MISTRA
FOOD FUTURES

IN A VOLATILE WORLD

Mistra Food Futures

Programme Year Two

TWO

Stockholm Resilience Centre
Sustainability Science for Biosphere Stewardship
Stockholm
University

In a volatile world

Mistra Food Futures
Programme Year Two

MISTRA
FOOD FUTURES

Content

Mistra Food Futures provides knowledge, perspectives and concrete results

The overall aim of Mistra Food Futures is to create a science-based platform to help enable a transformation of the Swedish food system into one that is sustainable, resilient and delivers healthy diets.

The increasingly visible effects of climate changes and substantial effects of the Russian war in Ukraine on the food system both globally and in Sweden make the Mistra Food Futures programme even more relevant. It has become obvious that our food system is fragile and must be transformed.

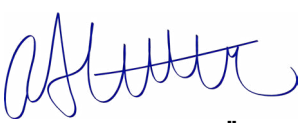
The food system is complex with many interrelations and dependencies. The broad approach in Mistra Food Futures provides knowledge, perspectives, and concrete results to help policy makers and the private sector enact needed change.

Predicting the future is not easy. This year, the programme has developed future scenarios for a food system. These can be used to as a basis to discuss what future food systems may look like, and what effects current activities may have over the long-term, to help find policy options for good decisions.

Another example is a study that has contributed to a better understanding of how the concept of sustainability is perceived. Such knowledge helps to create a common understanding and starting point, which makes it easier and more effective for all of us to find the best solutions to achieve a sustainable food system.

A more concrete example is a set of studies which evaluate the potential of a range of specific measures which can be taken in agriculture to reduce the sector's greenhouse gas emissions. This knowledge helps in understanding the potential in each specific measure to contribute to more climate-friendly agriculture.

This year, the programme has really taken off, a benefit for many stakeholders aiming for a more robust and sustainable Swedish food system.



ANNICA SOHLSTRÖM
Director General, Swedish Food Agency.
Chairperson of the Board,
Mistra Food Futures

Predicting the future is not easy. This year, the programme has developed future scenarios for a food system.

Mistra Food Futures – in a volatile world

We are now more than two years into Mistra Food Futures' endeavours.

Established in 2020, the programme exists in a volatile world, dominated by the pandemic of 2020-2021 and Russia's invasion of Ukraine in 2022, followed by the increased geopolitical unrest and an inflation rate which we have not experienced in the last 30 years.

Mistra Food Futures is a response to the features of our unsustainable food system. Contributing to, and being affected by, climate change, current food systems need to adopt both mitigation and adaptation strategies. They also need to end their negative impacts on biodiversity and soil health, find ways of improving the economic viability of, in particular, the agricultural component of the food system, and encourage healthy diets and eating habits in the population.

On a global scale, safe and nutritious amounts of food are not available to everyone. Challenges are substantial and the Swedish food system is no exception.

In Mistra Food Futures, our over-arching vision is to be a science-based platform that contributes to a transformation of the Swedish food system into one that is sustainable and resilient and that delivers healthy diets. This is a very ambitious and motivating vision! By collaborating across several natural- and social-science disciplines and together with the agricultural, food industry and retail sectors, as well as with authorities and region partners we are developing science-based knowledge about how a food system transformation can take place.

Food systems are currently high on the public agenda. Over the past year, the discussion about food security and food system preparedness has intensified, even here in Sweden where we have long taken access to food for granted. Following shortages and price increases in critical production inputs such as fertilizers, energy, and fossil fuels and the associated inflation in food prices, this situation has changed.

Helena Hansson

Per-Anders Hansson

Mistra Food Futures is a response to the features of our unsustainable food system.

Living in times of multiple crises, we need to start looking for solutions that remedy multiple problems. In the food system, a shift towards better food security and preparedness should go hand in hand with a transition towards sustainability. In short, we need to avoid building preparedness for a system that is not sustainable.

Over the second programme year, several important new insights and analyses have emerged from Mistra Food Futures, thereby starting to reveal how a transition towards a sustainable food system can happen. Notably, several innovative measures for reduced greenhouse gas emissions, implies that farms, if adopting them, can simultaneously become less dependent on externally purchased inputs. Steps in this direction would contribute to a more robust system that is less vulnerable to disturbances in input supply. **Innovative solutions for one problem may therefore also assist in solving another and help the food system to cope with a volatile world.**

Over the last year the discussion about food security and food system preparedness has intensified, also here in Sweden where we for long have taken access to food for granted.

HELENA HANSSON
Professor, Programme Director Mistra Food Futures, Department of Economics, SLU

PER-ANDERS HANSSON
Professor, Programme Director Mistra Food Futures, Department of Energy and Technology, SLU

Vision - A science-based, collaborative platform

The overarching vision of the Mistra Food Futures programme is to create a science-based platform that contributes to a transformation of the Swedish food system into one that is sustainable. We consider sustainability in all three dimensions of the concept: environmental, economic, and social. A system that is resilient and delivers healthy diets to all.

By taking a holistic perspective and addressing issues related to agriculture and food production, as well as to processing, retail and consumption, Mistra Food Futures aims to play a key role in initiating an evidence-based sustainability and resilience transformation of the Swedish food system. The programme is a part of a force leading the transformation of the Swedish food system and inspires research and action internationally.

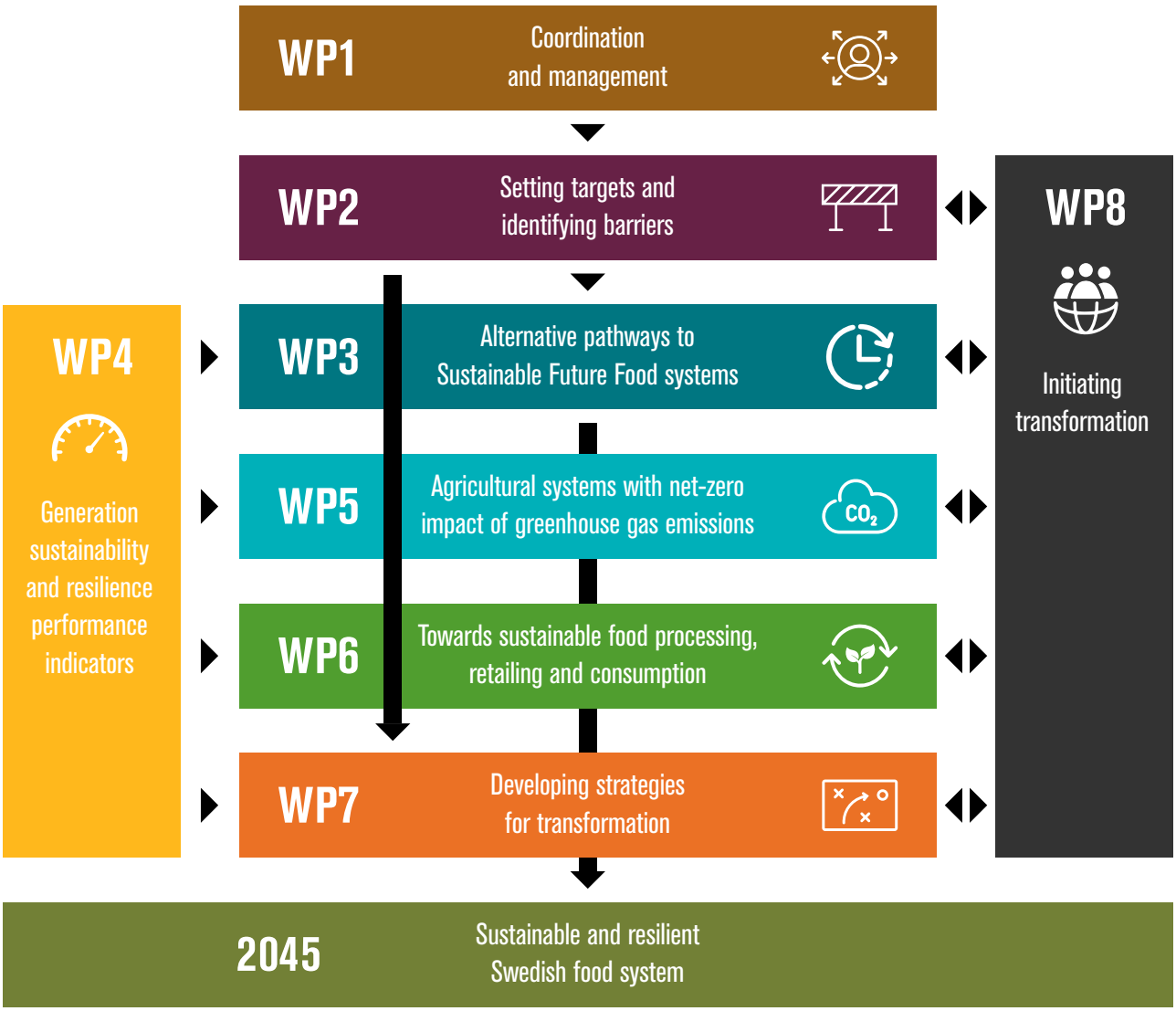
Mistra Food Futures has created a unique platform of partners, including companies, authorities, regions, and academic researchers from the entire food system, all collaborating for transformative change. It is comprised of some 18 partners together with three core academic and research institute partners.

Our four main strategies:

1. Identification and synthesis of on-going research on how to achieve net-zero greenhouse gas and sustainable agricultural systems as well as sustainable food value chains.
2. Research into actions to fill key knowledge gaps for achieving sustainable transformation at all levels in the food system.
3. An encompassing approach to sustainable development, covering its environmental, economic, and social dimensions.
4. Initiation of a transformation process, together with stakeholders.

Work package 1–8 in brief

Mistra Food Futures is organised into eight distinct but highly coherent work packages (WPs) designed to work in close iteration to deliver individual and joint results centred around four main strategies.



WP1

Coordination and management

Leading and ensuring scientific rigour as well as knowledge transfer, uptake and exploitation of results, and an efficient and transparent management structure. Building and developing Mistra Food Futures' identity and brand. Communicating and disseminating project results to relevant stakeholders and society at large (Public affairs). WP leaders: Helena Hansson and Per-Anders Hansson

WP2

Setting targets and identifying barriers

Setting targets that a sustainable and resilient food system needs to achieve, identifying likely barriers to these targets, and exploring strategies to turn the barriers into leverage points for change. WP leaders: Beatrice Crona/ Malin Jonell

WP3

Alternative pathways to Sustainable Future Food systems

To help find policy options for good decisions. Explores alternative pathways towards the sustainable food system targets identified in WP2. Indicators from WP4 are used to identify trade-offs and the resilience of the pathways is assessed against factors that may impact future food systems, such as greenhouse gas emissions and socioeconomic and technological developments. WP leader: Line Gordon

WP4

Generation sustainability and resilience performance indicators

Indicators for assessment and progress monitoring. With an interdisciplinary approach, we develop a conceptual framework for a sustainable food system and develop the next-generation sustainability and resilience performance indicators to assess and monitor performance of the food system in delivering food from a system that is sustainable and resilient. WP leader: Helena Hansson

WP5

Agricultural systems with net-zero impact of greenhouse gas emissions

Agricultural systems with net-zero impact on greenhouse gas emissions are identified to explore agricultural systems with the potential to make agriculture net-zero regarding GHGs by 2045, as well as to deliver on several of the targets as defined in WP 2. WP leader: Per-Anders Hansson

WP6

Towards sustainable food processing, retailing and consumption

Sustainable supply chains – combining real production with the bigger system. WP6 aims to generate knowledge and processes for designing the post-farm supply chains of the future. By addressing the very complex questions via a structured and transparent process, all participants will reach a much deeper understanding, and hence be better prepared for making decisions. WP leader: Ulf Sonesson

WP7

Developing strategies for transformation

A transformation of the food system requires a change in practices and behaviour of food system actors, including e.g., primary producers, consumers, retailers, food production and service companies, and governmental agencies and actors. But how can such changes in behaviour and practices be initiated and scaled up for transformative change, especially in a turbulent world? Such understanding requires knowledge about drivers and motivators of change for food system actors. WP7 contributes to filling this knowledge gap and provides an understanding about how drivers and motivators of food system actors can be modified, enhanced, or completely redesigned for rapid transformative change. WP leaders: Therese Lindahl and Helena Hansson

WP8

Initiating transformation

Exchange of knowledge and experience with community stakeholders and industry. Initiates transformation by engaging food system actors in close iteration to co-develop strategies for achieving a sustainable and resilient food system, and to develop projects and transition experiments that enable transformative change by actors. Testing the new strategies and results derived from other WPs.
WP leader: Maria Hellström

In good company

Mistra Food Futures is formed around a 21-partner consortium, including university and research institute partners, food value chain partners, authorities and regions.

We are all in each other's good company aiming to contribute to enabling the transformation of the Swedish food system into a system that is sustainable and resilient and that delivers healthy diets.

New tools for solving complex problems and a common model for understanding systemic change. In 2022, the work related to initiating transformation (WP8) had two main focuses: a course on "Evidence-Based Problem Solving" and a dialogue series on "Ideas and Strategies for Tomorrow's Food System". Both targeted companies in the food system.

In the course, "Evidence-Based Problem Solving," we worked on practical tools and methods that can facilitate finding new solutions to complex problems. **Participants in the course each brought a challenge or problem from their own business that became the basis for the course focus and an active "case" for the work.** At the end of the course, the lessons from the course were presented in a dialogue meeting, as a blog post, and in a report entitled, "Lessons from the Evidence-Based Problem Solving Course Spring 2022".

WP8 followed up on one of the tracks that was clearly requested during the 2021 problem-solving workshops, namely the need to think differently about future business models. Therefore, a three-part dialogue series on the role of business models in sustainable transformation was planned and implemented. Both partners within Mistra Food Futures and external stakeholders were invited to the dialogues to provide a wide range of perspectives. By the end of the three dialogues, participants had gained insights into the developments needed in various areas of society to achieve a sustainable future, and had tested how concrete innovation themes could fit into or be adapted to tomorrow's business models.

Core consortium partners

Swedish University of Agricultural Sciences (programme host)

Stockholm Resilience Centre at Stockholm University

Research Institutes of Sweden (RISE)

Other partners

Arla Foods

Axfood

Coop Sweden

HKScan Sweden

Lantmännen

Matilda FoodTech

Orkla Foods Sweden

Polarbröd

LRF (Lantbrukarnas Riksförbund)

Livsmedelsföretagen (The Swedish Food Federation)

Chalmers University of Technology

The University of Gothenburg

Folkhälsomyndigheten (Public Health Agency)

Jordbruksverket (Swedish Board of Agriculture)

Livsmedelsverket (Swedish Food Agency)

Västra Götalandsregionen

Region Östergötland

Region Kalmar

Mistra Food Futures' partnership gives us the opportunity to contribute knowledge from our everyday lives and future perspectives. At the same time, we get close to the research questions and research results that are important for jointly achieving a sustainable food system. Workshops and lectures increase our knowledge and understanding. The breadth of the research programme is impressive and creates anticipation about the future.

Anneli Bylund, Senior Sustainability Manager, Coop Sweden

We participate in Mistra Food Futures to keep updated with the latest research, contribute with our knowledge, and highlight identified needs from a primary production view. The program has given us increased knowledge on specific issues. For example, the recent publications on precision agriculture and intermediate crops can contribute to The Swedish Board of Agriculture's ability to evaluate and develop the eco-schemes for such measures that have just been implemented in EU's new common agriculture policy (CAP). Furthermore, our participation has increased our understanding of the perspectives of other parts of the food system, given us extended networks and lowered thresholds for contacting other actors in the food system. Coop Sweden The program is in line with our mission to promote sustainable and increasing food production. To fulfil that mission, we need science-based recommendations on how to support a transition towards sustainable food systems. In the future, we hope that Mistra Food Futures will continue to do applied research and communicate publications and results in an easily accessible way, also to those not participating in the program.

Camilla Burman, Food Chain and Export Unit, Swedish Board of Agriculture

---

Orkla is a leading supplier of branded consumer goods to the grocery, out-of-home, specialised retail, pharmacy and bakery sectors. For Orkla, sustainability is business critical and a requirement for future growth, and we have set ambitious sustainability targets. To achieve these targets, cooperation and knowledge co-creation with various stakeholders is a necessity. Mistra Food Futures has so far proven valuable in this co-creation process with meeting places for various stakeholders being inspirational and, equally important, challenging the current logic in the food system. We will expect more of this from Mistra Food Futures in the future, and we will continue to contribute with our large knowledge about value creation in the food chain throughout the programme.

Anders Högberg, Research & Strategic Partnership Manager, Orkla Foods Sweden

---

For us as a FoodTech software provider, participation in the programme is valuable – it provides insight into how the entire food system will evolve over time. This provides invaluable input to our platform development agenda.

Erik Bergseth, CEO/VD – Matilda FoodTech

Results

During programme year 2, Mistra Food Futures has generated significant research results, all contributing important insight to the understanding about how food system transformation can take place.

Alternative pathways to sustainable future food systems. Four major future scenarios have been developed. All envisioning a sustainable food system, but in very different ways. The scenarios focus around the food industry, food technology, food as culture and a world where food is forgotten.

Perspectives among food system actors on sustainable food systems. Conceptualizing what a sustainable food system might entail, perceptions among food system actors regarding a sustainable food system was studied. Three dominating and different perspectives emerged. A sustainable food system is not the same to everyone.

Towards net-zero primary production. Assessing the climate impacts of a wide array of measures to reduce climate impact in primary production, an encompassing analysis of measures possible to implement on-farm was conducted. Concrete actions such as increased production of ley, use of technology, smart use of byproducts, and bio-gas production offer interesting opportunities to adapt current agricultural systems.

How can we anticipate and visualise what the future holds in a world that is turbulent, uncertain, novel and ambiguous?

How will conditions for food production in Sweden change due to climate change, technological advancements, and demographic developments? What type of food will today's children eat when they are adults, and what will the children of 2045 eat? Where will our food come from; to what extent will it be grown on land or in oceans or manufactured in factories located in Sweden or elsewhere?

It can be hard to imagine what a sustainable food future would look like and how to get there. We used a scenario development approach to explore the future of the Swedish food system. In this work, we define a scenario as a plausible, simplified description of how the future could develop, based on coherent and internally consistent sets of assumptions about driving forces and key relationships.

By providing a structured way of thinking about the future Swedish food system, **scenarios can be used to evaluate how current action and inaction can create alternative pathways and futures** related to climate, biodiversity and nutrition. They will also be used to detail the future work within Mistra Food Futures. The four scenarios presented here demonstrate that there is a variety of pathways that could achieve ambitious territorial and consumption-based targets for Sweden's food system.

What type of food will today's children eat when they are adults?

Scenario 1. Food as industry

INCREASED GLOBAL DEMAND FOR PRODUCTS WITH HIGH SUSTAINABILITY VALUE

In 2045, food is highlighted across Swedish society as an important Swedish industry that creates jobs and a thriving rural landscape; as an engine for export of sustainable products worldwide; and as an important measure for reaching healthier populations, driven by public policy. Food is considered an important commodity for investment and policy interventions.

Investments into the agricultural and food sector have led to increased food production and a competitive Swedish food sector, thereby replacing less climate-efficient production in other countries and increasing employment in the food sector across the whole country. Improvements in productivity, technological development and management in food production have been enabled by support from both government and the private sector with the result that Swedish products are competing well to meet the increased global demand for products with high sustainability.

Scenario 2. Food as Food Tech

THE AVERAGE SWEDISH CONSUMER FOLLOWS PERSONALISED DIETARY GUIDELINES

In this scenario, it is easy to notice large changes in 2045 compared to 2015. Activity tracking watches and wristbands of the early 2020s have evolved into a wide variety of wearable technologies that guide individuals to healthier lifestyles. The average Swedish consumer follows personalised dietary guidelines. They are tracked by new technologies, such as nutrient density trackers and microbiome mapping that are coupled to smart kitchens and various apps that develop weekly sustainable and healthy menus.

Healthy and sustainable diets are the norm, aided by the increased accessibility of novel food products that are considered convenient to prepare. These include artificial meat from cell cultures, bacterially and fungally produced proteins, and novel, plant-based products replacing some of the original food groups, with these being used in combination with such novel technologies as 'printing' meat.

While diets are more personalised, it does not mean consumer control, but rather that the food environment is enabled and shaped by transnational corporations producing, processing and selling food. Swedish food processing has increased substantially since/compared to 2015, while the size of the primary production sector has declined.

Scenario 3. Food as culture

A NEW WAVE OF URBAN TO RURAL MIGRATION

The Swedish food system has changed quite drastically since 2015, with an increased rural focus in policy and a closer relationship between consumers and food production, to a large extent driven by social movements. Work in primary production is perceived as more attractive, and there is increased governmental investment. This new cultural vision of rural-urban and human-nature relationships makes healthy and sustainable food, food production and food security of great importance on a national policy level and in the everyday life of most Swedes.

Food trends that were small-scale in 2015 continued to grow and constitute a substantial part of the food system in 2045. People buy more locally produced and diverse food products that have become more easily accessible and spend more time preparing and sharing meals, as well as in engaging in small-scale food production.

Enabled by digitalisation and an increased rural job market, living close to nature in rural and peri-urban areas is generally perceived as more attractive. The specialised farms in the 2020s have transformed to create multifunctional and multicultural landscapes. Changes in both Swedish and EU policy reflect the societal recognition of a larger integration of policies around social equality, self-sufficiency, climate, and environmental justice at local, national and EU levels.

Scenario 4. Food forgotten

EMPHASIS OF CLIMATE AND BIODIVERSITY RATHER THAN FOOD PRODUCTION

On the surface, the Swedish food system has not changed much in 2045 compared to 2015. People seem to eat similar food and there are farms and red barns all over the countryside. However, rural areas produce different products and services than before and although the food looks the same as in 2015, it now contains different ingredients imported from new regions.

A shift towards healthier eating habits has been made possible by new policies, especially at EU level, yet food in 2045 is generally given less importance in people's daily lives. Increased action to reduce climate emissions, adapt to the impacts of climate change and address biodiversity issues has shaped the food system, including food production and consumption in Sweden and Europe, in a way that has led to new jobs, activities and actors.

Due to the strong focus on climate adaptation, farmers have converted land previously used for food and feed to bioenergy production, climate adaptation infrastructure and climate adaptation.

Three dominating perspectives on challenges, possibilities and solutions for a sustainable food system

We talk about sustainability all the time, but what meaning does everyone actually attach to the concept? Are we talking about the same thing, or does sustainability imply one thing for one person and something else for another?

To contribute to the transformation of the Swedish food system into one that is sustainable, it is important to investigate and clarify what perspectives on challenges, possibilities and solutions exist for a sustainable food system. In a study in Mistra Food Futures, we investigated food system actors' perceptions in this regard. We asked what the dominating perspectives are, where their clear differences in opinion are and where areas of more consensus are. Our results point to five very different perspectives, but also to entry points for action that can contribute to a sustainability transition of the food system, if implemented already now.

The study is based on the so-called Q methodology. A set of statements about sustainable food systems were gathered from food system actors' websites and written material. These were discussed in-depth among the researchers and with food system actors. Through this process, they were reduced to a set of statements that comprehensively covered all important perspectives on challenges, possibilities and solutions for a sustainable food system. Following this, food system actors were invited to sort the statements to reflect their perceptions on how they relate to a sustainable food system. Only respondents who had previously not been involved in the discussions were invited to this task.

Using statistical methods, we grouped the sorting of the statements to reveal the dominating perceptions across respondents. Five clusters of statements were retained from the analysis, with three dominating it:

The diagnostic perspective has a clear focus on reducing emissions from the food system, on reduced meat consumption and on food waste.

The regenerative perspective focuses on biodiversity and diversity in crops as well as in types of businesses, and on quality food rather than on profitability, technology and global trade.

The fossil-free perspective puts emphasize on reducing the dependence on fossil fuels, on profitable businesses and on climate mitigation and adaptation.

Looking at aspects where respondents are largely in agreement and where there is consensus between the dominating perspectives highlights entry points for action that the food system should be able to start working on immediately:

- **Reduce the use of soy meal in animal production**
- **Schools have an important role**
- **The food system should contribute to attractive landscapes**
- **Food preparedness needs to be improved**
- **Social aspects need more attention**
- **Water management**

There are also some aspects that were important to some actors and neutral to others. These are possible entry points for fast change:

- **Healthy diets**
- **Increased production of fruits, vegetables and legumes**
- **The responsibility of the retail sector**
- **Adaptation to climate change**
- **Reduced food waste**
- **Improved soil health**

This study is part of the work in Mistra Food Futures to understand what a sustainable food system actually entails. Results are also highly valuable in themselves. A better understanding about the content of different perspectives on a sustainable food system contributes to improved understanding and nuances in food system debates. The entry points for actions identified in this study highlight openings for immediate actions.

Specific measures with the goal of making agriculture climate neutral

Mistra Food Futures work to describe and evaluate various individual measures to reduce the climate impact from Swedish agriculture. So far, 10 studies of various promising measures have been published and several additional studies are on the way.

An important goal for the entire Mistra Food Futures program is to improve the climate balance of Swedish agriculture. There is a large number of measures that are potential candidates to contribute to this. We have done a broad mapping of these and also studied a number of specific measures to quantify their potential.

The work so far is a basis for continued work where we study the entire production system and where the individual measures are combined. The goal is to find systems that are climate neutral (net zero) but also to assess whether such systems are reasonable to implement, given the other effects they will entail.

The reports are produced in collaboration with specialists in the respective areas and systems researchers with LCA competence. The projects focus on issues that are spread across the entire agricultural area. During the year 2022, 10 reports were presented and almost as many will be presented during the year 2023.

Increased cultivation and use of ley

Increased cultivation of pasture turns out to have the potential of having a positive impact on the climate while also providing the opportunity to feed pigs in a climate-friendly manner.

Three of the completed projects are linked to ley production. Two of them study the effects of including ley in crop rotations, while the third studies the effects of introducing grass-clover ley as part of the feed for fattening pigs.

In the past, it was common in field experiments on crop production to only measure the amount of carbon in the topsoil, while the carbon under plowing depth often was neglected. But new measurements from long-term field trials have made it possible to also include the carbon further down in the soil (the sub-soil) profile in the calculations. This proved to be important at one of the two sites studied in one of the projects (ref Report 3). At one of the sites, there was a slightly lighter loam. There, significant amounts of roots had penetrated below plow depth. The other site had a heavier clay soil, and there it was found that almost all the roots were in the upper soil layers and therefore had little carbon accumulation in the sub-soil. The ley-dominated rotations increased soil organic carbon stocks at both sites over time, contributing to a decrease in overall climate impact of 7% (clay) and 18% (loam).

The effects of ley in crop rotations were also studied in a second project (ref Report 2), where the effect was put in relation to the total yield over a crop rotation. In the field experiments behind the calculations, the amount of nitrogen fertilizer had also been varied. The climate impact per cereal unit was lower for the crop rotations with ley. The lowest climate impact was calculated for the crop sequence with a ley also containing nitrogen-fixing legumes and at a lower application level. This was due to the relatively high yield in combination with smaller quantities of inputs, mainly mineral nitrogen. One conclusion was, however, that potential areas of use of the extra amount of silage that would be produced with the changed crop rotations is required if the great potential of this type of measures is to be utilized.

The effects of using a grass-clover mixture as feed for fattening pigs were found to be significant (ref Report 11). The climate footprint for one kg of pork could be reduced by at least 13% with a changed feed ration according to the performed LCA calculations. There are several additional benefits of introducing ley feed into pig production including improved pig welfare, increased soil fertility and biodiversity, and reduced use of imported inputs. Cultivating and managing the ley and feeding the pigs with the new forage requires different machinery and different equipment in the barn, but such systems have already been developed for dairy and beef production.

The climate impact per cereal unit was lower for the crop rotations with ley.

New technology can provide more climate-friendly production

New technology is entering agriculture. The digital revolution offers great opportunities. It turns out that the technology can also contribute to significantly more climate-friendly agriculture.

Three of the completed projects study the climate effects of new technology in various forms. One project studies how the use of autonomous electric vehicles can reduce the climate impact from a grain-producing farm. The second project studies the possible impact of the new digital technology on dairy production and the third how technology for precision farming can reduce the climate effects from grain production.

Electric tractors are entering the market. They are more energy efficient, but if the battery size is to be reasonable, they require that the batteries be charged or replaced at significantly shorter time intervals than you need to refuel a traditional diesel tractor. However, if the machines can then be made autonomous (self-driving), they can work more hours each day and the total capacity does not need to be reduced. Autonomous machines can also be made lighter and contribute to less soil compaction because an operator can "drive" several machines at the same time. The climate impact from the tractors on a 200-ha grain farm was simulated using event-driven simulation and life-cycle analysis (LCA) (ref Report 10). It turned out that the climate impact could be reduced to about a third with the self-driving electric machines compared to today's large diesel tractors. In addition, harvests would increase because of less soil compaction.

Digital technology can be used in many ways on a dairy farm. Sensors and monitoring systems can find sick animals at an early stage, increase feed utilization, increase the longevity of cows in production, streamline the production of forage and more. In one of the studies (ref Report 5) a systematic review of these effects was made. An LCA was done applying assumptions from literature on these effects showing that the total climate effect per kg of milk could be reduced by approx. 14% if the new technology could be used effectively. Most of this reduction was linked to reduced emissions from the animals, while feed production had a smaller impact.

Technology for precision nutrient application is becoming more and more developed. The technology makes it possible to, for example, control the supply of nitrogen to a crop so that it closer to crop demand and takes into account the crop's development, weather, prices of inputs and products, etc. The timing of the input can also be controlled so as to be as optimal as possible. A more optimal supply of nutrients also contributes to climate gains. The study that was carried out showed about 5% reduced emissions of nitrous oxide per kg of grain if technology for field-specific nitrogen application is used. The overall effects on climate are highly dependent on how much the soil conditions vary across the field; adjusting to within-field variations further decreased field N_2O emissions, by 1-10% (depending on within-field variation of the specific field).

Residual products can provide climate benefits

Food production has many byproducts and residues which, if used smartly, can contribute to reducing the climate burden from a life-cycle perspective.

In the studies carried out, two different possibilities for using by-products have been studied. One project is studying the use of straw from grain production to produce biochar. In a second project, the climate effects of producing vehicle fuel from straw using fat-producing yeasts are studied.

Biochar is produced by incomplete combustion of biomass such as straw. Part of the energy in the straw can then be used as heat, while the remaining char fraction can be returned to the ground and there contribute to a long-term storage of carbon that is of great benefit to the climate. The baseline scenario in the reported study (ref Report 4) showed that the climate impact from grain production was almost halved in the biochar system compared to systems where the straw was either plowed into the ground after harvest or completely burned to produce heat. The study also reports how various changes in the analyzed system alter the climate effect.

Yeast oil can be produced from lignocellulosic materials such as straw or forest residues by oleaginous yeasts. In the conversion process, cellulose and hemicellulose are consumed to produce the yeast oil that can be used for producing biobased vehicle fuels or even for utilization as a substitute for rape seed oil in, e.g., fish feed. The lignin fraction is left almost unused but can be used for other products. The reported results (ref Report 6) showed in general good climate characteristics for the whole process and especially if the lignin was used as amendment for asphalt, serving as a carbon sink.

The study also reports how various changes in the analyzed system alter the climate effect.

Biogas system

Production of biogas and return of the biofertilizer to agriculture can contribute to great climate benefit and also contribute to the crop's nutritional supply.

Biogas systems have been central to two of the projects reported so far. One studies the climate effects of harvesting intermediate crops as raw material for biogas production instead of plowing them into the soil. The second studies the effects of that the residue after digestion (the so called digestate) can be returned to agricultural land as bio-based fertilizer.

One study focuses on intermediate crops (ref Report 7) and was based on experimental data from the cultivation of oilseed radish grown directly after harvesting cereals. After the biogas production from the harvested biomass, the majority of the nutrients in the oilseed radish could be returned to the cultivation through the digestate. Emissions of nitrous oxide were particularly measured in the field experiments as there were indications that these could be reduced if the biomass was removed instead of being used directly. The results were found to be clearly dependent on the establishment and harvest time of the intermediate crop but generally showed a relatively large potential to reduce the climate impact from agriculture by harvesting the intermediate crop.

In the study of the return of the biofertilizer (ref. Report 8), the climate effects were quantified both from the return and also from the entire biogas system. The calculations were based, among other things, on laboratory measurements of soil carbon changes when the biofertilizer decomposes in the soil. **The results show that both the use of the biofertilizer itself and the entire biogas system that was studied have large beneficial effects on the climate. Systems with low resource consumption and low emissions can even result in negative emissions, i.e. reducing global warming when the soil carbon effect is included.**

Mistra Food Futures Programme Year Two

2022, another interesting year, full of several scientific results, meetings, important and interesting talks. In this second programme report from Mistra Food Futures, besides all research results, we present key activities and share some second programme year insights, reflections, aims and ambitions.

Strategic investment in communication

A full-time communicator has been assigned to the program, to enable an in-depth focus on internal and external communication, dissemination and public affairs.

Table talk

Targeted meeting between partners and WP-leaders to discuss how transformation towards sustainability can take place while the war in Ukraine is ongoing.

Mistra Food Futures consortium meeting, October 17–18th

This was the first opportunity for the consortium to meet physically, after the Covid-19 restrictions were lifted. During this lunch to lunch meeting, we discussed transformation of the food system in a changing environment and listened to results from the work packages.

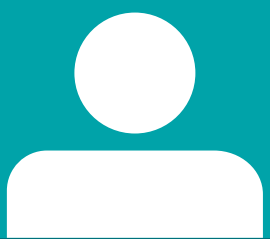
Public affairs

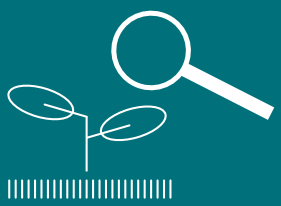
We see the importance of MFF existing and delivering into the community building.

Our research has great relevance, and we are eager to deliver on that, not least into the crisis and preparedness work. A process has started to become more visible on social media, to various decision-makers in different parts of the society – politicians at all levels, relevant officials in relevant agencies, including the parliament and the Government Offices.

Digital dialogues & workshops

Valuable dialogues and workshops with the programme's partners and external stakeholders in the food system.





Young researcher network established

The network is mainly aimed at early career researchers such as PhD students and postdocs whose research concerns the transition to sustainable food systems. However, we do not exclude research and project assistants who contribute to research projects. The network takes as its starting point the fact that the food system faces complex and wide-ranging challenges, which means that the generation of knowledge that can contribute to the transition to more sustainable food systems cannot be limited to individual research disciplines. The network therefore aims to create a multidisciplinary meeting place where participants can learn more about different research areas relevant to the transition to sustainable food systems and explore opportunities for collaboration within and across disciplines, which in turn can foster interdisciplinary collaboration. However, the network is in its infancy and has mainly been about getting to know young researchers within Mistra Food Futures and recruiting participants. During 2023 we will take this part to the next level with more digital meetings and a physical lunch-to-lunch meeting are planned.

Almedalen

Joint talk on the scene at Almedalen with Mistra Digital Forests and Mistra InfraMaint – In times of crisis - how do we stay on course for sustainable food, water and forests?

11 reports 13 scientific articles

We have published a significant amount of scientific results, both in the format of reports and in the format of scientific papers. Examples of scientific results include analyses regarding the potential to improve the climatic impact from agriculture, the design of four food future scenarios and what a sustainable food system entails.

Most sustainable

Several researchers and partners are now found among Sweden's most sustainable 2022 and the list of the world's most influential people.

Minister of Rural Affairs and Infrastructure visited SLU

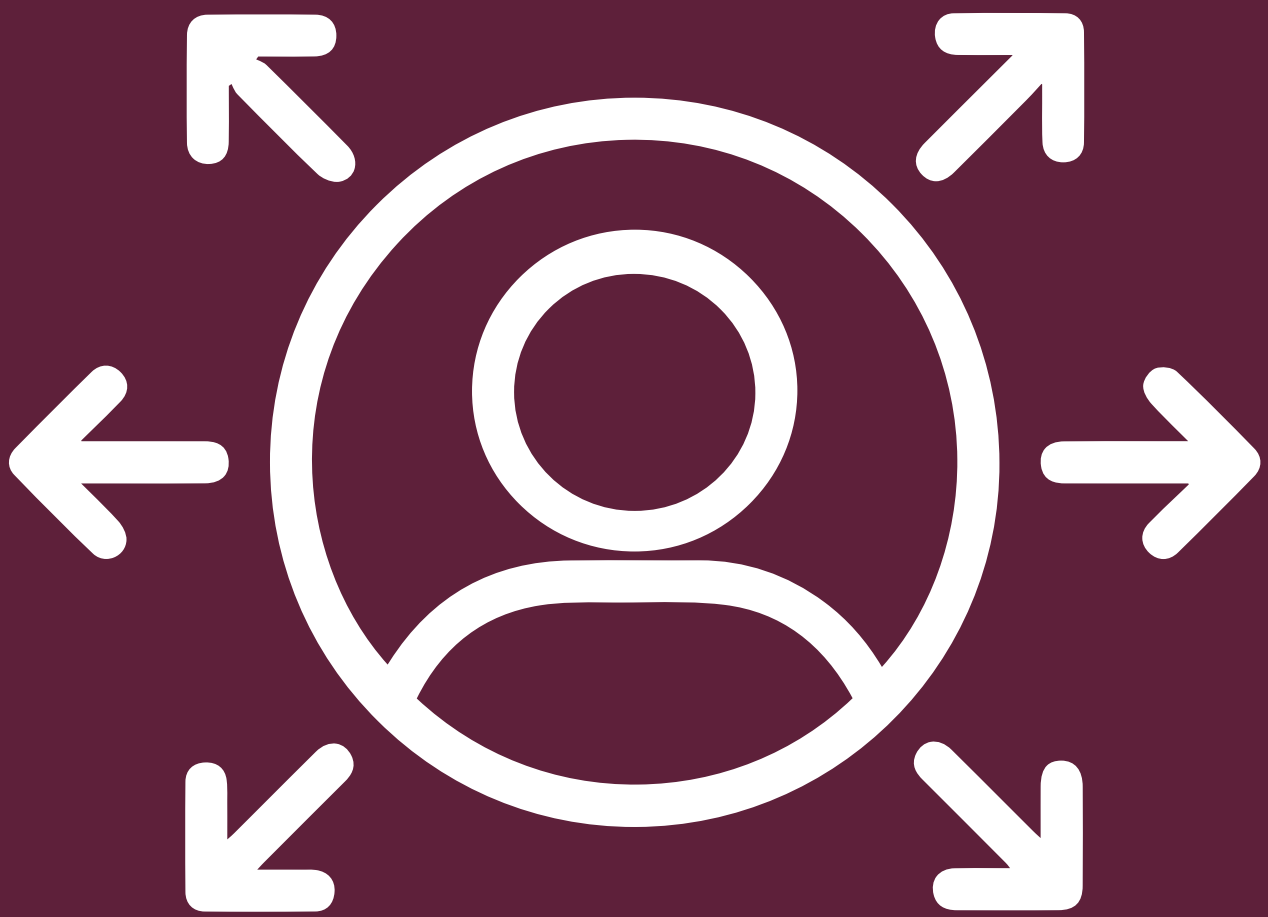
Helena Hansson had the opportunity to talk to the Minister of Rural Affairs and Infrastructure about the model Mistra Food Futures is developing to define what constitutes a sustainable food system, and how it connects with the highly topical subject of preparedness.

Sustainability day 2022

25 October 2022, the Swedish Chef Award in Gastronomic Sustainability and the Influencer of the Year in Sustainable Food Award were announced during a sustainability event at the Grand Hotel. Helena Hansson and Malin Jonell were invited to give research presentations.

What's cooking: Year Three

Mistra Food Futures is all about creating and sharing science-based knowledge, addressing issues and insights that are of interest across the consortium itself and to the Swedish food system at large. What is going on and what is expected to come up in the coming year?



WP2 We are finalizing a report proposing environmental and health targets for the Swedish food system, both for production and consumption. The targets for climate, biodiversity and human health are used in the WP3 scenario analysis, but in this report, we provide a thorough background to how the targets were set, and also suggest targets for a larger set of stressors, including freshwater consumption, leakage of nutrients and pesticide use. We are also putting the finishing touches to a study where we have mapped and analyzed sustainability targets from the largest private actors in the Swedish food system. The purpose has been to investigate what sustainability dimensions (planetary boundaries) that targets relate to, the companies' portfolio of "how" targets (i.e. targets to achieve the "what" targets) and their effectiveness with respect to reducing pressures on the environment. In project year three, we plan to, in collaboration with WP7, execute a qualitative interview study with representation from the same companies to explore the role of targets for accelerating a shift to sustainability, and identify key barriers and levers for transformational change.

WP3 In WP3, we will work on the modelling of the Mistra Food Futures´ scenario skeletons. We will develop modelling scenarios of Swedish food systems with plant-based alternatives, along the "Food as Food Tech" scenario. As part of their thesis work, a MSc student is using Fuzzy Cognitive Mapping for the semi-quantitative modelling of the scenarios. We will also continue to present the scenario skeletons to other work packages in order for these to be used in other work in Mistra Food Futures, including in WP2, WP5, WP6 and WP8.

WP4 We will work intensively with finalizing a first version of a framework for a sustainable Swedish food system. A theoretical model is being developed to illustrate a sustainable food system from a conceptual point of view. The model is populated with indicators which are adapted to the conditions of the Swedish food system. We are also finalizing a critical analysis of secondary data for sustainability measurement. We will start filling our food system framework with real data, and we will start analyzing how sustainability indicators are used for decision-making among actors in the food system. We will also discuss the indicator framework in several settings.

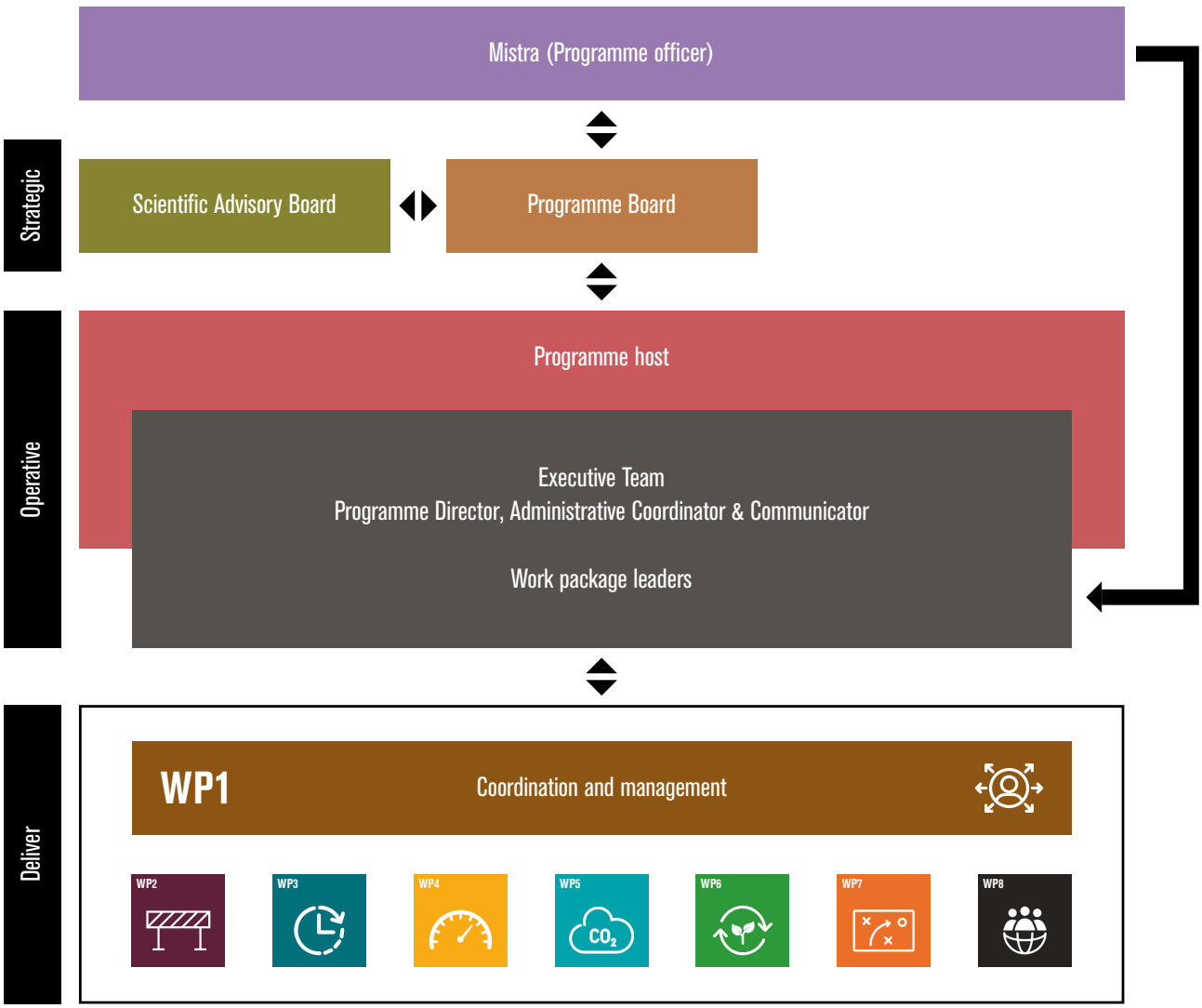
WP5 The extensive assessment model developed in WP5 will be used to quantify the greenhouse gas (GHG) emissions from the national agricultural sector in 2020. Scenarios for reaching net-zero in GHG until 2045 will be developed and assessed (also for non-GHG-related effects)

WP6 WP6 will continue the work on developing and applying a working process to support supply chains stakeholders in decisions on how future sustainable food supply chains could look. The research builds on close collaboration between partner companies in the supply chain and the research group. This has proved to be very beneficial for methods development as well as for the case studies being performed. The integration of Mistra Food Futures´ scenarios added new insights into the challenges stakeholders face, the need for new approaches as well as new ways of thinking and collaboration. In 2023, WP6 will deliver results from three case studies and an evaluation of the working process itself, and we will also start the process of how to address longer time horizons.

WP7 We will work on finishing our analyses of data of collected on farmers' perceptions and perspectives for adopting more sustainable practices as well as consumers' perspectives on public policy interventions aiming to steer consumption. We will also start collecting data on, for example, perceptions of key food actors on the barriers and levers for improving the environmental performance and health of food available to consumers (also during times of crisis).

WP8 More and closer cooperation with our partners in projects where we test new ideas and solutions. We will build on the role of models in creating change, perhaps in the form of a game or everyone having roles reversed. Stay tuned! You can find more about what´s happening on pg. 12 under Partners.

Organisation



Programme Board

Annica Sohlström
Swedish Food Agency), Chairperson

Bo Jellesmark Thorsen
Department of Food and Resource Economics (IFRO), University of Copenhagen

Minna Kaljonen
Finnish Environment Institute (SYKE)

Elisabet Rytter
The Swedish Food Federation)

Anna Richert
The World Wide Fund for Nature Inc., WWF

Programme host

Swedish University of Agricultural Sciences, SLU

Executive team

Programme Directors

Helena Hansson

Per- Anders Hansson

Programme coordinator

Annsofie Wahlström

Economy

Lena Karlsson

Communication

Anne Lennartsson

WP-leaders

WP1: Helena Hansson: Programchef
Per-Anders Hansson: Assisterande programchef

WP2: Beatrice Crona/Malin Jonell

WP3: Line Gordon

WP4: Helena Hansson

WP5: Per-Anders Hansson

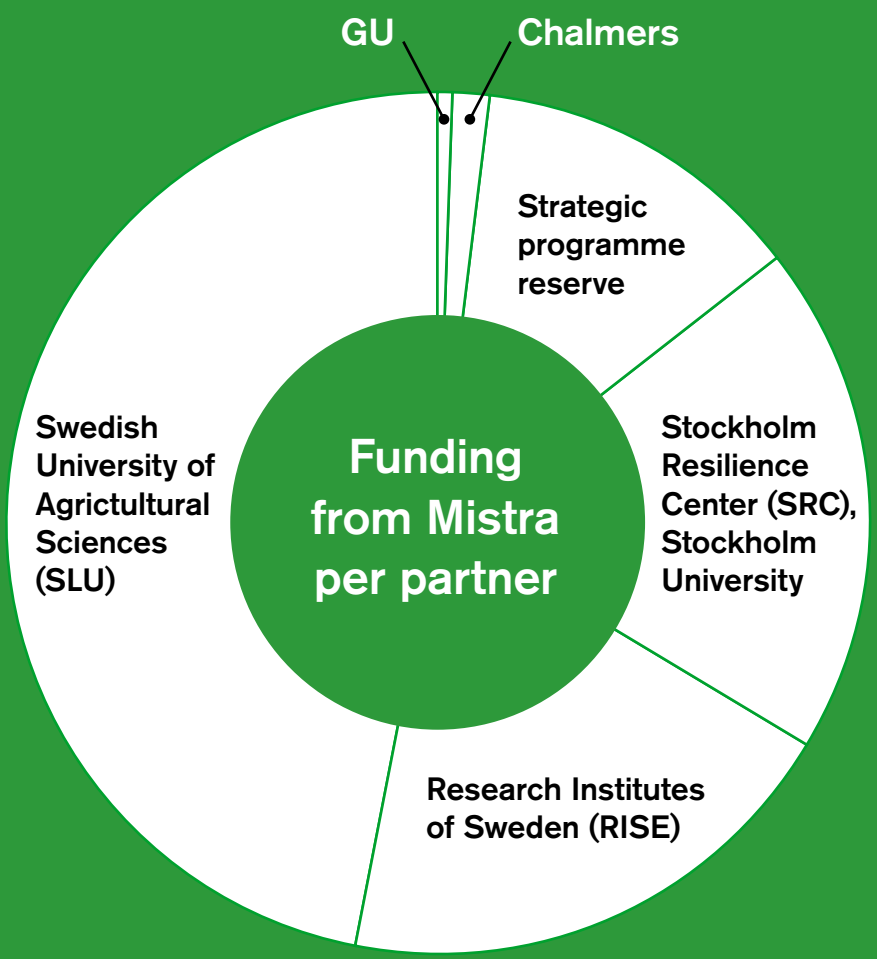
WP6: Ulf Sonesson

WP7: Helena Hansson/Therese Lindahl

WP8: Maria Hellström

Funding

Funding from Mistra per partner	SEK
University of Gothenburg	400 000
Chalmers Technology University	993 000
Strategic programme reserve	8 000 000
Stockholm Resilience Center (SRC), Stockholm University	12 280 000
Research Institutes of Sweden (RISE)	12 383 000
Swedish University of Agrictultural Sciences (SLU)	29 944 000
Total	64 000 000



Further strengthening of research linked to Mistra Food Futures

A lot of important research within Mistra Food Futures is supported by funding received from Mistra and from the program's partners. But the complex issues require even more efforts and, in addition, there are constantly new questions and new conditions that affect our food systems. It is therefore very encouraging to note that the research groups involved in Mistra Food Futures have recently received additional funds from various funders to build on the research directly linked to Mistra Food Futures' research questions. The collaborative networks already established within the program have been of the utmost importance for these new activities to materialize.

Two new, extensive projects focus on fossil-free agriculture and how it should be designed in the best way. We will investigate how the fossil-free systems should actually be designed, as well as how they affect production costs and what climate benefit they contribute. In addition, the farmers' attitudes to adopting these types of measures will be analyzed along with the possibilities of using political measures to encourage the transition. Per-Anders Hansson leads one of these projects, which has a broad focus on different types of agriculture, and Vivian Wei Huang leads another that focuses on dairy farms. In both cases, Formas is the main funding agency and collaboration takes place with various researchers and partners in Mistra Food Futures. The fossil-free production systems are based on renewable and often local resources and decentralized systems. This makes them generally more robust against unexpected disturbances (more resilient), which will also be studied in the projects above. This need has become especially relevant recently, when the outside world is no longer as stable as it used to be. Another new project funded by Formas and led by Helena Hansson in collaboration with various partners in Mistra Food Futures links to resilient production. An important question in this project is how the work to make the food system sustainable can coincide with the work for increased resilience. In this project, the researchers will develop the concept of *sustainable preparedness*, merging food system sustainability thinking with food security and food preparedness thinking. They will also develop indicators to assess *sustainable preparedness* and analyse how policy can help move production towards *sustainable preparedness*. The project focuses on the agricultural component of the food system.

How can policy help move production towards sustainable preparedness?

Appendix

Mistra Food Futures reports.

Mistra Food Futures Report #1. Food as Industry, Food Tech or Culture, or even Food Forgotten? A report on scenario skeletons of Swedish Food Futures. Line J. Gordon, Klara Eitrem Holmgren, Jan Bengtsson, U. Martin Persson, Garry D. Peterson, Elin Röös, Amanda Wood, Rakel Avlstad, Shyam Basnet, Anne Charlotte Bunge, Malin Jonell, Ingo Fetzer (2022).

Mistra Food Futures Report #2. Vall i växtföljd för minskad klimatpåverkan – Avkastning och klimatpåverkan i långliggande fältförsök. Johan Nilsson, Fatima F. El Khosht, Göran Bergkvist, Ingrid Öborn, Pernilla Tidåker (2022).

Mistra Food Futures Report #3. Effect of ley inclusion in crop rotations on soil carbon stocks in a life cycle perspective. Emma Moberg, Hanna Karlsson Potter, Martin Bolinder, Thomas Kätterer, Nargish Parvin, Rong Lang (2022).

Mistra Food Futures Report #4. Biochar in Swedish agriculture – straw pyrolysis as a first step towards net-zero. Elias S. Azzi, Louise Jungefeldt, Shivesh Karan, Cecilia Sundberg (2022).

Mistra Food Futures Report #5. Potential to reduce climate impact with digitalisation in agriculture – literature review and a case study of milk. Frida Edman, Fereshteh Pourazari, Serina Ahlgren, Danira Behaderovic, Per Peetz Nielsen, Victor Kardeby (2022).

Mistra Food Futures Report #6. Climate impact of some alternative uses for the lignin-rich byproduct from yeast oil production. Hanna Karlsson Potter, Johanna Blomqvist, Volkmar Passoth (2022).

Mistra Food Futures Report #7. Mellangrödor som verktyg för att minska jordbrukets klimatpåverkan – En jämförande livscykelanalys av olika hanteringsåtgärder. Johan Nilsson, Thomas Prade, Maria Emfors, Per-Anders Hansson (2022).

Mistra Food Futures Report #8. Fossilfri produktion – biobaserade gödningsmedel. Effektiv användning av näringsrika biprodukter för att ersätta mineralgödsel inom jordbruket. Niclas Ericsson, Sigrun Dahlin (2022).

Mistra Food Futures Report #9. Precision nitrogen application – potential to lower the climate impact of crop production. Hanna Karlsson Potter, Sofia Delin, Lena Engström, Bo Stenberg, Per-Anders Hansson (2022).

Mistra Food Futures Report #10. El-traktorers potential att minska Sveriges klimatpåverkan – En studie av maskinsystem i lantbruket. Oscar Lagnelöv, Gunnar Larsson, Anders Larsolle, Per-Anders Hansson (2022).

Mistra Food Futures Report #11. Minskad klimatpåverkan med vallfoder till gris – beräkning av klimatavtrycket ur ett livscykelperspektiv. Elin Röös, Stanley Zira, Eva Salomon, Magdalena Åkerfeldt (2022).

Publications in scientific journals.

Röös, E., Wood, A., Säll, S., Abou Hatab, A., Ahlgren, S., Hallström, E., Tidåker, P. & Hansson, H. (2023). Diagnostic, regenerative or fossil-free – exploring stakeholders' perceptions of the sustainability of the Swedish food system. Ecological economics. Vol. 203, 107623

von Greyerz K, Tidåker P, Karlsson J, Röös E. (2023). A large share of climate impacts of beef and dairy can be attributed to ecosystem services other than food production. Journal of Environmental Management 325:116400

Opdenbosch, H., Hansson, H. (2023). Farmers' willingness to adopt silvopastoral systems: investigating cattle producers' compensation claims and attitudes using a contingent valuation approach. Agroforestry Systems. 97, 133-149.

Amanda Wood,A., Queiroz, C., Deutsch, L., González-Mon, B., Jonell.,M., Pereira, L., Sinare, H., Svedin, U., Wassénius, E. (2023). Reframing the local–global food systems debate through a resilience lens, Nature Food 4, 22–29.

Adamie, B., Uehleke, R., Hansson, H., Musshof, O., Hüttel, S. (2022). Dairy cow welfare measures: can production economic data help? Journal of Sustainable Production and Consumption. 32, 296-305.

Guo, A., Bryngelsson, S., Strid, A., Bianchi, M., Winkvist, A., Hallström, E. (2022). Choice of health metrics for combined health and environmental assessments of foods and diets: a systematic review of methods. Journal of Cleaner Production, 365, 132622.

Macura, B., Ran Y., Persson, U.M., Abu Hatab, A., Jonell, M., Lindahl, T and E. Röös. (2022). What evidence exists on the effects of public policy interventions for achieving environmentally sustainable food consumption? A systematic map protocol. Environmental Evidence 11(1):17.

Hammar T, Hansson P-A, Röös E, (2022). Time-dependent climate impact of beef production – can carbon sequestration in soil offset enteric methane emissions?, Journal of Cleaner Production 2022:331

Sieber, P., Ericsson, N., Hammar, T., Hansson, P.-A. (2022). Albedo impacts of current agricultural land use: Crop-specific albedo from MODIS data and inclusion in LCA of crop production, Science of the Total Environment, 2022:835, 155455

Martinsson, E., Hansson, H. (2021) Adjusting eco-efficiency to greenhouse gas emissions targets at farm level – The case of Swedish dairy farms. Journal of Environmental Management. Volume 287, 1 June 2021, 112313.

Bennett, E.M., Biggs, R., Peterson, G.D. and Gordon, L.J., (2021). Patchwork Earth: Navigating pathways to just, thriving, and sustainable futures. One Earth, 4(2), pp.172-176.

Röös, E., Bajzelj, B., Weil, C., Andersson, E., Bossio, D. and Gordon, L.J., (2021). Moving beyond organic – A food system approach to assessing sustainable and resilient farming. Global Food Security, 28, p.100487

Lagnelöv, O., Larsson, G., Larsolle, A., & Hansson, P.-A. (2021). Life Cycle Assessment of Autonomous Electric Field Tractors in Swedish Agriculture. Sustainability, 2021:13, 11285

Blog posts

Access all blogs at mistrafoodfutures.se/blog

Alvstad, R (2022). Att omsätta planetära gränser till företagsmål

Sonesson, U (2022). Ultraprocessad mat och vikten av definitioner och signaler

Hansson, P-A (2022). Klimatnytta och ökad resiliens går ofta hand i hand inom lantbruket

Hansson, H, Lindahl, T (2022). I tider av kris – hur håller vi kursen mot hållbar mat?

Johansson, M (2022). Evidensbaserad problemlösning – ett verktyg för omställning

Hansson, H (2022). För att säga "hur" behöver vi först förstå "varför"

Scheuermann, M, Bunge A.J, Gordon, L. J (2022). Can legumes increase food system resilience? - The urgent need to transform the current food system in times of crisis instead of just fixing it

Vinkvist, A (2022). Sambandet mellan hälsosam och klimatsmart mat är långt ifrån glasklart

Hatab, A A (2021) Why do we need better sustainability indicators for the Swedish food system? "What gets measured, gets done!"

Hansson,P, Lindfors, B C.Norden tar köksvägen till ett mer hållbart livsmedelssystem

Hansson, H. (2021). Vem tar ansvar för att hållbarhetsproblem åtgärdas?

Hansson, H. (2021). Att prata hållbarhet – det enda hållbara i längden.

Hansson, H. (2020). The urgent need for system transformation.

Lindahl, T. (2021). Att förändra vår matkonsumtion

Lindahl T. (2021). Vad tycker vi medborgare om att bli styrda? Och varför är det en viktig fråga?

Sonesson, U. (2021). Från pastörisering, mikrobiologi och förpackningsval till globala utmaningar.

Sonesson,U. (2021). Konkreta beslut inom något så krångligt som hållbara och resilienta produktionssystem.

Hellstrom, M. (2021) Vill vi ha annorlunda måste vi göra annorlunda.

Hansson, P-A (2021). Systemsyn och klimatvänligt jordbruk.

Wood, A., Eitrem Holmgren, K. Konsten att föreställa sig ett nytt framtida och hållbart livsmedelssystem.

Gordon, L.J. The future is always full of surprises.

Malin Jonell (2021). Hållbara mål för Sveriges matsystem – vilka är de och hur få dem att hända?


Helena Hansson


Per-Anders Hansson


Malin Jonell


Beatrice Crona

WP-leaders
in
Mistra Food Futures


Line Gordon


Ulf Sonesson


Therese Lindahl


Maria Hellström

MISTRA

FOOD FUTURES

The overarching vision of the Mistra Food Futures programme is to create a science-based platform that contributes to enabling transformation of the Swedish food system into a system that is sustainable, resilient and delivers healthy diets. By taking a holistic perspective and addressing issues related to agriculture and food production, as well as to processing, retail and consumption Mistra Food Futures aims to play a key role in initiating an evidence-based transformation of the Swedish food system towards sustainability and resilience.

FUNDED BY

MISTRA

The Swedish Foundation for
Strategic Environmental Research