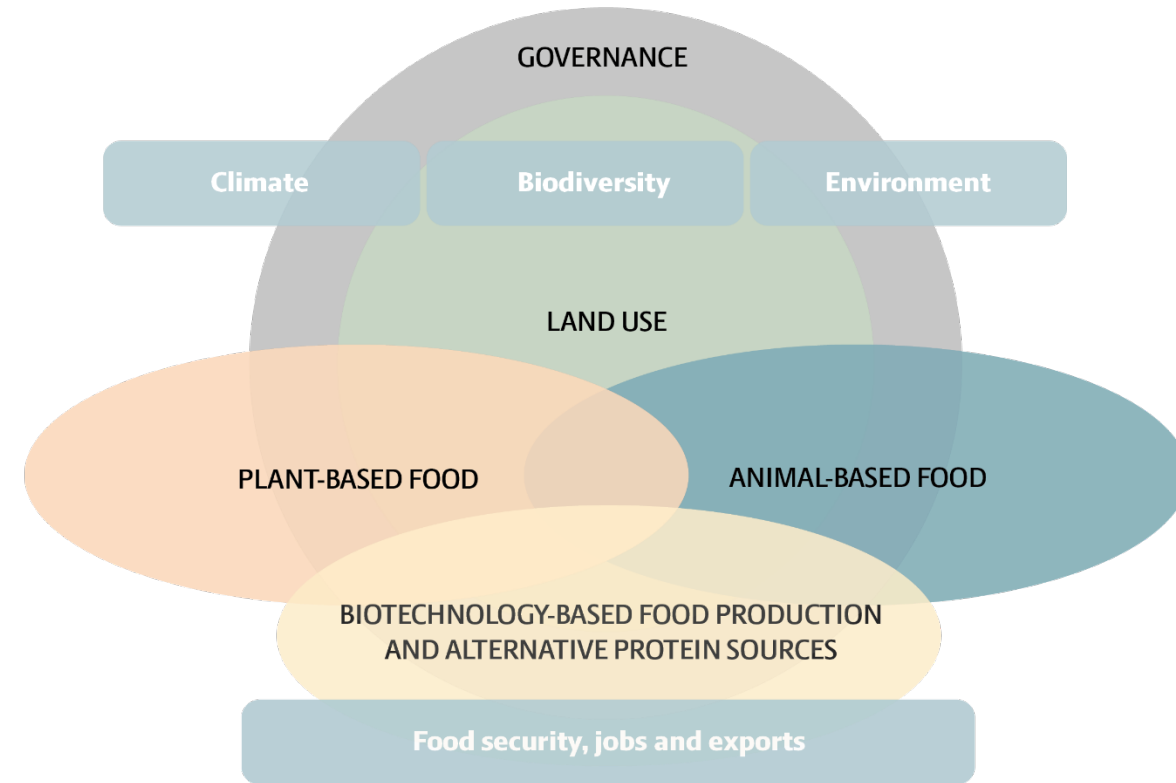
- Ministry of Food, Agriculture and Fisheries
 - Focus on 2030, subtargets for 2025 and 2030
 - Reduced GHGs from agriculture
 - Food consumption patterns with less climate impacts
 - Climate change adaptation
- Innovation Fund Denmark, AgriFoodTure
 - Roadmap for 2030 and 2050 (carbon neutrality)
 - Achieving other sustainability targets, including environment and biodiversity
 - Four tracks to support transition with land, livestock, plant foods and biotechnology

Innovation Fund Denmark - Innomissions



Multiple sustainability objectives

- Reducing environmental and climate impacts of food and agricultural production systems
- Reversing the decline in pollinators and loss of biodiversity in general, including endangered species
- Setting aside land for multiple functions, including climate change adaptation, nature and recreational use
- Increasing food supply in support of growing demands
- Securing jobs based on innovative and sustainable solutions benefitting Danish exports and economy



GLOBAL FOOD SYSTEM

Human demands, social and cultural transformation

Stakeholder management across value chain

Political governance regulations

Political governance regulations

Accounting GHG emissions



Climate change



GHG = CH₄

GHG = N₂O + CO₂

LAND USE MANAGEMENT

Rewetting organic soils
Drainage mineral soils
Reestablish wetlands

Fertilisation
Cropping systems
Forage crop production
Perennial cropping
Plant breeding
Nutrient loads
Pesticides
Biochar

Afforestation
Nature + biodiversity
Multifunc. landscape

Farms & companies:
Adaption, possibilities and barriers

Farmer

DATA

Circularity: slurry, manure

Feed

PLANT-BASED FOOD

Plant breeding
Plant biologicals
Robotics and farming systems

Upcycling and recycling
Proces. raw materials
Product development

ANIMAL-BASED FOOD PRODUCTION

Nutrition
Breeding / genetics
Production systems
Technologies
PLF

DATA

Meat
Dairy
Eggs

Food

BIOTECHNOLOGY-BASED SOLUTIONS

Cellular agriculture and alternative proteins

Landbased aquaculture production

Invertebrates, mussels, crustaceans, fish, algae, seaweed

Biorefining

Recirculation of nutrients

Environment: CO₂, air quality, water
Biodiversity – Nature

Energy: Gas, oil, water, sun, wind, biofuel

Food products + food processing

Consumers:
preceptions and preferences

Dietary changes
Human nutrition

Consumers

Living labs

Value chain

\$

Employment

Living labs

Science – Technology
Research – Innovation

Science – Technology
Research – Innovation



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Land use and management

Objectives

- Develop technological and governance solutions that will allow for a carbon neutrality at the landscape level in 2050 and large GHG reductions by 2030 coupled with reductions in N and P loads to the aquatic environment, as well as substantial reductions in pesticide use, and a landscape that supports biodiversity in all major Danish ecosystem types.
- Develop the foundation for documenting progress and to develop governance structures to support rapid transitions towards sustainable land use and management.

Key activities and work streams

Cli	Env	Inn	Nat	Barr	
				G	Rewetting of organic soils
				C	Drainage of agricultural mineral soils
				GC	Re-establishing and constructing wetlands
				C	Fertilisation management for lower nitrous oxide and nitrate leaching
				CL	Arable cropping systems
				C	Forage crop production
				LR	Perennial cropping systems
					Plant breeding for sustainability
				GC	Afforestation and forest management [for sustainability and biodiversity]
				GC	Nature and biodiversity protection in the agricultural landscape
				G	Multifunctional landscape planning and governance
				CL	Circular biomass and nutrient flows at farm and landscape scales

Effects on Climate (Cli), Environment (Env), Growth and Innovation (Inn), and Nature (Nat) from key activities within the track. Relative contribution is assessed by the colour intensity: darker is higher contribution than lighter, white is no contribution. In addition, barriers (Barr) are identified and include C Cost; G Governance and Legislation; L Logistics; R Resistance to change in the sector.

Animal-based food production

Objectives

- Develop production of the most climate efficient animal-based food products in the world to accommodate and meet a growing worldwide demand for animal-based proteins and foods.
- Documentation and datasharing e.g., use of big data and technologies through an established common data platform collecting data from sensors and other sources to enable intensive monitoring, control and decision support for precision management thereby increasing resource efficiency and waste utilisation as well as reducing emissions.

Key activities and work streams

Cli	Env	Inn	Nat	Barr	
				BHR	Farmers' and consumers' perceptions as possibilities and barriers for reaching the climate goals for livestock farming
				CFG	Methane and ammonia reduction (Livestock)
				CFG	Capturing methane and ammonia (Buildings and systems)
				CFG	Circular perspectives
				FGR	Management and precision livestock farming
				CFR	Food product processes
				BFR	Alternative animal production systems

Effects on Climate (Cli), Environment (Env), Growth and Innovation (Inn), and Nature (Nat) from key activities within the track. Relative contribution is assessed by the colour intensity: darker is higher contribution than lighter, white is no contribution. In addition, barriers (Barr) are identified and include B Behaviour (Consumer); C Cost; F Financing; G Governance and Legislation; H Health; R Resistance to change in the sector.

Plant-based food production

Objectives

- Contribute to the reduction of global GHG emissions by supporting the global transition towards healthier and more sustainable plant-based diets.
- Develop plant-based protein-rich crops for the manufacturing of gently processed, nutritious and tasty plant-based food products of high quality for both domestic use and export, they could replace the consumption of between 325,000 and 515,000 t meat (40% beef, 40% pork and 20% chicken).

Key activities and work streams

Cli	Env	Inn	Nat	Barr	
				BFLR	Collaboration and value chains
				BG	New and improved traditional breeding and propagation technologies
				FG	Plant biologicals
				CF	AI, robotics, remote sensing
				BR	New food crops and farming systems
				BFGL	Upcycling and recycling
				CFHL	Sustainable value-added processing of raw materials
				BGHL	High quality plant-based food products
				BCGH	Consumers and dietary change
				CFGR	Drivers and measures

Effects on Climate (**Cli**), Environment (**Env**), Growth and Innovation (**Inn**), and Nature (**Nat**) from key activities within the track. Relative contribution is assessed by the colour intensity: darker is higher contribution than lighter, white is no contribution. In addition, barriers (**Barr**) are identified and include **B** Behaviour (Consumer); **C** Cost; **F** Financing; **G** Governance and Legislation; **H** Health; **L** Logistics; **R** Resistance to change in the sector.

Biotechnology-based food production

Objectives

- Reduce the harmful impacts of food production on climate, environment, and biodiversity and to lower the land use required for feeding the growing global human population through
 - biorefining for feed and food
 - cellular agriculture
 - alternative proteins and side-stream upgrade
 - new functional feed additives and biologicals
 - food processing technology to reach circularity

Key activities and work streams

Each work stream contributes to different Innomission targets and are characterised by several key barriers.

Cli	Env	Inn	Nat	Barr	
				BCG/H	Biorefining for feed and food
				BCFG/R	Cellular agriculture – stem cell meat, microalgae, precision fermentation
				CFR	Microbiome engineering in agriculture, aquaculture, and bioprocesses
				BCHLR	Microbial and enzymatic upgrade and value-added products from side streams
				BCHR	Alternative proteins and other food ingredients
				CR	Optimising existing processes for resource efficiency

Effects on Climate (**Cli**), Environment (**Env**), Growth and Innovation (**Inn**), and Nature (**Nat**) from key activities with the track. Relative contribution is assessed by the colour intensity: darker is higher contribution than lighter, white is no contribution. In addition, barriers (**Barr**) are identified and include **B** Behaviour (Consumer); **C** Cost; **F** Financing; **G** Governance and Legislation; **H** Health; **L** Logistics; **R** Resistance to change in the sector.

Stipulated GHG reduction (carbon neutrality)

Source	Baseline (Mt CO ₂ eq)	Reduction (%)		Reduction (Mt CO ₂ eq)	
	2018	2030	2050	2030	2050
Enteric fermentation (CH ₄)	3.77	40	70	1.51	2.64
Manure management (CH ₄ , N ₂ O)	2.81	50	90	1.41	2.53
Fertilization (N ₂ O)	2.83	40	70	0.91	1.60
Crop residues (N ₂ O)	0.61	10	40	0.06	0.24
Ammonia volatilization (N ₂ O)	0.34	20	40	0.07	0.13
Nitrate leaching (N ₂ O)	0.33	10	30	0.03	0.10
Liming (CO ₂)	0.24	10	20	0.02	0.05
Energy use (CO ₂)	1.25	50	100	0.62	1.25
Organic soils (CO ₂ , N ₂ O)	5.75	30	80	1.73	4.60
Soil carbon (CO ₂)	-	-	-	1.80	4.30
Total	17.37	48	100	8.16	17.44

Targets are extremely ambitious, but feasible with extraordinary large and coordinated efforts

Next step – Roadmap and partnerships

Innovation Fund Denmark:

12 ROADMAPS submitted for the 4 missions

August – call for partnerships

Partnerships in planning:

Livestock and land management

Jørgen E. Olesen, AU: iCAP (webinar 26 March 2021, slides available online at AU-DCA)

Plant-based foods

Svend Christensten, KU: in planning

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Others – please consider potential partnerships and participants



WHITEPAPER

AgriFoodTure

ROADMAP FOR SUSTAINABLE TRANSFORMATION OF THE DANISH AGRI-FOOD SYSTEM



WHITEPAPER PUBLICATION

- **Whitepaper: extended version of submitted IM3 Roadmap**
- **Release: week 26**
- **Where: SEGES web and university websites**