MISTRA FOOD FUTURES

Mistra Food Futures

– Final report phase one

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Mistra Food Futures Report #25

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Mistra Food Futures: final report phase one
Mistra Food Futures: slutrapport fas ett

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Mistra Food Futures was formulated as a response to the call Livsmedelsförsörjning och hållbara livsmedelssystem in 2019 made by Mistra – the Swedish foundation for strategic environmental research. The call asked for research programmes that could achieve the following fundamental aims: Make explicit assumptions about possible future food system pathways; provide options for how the primary production can achieve net-zero in greenhouse gas emissions by 2045; identify next-generation metrics for performance measurement of the food system; and develop knowledge on how a transformation process can be supported.

This report includes an account of the scientific results achieved during the first programme phase (September 1st 2020 – August 31st 2024), their applications, and the capacity-building the programme has contributed to.

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Sammanfattning

Detta dokument sammanfattar och syntetiserar arbetet i fas ett av forskningsprogrammet Mistra Food Futures. Detta tvär- och transdiciplinära program startade den 1 september 2020 och den första programfasen avslutades den 31 augusti 2024. Den andra programfasen är igång sedan den 1 september 2024 och förväntas pågå till och med februari 2029. Programmets övergripande vision är att skapa en vetenskapligt baserad plattform som kan bidra till att det svenska livsmedelssystemet att transformeras till ett som är hållbart (i begreppets samtliga tre dimensioner, miljömässigt, ekonomiskt och socialt), resilient och som levererar hälsosam kost. Programmet utformades som ett svar på utlysningen Livsmedelsförsörjning och hållbara livsmedelssystem 2019 hos Mistra – Stiftelsen för miljö-strategisk forskning. Utlysningen efterfrågade forsknings-program som kunde uppnå följande grundläggande mål: Utveckla tydliga antaganden om möjliga framtida scenarier för livsmedelssystemet; föreslå sätt på vilket primärproduktionen kan uppnå nettonoll när det gäller växthusgasutsläpp till 2045; identifiera nästa generations mått för att mäta hållbarhetsprestanda i livsmedelssystemet, samt som kunde utveckla kunskap om hur en transformationsprocess kan stödjas.

Mistra Food Futures första fas organiserades runt åtta distinkta, men sammanlänkade arbetspaket (workpackages, WP). Programmet formerades runt sex vetenskapliga områden, vilka inom den första programfasen har bidragit med betydande ny vetenskaplig kunskap inom utlysningens fokusområden:

1) Förslag på mål för det svenska livsmedelssystemet (WP2). Detta har bidragit till en vision för det framtida livs-medelssystemet i Sverige och till en analys av hållbar-hetsmål för svenska livsmedelsföretag, med de planetära gränserna som ram.
2) Utveckling av alternativa vägar till hållbara framtida livsmedelssystem (WP3). Fyra scenarier har utvecklats: food as industry, food as culture, food as food tech and food forgotten.
3) Utveckling av en uppsättning resultatindikatorer för ett hållbart livsmedelssystem, inklusive en konceptuell modell som beskriver sambanden mellan olika hållbarhetsdimen-sioner (WP4). En modell för ett hållbart livsmedelssystem har tagits fram, tillsammans med en indikatorkatalog för att mäta hållbarhet. En kritisk bedömning av tillgänglig sekundärdata för hållbarhetsbedömning på gårdsnivå har genomförts.
4) Applicering av systemperspektiv på åtgärder med potential att bidra till att jordbruket når nettonoll när det gäller utsläpp av växthusgaser, utvärdera åtgärderna samt utveckla en modell för att simulera åtgärdernas övergripande effekter i det svenska lantbruket (WP5). Tjugo specifika åtgärder vilka syftar till att minska lantbrukets klimatpåverkan har utvärderats i ett systemperspektiv. Vidare har en modell utvecklats och börjat tillämpas för att kvantifiera utsläpp och näringsflöden från det svenska lantbruket, med en upplösning om 106 områden i Sverige.
5) Utveckling av förslag på hållbara värdekedjor för olika typer av livsmedel (WP6). Ett ramverk som kan användas för att designa hypotetiska framtida värdekedjor från att råvarorna lämnar lantbruket och tills att de når detalj-handeln har utvecklats och tillämpats i tre fallstudieområden.
6) Analys av barriärer och drivkrafter för producenter och konsumenters beteendeförändringar i linje med ett mer hållbart livsmedelssystem (WP7). Lantbrukares preferen-ser när det gäller avvägningar mellan olika hållbarhets-dimensioner har utvärderats, samt lantbrukarnas prefe-renser för olika policyattribut när det gäller policy som uppmuntrar till mer hållbara produktionsmetoder. Vidare har heterogeniteten hos konsumenterna avseende deras stöd för olika typer och design av policyinsatser som uppmuntrar mer hållbar livsmedelskonsumtion estimerats.

Utöver programmets vetenskapliga områden syftar det till att aktivt inspirera till en transformation till ett mer hållbart livsmedelssystem, genom riktade aktiviteter inom konsortiet, public affairs-aktiviteter och bred spridning av programmets resultat (detta organiseras i programmets WP1 och WP8). I den första programfasen har programmet etablerat sig som den självklara vetenskapligt baserade plattformen när det gäller hållbarhetstransformation av livsmedelssystemet i Sverige. På så sätt har programmet möjliggjort ett betydande bidrag, både genom sitt partnerskap mellan universitet, forskningsinstitut och samhällspartners (aktörer i livsmedels-värdekedjan, myndigheter och regioner), som genom programmet har en plats att mötas och på djupet diskutera hur en transformation av ett livsmedelssystem kan gå till, samt genom programmets public affairs-aktiviteter där vetenskapligt baserad kunskap från programmet länkas in i relevanta policyprocesser.

Sedan programmets start har betydande omvärldsför-ändringar skett. Baserat på detta och på resultat och insikter från den första fasen, formulerades programmets andra fas att fokusera på ett långsiktigt perspektiv mot 2045, inkludera livsmedelsberedskap, ta ett globalt perspektiv och ställa den grundläggande frågan om vilka avvägningar medborgarna är villiga att göra i förhållande till andra samhällssystem om netto-noll inte kan uppnås i livsmedelssystemet utan för samhället oacceptabla ekonomiska och sociala konsekvenser.

Summary

This document is a report and synthesis of the research and other activities in the research programme Mistra Food Futures. This inter- and transdisciplinary programme started on September 1st, 2020 and its first programme phase ended on August 31st 2024. The second phase started in September 2024 and is planned to run until the end of February 2029. The programme's overall vision is to create a science-based platform that can enable the Swedish food system to transition into one that is sustainable (in all three dimensions: environmentally, economically and socially), resilient and that delivers healthy diets. The programme was formulated as a response to the call Livsmedelsförsörjning och hållbara livsmedelssystem in 2019 made by Mistra – the Swedish foundation for strategic environmental research. The call asked for research programmes that could achieve the following fundamental aims: Make explicit assumptions about possible future food system pathways; provide options for how the primary production can achieve net-zero in greenhouse gas emissions by 2045; identify next-generation metrics for performance measurement of the food system; and develop knowledge on how a transformation process can be supported.

Mistra Food Futures phase one was organised around eight distinct, while interlinked work packages (WPs). In particular, the programme was formulated around six core scientific activities within which the first programme phase has delivered significant new scientific knowledge within the focus areas of the call:

1) Suggesting goals for the Swedish food system (WP2). This has contributed to a joint vision for the future food system in Sweden and an analysis of sustainability targets of Swedish food companies, using the planetary boundaries as a framework.
2) Developing alternative pathways to sustainable future food systems (WP3). Four scenarios were developed: food as industry, food as culture, food as food tech and food forgotten.
3) Developing a set of performance indicators for a sustainable food system, including a conceptual model to explain the interrelationships between different sustainability dimensions (WP4). A model of a sustainable food system was developed, along with a catalogue of indicators to measure sustainability. A critical assessment of available secondary data for sustainability assessment at the farm level was conducted.
4) Adding systems perspective to, and evaluating, measures with potential to make agriculture net-zero in greenhouse gas emissions, and developing a model of Swedish agriculture to simulate overall-impacts of measures (WP5). Twenty specific measures aimed at reducing the climate impact of the agricultural sector were evaluated in a system perspective. A model was developed to quantify emissions and nutrient flows from the national agricultural sector, at a resolution of 106 areas in Sweden.
5) Developing suggested sustainable value chains for a set of example foods (WP6). A framework for the design of hypothetical future supply chains from farm-gate to retail was developed and applied in three case study areas.
6) Analysing barriers and drivers for food system change among both consumers and producers (WP7). Farmers' preferences for sustainability trade-offs were assessed as well as their preferences for policy attributes. Consumers' heterogeneous support for different types, designs and policy interventions was been estimated.

Moreover, the programme aims at actively inspiring transition through targeted activities within the consortium, public affairs and general and wide-spread dissemination of programme results (organised through WP1 and WP8). In its first phase, the programme has made significant progress in establishing itself as the obvious science-based platform related to food system transformation in Sweden. In this capacity, the programme has made notable societal impact both through its partnership between universities, a research institute and societal partners (food value chain actors, authorities and regions), which through the programme has an arena to meet and discuss in-depth how a food system transformation can happen, as well as through the programme's public affairs activities where science-based knowledge is fed into relevant policy processes.

Based on first phase results and insights, and on the significant changes that have taken place in the surrounding environment since the development of the phase one programme plan, the second phase has been formulated to achieve a set of fundamental research aims which builds on phase one aims but extends by focusing on a long-term perspective towards 2045, includes preparedness with respect to the food system, takes a global perspective and asks the fundamental question about which trade-offs citizens are willing to make with other societal systems if a net-zero food system cannot be achieved without (for society) unacceptable economic or social consequences.

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1. Introduction

This document reports and synthesises the research and other activities conducted in the first phase (2020-2024) of the research programme Mistra Food Futures, and draws overarching conclusions about the programme's scientific and social impacts. Mistra Food Futures is an inter- and transdisciplinary research programme where researchers from multiple scientific disciplines collaborate with societal actors representing the food industry (including farmers and agriculture, processing companies and retail), relevant authorities and some of the local regions. The programme's overall vision during its first phase was to create a science-based platform that can enable the Swedish food system to transition into one that is sustainable, resilient and that delivers healthy diets. The programme takes a holistic perspective on sustainability, encompassing its environmental, economic and social dimensions and delivers research results that are needed to understand how a sustainability transition of the food system can happen.

Mistra Food Futures started on September 1st 2020. Its first phase ran until the end of August 2024. The second phase runs between September 2024 – February 2029. The programme was formulated as a response to the call Livsmedelsförsörjning och hållbara livsmedelssystem in 2019 made by Mistra – the Swedish foundation for strategic environmental research. The call asked for research programmes that could achieve the following fundamental aims: Make explicit assumptions about possible future food system pathways; provide options for how the primary production can achieve net-zero in greenhouse gas emissions by 2045; identify next-generation metrics for performance measurement of the food system; and develop knowledge on how a transformation process can be supported.

In its response to the call, Mistra Food Futures phase one was formulated around seven core activities:

1) suggesting goals for the Swedish food system;
2) developing alternative pathways to sustainable future food systems;
3) developing a set of performance indicators for a sustainable food system, including a conceptual model to explain the interrelationships between different sustainability dimensions;
4) adding systems perspective to, and evaluating, measures with potential to make agriculture net-zero in greenhouse gas emissions, and developing a model of Swedish agriculture to simulate overall-impacts of measures;
5) developing suggested sustainable value chains for a set of example foods;
6) analysing barriers and drivers for food system change among both consumers and producers; and
7) inspiring transition through targeted activities within the consortium, public affairs and general and wide-spread dissemination of programme results.

During its first phase, the programme had at its disposal a total budget amounting to 80 MSEK (whereof 64 MSEK represented funding from Mistra and 16 MSEK represented co-funding from programme partners). The second phase is organised around a similar budget structure. Thereby, Mistra Food Futures is the largest food system related research programme in Sweden. The programme is hosted and lead by the Swedish University of Agricultural Sciences (SLU), in close collaboration with its two phase one core partners Stockholm Resilience Centre at Stockholm University (SRC) and Research institutes of Sweden (RISE). In the second phase, the Beijer Institute at the Swedish Royal Academy of Sciences entered as a core partner. In total, the first programme phase was organised around a 21-partner consortium consisting of the following partners: SLU (host), SRC, RISE, Gothenburg University, Chalmers, ArlaFoods, Axfood, Coop, HKScan, Lantmännen, Matilda FoodTech, Orkla Foods Sverige, Polarbröd, The Swedish Food Federation, The Federation of Swedish Farmers, The Swedish Board of Agriculture, The Swedish Food Agency, The Public Healthy Agency of Sweden, Region Västra Götaland, Region Östergötland, Region Kalmar.

2. Point of departure and programme focus

Mistra Food Futures takes as its starting point the influential and abundant scientific evidence that emphasises that societies are at a crossroad, where current unsustainable ways of organising our lives need to significantly transform to be in line with sustainable development. The urgency of the action is underlined by significant evidence of global environmental change (1–4), a change which risks the very foundations of our civilisations. Transitioning towards sustainable development is also key to live up to global commitments made in the Paris agreement, the 17 Sustainable Development Goals (SDGs) and the Kunming-Montreal Global Biodiversity Framework.

Looking at the production and consumption of food, it can be concluded that current food systems are not sustainable at the global level (1) or at local levels, for instance in Sweden (5,6) – the empirical focus area of Mistra Food Futures. Sustainability problems relate to both practices applied in production, processing and retail, as well as to consumption patterns and dietary choices. Food systems are globally interlinked and working towards more sustainable production practices in one country will not remedy its food system sustainability problems unless its consumption patterns are also changed to be in line with sustainable development. Globally, food systems are responsible for about one third of total anthropogenic greenhouse gas emissions (7) and agricultural production

practices cause significant harm to biodiversity (4). At the same time, intake of uniform and low-quality diets is a risk factor for premature death (8) and the many small businesses, including the farms that represent most of the raw-material production in the food system, struggle with slim economic margins and thus by large unsustainable economic conditions. The importance of the food system, in a sustainability perspective is thus significant. This is also underlined by the fact that food and agriculture is a cornerstone of Agenda 2030 and is inherently linked to all sustainability goals (5,9,10). Achieving sustainable food systems is a key priority to transitioning entire societies towards sustainable development. A fundamental question is *how* a food system transformation can happen. Mistra Food Futures is formulated around this key question and its research activities overall aims to produce science-based evidence that is needed to understand how the food system transition can take place. To achieve this, the programme also asks the fundamental question about what a sustainable food system in Sweden can look like.

In Mistra Food Futures, we focus on the Swedish food system and develop science-based knowledge that is needed for it to transition towards sustainability. Sweden generally performs well on overall-sustainability rankings (11,12). Still, average diets are resource demanding, trespassing five of six planetary boundaries (6) and the production represents almost fifteen percent of territorial greenhouse gas emissions (13). More than fifty percent of the adult population is overweight or obese (14) and the population's diet is lacking nuts, legumes, fruits, vegetables and wholegrain, while it is too rich in sugar, saturated fats and red meat (5,15). The population is not adhering to the official, science-based nutritional guidelines based on the Nordic nutritional recommendations which the country has had for a long period of time. On the production side, Swedish primary producers struggle with poor profitability, especially the smaller agricultural producers (16), although figures from 2021 points towards a somewhat less pressing situation after the output price increases that happened that year (17). Measures have been taken to reduce the use of antibiotics in the livestock sector and Sweden is now among the countries with lowest use in the European Union (EU) (18), although some evidence exist to suggest that this may be achieved at the expense of the longevity of in particular dairy cows (19), who transition to meat production after on average only few lactations. Sweden has also implemented measures to reduce the use of mineral fertilizers (20) and nitrogen losses (21). Still, Swedish cropping systems, similar to cropping systems in most industrialised countries, are by large represented by monocultures. Livestock and cropping systems are generally separated, which hinders the opportunities to realise sustainability gains from more diverse production systems. Aquatic foods from fisheries and aquaculture are an important element of a healthy diet. However, one of three Swedes eat no seafood at all, and two of three should increase their consumption for health reasons (22). On the production side, there is an alarming negative trend for some key Swedish fish stocks (e.g. Baltic Sea cod and herring), aquaculture production is low and around 70% of the seafood consumed in Sweden is imported (22). Stimulating an increased production of sustainable aquatic food in Sweden would help realize both health- and environmental targets.

Against this background, we formulated Mistra Food Futures phase one to focus on setting goals for the food system; identifying barriers and opportunities to deliver on them; developing plausible future pathways for the Swedish food system; developing a suite of indicators to follow and monitor progress towards transformation; identifying and exploring action strategies for the Swedish agricultural system to achieve net-zero in greenhouse gas (GHG) emissions by 2045, and to achieve sustainable domestic food production, retailing and consumption; identifying strategies for implementation; and to initiate actual transformation among the programme's societal partners. The programme phase one was organised around eight work packages (WPs; Figure 1), of which WP1 focused on coordination, management, communication and public affairs, and the other WPs (2–8) were formulated to respond to the focus areas above.

After the formulation of Mistra Food Futures phase one, significant changes took place in the surrounding environment: the Covid-19 pandemic, Russia's invasion of Ukraine and the significant price inflation which during a few years heavily affected both producer and consumer prices in the food system. Programme phase one maintained its focus on the fundamental question about how the food system can transition to a sustainable one. The second phase programme was formulated to explicitly take into consideration preparedness with respect to the food system (food preparedness from hereon), resilience as well as the global interdependencies of our food system, while continuing to investigate the programme's fundamental research questions related to *how* the food system can transition into a sustainable one and what a sustainable food system in Sweden can entail.

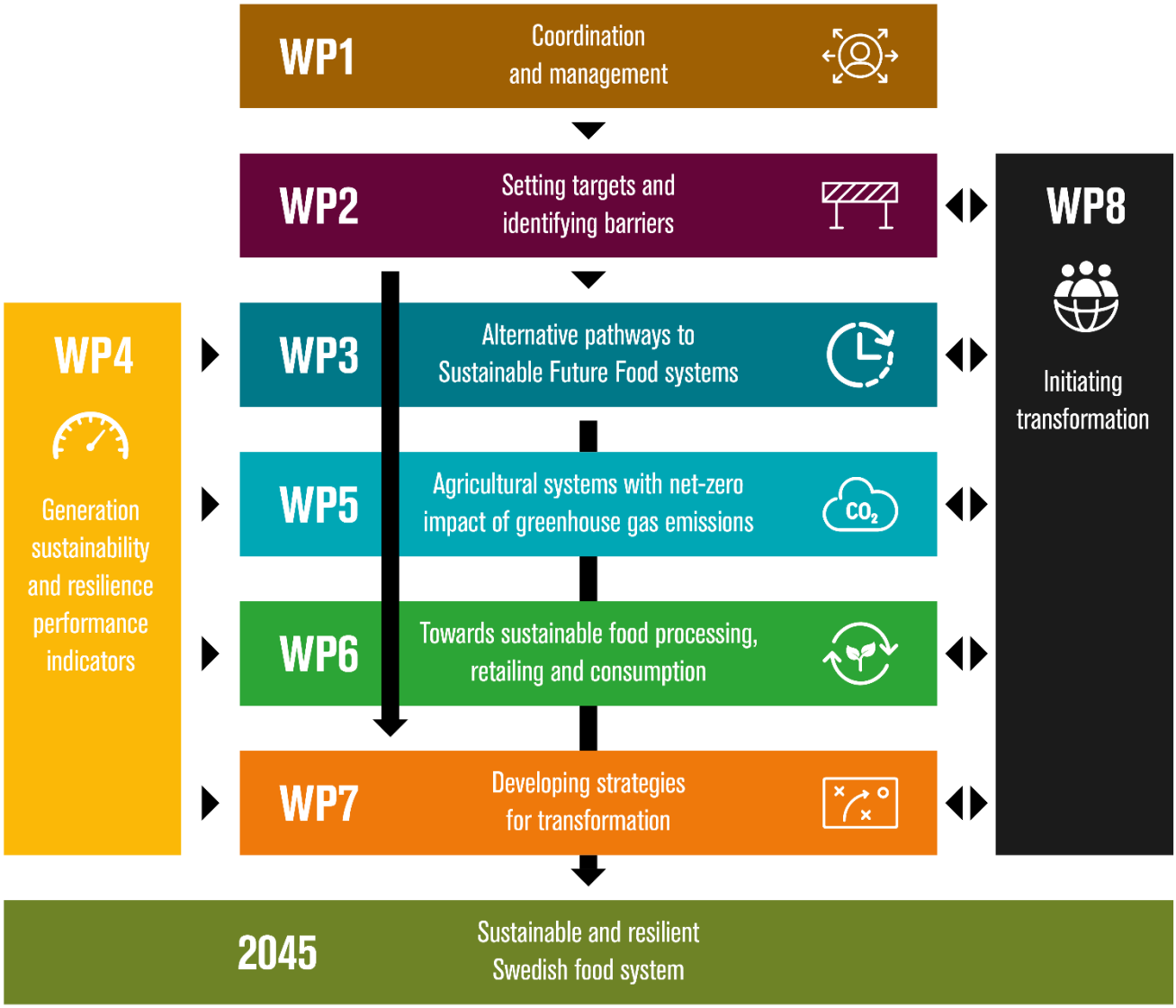

Figure 1. Work package organization in programme phase one.

3. Key results by WP

In this section we report the key results during phase one by WP2 – 8, i.e. the WPs which responded to the focus areas of the programme. The WPs were organised around different focus areas and were also of different size. In particular, the WPs worked with the following overall budget (rounded figures and including co-funding): WP2: 6.3 Mkr; WP3: 7.2 Mkr; WP4: 8.2 Mkr; WP5: 16.7 Mkr; WP6: 7.1 Mkr; WP7: 7.0 Mkr and WP8: 10.1 Mkr.

WP2: Setting targets and identifying barriers

Aim and research questions

The aim of WP2 was to identify the targets that a sustainable and resilient food system needs to achieve. Moreover, to identify likely barriers to these targets, and explore strategies to turn the barriers into leverage points for change. Three overarching research questions were formulated to guide the work in WP2:

- What are targets for a sustainable and resilient food system by 2045, and what are sub-targets that can be achieved by 2030? (RQ1)
- Which are the main barriers to achieve these targets? (RQ2)
- What could strategies look like that turn these barriers into leverage points for change? (RQ3)

Key results

Mapping and assessing targets currently developed for the Swedish food system.

The aim of WP2 was originally to set the targets that a sustainable and resilient food system needs to achieve, identify likely barriers to these targets, and explore strategies to turn the barriers into leverage points for change. However, given the urgency and relevance of such targets many actors in the Swedish food system have already mobilized to develop such targets (e.g the target synthesis work of ten Swedish authorities (23) and the sustainable value chain (HLK) moderated by WWF (24).

As a result, WP2 revised its aims, away from a target-setting process facilitated by stakeholder input, and towards knowledge-generating to support (rather than to duplicate) ongoing processes, as well as an analysis of current private sector targets in the Swedish food system. Below we report three areas of result.

Mistra Food Futures Report: Climate, biodiversity and health targets for Swedish food production and consumption

Instead of relying on non-academic stakeholder input for setting targets for the Swedish food system, an academic expert guided procedure to set targets for the Swedish food system was undertaken. The set of potential targets were developed in tandem with WP3s production of scenario skeletons and WP4s work on an indicator framework for measuring sustainability in the Swedish food system (25).

Climate change and biosphere integrity have been defined as core planetary boundaries since altering these significantly would drive the earth system to a new stage (2). In addition, human health is considered a key priority and the very basis for sustainable food systems. Biodiversity, Climate, and Diet quality & health were therefore the three core target areas covered in the report. The targets developed by WP2 were used as a guiding star for the four food system scenarios developed by WP3.

Scientific paper: Planetary boundary-based? – an analysis of Swedish food system targets

In parallel with suggesting targets for the Swedish food system, WP2 compiled and evaluated private sector targets with respect to (i) the extent to which *impact* targets consider impacts on the planetary boundaries and (ii) whether company operational targets are effective in reducing impacts on the planetary boundaries (26). The 20 largest food companies in Sweden (based on revenue) were included in the analysis and targets were gathered from the latest annual- or sustainability reports as of June 2023. Over half of the *impact* targets had a focus on reducing impacts on climate change (38 out of 60 targets). Three targets on Chemicals & pesticides were identified as well as only two on Halting biodiversity loss. The most common *operational* target category was Recycling & packaging (with 53 out of 185 operational targets). The three categories with the fewest targets in the sample were Stimulate a shift to more plant-based food (2 targets) and Enhance producer capabilities (3 targets). Notably, the most prevalent operational targets are deemed relatively ineffective in addressing impacts on the planetary boundaries. Operational targets centring on interventions effective in reducing impacts on several planetary boundaries, e.g. a shift to more plant-based diets and protect and restore nature were few. This work will be submitted to a scientific journal during fall 2024.

System diagnosis

Regarding system diagnosis, two areas of results were achieved, as reported below.

Webinar on CAP. A synthesis of the current Common Agricultural Policy (CAP) was conducted as a first step in the work to review current and suggested public policy aimed at production and consumption and evaluation of these in relation to the overall goal of a food system. This resulted in a webinar, which summarized the current CAP, issues with it, what is expected from the proposed CAP reform, the Swedish policy process in relation to this (including the needs assessment led by the Swedish Board of Agriculture (27), and links to Climate Change policy at EU and Swedish level which resulted in a Webinar in May 2021.

Scientific paper: Towards environmentally sustainable food consumption – a review of the effectiveness of policy instruments. To better understand the effectiveness of current and suggested public policy we conducted comprehensive literature review focusing on policy measures aimed at promoting environmentally sustainable food consumption in collaboration with another project ('Towards a Sustainable Swedish Food System – a Knowledge Synthesis on Environmental Effects and Policy Alternatives', Naturvårdsverket 2020-00076). The overarching objective of this review was to gather and outline the existing body of evidence concerning public policy interventions that have been put into practice, proposed, or have the potential for implementation to encourage environmentally sustainable food consumption. The central research question guiding our review was: What evidence is available regarding the impact of public policy interventions designed to promote environmentally sustainable food consumption? A systematic meta review (review of reviews) was conducted to synthesize best available knowledge.

Results show that there is considerable evidence suggesting that various cost-effective and low-risk policy measures typically yield favourable outcomes in reducing the environmental impact of the food system. These include strategies such as restructuring menus, utilizing visual cues and tailored information campaigns, implementing educational programs, and reducing plate and portion sizes. It is also well-established that price-based incentives, such as taxes and subsidies, can be effective tools – a fact supported by numerous simulation studies (28). However, it is worth noting that this type of research has not been exhaustive. The evidence is more robust when it comes to reducing food waste compared to promoting dietary changes. Several factors, including the specific context (such as the type of

restaurant setting), demographic variables (like gender), and the calibration of the intervention (e.g., 'light' versus 'comprehensive' labelling), significantly influence the effectiveness of these measures. Further discussion is needed to explore these nuances. Generating generalizable results regarding the magnitude of effects across different types of interventions is challenging due to the substantial heterogeneity in how these interventions are implemented, the various contexts in which they are applied, and the diverse study designs employed.

Identification of barriers and leverage points

Dialogue series to unpack barriers and strategies. To explore barriers and strategies to reach the climate-, biodiversity- and health targets (29) a dialogue series with Mistra Food Futures partners as well as other key stakeholders was conducted. This work was led by WP8 in collaboration with WP2. The four scenarios for a future food system (30) developed by WP3 were used a as a starting point and the discussions centred on identifying barriers and leverage points. The first dialogue concentrated on establishing a shared understanding of what a shift toward a sustainable food system might entail, employing scenarios – alternative visions of the future – to ignite creativity, transcend existing paradigms, and discover fresh ideas, optimism, and motivation. Participants delved into the potential pathways leading to these diverse futures, with the aim of elucidating the driving factors and obstacles that could emerge during a sustainable transition.

In summary, most levers identified focused around the scenario "Food as Industry." This outcome was expected, as "Food as Industry" is generally depicted as an extension of the existing food system, making it easier to pinpoint changes aligned with a linear progression. One recurring theme revolved around political and policy-related obstacles and the imperative for change. Clearer regulations and increased political investments in innovation were recognized as catalysts for steering development in the right direction. Additionally, there was an emphasis on the importance in building a domestic knowledge base linked to the food sector.

Related to this is the necessity for technological advancement to facilitate transformation. This encompasses a spectrum of needs, from advancements in food technology for the creation of new products to enhancing transparency in value chains and employing technology to connect smaller enterprises and producers with larger industry players. However, it is worth noting that it was suggested that technology can also serve as a barrier, particularly concerning consumer attitudes towards highly industrialized ingredients and products, which may hinder a transition reliant on new types of food products.

Collaboration across the entire value chain emerges as a recurring pattern across the scenarios, albeit with differing levers depending on the envisioned future trajectory. Greater consolidation within the value chain is recognized as an enabler for "Food as Industry" and "Food as Food Tech," two scenarios capable of achieving sustainability goals through large-scale production. Conversely, closer connections between producers and consumers through smaller, local cultivation are seen as a lever against "Food as Culture" and "Food Forgotten."

To achieve a transition toward a sustainable food system, likely comprising elements from all four scenarios, a combination of the described levers will be essential. This would necessitate closer collaboration between stakeholders, including policymakers. Perhaps most evident is the need for actors to cooperate more extensively, irrespective of whether the focus is on technology or product development, the establishment of new business models, or knowledge development within the industry or among consumers, all with the goal of effecting systemic change. Cautious consideration must however be given to the potential risks entailed in intensified collaborative efforts, notably the emergence of monopolistic entities capable of inflating pricing structures and fostering inefficacies within market-oriented solutions. Put differently, mitigating specific sustainability challenges, may concurrently exacerbate others. Collaborative efforts should therefore be monitored closely to better understand risks and success factors.

Mapping the Swedish risk landscape

Provided several major events affecting food systems since the start of Mistra Food Futures phase one, we used funding from the programme strategic reserve to conduct an assessment of current and emerging risks for the Swedish food system (31). What risks we need to anticipate, mitigate, adapt and prepare for changes quickly and the new risk landscape of the Swedish food system needs to be navigated at the same time as efforts to deliver on sustainability, equity, and resilience are not compromised but prioritized.

To increase the understanding of the new risk landscape a Delphi study with 30 invited experts from the Swedish food system was conducted. The risks were identified via a scoping literature overview including scientific and grey literature. A total of 159 risks were identified and through iterative rounds condensed to 37 risks and 26 trends.

Through two survey rounds the expert's assessment of the current risk landscape solidified, and between the rounds, the participants reached a higher overall agreement in their assessments for most of the identified risks and trends. However, disagreements still existed and varied across questions. For certain questions, the experts agreed less than in round one, specifically for risks relating to power cuts and their potential impacts. Certain risks, such as those related to climate change, war, and geopolitical events, were consistently seen as most impactful if they were to occur, even if their probability varied somewhat. Some risk categories, particularly accidents and sudden shortages, showed the most disagreement among participants, indicating lower consensus. When assessing already ongoing trends and their impacts on food system resilience, the five most important areas to prioritize action on according to the experts were: 1) Climate change, 2) The low profitability in food production, 3) The loss of biodiversity, 4) The lack of investment in the Swedish food system, and 5) The burden of rules and administration.

Finding pathways, synergies, and prioritize for navigating and build resilience in this new risk landscape will need further research efforts and dialogues with stakeholders

Key scientific publications, manuscripts and reports

- Jonell, M., R. Alvstad, K. Eitrem Holmgren, J. Bengtsson, M. Persson, G. D. Peterson, E. Röös, L. J. Gordon, I. Fetzer, and A. Wood. 2024. Climate, biodiversity and health targets for Swedish food production and consumption. *Mistra Food Futures Report #20*
- Scientific paper: Jonell et al. Planetary boundary based? – an analysis of Swedish food system sustainability and health targets. Manuscript in preparation.
- Scientific paper: Ran et al. Towards environmentally sustainable food consumption – a review of the effectiveness of policy instruments. Manuscript under review.
- Jonsson A., Mazac R., Jonell, M, Queiroz C, Nyström, M., Sonesson U., Pousette S., Gordon J. L Navigating and understanding the changing risk landscape of the Swedish Food system – a Delphi study. Manuscript in preparation.

WP3: Alternative pathways to Sustainable Future Food Systems

Aims and research questions

WP 3 used scenario planning to explore a set of different pathways along which the Swedish food system plausibly could develop. A scenario is a plausible, simplified description of how the future could develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships, and a pathway is the course of action within each scenario. Scenario planning uses diverse methods to explore how structural change in the food system can emerge from the interactions of conflicting actors, in a rapidly changing, and sometimes turbulent, dynamic world. Scenario planning is thus a method that can help researchers and stakeholders analyse pathways to a transformation by integrating diverse assumptions, data, models, and goals, as well as rigorous and creative probing of ideas of how change takes place. WP 3 focused on the following broad research questions:

- What are alternative ways in which future food systems can meet WP2's identified targets and what coherent and internally consistent pathways can explain how and why Sweden could arrive to those futures? (RQ1)
- How would pathways representing the competing priorities of food system actors perform in relation to each other? What compromises among competing priorities would be needed to be resolved in order to deliver on as many food system targets as possible? (RQ2)
- What roles does national pathways (of Sweden) play in global scenarios? (RQ3)

Which uncertain dynamics could push the development of the Swedish food system away from desired pathways, and what actions, strategies and policies can build resilience to these dynamics? (RQ4).

Key results

The key results from this WP were the articulation of alternative pathways to achieve common goals for food system transformation in Sweden. Scenario narratives identified commonalities and trade-offs among alternative pathways to the same goals, in ways that facilitates stakeholder dialogues. The storylines behind the pathways can be used as a basis for quantitative and qualitative modelling of national food system transformation. The pathways fit with a specific social/cultural-economic-ecological context (Sweden), but can be adapted for other places facing similar challenge.

In the first two years we focused on developing qualitative scenario narratives, with the aim to provide insights of relevance for the other WPs. We focused on target seeking scenarios, a type of scenario planning that has recently gained more attention, describing four different pathways along which these targets may be met. In year three we developed quantitative models to assess the feasibility of the targets in the different scenarios, as well as identifying potential trade-offs. In year four, we finalized the papers started in years 1-3 . We had an article accepted in Nature Communications on "Sustainability benefits of transitioning from current diets to plant-based alternatives or whole-food diets in Sweden."(32). We submitted one paper on "Interacting strategies for food system transformations: Fuzzy Cognitive Mapping of Swedish scenarios"(33). We have also submitted one paper quantifying the gap between current environmental and health impact of the four pathways and the targets, "From national pathways to global boundaries: Environmental and health outcomes of diets in four food futures"(34). We are also doing an in-depth analysis of "Fika in the Anthropocene" as a link between Food as Food Tech and Food as Culture scenarios(35).

Targets for scenarios

We first identified the targets (25). We chose three targets (for Climate, Biodiversity and Health), in order to balance the complexity of creating scenarios (which increases exponentially as the number of targets goes up) against the need to capture a diversity of goals of the Swedish food system. Each target is represented by two target levels with a slight variation in ambition level (more ambitious and ambitious). All targets have both a territorial target (what Sweden should achieve in its own territory) and a consumption-based target (the overall impact of Swedish diets including both territorial and international impacts) (30).

Developing scenario storylines

We developed four alternative scenarios, each articulating an alternative pathway to achieve the same common goals for food system transformation. Each scenario highlights a perspective and narrative that is common among stakeholders within, or outside of the food system, and who have power to shape the future of the food system (30,36). The four scenarios are:

- *Food as Industry*, a narrative common among the dominant actors in the current food system and where agriculture and food processing is considered an important Swedish industry both nationally and for export of sustainable products worldwide;
- *Food as Food Tech*, a narrative common among actors currently primarily on the margins of the Swedish food system, but interested in making disruptive investments for sustainability and health transformations;
- *Food as Culture*, a narrative driven by niche actors in the current food system where a new cultural vision of rural-urban and human-nature relationships enables more healthy and sustainable food; and
- *Food Forgotten*, a narrative not really driven by anyone, but where developments in the policy environment and other sectors outside of Swedish agriculture shape the future of the Swedish food system.

Out of these four scenarios, it is Food as Industry that is most similar to current national food policies in Sweden. This is due to that we adapted Food as Industry based on in-depth stakeholder engagements with private and public sector stakeholders, in another linked project (North Western Paths) (37). In order to ensure that these food futures are not deviating too much from past trends we developed a trend report, that looked into food system trends for the Swedish food system between 1950 and today (38).

Using modelling to explore inconsistencies, trade-offs and synergies among the scenarios

The scenario narratives were reinterpreted as Causal Loop Diagrams that were then used as the basis for constructing a food system model in the form of a Fuzzy Cognitive Map (39). Simulations were run to investigate the conditions under which the key developments in the scenarios could be reproduced by modelling(33). The modelling uncovered several system dynamics in how the scenarios interacted with each other: the competition or shared interests of different types of agriculture; the system impacts of novel foods; the vulnerabilities of localized food systems; the importance of food culture; and the interactions of environmental policy with farming systems. A set of scenario alternatives, that were a mix between several of the scenarios were also developed. The analysis of specific dynamics can be used to inform upcoming scenario iterations, and alternative scenarios can be used to maintain analytical depth when scenario interactions are discussed.

Quantifying the scenarios

We developed the scenarios (i.e., Food Futures) into four scenario diets—Food as Food Tech, Food as Industry, Food as Culture, and Food Forgotten (34). Nutritional intakes and environmental impacts of each diet scenario were quantified and their relative levels mapped to respective climate, biodiversity, cropland, and health boundaries set for the Swedish population. Results show that the current diet surpassed safe boundaries for climate, biodiversity, and cropland, but with large uncertainty ranges for biodiversity loss. All of the scenarios reduced the impacts compared to current diets, with the greatest reductions in climate impact, at over 80%. The biophysical territorial impacts is analysed with the model developed in WP5. In WP3, we have therefore focused primarily on consumption-based impacts, in Sweden and abroad, as well as socio-economic developments.

Special focus on Food as Food Tech

The arguably most novel scenario compared to other national food system scenarios is Food as Food Tech (30). The novelty of emerging food technologies presents a challenge in terms of data availability. To overcome this, we have done a systematic scoping review of sustainability impacts of four different technologies that get the most attention by food system investors (40). We found that most research on novel food system technologies so far has had a dominant focus on environmental sustainability and less on public health and socio-economic sustainability. Gaps in the literature include empirical assessments on the sustainability of blockchain technology, plant-based seafood alternatives, public health consequences of food deliveries and socio-economic consequences of vertical farming. We also conducted a dietary modelling study to advance the evidence base on the role of plant based alternatives in more sustainable diets, comprehensively assessing their sustainability implications(32). In the models we replaced animal sourced foods with plant-based alternatives (both whole foods and new products, such as soy-based meat and plant based dairy alternatives). We showed that plant-based alternatives can reduce the environmental impact of, and be more nutritious than, current Swedish diets while being cost-competitive and meeting most nutritional recommendations. We also showed that an emphasis should be placed on reducing animal sourced food consumption and expanding the variety of available whole food and plant based alternatives to ease dietary transitions by regarding them as complementary alternatives for diverse consumer groups with different preferences.

To model the Food as Food Tech scenario in the same way as the three other scenarios, we have also realized that we need better conceptualizations and data on alternative food system technologies. We are therefore developing a paper on classifying novel foods for use in food system models (41).

Linking the Swedish scenarios to other national and international scenario development initiatives

The work with the Swedish national scenarios has also been used by WP3 researchers in their work with other scenario processes (37,42), and in analysing the role of national and regional pathways to achieve global goals (43–46). Insights from our work has also fed into international work on biodiversity scenarios work connected to the IPBES Natures Futures Framework (47,48), and the Anthropocene (49). It has also been used in discussions on biodiversity friendly landscapes (50). Additionally, some of the work on novel food is now contributing to modelling for the EAT-Lancet 2.0 process (51).

Using the Scenarios in other work packages

The qualitative scenarios were developed to be used in other Mistra Food Futures work packages. The scenarios have been used in WP5 to guide assumptions on variables used as inputs in the quantitative modelling of the agro-food system. Workshops have been conducted with stakeholders using the scenario narratives as a base to quantitatively describe e.g. crop yields, nutrient use efficiencies, animal mortality, productivity and feed rations. WP6 included the scenarios in several workshops held with stakeholders, and by incorporating these, the discussions on supply chain transformations, impacts and solutions improved significantly. WP2 and WP8 used the scenarios in a dialogue series that brought together actors within the food system to create a mutual understanding of the necessary changes, barriers, business models and innovations on the way to a sustainable transition. The participants explored how the path towards the different futures could look like, to highlight the driving forces and barriers that can arise in a sustainable transition.

Key scientific publications, manuscripts and reports

- Bunge, A. C., Mazac, R., Clark, M., Wood, A., & Gordon, L. (2024). Sustainability benefits of transitioning from current diets to plant-based alternatives or whole-food diets in Sweden. *Nature Communications*, 15(1), 951.
- Gordon LJ, Holmgren KE, Bengtsson J, Persson UM, Peterson GD, Röös E, et al. 2022. Food as Industry, Food Tech or Culture, or even Food Forgotten? A report on scenario skeletons of Swedish food futures. *Mistra Food Futures report #1*
- Bunge, A. C., Clark, M., & Gordon, L. Fika in the Anthropocene Manuscript in review.
- Rut Carlsson, H., Mazac, R., Persson, U.M., Röös, E., Peterson, G., and Gordon, L.J. Interacting strategies for food system transformations: Fuzzy Cognitive Mapping of Swedish scenarios. Manuscript in review.
- Mazac, R., Karlsson Potter, H., Bengtsson, J., Rut Carlsson, H., Einarsson, R., Persson, U.M., Gordon, L.J., and Röös, E. From national pathways to global boundaries: Environmental and health outcomes of diets in four food futures. Manuscript.

WP4: Next generation sustainability and resilience performance indicators

Aims and research questions

WP4 aimed at identifying the next generation of indicators to monitor performance of the food system in delivering healthy diets from a system that is sustainable and resilient. One ambition was to develop a framework that can be used to assess sustainability and resilience performance in a holistic way, considering the whole system, rather than focusing on single aspects of performance such as yield per unit of production. The WP was guided by four overarching research questions:

- What are the next generation key indicators that successfully monitor sustainable performance across its three dimensions – environmental, economic and social, and resilience of the food system – at different levels? (RQ1)
- How are these indicators correlated across the environmental, economic and social dimensions of sustainable development? What are the potential conflicts and synergies between factors measured by the indicators identified by society and different stakeholders in the supply chain? (RQ2)
- How can indicators be populated with data and used for monitoring and evaluation? What data are available and reliable, and what kind of additional data collection and generation is needed? (RQ3)
- How can supply chain actors, policy makers and society use indicators for decision making? (RQ4).

Key results

A fundamental aspect in developing the next generation sustainability indicators is to establish what a sustainable food system actually entails. This was an integral part of WP4 and comprised one of key themes of WP4. We approached the task from two perspectives: by investigating stakeholders' perceptions about food system sustainability challenges and solutions, and by developing a national framework for a sustainable food system, using Sweden as a case (for RQ1 in particular but also relevant for RQ2).

In parallel, we developed a suite of indicators to assess food system sustainability at system level. We also assessed the critical role of secondary data in sustainability measurement, including the potential limitations posed by data availability, using dairy farming as a case study. This comprised the second key result theme of WP4 (for RQ 3 in particular, but also for RQ2). In later WP4 work, we produced knowledge for RQ4, the third result theme of the WP.

Starting in the first key result theme, the study by Röös et al (52), based on Q-methodology, concluded that stakeholders' perceptions about food system sustainability challenges and solutions can be summarized into three main perspectives: the diagnostic perspective, focusing mainly on approaches to mitigate and adapt to climate

change; the regenerative perspective, focusing mainly on diversity, soil health and organic agriculture as a solution to sustainability challenges; and the fossil-free perspective, emphasising the role of profitable companies in the Swedish food system to transition towards fossil free production. Data were collected from stakeholders representing different parts of the food system as well as different communities of practices. Interestingly, we found that each perspective was represented by a diversity of different types of stakeholders, something which suggests that perspectives are not homogeneous across stakeholder types.

Looking into how to conceptualise sustainability performance from a theoretical perspective, the study by Martinsson and Hansson (53) first approached this by developing the well-established eco-efficiency (54) score to account for limitations in absolute amounts of emissions, thus incorporating into the model that emissions cannot be justified simply by increasing the economic value-added in businesses. Moreover, in the study by Hansson et al. (55), we developed a national food system sustainability framework, using Sweden as a case study. Departing from already available frameworks, in particular by Hebinck et al (56), we developed a model that already at a conceptual level can facilitate priorities between sustainability dimensions. Furthermore, the model differentiates between production and consumption impacts. We proposed to use a house as a metaphor to represent a sustainable food system. Resulting in the *Food System Sustainability House*, the ceiling consists of the societal dimensions of sustainability, the floor represents the environmental dimensions, and the walls, represented by the economic dimensions and governance, links the floor to the ceiling and thus represent activities which enable the implementation of the system objectives while respecting the environmental pre-conditions. Finally, we operationalised the model for Sweden by suggesting themes, subthemes and indicators to trace performance in the different parts of the model. In the manuscript by Säll et al (57) we conceptualized a sustainable food system as a collective action problem, highlighting the social dilemmas where actors prioritize short-term profits above future utilities. Based on this, we used the Collective action framework to identify main issues hindering Swedish food system actors to cooperate for preserving common goods. The framework consists of enablers and stressors that either support or hinder cooperation within the food system, and thus point to key areas in need of governance. Results indicate that the inability to agree upon what main objectives the food system should achieve, based on differing views on what sustainability actually entails, is one of the main issues hindering sustainable development. In addition, the absence of quantified environmental targets makes it possible for actors to not take responsibility for the negative impact arising from the food system. Governance thus need to be focused onto these areas to ensure that the Swedish food system becomes more sustainable in the future.

In the second key result theme, we developed a catalogue of indicators to assess the individual aspects of the *Food System Sustainability House*. Results are presented in (58). We also collected data to assess the sustainability of the Swedish food system based on the food system sustainability framework, the house (55). For a total of 95 indicators describing 15 sustainability themes, we collected time series data when available (ranging to full time series over 30 years to a few data points), policy targets and other relevant benchmarks. In still ongoing work, we explore if trends can be identified for the development for the different indicators and also calculate the 'distance-to-target' for each indicator (where possible), i.e. how far from policy target or benchmark the indicator is. We develop a novel way of summarizing the results from the sustainability assessment illustrating both trends and distance-to-target. We also develop a method to evaluate the quality of the different indicators including their validity, data availability, reliability, time series quality and whether there exists official statistics and targets for the indicators. We perform the assessment from a territorial and consumption based perspective. Tentative results indicate that many indicators show reasonable quality but for some areas (e.g. the consumption of seafood, market concentration, meals reflecting Sami cultural in public institutions and import dependency for inputs) there is a complete lack of data. In terms of the sustainability performance, results are mixed, showing both negative and positive developments, even within sustainability themes. For example, in the theme Healthy and adequate diets there are both positive trends (e.g. increase in fruit and vegetables intake) and negative trends (e.g. rising obesity). Developments are generally more favourable for the territorial impacts than for consumption based impacts.

Focusing on the agricultural component of the food system, in the study by Robling et al. (59) we also assessed the critical role of data in indicator construction and highlighted limitations secondary data availability can impose on farm-level sustainability assessment, using dairy farming as an example. We concluded that as many as 20 indicators, organised under 12 of a total of 20 considered sustainability themes had measurement issues. This is notable, given the critical role of secondary data for cost-efficient sustainability assessment and for industry over-time comparisons.

Through the study by Guo et al. (60), a specific focus was taken on health metrics and methods, which fed into our over-arching indicator catalogue. This study is a systematic overview of health metrics and methods to combine health and environmental assessment of foods and diets. A total of 33 articles using nine different health metrics in combination with environmental assessment of foods were identified. Key methodological considerations of importance for best practices were highlighted as well as trends over the past decade, and future research needs.

Through the study by Adamie et al (61), we had a unique opportunity to contribute to WP4, although the data were based on German agriculture: here we were able to validate the use of secondary production data to assess the welfare of dairy cows (animal welfare being a significant part of a sustainable food system), using animal welfare data collected based on the Welfare Quality® protocol.

Secondary production data is particularly useful as indicators of sustainability for analysis of policy interventions where historical panel datasets are often necessary to assess behavioural change among participating actors. Based on the results by Adamie et al. (61) it is possible to discuss how secondary production economic data can be used to produce a proxy of animal welfare in dairy cows using such secondary data and long panels.

Turning to the third result theme, in a study by Robling et al. (62) we collected information about food and beverage companies' use of sustainability indicators, including the amount, scope and target connection of the indicators and how heterogeneity in terms of size, multinational affiliation and industry specialisation can explain differences in indicator use. Results indicate that almost 90% of the 98 companies in the sample measure emissions while only 4% measure anti-competitive behaviour. As the quantity and scope of indicators remain fairly constant, the share of indicators with connection to an internal target increases over the time-period 2017-2021. Preliminary findings also suggest that firm size has a minor influence on the quantity, scope and target connection of sustainability indicators, while global connections have a larger influence, in particular for the companies with the most developed measurements.

We also investigated how consumers use sustainability information in their purchasing decisions(63). Two choice experiments were used, one conducted online and one from in-store customer meetings, covering the protein choice for cooking a pasta sauce. Consumers could choose between meat and plant-based options with different characteristics such as Swedish, imported and organic products. The results show that Swedish products were most important to consumers and that the willingness to pay for plant-based products was low.

An important remaining question in relation to WP4 is to understand how actors attribute responsibility for action when indicators signal that action is needed. This is key to understand how use of indicators actually impacts behaviours. This analysis is planned to continue in parallel with the start of phase two.

Key scientific publications, manuscripts and reports

- Hansson, H., Säll, S., Abou Hatab, A., Ahlgren, S., Berggren, Å., Hallstöm, E., Lundqvist, P., Persson, M.U., Rydhmer, L., Röös, E., Tidåker, P., Winkvist, A., Zhu, L. (2023) An indicator framework to guide food system sustainability transition – the case of Sweden. *Environmental and Sustainability Indicators*, 22, 100403
- Hansson, H., Röös, E., Säll, S., Abou Hatab, A., Ahlgren, S., Berggren, Å., Hallstöm, E., Lundqvist, P., Magnusson, U., Persson, M.U., Lydhmer, L., Tidåker, P., Winkvist, A., Zhu, L. (2023). A framework for measuring sustainability in the Swedish food system – indicator selection and justification. *Mistra Food Futures Report #14*.
- Robling, H., Abou Hatab, A., Säll, S., Hansson, H. (2023). Measuring sustainability at farm level – A critical view on data and indicators. *Environmental and Sustainability Indicators*, 18, 100258.
- Röös, E., Wood, A., Säll, S., Abu Hatab, A., Ahlgren, S., Hallström, E., Tidåker, P., Hansson, H. (2023). Diagnostic, regenerative or fossil-free – exploring stakeholder perceptions of Swedish food system sustainability. *Ecological Economics*, 203 (107623)
- 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*, 287, 112313.

WP5: Agricultural systems with net-zero impact of greenhouse gas emissions

Aims and research questions

The primary aim of WP 5 was to identify agricultural systems with potential to make the agricultural sector net-zero regarding greenhouse gas (GHG) emissions in year 2045, while trade-offs against other areas of sustainability are minimized. The following general research questions were defined:

- What is the potential of different measures to improve the GHG emission balance of the Swedish agricultural sector in different contexts? (RQ1)
- It is only possible to design a net-zero or climate positive system if sufficient counteracting carbon sinks (CSs) can be identified. What is the potential of different CS strategies for the sector in different contexts? (RQ2)
- How can the agricultural systems be designed to achieve net-zero in GHG emissions?, how comprehensive must the implementation of the measures mentioned in RQ 1 and 2 be and is it at all possible to reach net-zero? (RQ3)
- How will the possibilities to design, and the design of, a net-zero agricultural sector be affected by different scenarios (as defined in WP3) (RQ4)
- At what rate will the measures mentioned in RQ 1 and 2 be possible to implement and how are the external effects, especially the change of the average global temperature over time, dependent on this? (RQ5)
- What will be the environmental, economic and social effects of the new net-zero systems? (RQ6)
- How will the effects of an introduction of a net zero agricultural sector vary regionally within Sweden? (RQ7)
- How will the answers to RQ 1-7 be affected if also the sectors of fisheries and aquaculture are added to the system under study? (RQ8)

Work strategy and key results

Among the large number of projects at SLU and RISE focused on defining measures with potential to improve the GHG balance of the agricultural sector (including the blue sector) a selection of 20 projects was done (including 3 in the fisheries and aquaculture (blue) sector). Most of these projects were of experimental nature. By organising collaboration between these project groups, with specialists on each individual measure, and system researchers with high LCA competence, it was possible to quantify the climate effects in life cycle perspective of the studied measures (for RQ1, RQ2, RQ8). Knowledge with special interest for the regional and local effects was also assessed (for RQ7) and the possible time scale for large scale national implementation estimated (for RQ5). This information was of high value when estimating the potential for each measure and also in the work in the WP when the measures were combined into the full food system model. Out of the total number of publications from WP5, 16 reports and 10 of the scientific articles (including almost finalized manuscripts) are direct outputs of the 20 collaboration projects, and a few more are under preparation.

Some additional results of the strategy with organized collaboration between experimental researchers and system researchers were:

- The experimental researchers got feedback and advices on how to focus their coming research in the area.
- The experimental researchers were introduced to the system based research methodology and possible future collaboration possibilities with system researchers highlighted.
- The big network including the different specialist was very valuable for the work on how to define reasonable future development trends for WP5.2 and following tasks.

Furthermore, it has been possible to extract a lot of important knowledge from additional activities assessing important measures to reduce the climate effects from the agricultural sector, in which the main researchers of the WP have had leading roles, i.e. (64). However, since these activities together with the 20 projects still could not covered all relevant measures to improve the sector's climate effects, an extensive internal literature study was done in addition (for RQ1, RQ2) as help for the scenario defining work. The part dealing with more effective energy utilization was published as a report (65) and in a large number of articles in national media in the energy and agricultural areas.

To assess and answer the research questions related to the whole national sector (RQ3-RQ7) an extensive computational model (called CIBUSmod) has been developed as part of Mistra Food Futures. This model calculates in its present version the time-dynamic climate effects of all activities in the agricultural sector including the effects of the soil carbon dynamics (for RQ3). In CIBUSmod, Sweden is geographically divided into 106 smaller areas with separate assessments for each crop and animal types in each area (for RQ7). The effects of different scenarios for the development of the crop and animal production systems, the amount of different types of food needed to produce and other affecting factors can be calculated for each year from the base year 2020 until year 2045 and longer (RQ 3, RQ4).

CIBUSmod includes an optimization algorithm that regionally distributes crop areas and animal numbers while ensuring that scenario specific demand for agricultural production is met while adhering to a number of constraints such as on regionally feasible crop rotations, maximum allowed land expansion and feed areas that support regional livestock populations. The model also balances nutrient flows and endogenously calculates demand for mineral fertilizer. A large amount of input data have also been identified and included in the model. The focus for the model in its present version is GHGes and nutrient flows (RQ3), but more outputs connected to sustainability, for example land use, are also automatically calculated. Furthermore, based on the output a number of non-climate related sustainability indicators can also be calculated (for RQ6). The results for the blue sector are calculated separately and with a lower geographical resolution (for RQ8).

Some key results from the LCA studies includes (for detailed assumptions, please see the publications)

- The climate footprint for one kg of pork could be reduced by at least 13% with a changed feed state, including a grass-clover mixture (66);
- The total climate effect per kg of milk could be reduced by approximately 14% if the potential of the new digital technology (sensors, monitoring systems etc.) can be utilized (67);
- The use of a crop rotation with ley had a positive effect on the climate (8–19%) compared to a cereal crop rotation without ley (68);
- For implementation of precision nutrient application technology, the overall effects on climate are highly dependent on how much the soil conditions vary across the field, and calculations indicated values between 1 and 10 % (69);
- A relatively large potential to reduce the climate impact was indicated if an intermediate catch crop was harvested and used for biogas production, instead of just ploughed down, but the results were found to be clearly dependent on the establishment and harvest time of the catch crop (70);
- The climate load from grain production was almost halved if the straw was utilized in a bio-char system compared to systems where the straw was either ploughed into the ground after harvest or completely burned to produce heat (71);
- The climate load could be reduced to about a third with self-driving electric machines compared to the normally used large diesel tractors (72). In addition,

harvests would increase due to lighter machines and less soil compaction (73);
- If yeast oil (for feed or food) is produced from lignocellulosic materials such as straw or forest residues by oligeaginous yeasts, the climate characteristics for the whole process are favourable (74), especially if the lignin can be used as amendment for asphalt serving as a carbon sink (75);
- Rainbow trout had 64% lower GHG emissions when fed with an experimental feed including protein from insects and fava beans, compared to a normally used feed (76).

With the CIBUSmod model in operation, we have started to assess the possibilities for the agricultural sector in Sweden to be climate neutral (net-zero in GHG emissions) and how the climate effects then will change over time until year 2045. We have assessed a large number of scenarios and introduce the individual GHG reducing measures and their potential for implementation over time (RQ3, RQ5, RQ7). We will also (in collaboration with WP3) assess how the effects of for example changed consumption patterns and other external variables will affect the results (RQ4). Based on knowledge from an additional project, funded by the program's strategic reserve (see below), we have been able to adjust the scenarios according to outputs from interviews and workshops implemented with stakeholders as well as with the scientific expertise, for example researchers involved in some of the 20 projects described above.

We have also, for selected scenarios, assessed and quantified the change for a number of non-climate dependent indicators, based on the indicator framework developed in WP4.

Focus in this first programme phase has been on the agricultural and blue sector in Sweden as stated in Mistra's original call text from which Mistra Food Futures was funded. The additional effects of imports and exports, as well as the food processing and distribution parts, to get a complete view of the total food system related effects will be worked more on in the second programme phase.

Most of the results from the CIBUSmod development and simulations are not yet published. Some results have however already been presented at different national and international events. One interesting result of this is that a new research programme is funded by the Norwegian research council, where CIBUSmod will be adjusted to Norwegian conditions and sources of input data. Similar research questions as for Sweden will be assessed for Norway. Researchers from Mistra Food Futures will take part in the Norwegian project, which also offers possibilities to increase the resolution of the calculations for Sweden, due to improvement in the model in the field of by-product handling and recycling.

Some key conclusions from the national-scale modelling and simulations include:

Related to Method Development

- We identified a lack of a flexible framework for assessing national-scale agri-food system scenarios that can account for regional variations and key processes, particularly nutrient cycling in agriculture, which is crucial for GHG emissions estimation. This gap is significant, as decisions impacting the agricultural sector are often made at the national level, motivating the development of CIBUSmod.
- Multiple methods were developed or adapted for CIBUSmod to include regionally explicit land use allocation, endogenous calculation of crop nutrient requirements, manure generation responsive to changes in animal productivity and feeding, quantification of carbon inputs to soils, and circularity through by-product generation and waste treatment. This supports future national food systems scenario analysis.
- Model validation shows good alignment with national statistics on production, manure and mineral fertiliser application, and inventories of GHG and reactive nitrogen emissions.

Related to Scenario Analysis

- Environmental impacts of dietary changes under the four Mistra Food Futures scenarios developed in WP3 indicate that demand-side changes alone are insufficient to reduce the climate impact of Swedish food consumption to align with planetary boundaries for climate, let alone achieve climate neutrality. This underscores the importance of combined demand- and supply-side interventions to reach ambitious climate targets.
- Production-side measures could reduce GHG emissions from Sweden's agricultural sector by around 12% from current levels. This reflects a net effect of increased demand due to population growth, along with reduced emissions intensities from production-side measures. These measures offer significant mitigation potential but do not include all relevant measures and does not include carbon sequestration in biomass and soils.
- Coupling production-side measures with a dietary shift towards more plant-based diets could reduce territorial GHG emissions from agriculture by around 40%, again excluding changes in carbon stocks.
- Analysing the time-dynamic climate impact, including changes in biogenic carbon stocks, for a scenario with combined supply- and demand-side interventions and the introduction of woody crops on "spared" croplands (due to reduced agricultural demand) suggests that reaching climate neutrality in agriculture is challenging and would likely rely on large areas dedicated to carbon sequestration, such as biochar production from short-rotation coppice.
- Reassessing scenarios for increased organic farming in Sweden highlights the importance of detailed nutrient flow modelling, particularly under scenarios of

decreased reliance on synthetic fertilisers. CIBUSmod results emphasise that adequate nitrogen supply in organic cropping systems is crucial for land use efficiency, a factor often overlooked in similar modelling frameworks.

Key scientific publications, manuscripts and reports

- Lagnelöv O, *Electric autonomous tractors in Swedish agriculture*, Swedish University of Agricultural Sciences, Doctoral thesis 2023:13
- Nilsson J, *Grass and cover crops for biogas production and climate change mitigation – A life cycle perspective*, Swedish University of Agricultural Sciences, Doctoral thesis to be presented 231124
- Karlsson, J.O., Karlsson-Potter, H., Lagnelöv, O., Ericsson, N., Einarsson, R., Hansson, P.A. *CIBUSmod: A spatially disaggregated biophysical agri-food systems model for studying national-level demand- and production-side intervention scenarios*. Manuscript in preparation.

WP6: Towards sustainable food processing, retailing and consumption

Aims and research questions

The aim of WP6 was to identify and evaluate post-farm production systems with minimised GHG emissions and with significantly reduced environmental impact and resource use. A second aim was to design supply chains featuring resource efficiency, safe food and improved product quality. The following research questions were addressed:

- How should future food value chain be designed to contribute to a sustainable food system? What technologies, novel products, raw material use, packaging etc. have highest potential and how are they to be combined to deliver the best performance on systems level? (RQ1)
- What is the potential in sustainability performance of the above systems? (RQ2)
- How can improved sustainability performance be combined with increased food safety and food quality parameters, including nutritional quality? (RQ3)
- How can different solutions, be it technological or organizational, be implemented in present structures and what solutions needs a longer timeframe and additional transitions of the system before becoming viable? (RQ4)
- What are the risks of lock-in-effects of implementing novel solutions? (RQ5)
- How are supply chain solutions sustainability performance affected by geography, surrounding systems and demography? (RQ6).

Key results

The work in WP6 has focused on developing a comprehensive framework for designing future post-farm supply chains, a framework that allows a high level of detail in the descriptions of supply chains (technological, organisational) and at the same time maintain a connection to the higher systems-level sustainability perspective. Important aspects were to develop working processes to integrate knowledge from different scientific fields (technology, product safety, product quality, supply chain management) and also to integrate knowledge and perspectives from both academia and industry. The results from applying the framework are both quantitative (multi-criteria evaluation of supply chains(77)) and qualitative in descriptions of supply chains and product concepts, both in relative high level of detail.

During year programme year four, the three original case studies were finalised. The case studies exemplify two important sub sectors of the Swedish food industry (bread and slaughter, exemplified with products based on blood) and one that is rapidly growing and has possibilities to be an important part of a dietary changes (plant-based protein products). Hence findings can be used to understand challenges and solutions in a broader food chain perspective. The animal case study was during 2024 expanded by including a sub-case focussing on new ways to valorise meat from culled ewes, an important part of more sustainable lamb production.

The four-step design method used in this WP showed to be very useful as a vehicle for creative collaboration between academic and societal partner (food producers, retail). The framework and the process for developing it is described in (78). The process is partly built on the process suggested in (79). The use of the Mistra Food Futures Scenarios (30) proved to work well as a way to think in new directions, i.e., not being stuck in present days mindset. The iterative way of working facilitated alteration between open workshops followed by facts and concrete descriptions of possible limitations, which was critical to gain insights. To make it clearer what results the design process delivers, an example from the animal product case study is given. The working group consisted of production- and systems researchers together with product developers and sustainability experts from companies worked through the first step, which is to define the systems boundaries and research question, which was "how could we design systems to increase the share of the animal being for human food". The reason for this objective was that the group saw resource efficiency as a critical aspect for animal products to be relevant in future sustainable food systems, and that there was room for improvements in present supply chains.

The application in case studies of supply chains revealed minor weaknesses in the design method and improvements were introduced.

Originally the goal was to use LCA as a tool for evaluation, but during the second half of the project we decided to shift to multi-Criteria assessment (MCA) (80) as we realised that would better fit the purposes. The introduction of MCA proved to be very relevant, since it

offers a comprehensive picture of the very broad sustainability performance of suggested systems. MCA does not provide clear-cut answers, but instead makes it possible to screen the sustainability performance very broadly, hence providing a platform for decisions on what types of more detailed assessments that should be prioritized.

The case studies have been performed in close collaboration with Mistra Food Futures industry- and retail partners; this has been critical for the quality and relevance of the outcomes. The analysis covers the following aspects: What are the hotspots, contributing the most to sustainability performances of the chains? What to focus on to make the chains more sustainable? How to understand (but not predict) our sustainability performance in case of different managerial decisions (sensitivity analysis)?

The most consistent finding across case studies was that the indicators fell into clusters that co-varied. One cluster was indicators for aspects of more qualitative nature (cultural values, fairness, working environment) and indictors for ecosystem qualities (biodiversity). The other cluster was indicators capturing economic and more technological aspects. The different supply chain designs that were evaluated scored well in either of the two clusters. There were exceptions from this pattern, but not many.

Key scientific publications, manuscripts and reports

- Sonesson, U., Amani, P., Bjerre, K., Hamberg, L., Höglund, E., Karlsson, A.H., Olsson, M., Pousette, S., Röös, E., Östergren, K. (2023). Ramverk för design av mer hållbara leveranskedjor från gård till butik, *Mistra Food Futures Report #18*.
- Rad, M & Sonesson, U., 2024, Drivers of a more sustainable future food system – Lessons
- from Sweden, *Journal of Cleaner Production*, Vol. 462, 142639.
- Desiderio, E., Rad, M. & Östergren, K., Can green proteins be more sustainable? Multi-criteria assessment of the legume market in Sweden? Submitted manuscript.

WP7: Developing strategies for transformation

Aims and research questions

WP 7 aimed to contribute to an accumulation of evidence-based knowledge on drivers of change perceived and employed by key food system actors, how these can be modified or enhanced, or fundamentally redesigned for rapid, transformative change at scale. We addressed drivers of change among primary producers, key processing and trade segments of the food system, and among consumers. WP7 aimed to answer the following research questions:

- What are key drivers and motivational factors for farmers to use more sustainable production practices, and what are economic consequences of adoption? (RQ1)
- What are key motivators of consumers for changing food consumption towards more sustainable and healthier diets? (RQ2)
- What are policy measures that have potential to shift food consumption towards more sustainable and healthier diets? (RQ3)
- What are different drivers, enablers and barriers that exist among key processing and trade segments for engaging in measures to substantially improve the environmental performance of food available to consumers? (RQ4)
- What are different strategies employed by local governments that can ensure that public meals meet sustainability and health targets in turbulent times? (RQ5)
- How can innovation function as a driver of change? (RQ6)

Key results

Transforming production

As an example of a sustainable production practice in agriculture, we focused on dairy farmers' uptake of more grass-based feeding regimens for their dairy cows. More grass-based feeding regimens, as compared with feeding regimens based on purchased concentrates and/or cereals have several potential sustainability benefits including reduced greenhouse gas emissions through carbon sequestration in grassland and lay, improved animal welfare through higher roughage share in cow's diets and reduced feed-food competition by avoiding feeding animals produce that could essentially be directly consumed by humans (e.g. cereals). Results presented in a study by Oyinbo & Hansson (81) show that there are two distinct clusters of dairy farmers: the strong proponents of sustainability-enhancing feed rations are utility maximizing and thus motivated by sustainability attributes in all three dimensions (environmental, economic and social), whereas the weak proponents of sustainability-enhancing feed rations are mainly utility maximizing in the economic dimension. Farmers' underlying identities and attitudes are the main drivers of the observed heterogeneity in feed choices and in the trade-offs between sustainability attributes in the feed choice; observable farm and farmer characteristics played only a limited role. In another study (81) we investigated the effect of providing 'balanced sustainability information' on farmers preferences for more grass-based feeding systems. Results showed that on average, such information has only negligible effects on feed choices, but considering heterogeneity based on identities and prior knowledge, there is some support for a treatment effects. The study calls for critical reflection about the role of information provision as an instrument to nudge behavioural change.

We also investigated economic consequences of uptake of more sustainable production practices in agriculture in a

study by Mellon et al.(82). Again, we focused on the uptake of more grass-based feeding practices in dairy production as an example of a more sustainable practice. We also investigated possible social effects and environmental effects focusing on labour hours and the use of chemical fertilizers as indicators. Findings, at the average level, imply that the use of more grass-based feeding practices is associated with lower farm net income, lower spending on fertilizers and higher need of total working hours at the farm. Thus, results suggest that use of more grass-based feeding regimens is negatively related to the economic and social sustainability dimension but positively related to the environmental dimension. This highlights important trade-offs. Results are heterogeneous across the outcome variables. Results for instance point to that the use of more grass-based feeding practices is positively related with farm net income in the upper quantiles.

In a still on-going study, we analyse farmers' preferences for policy attributes aimed at encouraging their use of more grass-based feeding practices. We focus on forage-to-concentrate ratio, existence of a societal reward, commitment period of the policy, type of financial reward (direct subsidy payment, consumer price premium or tax relief), advisory support and size of financial reward. Preliminary results point to that respondents would receive utility from participating in the suggested policy scheme while there is significant heterogeneity in the preferences. On average, respondents prefer a lower forage-to-concentrate ratio, shorter commitment periods, direct subsidy payment and larger financial rewards. Social reward appears not important and respondents are indifferent as regards where advisory services come from.

In a study by Opdenbosch & Hansson (83) we investigated farmers' willingness to adopt silvopastoral systems, as another example of a more sustainable production practice in agriculture. We also analysed farmers' compensation claims related to adoption and how adoption and compensation claims are affected by their attitudes to silvopastoral systems. Fifty-two percent of respondents indicated willingness to adopt, and their average compensation claim amounted to SEK 3107 per hectare. Attitude towards silvopastoral systems is positively correlated with adoption, thus not only pecuniary factors drive the decision.

Collaborating with another project, in a study by Thompson et al (84) we conducted a systematic literature mapping of quantitative observational studies focusing on factors associated with adoption of ecological farming practices; thus here using ecological practices as a broad example of sustainable production practices in agriculture. Results show that sociodemographic and farm structural variables are often studied but are more often insignificant than significant. On the other hand, we found stronger support for behavioural factors such as cognitive or attitudinal variables in explaining uptake.

In agriculture, advisors and veterinarians can be significant in impacting the uptake of more sustainable practices. In a study by Svensson and Bergeå(85), the role that Motivational Interviewing (86) can take in veterinarians' and animal welfare inspectors' work was studied. Results point to five themes that impacted the use and perceived usefulness of motivational interviewing: the case and the client; acquisition and retention of skills; time; personal factors; and level of support and resources.

Shifting consumption

While WP2 explored (through a systematic review) the evidence that exists on the effectiveness of different policy interventions, in WP7 we have focused on the public support for different policy interventions, as it is a crucial component of whether or not policy interventions are feasible. We also want to know if there are socio-economic, and attitudinal factors that can explain why some people are more or less accepting towards policy interventions. Our results from qualitative interviews, a survey experiment, and a large-scale survey (+2000 Swedish citizens) show that people have in general more positive attitudes towards changing diets, or being steered to change diets towards one that is more sustainable if they have a significant environmental concern and identify as pro-environmental (87–89). Moreover, a person has more positive attitudes to change if she/he has been exposed to plant-based foods (or others who eat more plant-based foods) (87). The attitude also depends on what the person perceives that others think about the issue (what the norm is) (87,88). But a majority of the respondents in our larger survey (+2000 citizens) state that they do not think that individual consumers should take the main responsibility for eating more sustainably, rather that the industry and governmental offices/officials should take this responsibility (88).

Current interventions/measures that have been implemented by these actors (by actors in the industry or by governmental offices) to achieve a more sustainable food consumption have up to this point mostly been in the form of information provision, campaigns, education, and to some extent nudging (90). These implemented policies are generally accepted by citizens (otherwise they would not have been successfully implemented). However, they have not been sufficient for the change that is needed.

Other policies that could be effective but have not yet been implemented to achieve more sustainable diets include policies implemented by national, regional or local governments e.g., regulations towards industry or for public meals, and pricing instruments such as consumption taxes, or subsidies, choice restrictions, or a combination of several of these (90). But will such policy interventions be accepted by citizens? Our research shows that support depends on the type of policy. For example, a subsidy in the form of a VAT removal, or a mandatory carbon labelling is more accepted compared to an environmental tax on meat and other animal products with a high environmental impacts, whereas a carbon budget per portion or client/student given applied to public meals and a regulation directed towards the industry that nudging should be applied in restaurant settings are equally accepted/rejected (88). However, it is not only the policy itself that matters for support but what also matters is how the policy intervention is designed and implemented, where

for example the level of a tax is associated with significantly different support and how a subsidy is financed. Moreover, we also find that how a policy package is presented can influence support for the package. We also tested in an experiment whether or not a framing of the whole policy issues (emphasizing the need to reduce animal- based protein vs the need to increase consumption of plant-based protein) would affect policy support but found no such evidence (91). Looking into motivators and individual factors explain support we found that a left leaning ideology is associated with a higher tendency to support a tax, compared to a right leaning ideology. People living in urban areas are also more prone to support a tax compared to people leaving in rural areas (88).

In another study we investigated citizens' support for interventions that are implemented by private actors in the food chain, more specifically different types of nudging and choice restrictions in stores. We found that people are on average more accepting towards these types of interventions but also that they are more accepting towards the less intrusive nudging (92).

Turning to innovation, one study (93) investigated the emergence of mission oriented or transformative innovation policy in the food system, which points to the need of innovations to solve sustainability challenges

Transformation through mid-supply chain mobilisation

Building on the work in WP2 we have continued investigating achieving food system transformation through mobilization of mid-supply chain actors (both public and private). One study published as a report in 2024 focused on the role of municipalities and school meals and asks if there are synergies and/or trade-offs between sustainability targets and strategies and improved preparedness for external risks and chocks(94). The study examined how recent crises influence sustainable practices in school meal programs and identifies emerging strategies. A survey of 120 officials and five interviews revealed that officials generally see no trade-off between sustainability and preparedness. Instead, increased preparedness often supports local food systems and sustainable procurement. Although municipalities vary widely in their preparedness and environmental goals, a national strategy linking food preparedness with sustainability could better leverage synergies. Public meal programs could thus strengthen resilience while mitigating climate and environmental impacts, creating a unique opportunity to align preparedness with sustainability.

A second study (95)evaluated consumer acceptance of five retail-led interventions: information, norms, choice architecture, pricing, and choice restrictions. With a sample of 424, it was found that price-based and restrictive interventions are less accepted compared to information, norms, and choice architecture. A multi-level model revealed that perceived effectiveness, fairness, and freedom of choice predict acceptance across interventions, except that freedom of choice did not affect support for norms-based or choice architecture strategies. Meat-buying habits, positive attitudes toward meat, biospheric and altruistic values, and being female also influenced acceptability. A recommendation from this work is that retailers implement high-support strategies immediately (information, norms, choice architecture) and consider ways to improve consumer perception of price-based and restrictive interventions.

A third study (still ongoing) aims to investigate perceived barriers and enablers for food system transformation among key food companies and retailers (and different roles and functions in the companies) using mental model mapping and interviews as a method.

Actors' accuracy in predicting other actors' preferences

We used funding from the strategic reserve (see below) to initiate a study (96) where we investigated actors' accuracy in predicting each other's preferences. Accuracy in predictions of other actors' preferences is relevant to understand how well actors understand each other and can anticipate each other's behaviours. In total, we asked 305 farmers and 1,005 consumers about their beliefs of what consumers and farmers responded in earlier research of choice experiment type, where respondents typically chose between two choice options and one opt-out option. We found that farmers are slightly more accurate in their beliefs. Both, farmers and consumers, find it easier to forecast preferences for consumers compared to preferences of farmers. We also find that the opt-out alternative is predicted with much higher accuracy. Overall, we find that beliefs are relatively accurate, but respondents with a high confidence in their forecast tend to make greater errors.

Key scientific publications, manuscripts and reports

- Linder N., Bergquist M, Bjälkebring P., Jonell M. (Un)Acceptable Protein Shift: Consumer Attitudes Toward Retail-led Interventions Promoting Sustainable Diets. Submitted manuscript.
- Lindahl T., 2024 Citizens' support for taxes and subsidies implemented to achieve a more sustainable food consumption: the role of design and presentation. Beijer Discussion paper 282, Beijer Discussion Paper Series. (submitted to journal).
- Oyakhilomen, O., Hansson, H. Understanding dairy farmers' treadeoffs- between environmental, social and economic sustainability attributes in feeding systems: The role of farmers' identities. Journal of *Agricultural Economics*, 75, 869–888.
- Oyakhilomen, O., Hansson, H. Information provision and preferences for more sustainable dairy farming: Choice experimental evidence from Sweden. *Agricultural and Resource Economics Review*, 53, 119-143.
- Svensson C, Bergeå H. Factors influencing the use of advisory methodologies: The case of Motivational

Interviewing among dairy cattle veterinarians and animal welfare inspectors. Submitted manuscript.

WP8: Initiating transformation

Aims and focus areas

The aim of WP8 was to initiate the transformation of the current food system towards greater sustainability and a resilience, through co-development of implementation strategies via close, iterative stakeholder engagement. The following tasks guide the work in WP8:

- Task 1: Stakeholder and innovation infrastructure
  - Stakeholder panel
  - National Agrifood Sustainability group
  - Executive Education Programme
- Task 2: Sustainability adaptation and transformation
  - Open arenas and workshops
  - Match making and co-creation workshops and arenas
  - Implementation projects

Key achievements

The focus of WP8 was to initiate that transformation that the programme is aiming for in practise. In year 1, WP8 focused on establishing a stakeholder and innovation infrastructure for the programme (task 1), where we initially facilitated matchmaking of programme partners and programme WPs. Further, we developed a process for initiating implementation projects (task 2) and initiated the first implementation projects. Throughout the year we also delivered several collaborative workshops with colleagues from other WPs, and we established a way of working collaboratively with complex problems.

In year 2, focus was to continue building on the momentum of the now established way of working with complex problem solving through the delivery of a course available to all programme members (task 2). The course was delivered during spring through 5 lectures with individual exercises and interactions with the instructor and between attendants in between lectures. The attendants where given tools and methods on how to work evidence based on complex problem solving which they can take back to their own organizations.

During autumn the focus was on the planning and delivery of the first of three workshops in a series focusing on the role of business models in delivering transformation (task 2).

Furthermore, the Stakeholder panel and the National Agrifood sustainability group was made readily available for programme members as valuable sources for stakeholder interactions in the programme. Planning and launch of the Executive Education Programme was also completed in year 2, and the process of implementation projects was updated to also include thesis work.

During year 3, work package 8 has worked in three parallel areas of focus: Transition management (task 2), Implementation projects (task 2), and the Executive Education programme (task 1). Year two saw the development of work under Transition management on the role of business models in transitioning the food system, described in more detail below.

In the fourth year, WP8 followed up on the activities on transition management from year 3, and initiated a collaboration with the Swedish Agency for Economic and Regional Growth to engage stakeholders in developing networked business models for a fossil free food value chain, and exploring the policy interventions needed to implement this.

Transition management

In the focus area Transition Management the main area of work has been in building on the momentum created in year two on understanding the role of business models in driving transformation, and how to build organizational capabilities for transformative change. Three workshops were delivered during the winter 2022-2023:

- "Understanding the business models of the present and the future"
- "Evaluating the role of business models in transformation"
- "Explore the role of business models in sustainable transitions"

The first workshop focused on understanding the connection between future, transformation, and business models. The second workshop aimed at providing concrete knowledge about the design of business models for individual actors and contributing to knowledge needed to catalyze change at both a societal and organizational level. The final workshop aimed at helping stakeholders understand how new innovations can affect transitions, how collaborative processes can be initiated to make those innovations become part of the food system, and explore barriers in the current systems preventing innovations from being scaled-up.

The workshops had close to 60 participants, and the learnings from the workshops were summarized in the report "*Värdet av dialog i systemomställning – Vägar mot ett hållbart livsmedelssystem*" published in June 2023. Results from the workshops have also been presented at the 2023 Futures Conference in Turku, and an academic paper is being prepared for submission to a peer-reviewed journal.

As interest was high among the workshop participants to continue the dialogue on business models and their role in transition, a follow up workshop series was planned during late spring 2023, based on the feedback collected from the participants in the first workshop series. A strong interest was expressed to continue the collaborative dialogues but with a narrower theme, and thus the project "Aktörssamverkan för en fossilfri livsmedelsvärdekedja (actor collaboration for a fossil free food value chain)" was

planned and kicked off in September 2023, with the following aims:

- Designing actor collaborations that enable new business models
- Breaking lock-ins in the current system to accelerate the transition to fossil free value chains
- Understanding and proposing needed governance and policy interventions
- Development of prototyped networked business models to explore and test new investment models, risk and value sharing across the food system

The project was co-lead by Mistra Food Futures WP8 and Tillväxtverket (the Swedish Agency for Economic and Regional Growth), with a large group of interested stakeholders from both Mistra Food Futures partners and organizations in Tillväxtverket's coordination committee for the Swedish national food strategy, but also other actors such as Hållbar Livsmedelskedja, Sweden Food Arena, Fossilfritt Sverige, and others.

Two preparatory meetings were held in September 2023 together with a wider constellation of actors, after which a smaller working group continued working across three workshops according to the following plan:

- Workshop 1: Identifying transformation barriers and selection of emission areas in focus. Selecting a joint mission for the future.
- Workshop 2: Exploring collaboration models that can overcome the barriers and contribute to transition towards fossil free value chains.
- Workshop 3: Deepening and detailing of strategies towards fossil free value chains. Identification of development needs for testing and evaluation.

The workshops for the smaller working group were physical, full day meetings, and each workshop was followed by shorter, digital meeting where a summary of the previous workshop and key take-aways was presented to a larger reference group.

The three workshops were carried out during the autumn in 2023. These initial workshops were part of an exploratory phase to gather stakeholders, select areas of fossil emissions in the food systems to work with, and collaboratively build a networked business model canvas that could be tested against current system boundaries for the identification of necessary policy and financing interventions. The workshops resulted in two parallel work steams, one on packaging and one on logistics as areas of emissions that could be targeted by the method. Two canvases were developed and tested, though the final results were at a higher systems level making it difficult to discuss specific interventions for implementation. To further develop the model and working process dialogues with two regional initiatives were initiated: one in Skåne, led by Länsstyrelsen on bow to build a market for fossil free foods, and one on Gotland on using networked business models for either enabling net positive beef production or industrial symbiosis.

The dialogue with Länsstyrelsen Skåne led to the completion of another three digital workshops and a physical meeting during the spring 2024, together with a total of 22 stakeholders on the topic of networked business models for fossil free foods. The work resulted in the narrowing down of the scope towards establishing a market in southern Sweden for fossil free grain.

Executive Education Programme

From November 2022 through March 2023, a Mistra Food Futures adapted version of the Executive Education programme was held at Stockholm Resilience Centre.

The Executive programme in Resilience Thinking has been offered annually since 2018 with great success, and today over 75 CEOs and chair persons from influential companies have attended the programme. For Mistra Food Futures, the programme was adapted in several ways to specifically support the transformation towards a sustainable food system. Extra effort was put in to target CEOs and owners in the food system, a new session on food futures was created, and a special background brief was prepared on "Achieving a healthy food system". One third of the participants had a direct link to the food sector, but all 16 identified various connections to the food system in the food futures session. The food futures session and background brief will remain in the programme also in the future.

Implementation projects

The purpose of this task was to promote and facilitate collaboration between researchers and program partners to, on a small scale, develop and implement new solution in existing operations and to evaluate its potential to contribute to sustainable transformation. This task builds on ideas about transdisciplinary modes of knowledge production where researchers and practitioners co-design the purpose of the project, co-produce knowledge from the project, and co-disseminate practical insights to different audiences. This means that "implementation projects" cannot be determined in advance, but must be co-created between researchers and program partners. Thus, to promote such collaborations, WP8 engaged researchers and programme partners within Mistra Food Futures in an initial round of meetings during 2022 to inform them about this transdisciplinary research opportunity and to capture ideas that can form the basis for collaboration. To facilitate collaboration, WP8 made connection between researchers and program partners to initiate implementation projects. Additionally, funding from Mistra Food Futures was also made available for researchers to participate in implementation projects. Three projects were identified that has potential to involve transdisciplinary modes of knowledge production.

Orkla Foods: calculating climate and economic impacts of specific cultivation methods known to also improve biodiversity.

Collaboration for a sustainable food system: aims to find new collaborative ways of working towards 10 common

goals for a sustainable food system. Includes representatives from 9 different national authorities.

Node Gotland: Collaboration to support the implementation of initiatives that contribute to energy- and climate transition capabilities on Gotland.

To further extend collaboration between researchers and programme partners we identified the opportunity to engage master thesis projects (MSc) in Mistra Food Futures. The advantage with MSc projects is that it enable more collaboration projects to address a variety of problem areas where students perform case or pilot studies. Such studies can lead to further collaborations between researchers and program partners.

Key transformation activities and publications

A selection of key activities and publications include:

Workshops:

- Programme Matchmaking
- Pitching for collaborative action (two workshops)
- The role of business models in transformation (three workshops)
- Actor collaboration for a fossil free food value chain (seven workshops delivered over two processes – three initial full day workshops, and four additional shorter workshops together with Länsstyrelsen Skåne)
- Mistra Food Futures programme conference: "Med sikte på framtiden"

Courses:

- Evidensbaserad problemlösning (five lectures)

Reports:

- Johansson, M. (2023). *Mistra Food Futures Report #15*. Lärdomar från kursen Evidensbaserad problemlösning
- Persson, B., Norefjäll, F. (2023). *Mistra Food Futures Report #16*. Rapport Värdet av dialog i systemomställning.
- Mishagi, M., Norefjäll F., Persson, B. & Persson, M. (2024). Affärssamverkan för Systemförändring- en guide. *Guide produced together with the Swedish Agency for Economic and Regional Growth.*

Presentations:

- *Towards an integration of futures and sustainable transitions – a practical application*.
  Presented at the Futures Conference in Turku, 2023.
- *Making food fossil free: Stakeholder engagement and networked business models to enable a long-term shift of the food system*
  Presented at the Futures Conference in Turku, 2024.

Papers:

- Langendahl et al. *Fostering transformative learning among professional incumbents in pursuit of sustainability transitions*
  Manuscript in preparation.
- Persson BM, Andersson J, Forsberg P. *Exploring pathways for change: A practice-oriented integration of foresight and sustainability transitions.* Manuscript under review.

4. Overall programme results

In this section we describe the overall programme results, i.e. the programme activities that are organised under WP1 – Coordination and management. In this section, we also describe the programme related challenges we have encountered, how we have handled them and how the lessons learned from them have impacted the design of the second phase programme plan. The vision of Mistra Food Futures phase one was to create a science-based platform to contribute to enabling food system transformation into a system that is sustainable (in all three dimensions), resilient and that delivers healthy diets. Ending phase one, we can conclude that we have achieved our vision, and will in the second phase work with a more challenging one. Key aspects in establishing our platform circulates around the scientific leadership, the operational and administrative leadership and performance monitoring, the establishment of a well-functioning multi-actor consortium, communication and dissemination, impact and public affairs, and to maintain and develop the programme funding situation. In this section, we detail our achievements in each of those core aspects. However, the establishment of our science-based platform has not been without challenges, and those are discussed at the end of the section.

Scientific leadership

The programme directors and WP-leaders are responsible for the scientific leadership of the programme. This is organised around continuous activities within the WPs ensuring that the research tasks build on innovative and rigorous science, and that the scientific results are of high international relevance, as well as around monthly meetings between all WP-leaders to discuss common aspects, activities and WP progress. The overall outcome of the scientific leadership is reported in Section 3, and therefore not further detailed here.

Operational and administrative management and performance monitoring

SLU, the programme host, coordinates the operational and administrative management and is the focal contact point with Mistra. The following key operational and administrative and performance monitoring activities are in place:

- A grant agreement between SLU and Mistra for phase one is in place since August 2020. A phase two agreement is in place since August 2024.
- A consortium agreement between SLU and all partners for phase one is in place since the autumn 2020. The phase two consortium agreement is in place since November 2024.
- An overall budget allocation per WP and partner for phase one is available since the phase one application was prepared in 2019. It is available for phase two since the autumn 2023.
- Board meetings: the programme board met four times per year during the first phase. The phase one board meetings followed a yearly structure which specifies the aims of the meetings. Two meetings were held in person and two online. The phase one board members were Annica Sohlström (chair; the Swedish Food Agency), Bo Jellesmark Thorsen (Copenhagen University, Denmark), Minna Kaljonen (SYKE, Finland), Elisabet Rytter (The Swedish Food Federation) and Anna Richert (WWF).
- Yearly planning of the programme: in October each year, the programme plan for the coming year was detailed in terms of activities and deliverables. At the same time, the detailed budget for the coming year was prepared, and information about achievements during the current year was collected. The information was compiled into a yearly progress report, which was to be approved by the board in November each year and submitted to Mistra. A similar routine will be followed in the second phase.
- Follow-up of budget: at least twice per year. In September each year the follow-up was discussed with the board. A similar routine will be followed in the second phase.
- Performance of individual WPs during phase one was monitored as part of the monthly meetings with the WP-leaders. When needed, occasional meetings between individual WP-leaders and the programme directors were initiated to discuss the progress of specific WPs. A similar routine will be followed in the second phase.

Establishing, maintaining and developing the multi-actor consortium

A significant first phase activity was aimed at in-depth establishment of the collaboration within the Mistra Food Futures' consortium. These activities started already before the programme was started, with intense interactions during the application phase. Moving into the first phase, the programme commenced with a set of programme overarching workshops aimed at introducing, explaining and discussing the programme and its logics to all partners. Although all partners (except Coop, that joined after the programme was granted), had already been part of the application phase, this step was important to introduce the programme to new partner representatives, and to establish a more in-depth common understanding about the programme logics and its aims. We also explicitly discussed expectations and that expectations may differ between different partners due to their own interests and to the organisational logics of the organisations they represent. A very practical example of this is the divergences in expectations that may arise between researchers, who navigate in an academic organisation logic where publications, academic career and future grant applications are core activities, and private companies who navigate in a business organisation logic where profit, business survival and the often very practical day-to-day operations are core activities. Throughout phase one, explicitly discussing and highlighting the differences that might exist between different groups of partners has been of key importance. In doing so, we have been able to establish increased understanding among partners for our different goals and motivations.

To build, maintain and develop the multi-actor consortium around Mistra Food Futures, we have worked with five main activities, which will all continue in the second phase:

- Mistra Food Futures' dialogues. These are monthly opportunities (during the academic year) for everyone in the programme to meet and discuss current topics. The dialogues are organised as online meetings, starting with a presentation by a member of the consortium to introduce the topic of the day and continuing with an informal discussion among participants. Early in phase one, the dialogues aimed at introducing or problematizing a theme or concept that is central to the programme and at introducing more in-depth the partners and their organisations to the whole consortium. During programme year three, the dialogues shifted focus towards presenting and discussing the programme's research results.
- Mistra Food Futures' round table discussions. The round table discussions are closed meetings between societal partners and the WP-leaders to discuss pressing questions of common interest. Round-table discussions during phase one investigated how a focus on food system transformation towards sustainability can be maintained in the organisations while a war is ongoing in our part of the world, and how the transition focus can be maintained while producers and consumers struggled with a price inflation that we had not seen over the last thirty years and that both producers and consumers have very limited own experience with. To enable an open and honest discussion, the round table discussions are conducted under the Chatham House rule, implying that everyone is allowed to use the information that is shared but not to share who said what.
- Individual WP activities. The research and other tasks within the phase one WPs built on intensive multi-actor interactions to fine-tune the research questions and to discuss results and implementations. These

activities were both aimed at more general discussions and interactions about the research, but also in some research tasks workshop interactions with societal actors were significant parts of the research design. In those cases, care was taken to not compromise research integrity. In situations where information from stakeholders is part of the material used to answer research questions, care was taken that interviewed stakeholders were not the ones who are the organisation's representatives in the programme, as these individuals' perceptions and attitudes are likely impacted by the fact that they are closely related with Mistra Food Futures.

- Mistra Food Futures' consortium meetings. This is a yearly activity, where the programme gathered its entire consortium to a lunch – to – lunch event to discuss programme results and where results are contextualised in relation to ongoing societal developments.
- An internal newsletter. The phase one internal newsletter was published six times a year and aimed to summarise key results and activities that has happened since the last newsletter. With the newsletter, everyone in the consortium could be updated on what was ongoing, this is in particular important for individuals who are only involved in the programme to a smaller extent.

Communication and dissemination

Beyond activities within the consortium around Mistra Food Futures, we work with a communication strategy to enable efficient internal and external communication, widespread dissemination of programme results, as well as to stimulate awareness and interest in questions related to sustainable and resilient food systems. This will continue also in the second phase. The programme has established a Teams platform, which is the main channel for internal communication and storage of working documents. All participating researchers, societal programme representatives, board members and representative of Mistra have access to the platform and can follow the work of individual WPs. In addition, to facilitate the internal communication, and to make sure that everyone in the programme is updated on what is ongoing in the programme, the programme sends internal newsletters six times per year by email and posts them at the Teams platform.

To further popularise and explain both focus areas and research results, we also run a blog series where we introduce and problematize our areas and as well as the scientific results. We consider the blogs a very useful way to share information and to communicate with others about ongoing work and to promote transparency and knowledge dissemination. The blogs are aimed at programme partners as well as at external stakeholders interested in our results. The programme's website and LinkedIn channel are main channels for widespread communication and dissemination also beyond the consortium.

The programme uses LinkedIn as its social media channel. LinkedIn is used for networking, to reach a larger audience and for disseminating knowledge, research results, etc. The programme activity and visibility has increased significantly since 2023. In December 2024, Mistra Food Futures has 2500 followers. The platform is updated multiple times per week.

As part of our general communication and dissemination of research results, Mistra Food Futures researchers have been invited to give presentations on several scientific workshops and events as well as on stakeholder activities. Examples include presentations at Food Science Sweden, The Swedish Farmers' Federation, Matlust Södertälje, The Royal Swedish Academy of Agriculture and Forestry and a sustainability award ceremony for chefs (svenska kockpriset i gastronomisk hållbarhet).

There is a significant media interest in societal questions related to the programme. In particular, we noted much attention from media in relation to inflation in agricultural input and output prices and in food prices. Programme researchers have participated in the general media (the major newspapers such as DN as well as broadcasted media such as SR) as well as more targeted media towards the agricultural and food industry (such as Land Lantbruk, ATL) on several occasions. Through our LinkedIn profile we continuously make media aware of our results and to create networks with media.

Societal impact and public affairs

Public relations and public affairs relationship building is key to achieving real impact. We work with a public affairs strategy to scrutinise relevant policy processes where research results from Mistra Food Futures is relevant input. A pertinent part of successful public affairs is that societal policy makers are aware of the programme and the type of knowledge it can supply to their decision-making processes. We have therefore worked intensively to establish knowledge about the programme among policy makers to find ways in and to establish relationships with decision-makers and their staff. A key focus has been on politicians who are responsible for questions related to sustainable and resilient food systems. With a full-time programme communicator since November 2022, we have intensified and put a stronger focus on activities to reach outside of academia, to public opinion, societal policy makers, decision makers, and stakeholders with the programmes' research results and by highlighting current questions and issues.

With these activities, the programme aims to continue creating awareness of and interest in the Mistra Food Futures research and activities, and to position Mistra Food Futures as a science-based thought leader in the transformation of the food system towards sustainability. In particular, the following public affairs activities have been performed:

- Setting public relations/public affairs communication plan

- Narrative/message creation
- Writing articles and opinion pieces
- Performing interviews about research results, with participating researchers and partners
- Presenting fact- memos, reports, papers, etc. as active responses in relation to current societal needs
- Identifying and inviting relevant journalists and editorial offices to meet with the programme and discuss about specific research areas
- Identifying significant policy processes at the national and EU levels that we can relate the program to.
- Planning and organizing seminars for stakeholders and decision-makers at the national and EU-levels.
- Carrying out activities together with others – partners, external stakeholders, opinion leaders etc.
- Participation in the Almedalen Week, an event aimed at societal policy makers and the public.

Regarding societal impact and public affairs, we would like to highlight the following key activities and achievements during the first programme phase:

- Policy brief: Mistra Food Futures' WP-leaders published and submitted to the government a policy brief, putting forward six core recommendations to the government's ongoing work related to the revision of the national food strategy for Sweden.
- Policy brief: In collaboration with another research project, Mistra Food Futures' phase one WP-leaders published a policy brief about how improved preparedness with respect to food can be achieved through sustainable and resilient food systems.
- Debate articles: In relation to the publication of the policy briefs, we published debate articles in Land Lantbruk, one of the core trade magazines for agriculture and food in Sweden.
- Parliament seminars: Mistra Food Futures was invited to present the policy brief about the Swedish food strategy mentioned above in a parliament seminar hosted by the Committee on Environment and Agriculture. Some fifty stakeholders and members of the Swedish parliament participated in the seminar. The Defence Committee invited the programme to a second parliamentary seminar, centred on the policy brief and focused on building food preparedness through resilience. Organised in collaboration with Patrik Oksanen and Mistra Food Futures, the seminar began with Patrik discussing the use of food and starvation as weapons in warfare. Mistra Food Futures then expanded on this theme, focusing on ways to strengthen food preparedness through resilience. Mistra Food Futures also participated in a parliamentary seminar organised by RIFO and Formas on the topic *Secured Food Supply in Uncertain Times – Challenges and Opportunities*, which was held in in a well-attended Second Chamber of the Swedish Parliament.
- Participation as a speaker at the Nordic Council of Ministers' launch of the new report "Policy Tools for Sustainable and Healthy Eating," which provides guidance and recommendations for policy interventions to enable dietary shifts. The event included discussions with leading experts on the policy measures needed to create conducive food environments for better dietary habits.
- A meeting with the EPRS – European Parliamentary Research Service, to present our research to a group of researchers who provide the European Parliament with research data, in order to explore how we, as a research programme can contribute with our research.
- We were invited by the Swedish European Commission, to deliver a presentation followed by an open discussion on food preparedness. This event, which brought together key policy representatives and stakeholders from across the food chain, marked a significant milestone in our efforts to raise awareness and disseminate our research on a broader scale.
- Almedalen seminar 2022, I tider av kris – hur håller vi kursen mot hållbar mat, vatten och skog (In times of crisis – how to maintain focus towards sustainable food, water and forestry), collaborative seminar with Mistra Food Futures, Mistra InfraMaint and Mistra Digital Forest.
- Almedalen seminar 2023, Mat, konsumtion och material – Så uppnår vi hållbara och hälsosamma livsmedelssystem (Food, consumption and material – how to achieve sustainable and healthy food systems), collaborative seminar with Mistra Food Futures, Mistra STEPS, Mistra Environmental Nanosafety and Mistra Sustainable Consumption
- Almedalen seminar about the new Nordic nutritional recommendations (NNR), 2023. Helena Hansson was invited to participate in a panel discussion organised by the Nordic Council of Ministers at the Almedalen week 2023 to discuss the possible impacts of Swedish meat production by the new dietary recommendations.
- Almedalen seminar 2024 – Sustainable food preparedness, a well-attended event, in collaboration with SLU Future Food.
- Scientific reference group for governmental commission: Two Mistra Food Futures researchers (Helena Hansson and Elin Röös) were members of the scientific reference group which supported the Public Health Agency and the Swedish Food Agency in their work with a joint governmental commission about indicators and goals for a sustainable and healthy food consumption.
- Review board for the first Swedish citizen panel: Malin Jonell was the academic representative in the Swedish Food Agency's review board for the first citizen panel in Sweden focusing on identifying

strategies for reaching targets for sustainable and health food consumption.

- Per-Anders Hansson was an expert member of the governmental inquiry about fossil independent agriculture.
- Assisting the Swedish Food Agency with a governmental commission: Mistra Food Futures researchers supported the Swedish Food Agency with analyses pertaining to their governmental commission about the impacts on Swedish food production from the environmental considerations incorporated into NNR 2023.
- Next step conference – Food Forward - I tider av oro. To mark the end of phase one and the start of phase two, Mistra Food Futures organised a conference titled *Food Futures – I tider av oro* to gather expertise from across Sweden's food system, to engage in discussions on how to sustain a path toward sustainability in turbulent times. In addition to programme researchers and partners, the conference featured presentations by Daniel Värjö, climate and environmental reporter at *Vetenskapsradion Klotet* SR; Peter Alestig, climate editor at *Dagens Nyheter* and author; Olga Grönvall from Reformaten; and Martin Allard, an expert in total defence and civil preparedness and the main secretary for the Inquiry into a New Food Preparedness, among others. Following a morning session with partners, where the programme's second phase was discussed, an expanded group of around one hundred participants gathered in the Old Hall at Norrlands Nation in Uppsala. Here, they reflected on the conference theme from various perspectives and engaged in discussions on potential solutions.

Funding

Mistra Food Futures' total phase one budget amounting to 80 MSEK consisted of 64MSEK received from Mistra and 16 MSEK co-funding (in-kind and cash) obtained from programme partners.

Additional funding to expand the programme: Already from the programme's first phase, it has been our clear ambition to increase the programme activities by applying for additional funding which can be directly linked to the activities in Mistra Food Futures. As a result of the collaboration within Mistra Food Futures, we have been able to attract the following externally funded research projects. The projects listed here will in their whole provide results that are direct inputs to Mistra Food Futures' overarching vision and will contribute to deepen analysis already organized within the programme. The projects can thus be considered 'add-ons' to Mistra Food Futures. In addition, programme members have several ongoing projects which are relevant for Mistra Food Futures. These are not listed here.

- Formas. How do we achieve fossil free agriculture in Sweden? Formas, 2021–2025, applicants: Per-Anders Hansson (PI), Helena Hansson, Gordana Manevska Tasevska, Wei Huang, Åke Nordberg, Peter Annas (Industry partner Lantmännen). 7 993 383 SEK.
- Formas. ReSus" Retail for Sustainability – Mid-value chain engagement for food system transformation, applicants: Malin Jonell (PI), Elin Röös. Beatrice Crona, Cecilia Mark-Herbert, Genevieve Metson, Nils-Hassan Quttineh, TSEK 7 999.
- Formas. Towards fossil-independent dairy farming in Sweden: Technical strategy, climate and economic effects, drivers and barriers. PI: Vivian Wei Huang. Co-applicants: Helena Hansson, Anna Kristina Edenbrandt, Per-Anders Hansson, Gordana Manevska-Tasevska. 2023–2025. TSEK: 3999.
- Formas. Towards sustainable preparedness in Swedish agriculture. PI: Helena Hansson. Co-applicants: Nicklas Bengtsson, Georg Carlsson, Camilla Eriksson, Pia Nilsson, Elin Röös. 2023–2025. TSEK: 5994.
- Formas. Climate Action through Product Sustainability in the Food System, applicants: Malin Jonell (PI), Elin Röös, Ylva Ran, Patrik Henriksson, Max Troell, Per Olsson. 2023-2027. TSEK 9 998.

This report is the progress report of Mistra Food Futures, hence, we do not report the progress made in those five projects since they are from an organisational point of view separated from the programme. That said, we consider the collaboration in Mistra Food Futures a cornerstone for obtaining those additional projects.

Challenges

Establishing and running a large research programme is not without challenges, and Mistra Food Futures is not an exception. We have encountered several challenges since the start of the programme, which have contributed to shaping both the first phase of the programme and the programme plan for the second phase and generally stimulating learning opportunities for us. Here we introduce how we have dealt with them and what we have learnt from the major challenges encountered so far.

Inter- and transdiciplinarity

Mistra Food Futures is organised as an inter- and transdisciplinary research programme. These are core features of the programme design both for phase one and phase two. Nevertheless, scientific collaborations across separate academic disciplines are known as challenging and it is well-known that it can take time to establish well-functioning and productive research collaborations across disciplines (97). Significant effort was taken in the first programme phase in particular within the individual WPs to establish an understanding about each other's fields and common basis for joint scientific work. Similarly,

transdisciplinary collaborations based on collaborations between academic researchers and societal partners can be challenging from the perspective of research integrity and the understanding of the societal partners' interests and logics. In particular, to maintain and secure research integrity there is a need to maintain 'arms-length' distance between researchers and societal partners in sensitive aspects of the research process like choice of data and research method. In Mistra Food Futures phase one, there has been signals that some societal actors have felt disconnected from the programme, something which may have happened as a result from researchers' strives to keep discussions about material and methods strictly among themselves. Efforts have been taken to increase the internal communication from the programme leadership to the societal partners as a means to remedy their feelings of being disconnected from the programme.

Moving into the second programme phase, we have learned from the inter- and transdisciplinary collaborations to make the programme expectations on societal partners more clear. In preparing for the second phase application we have for instance discussed in-depth with several partners about the role they can take in the programme.

In the second phase we will establish the Mistra Food Futures academy around the programme's young researchers. All young researchers in the academy should be mentored by both an academic group and by societal partner mentor. The organisation of the academy will facilitate both the interdisciplinary and the transdisciplinary collaborations. Care will also be taken in the second phase to even more extensively discuss expectations among different types of partners, to highlight and create common understanding about everyone's motives for being part of Mistra Food Futures. We will also maintain our now very well-functioning internal communication and interaction activities with the societal partners.

Alignment of WPs and researcher activities

Related to the time required to establish the inter-disciplinary collaboration highlighted above, we have also experienced a few challenges in fully aligning the individual WPs. While the individual WPs have delivered on their individual goals and aims, taking a more critical perspective on them reveals that the potential for the WPs to fully build on and contribute to each other could be more exploited. Originating from the time and efforts that are needed to fully build an interdisciplinary collaboration, the alignment between WPs have been a top priority for the design of the second phase programme plan. In addition, we plan more focus on programme overarching activities to further stimulate interactions between WPs. These activities include the Mistra Food Futures' academy and the researcher conferences.

Researchers' time availability

The research activities in the first phase of Mistra Food Futures were by large staffed by relatively senior researchers (beyond post-doc) mostly working only part-time in the programme. While this implies possibilities to benefit from their seniority and in-depth expertise, there are also challenges from the perspective of time availability as senior researchers are often involved in several parallel projects. In the second phase, the programme research activities are instead planned around the Mistra Food Futures academy where a group of PhD students and post-docs will receive their training in the programme and the senior researchers will take more of supervisory and mentoring roles in relation to the younger researchers. More importantly, the Mistra Food Futures academy will allow us to develop the next generation food system researchers with a clear inter- and transdisciplinary training.

Resources devoted to communication and public affairs

The first phase programme plan significantly underestimated the resources needed for internal and external communication activities and public affairs. To enable efficient internal and external communication and dissemination activities, as well as public affairs-related activities, we realised that a full-time communicator was needed. In the first phase, we were able to re-organise the programme in this regard by using funds form the programme strategic reserve to secure enough resources for communication, dissemination and public affairs. The second programme plan is planned from the beginning to include a full-time communicator in the programme management team.

Covid-19 restrictions

Starting in September 2020, the programme commenced only six months after Covid-19 restrictions had come into effect which significantly limited the social contacts. As an effect, all interactions took place online, including programme workshops, meetings and programme conferences. The whole consortium met physically for the first time in October 2022, i.e. towards the end of the second programme year. Of course, the restricted social interactions impacted the efficiency with which we could develop the interactions within the consortium during the programme's first year and most of the second year. After the restrictions had been lifted and the consortium was able to meet physically, we believe that the quality of the interactions has improved. That said, the restrictions also fostered an online-culture for meetings and interactions which is resource and time efficient and which minimizes emissions related to travels. Many of our meetings continue to be organised online. Still, being able to meet physically on a regular basis helps create the "social glue" needed for high quality research and building a sense of belonging to the programme.

5. Programme impacts

Mistra Food Futures phase one has produced a range of different outputs, through which it significantly influences both the scientific society as well as the food system in which it is positioned. Moving forward, the programme will continue and intensify its impact. Here we describe the impacts made by the programme so far.

The establishment of a science-based transdisciplinary platform in the food system

Notably, the establishment of Mistra Food Futures means that researchers, companies and authorities with a focus on, and interest in a sustainable and resilient food system, have a science-based platform where they can meet, interact and discuss. Spanning over the entire food system, Mistra Food Futures takes an overarching and systemic perspective on the food system, which does not to the same extent exist in other existing food-related research programmes in Sweden. In particular, establishing Mistra Food Futures as a science-based platform related to food system transformation towards sustainability in Sweden implies that we have been able to achieve the following main impacts:

- Food system actors (including the participating academia, research institutes, industry, authority and region actors) have a platform to meet and discuss sustainability and resilience challenges across the food system. This implies a unique opportunity for knowledge exchange and mutual learning.
- The transdisciplinary consortium carters for increased understanding about each other's different motives, which for instance facilitates creation of better research questions and increased understanding about the research process and how science-based knowledge is created.
- Collaboration beyond the WPs in Mistra Food Futures. Examples include that programme researchers were part of the scientific reference group of the Public health agency's and the Food agency's governmental commission regarding goals and indicators for sustainable food consumption and that programme researchers contributed science-based knowledge to the Food agency's governmental commission regarding the implementation of the Nordic nutritional recommendations in Sweden, as well as new granted research projects in collaboration between programme researchers and societal partners.
- Establishment of a science-based platform that produces knowledge that is asked for by society in general, exemplified for instance by media's interest in our work.

Societal partners' pathways to change

Being a societal partner in Mistra Food Futures opens opportunities for organisations to transition towards sustainability, which might not have been there without the partnership. To highlight how Mistra Food Futures has created pathways to change for partners, we use impact stories where partners describe their programme partnership and how their organisation has been affected by the partnership. Four partners were interviewed in-depth using impact stories to highlight their pathways to change in response to being a member of the programme. Findings are presented in Figures 2 - 5. In summary, it was the programme's systemic approach that attracted participation. The partnership has provided important knowledge and inspiration. Being able to take part in the researchers' work, discussing and exchanging perspectives with other actors along the entire food chain has been valuable.

IMPACT STORY: THE SWEDISH FARMERS' FEDERATION (LRF)

"Working together is the key," says Lars-Erik Lundkvist, an agronomist and business policy expert at LRF.

- Confidence in Swedish farmers is high on the Swedish market. In this aspect, we feel safe, but we also need to adapt to the world around us. It is important for our members to be involved in the conversations and discussions about future food production and consumption.

Close cooperation with research, in this case, Mistra Food Futures, has raised awareness that responsibility for the transition lies with the entire chain, and that everyone needs to take responsibility for their respective roles.

- The partnership with Mistra Food Futures has provided LRF with unique opportunities to engage with a diverse range of stakeholders throughout the entire food chain, individuals we might not have encountered in this manner otherwise. We all entered the program with various viewpoints and expectations, distinct strategies, and objectives regarding future production and consumption. This diversity is both challenging and enriching. I would say that our conversations have improved and evolved over time, says Lars-Erik.

On one hand, there is a need to alter consumption patterns to avoid continually exceeding planetary boundaries. At the same time, there's the challenge of managing a growing population and shifting consumption habits within a free and open market.

There is no doubt that Swedish farmers are eager and in need of changing their production methods. To make this transition possible, Lars-Erik suggests that consumers must be actively involved in the process. Without consumer engagement, he believes that the outcome will be increased imports, resulting in the continued export of environmental impact, which is an undesirable situation.

LRF has at times expressed concerns about the national dietary guidelines and recommendations. However, they also recognize that a discussion about our dietary choices and their impact on our health is essential and a part of an open society. It is not possible to compel consumers to change their eating habits, but policy instruments and information are necessary to guide consumption to some extent in alignment with the transition.

- There is a need for a stronger consensus on how to establish a resilient food chain. We must also be more determined in translating research into contemporary methods and products. For instance, we need to meet the growing demand for plant-based consumption. Additionally, we should harness the strengths of Swedish animal production to meet future demands, says Lars-Erik.

In addition to the crucial issues of reducing the use of plant protection products and antibiotics, LRF has also been actively engaged in efforts to achieve fossil-free food production. This entails transitioning agricultural machinery away from fossil diesel as a fuel source. While electrification is making progress it is advancing slowly, so there will likely be an ongoing need for liquid fuels in the future. Sweden with its abundant forestry resources, has the potential to achieve complete self-sufficiency in fuels providing raw materials for the Swedish market.

Lars-Erik believes that we must enhance our efforts in policymaking to ensure that a greater portion of research is put into practice and becomes a reality. For instance, active participation within the context of ongoing work on the food strategy and early involvement in EU cooperation processes would be highly beneficial. He concludes that having a unified and shared vision of the future of food production and consumption would greatly facilitate these endeavours.

Figure 2: Impact story LRF

IMPACT STORY: THE PUBLIC HEALTH AGENCY

The program's systems thinking approach was the primary attraction for the participation of the Public Health Agency of Sweden (Fohm). The background to this is that Fohm was exploring how to advance their efforts in the field of food, partially driven by a government commission in 2021 in which they produced a memorandum containing proposals for enhancing their work from a systems perspective. Among other considerations, Fohm started with a depiction of the food system created by the FAO (Food and Agriculture Organization of the United Nations) and used it as a foundation to examine how they could address food consumption. Fohm aimed to incorporate various sustainability aspects into their work, and because food has a significant impact on many of the Sustainable Development Goals (SDGs), it was essential to adopt a systemic approach. When Mistra Food Futures commenced its work and it became apparent that the program employed systems thinking, it was a natural fit for Fohm as a government agency to become an active partner.

- Highlighting the consumer perspective has been the paramount focus for us in this partnership, says Pia Lindeskog, expert at the Public Health Agency. For decades, the primary emphasis has been on production, and the consumption perspective has been largely overlooked, even though food is fundamentally about nutrition and health for us as consumers.

The government comission, which has largely shaped the partnership, was to formulate recommendations for objectives and areas of action aimed at promoting sustainable and healthy food consumption, and to suggest indicators for monitoring, among other things. Mistra Food Futures has been highly effective in delivering on this, with one of the research projects focused on developing indicators to assess the sustainability of food systems, allowing for the evaluation, mitigation, and ongoing monitoring of results. The illustration, particularly the "Sustainable House," depicting the food system, has proven to be immensely helpful in comprehending the comprehensive scope of the system.

- This collaboration has truly emphasized, for us at Fohm, the significance of our involvement as an authority in highlighting the public health perspective. We have gained knowledge and received support in various forms through our participation in various dialogues, individual discussions with researchers, and by contributing to several of the published reports. Moreover, this collaboration has led to that Helena Hansson, the programme director for Mistra Food Futures, is now a member of our reference group associated with ongoing government commission, which is of great value to us, says Pia. An effective partnership is built on exchange, and this has certainly been the case.

To have the opportunity to partake in the work of researchers, to have discussions and exchange perspectives with other stakeholders throughout the entire food chain has proven extremely valuable for Fohm. It not only allows them to acquire a wealth of factual information but also continuously refine their own ideas and have the opportunity to contribute to the efforts of Mistra Food Futures.

Regarding to the future, Fohm’s primary perspective is to persist in adressing the consumption aspect from a systems perspective. As long as the existing system results in significant public health issues, has a substantial climate impact, affects biodiversity, water usage and more, there is work to be done. Successful efforts will necessitate collaboration.

- The systems approach within the programme is a strength and that is what makes it so intriguing. Systems thinking facilitates a different kind of discourse compared to traditional research. Ultimately it leads to a unique form of knowledge and output that can be advantageous for decision-makers, concludes Pia Lindeskog.

Figure 3: Impact story The Public Health Agency

IMPACT STORY: AXFOOD

- It was the systemic approach of working with future food consumption and production that attracted the partnership, says Åsa Domeij, Head of Sustainability at Axfood.

Axfood carries out a lot of work within its organization regarding climate-smart transportation, modernization and investments in stores to reduce climate impact. At the same time they realize that it is impossible to ignore the fact that the real major challenges lie within consumption habits and production. This is the reason why the partnership with Mistra Food Futures is important for Axfood.

Axfood has intentionally involved a wide range of employees and roles in various activities and also disseminated materials within its organisation, which has been valuable. They appreciate the rich and varied mix of activities invited by Mistra Food Futures, a real smorgasbord where participants have had the opportunity to meet the researchers up close, interact with various stakeholders in the food chain, attend lectures, engage in discussions and dialogues in small groups, participate in both physical and digital meetings on a wide range of topics, and there has been ample time for discussions and providing input.

- Personally it has been very valuable to me in my role to receive guidance on where to find more information about topics relevant to my work, reports and interesting articles. On busy days there isn´t always enough time even if you want to, to search for necessary information and knowledge. This has truly assisted me in staying up-to-date with current research, says Åsa.

Mistra Food Futures is an important source of knowledge for Axfood. The partnership has provided important new knowledge and inspiration, which has a major positive impact on Axfood as an organisation. Åsa emphasizes the importance when employees have the opportunity to listen to researchers who describe the state of knowledge in an educational way and create understanding among all those who are out doing the work.

Knowledge means development. Mat 2023 – Axfood's proposal for a sustainable food strategy - which is aimed at the business community, authorities and politicians would not be as good as it is without the important knowledge Axfood has gained from the partnership. The knowledge gained through this type of collaboration also has an impact on the discussions regarding sustainable products that Axfood wants to develop. The minced meat produced by Axfood with half meat and half vegetables is an example of this. Making it easy for consumers to be climate-smart while getting a cheaper product is an important part of changing consumption habits.

- We would have done Mat 2023 anyway, but the collaboration with Mistra Food Futures has influenced the focus and the content. Another important thing is the internal training programmes within the Axfood family - stores, wholesalers, Mathem, etc. where the focus and content of these training programmes for our staff have definitely been influenced by the knowledge we have gained.

Åsa believes that it would be exciting if the dissemination of knowledge also extended to categories within the industry that do not directly deal with sustainability issues in their day-to-day work, such as sustainable sales, those involved in the procurement of meat and charcuterie or fruits and vegetables. Inviting these groups to seminars where they can gather and learn more about incorporating sustainability into their roles can be highly beneficial. Despite the presence of internal training programs, external invitations can serve as an important supplement and addition.

Figure 4: Impact story Axfood

IMPACT STORY: ORKLA FOODS SWEDEN

Interview with Lars Lundahl, Environmental Manager at Orkla Foods Sweden, also working on environmental issues within the central sustainability group at the parent company Orkla ASA.

What motivated your involvement as partners in Mistra Food Futures?
We routinely monitor and evaluate various research projects and programs within the company and discuss them in our sustainability group to assess their relevance and the commitments required. Mistra Food Futures attracted our interest due to its strong connection to our core business: sustainable and healthy food. The programme's holistic perspective on sustainability was particularly appealing. We aim to stay at the forefront, and this partnership provided an opportunity to participate in a large, comprehensive forum with many interesting stakeholders, well aligning with our profile as a major food company in Sweden. Keeping up with the latest research and developments relevant to our core business is crucial for us. Personally, I always strive to engage in tangible projects rather than merely attending seminars and discussions. One such ongoing project, though not yet fully finalised, is a case study focused on quantifying the environmental and economic impacts of measures to enhance biodiversity and reduce climate impact in crop cultivation. We have high expectations for this project.

Has the partnership been of practical benefit to Orkla Foods?
We look forward to gaining valuable insights from the ongoing case study. Additionally, we have participated in various work packages, webinars, and some physical meetings. One of the most valuable aspects of the collaboration is the connection between daily operations and research, where we can mutually benefit from each other. For instance, we involved our cultivation manager, who works directly with our contract farmers. His participation has brought concrete and practical insights to the above-mentioned case study, offering a deeper understanding of real-world practices among farmers and the demands we now place on them. Personally, I have been involved in the work package on indicators for assessing the sustainability of food systems. While the focus has been on societal and policy-level decision-making, which is important for positively influencing policymakers, I initially hoped we would develop indicators directly applicable to our company.

What does the future look like?
We look forward to seeing the results from the case study. The discussions surrounding its planning and design have been highly rewarding. Such dialogues are valuable in themselves and have also led to new contacts that could prove beneficial in the future. With the partnership we aim for it to result in us doing something different and new within the company. So far, the greatest gain has been an increased level of knowledge, and I hope the collaboration will generate more direct impacts on the company's work moving forward.

Figure 5: Impact story Orkla Foods Sweden

Scientific impacts

Overall, the design of the programme makes significant scientific impact by its systemic approach to food system research, thus enabling analysis at the level the food system. This means that we approach the scientific inquiry with the perspective that we need to consider the food system as such and the interlinkages between the system and more detailed level of analysis. Furthermore, our interdisciplinary approach ensures combination of natural science insights about climatic and environmental impacts with human behavioural and economic insight from social sciences. The overall scientific impact of the programme thus lies in its overall design, something that we currently document as a case study.

In the remaining parts of this section, we summarise the main scientific impacts by each WP. It is important to note that that all works that we consider of major scientific value have not yet been published in academic journals due to the time lags in the peer review processes.

WP2. Through developing and analysing targets for the Swedish food system, WP2 has contributed to a joint vision of the future Food system in Sweden. Work in WP2 has centred on developing environmental and dietary quality targets for the Swedish food system using a structured scientific approach and expert elicitation. Moreover, the WP has contributed with a novel analysis of the sustainability targets of Swedish food companies, using the planetary boundaries as a frame. The WP also contributed to a comprehensive literature review focusing on policy measures aimed at promoting environmentally sustainable food consumption. The overarching objective of this review was to gather and outline the existing body of evidence concerning public policy interventions that have been put into practice, proposed, or have the potential for implementation to encourage environmentally sustainable food consumption.

WP3. The focus of WP3 has been to craft compelling scenarios. These scenarios provide valuable insights into the diverse potential trajectories that can lead to achieving ambitious territorial and consumption-based targets for Sweden's food system, in the context of climate, biodiversity, and nutrition. The outcomes of WP3 have unveiled the considerable variation in food system development outcomes among the scenarios, highlighting the substantial and distinct consequences for various stakeholders, including those involved in production, processing, retail, trade, restaurants, and the public sector. These scenarios also differ significantly in terms of food system ownership, domestic production versus imports, the visual landscape of Sweden, dietary habits, and the composition of the Swedish diet. The work in WP3 has not only provided a clear understanding of the potential pathways for the Swedish food system but has also enriched our knowledge of how these different scenarios can impact sustainability, resilience, and the interconnected dimensions of food systems. This work has sparked important discussions on the dynamics of future food systems, contributing to the scientific discourse on the intersections of climate change, biodiversity conservation, and human nutrition within the context of Sweden's food landscape.

WP4. Work in WP4 enabled a renewed and more encompassing understanding about what a sustainable food system entails. In particular, the WPs approach to understand this question from both an empirical as well as from a conceptual perspective has contributed to articulating what a sustainable food system actually means. From a theoretical perspective, work (55) in WP4 has clarified how sustainability dimensions are interlinked, at the level of the food system, which is a key scientific contribution of the WP. Furthermore, the WP has suggested an indicator framework for sustainability assessment at the level of the food system (58), critically assessed the limitations in secondary data for sustainability assessment at the farm level (59) and investigated the use of sustainability indicators among food and beverage companies (62). These are also key novelties of WP4.

WP5. The contributions of WP5 are both connected to the specific findings in the case studies and to the modelling and assessment of the national agricultural sector. Each of the 20 collaboration projects in WP5.1 delivers new scientific knowledge. Here is only space for a few examples: 1. The potential of bio-char as a technology to produce negative GHG emissions was clearly shown and the bio-char strategy was also better in terms of emissions than the strategy to burn the straw for heat production to substitute fossil resources and thereby avoid emissions. 2. In the meat production, the substantial potential to decrease the climate load by adding more ley to the pigs' feed was an important finding and 3. The large potential to decrease the climate effects with electric tractors, including also yield effects due to lower soil compaction if smaller self-driving vehicles can be a reality.

The CIBUSmod model developed in WP5 quantifies emissions and nutrient flows from the national agricultural sector with a resolution not previously shown (modelling the country in 106 areas with separate data for crop areas, animal numbers and other affecting factors). Climate effects over time (AGTP) as well as other environmental indicators are calculated for possible scenarios including partial or total transformation of the sector to be sustainable. The model includes an optimization algorithm that regionally distributes crop areas and animal numbers while ensuring that scenario specific demand for agricultural production is met while adhering to a number of production constraints. The model design in itself is a valuable scientific contribution and it enables also the scenario simulations to get additional answers on the research questions defined for WP5.

WP6. WP6 developed a framework for the design of hypothetical future supply chains from farm-gate to retail. The aim was to use the framework to create understanding and preparedness among industrial stakeholders while at the same time present supply chain solutions with improved sustainability performance. The framework has been applied in three case studies in close collaboration with industry partners. Main output hitherto has been the

confirmation of that the framework gives value to stakeholders as well as researchers by providing a way of working that connects the larger challenges of sustainable food systems with the questions companies face and can influence. The inclusion of scenario skeletons from WP3 have proved to be critical for the process and the use of Multi Criteria Assessment is very promising since it covers the breath of impacts in a comprehensive way.

WP7. Work in WP7 has focused on drivers for change among actors across the food system. Main scientific contributions include an assessment of dairy farmers' preferences for trade-offs regarding sustainability attributes in their uptake of sustainable practices, exemplified using farmers' uptake of more grass-based feed rations. Another major scientific contribution include work on farmers' preferences for policy attributes aimed at supporting uptake of more grass-based feed rations for dairy cows, where we are able to distinguish between social rewards and private or public origin of support. Consumer preferences have also been under investigation, namely in the form of public support for different types of policy interventions that can be implemented by national, regional or local governments or by private actors in the food value chain. Support has been estimated for different types, designs and presentations of policy interventions. Support has also been linked to individual specific factors, such as attitudes, perceptions on norms and socio-economic background.

WP8. Originally, WP8 did not have any planned scientific impact, but was instead focused on initiating and conducting collaborations with organisations and authorities to transform the food system. As part of this WP8 has established a stakeholder panel with actors representing a range of organisations and institutions in the food system. A total of 60 stakeholders took part in a dialogue series on the role of business models in a sustainable transition of the food system, which drew heavily on published scientific work in the areas of foresight, sustainability transitions, and business modelling. Based on this work a scientific paper on the integration of foresight and sustainability transitions as a method for guiding stakeholders in processes of transformative change has been submitted for publication in the journal Futures and Foresight Science, with the title Towards a Multi-level foresight: A practice-oriented integration of foresight and sustainability transitions in the Swedish food system. The work was also presented at the 2023 Futures Conference in Turku, Finland, organized by the Finland Futures Research Centre and Finland Futures Academy at the University of Turku.

Researcher collaborations

Collaborations between SLU, SRC and RISE

Initiating Mistra Food Futures also marked the start of intensive new collaborations between research groups at SLU, SRC and RISE. While researchers at those three organisations had previously collaborated, Mistra Food Futures implies a large-scale collaboration in food systems research that has previously not been conducted. As such, the programme has thus spurred successful new collaboration which will be even further intensified in the coming programme phase with the organisation around a Mistra Food Futures academy with joint mentorship of PhD students and post-docs, and a transition lab which will bring science-based food system research to implementation while strengthening the transition capabilities of programme societal actors and beyond. Those plans signals the maturity of the collaboration which has been possible thanks to the activities in the first phase. It should also be noted that at SLU, Mistra Food Futures has implied successful collaboration between research groups that did not previously know each other well. One example is the collaboration between the two programme directors' respective research groups which has led to even further funding being granted.

Collaborations between system researchers and disciplinary oriented researchers

Some of the most prominent research linked to the environmental effects of innovative technology or system solutions in a life cycle perspective occurs when skilled disciplinary oriented researchers or developers with special knowledge of a technology or specific measure can collaborate with experts in system analysis and the most developed LCA methodology. This is especially clear when working with technology and measures that are still in a development phase and relevant published experimental results and experiences are normally lacking. In Mistra Food Futures phase one, we have enabled such collaboration by allocating funds for 20 collaborative projects in WP5. In these, specialists from applied agricultural and energy research have collaborated with experienced LCA researchers. The strategy has been highly successful, a large number of scientific reports and articles have been produced (see the project report of WP5), the interest from the external parties has been considerable at our presentations and we have also seen a significant interest in popular science writings with the results as a basis. In addition, the work has made a very valuable contribution to the continued system-based work in Mistra Food Futures. Furthermore, the results have contributed with feedback to the "disciplinary oriented" researchers for prioritization and justification of future experimental research and also increased understanding and interest in continued collaboration with the systems researchers and with Mistra Food Futures in general.

Young researchers

Training young (early career) researchers, including research assistants, PhD students and post-doctoral researchers is fundamental in academic activity. To facilitate networking and professional development among the young researchers in the programme, we initiated a young researcher network about one year into the programme, with targeted activities to foster collaboration and networking between the young staff-members of the programme, but also beyond,

extending to young staff-members in related projects. Here we highlight how Mistra Food Futures has impacted the professional training among our young staff-members, using four impact stories as examples. A total of four early career staff members have been interviewed using impact stories to address how Mistra Food Futures has contributed to them.

IMPACT STORY: PHD STUDENT HELENA ROBLING

Helena Robling, a doctoral student at Mistra Food Futures, has been deeply involved in sustainability and food-related issues since her internship at the UN Food and Agriculture Organization (FAO) in Rome back in 2012. Her initial encounter with SLU (Swedish University of Agricultural Sciences) occurred during her master's studies in Agriculture, Food, and Environmental Policy Analysis. Although Helena was interested in pursuing a doctoral degree immediately after completing her master's program, she didn't find the perfect research topic at that time. Instead, she began working at the Swedish Public Procurement Agency, where she focused on developing sustainability criteria for food procurement in the public sector. Helena is currently two years into her PhD journey.

- Working at the Swedish Public Procurement Agency, we collaborated with diverse stakeholders to address sustainability challenges. Mistra Food Futures is very much in line with that approach, but with a primary focus on research. This research programme and the PhD topic were an absolutely perfect fit for my interests, and I felt like this was the opportunity I had been eagerly waiting for, says Helena.

As a PhD student in the program, Helena has the opportunity to participate in all the activities organized by Mistra Food Futures in collaboration with government authorities, companies, and organizations. This serves as a valuable source of practical knowledge and experience from various actors within the Swedish food system. It is an inspiring experience that also demands continuous adaptation and consideration of the fact that the research pursued should have practical utility. An important lesson is that the sooner knowledge and experience from external actors are integrated into the research process, the more likely it is that the results will be practically applied.

- One challenge I observe in interdisciplinary research, as we do in Mistra Food Futures, is the necessity for various research domains to establish a common language for research questions. This process can be time-consuming compared to classical research, which might begin with a more standardized approach from the outset. However, once you've begun working in an interdisciplinary manner, it becomes challenging to revert to a more isolated approach because you become aware of essential perspectives that must be considered. Yes, it may take a bit more time, but the ultimate goal is to gain valuable insights that contribute to results and solutions that address real-world issues, says Helena.

Figure 6: Impact story Helena Robling

IMPACT STORY: RESEARCH ASSISTANT RAKEL ALVSTAD

At the Beijer Institute of Ecological Economics, you will find Rakel Alvstad. Her primary responsibilities as a research assistant include collecting data, conducting interviews, processing data, and collaborating closely with senior researchers to write research reports and scientific articles.

- Working within an engaging and interdisciplinary research environment and contributing to high-quality research is both an educational and inspiring experience. I consider myself fortunate to continually learn new things through my collaboration with outstanding researchers and experts. I appreciate the holistic approach, the spirit of collaboration and the process of piecing together seemingly disparate elements of the puzzle that are, in fact, interconnected.

What attracted Rakel to this particular research program is its holistic approach. Instead of solely focusing on isolated components of the food system, this program addresses all three dimensions of sustainable development spanning all levels within the food system. The aim is to achieve a transformation that encompasses health, fairness, and sustainability.

- Mistra Food Futures has been the ideal entry point into the world of research for me. I'm impressed by the numerous innovative approaches where researchers from diverse disciplines and research traditions collaborate with food value chain partners, authorities, and regions, all working toward a shared objective, says Rakel.

Rakel takes pride in being a part of Mistra Food Futures, which is undeniably an inspiring environment. While it's hard to predict precisely what the future holds, perhaps including a Ph.D., she is confident that she will continue her work on food system transformation from various perspectives. This experience has undeniably given her a solid foundation to build upon, not only in terms of knowledge but also in establishing an important network.
If she were to summarize Mistra Food Futures in three words, they would be collaboration, innovation, and systems thinking. The program's foundation is the recognition that the food system confronts highly complex and far-reaching challenges. Consequently knowledge and research that can contribute to the transition to more sustainable food systems cannot be confined to individual research disciplines. The programme's strength lies in its holistic approach.

Figure 7: Impact story Rakel Alvstad

IMPACT STORY: POSTDOCTORAL RESEARCHER MEHRAN RAD

Mehran Rad completed his PhD in sustainability assessment at Lund University. Since June 2022, he has been working as a researcher at RISE.

- With a background in Civil and Environmental Engineering, I've worked extensively in sustainability assessment, particularly with a specialized technique connected to management science. I later discovered that RISE had been seeking this expertise for several years. There was a specific need for this expertise in Work Package 6, and that's how my connection with Mistra Food Futures was established. I have recently developed a model for evaluating the sustainability of various scenarios, says Mehran.

Mehran is in the early stages of his career and as he describes it, still a long way from being an experienced senior researcher. He is impressed by the respect, attention and support he receives from the work package leader, senior researchers and professors, who not only listen to him, but also want to learn from him and support his ideas.

- I have had a fantastic start to my research career, and I'll always remember the trust and support I received from the more senior researchers. I believe it would be beneficial, both for the programme and for other young researchers in the early stages of their research careers, to participate in such a programme. Early-career researchers typically don't have as much responsibility, which provides them with more time and focus to get the job done. It also allows them the luxury of observing how research tasks are led by senior research leaders.

Figure 8: Impact story Mehran Rad

IMPACT STORY: YOUNG RESEARCHER HANNA KARLSSON POTTER

Hanna Karlsson Potter specializes in environmental systems analysis at SLU. Following her postdoctoral research, it became evident that Hanna's knowledge and research interests aligned exceptionally well with the mission of Mistra Food Futures. It felt like a natural and indeed a joyful opportunity to continue her research within the programme.

Hanna is a part of the work package responsible for modelling the environmental impact of the Swedish agricultural system. They collaborate closely with the work package that has developed four different future scenarios for Swedish food production and consumption.

- One of the programme's strengths is that researchers can draw benefits from each other's research in various ways. As demonstrated in this case, research conducted in one work package acquires a new dimension when viewed through the scenario perspectives of another work package, says Hanna.

From time to time, situations arise where there's a need to reach out to other researchers who possess more knowledge in a specific field. Mistra Food Futures offers expertise in a wide range of areas. Hanna emphasizes the value of the interdisciplinary approach. It's a significant advantage for researchers to tap into a broader network of contacts, to connect and collaborate with researchers working in their own field, as well as those involved in research and activities outside of their own area. This provides opportunities to collaborate with external stakeholders and researchers from different disciplines, other universities, research institutes, and organizations.

- It's both stimulating and enriching to witness how your own research can contribute to the work of others, while also actively participating in the research of others. The interdisciplinary approach unquestionably enhances and introduces important perspectives to the research process.

Hanna believes that collaboration is a defining feature of the program, and it is indeed one of its strengths.

- There's always room to enhance and deepen cooperation further. I believe that all of us can contribute to this effort in various ways.

Figure 9: Impact story Hanna Karlsson Potter

6. Strategic reserve

From the start of Mistra Food Futures phase one, we had set aside a total of 8 MSEK as a strategic reserve. The aim was to create an opportunity to act on unforeseen opportunities as well as to cover items that had previously been allocated a too slim budget. The programme directors submitted proposals to the programme board for how to allocate the strategic reserve, after discussion and consensus in the group of WP-leaders. The board made the final decision about the use of the strategic reserve. During phase one, the strategic reserve was allocated to new initiatives and projects, according to the following:

- Increased funding allocated to communication, dissemination and public affairs. About one year into the programme we realised that the initial allocation to communication, dissemination and public affairs activities had severely underestimated the resources needed to make significant programme impacts. As a result, the board allocated support to public affairs training and consultation for the consortium as well as to the programme's initial social media management. Furthermore, the board allocated funds to support employment of a full-time staff-member with responsibility for communication, dissemination and public affairs. The programme communicator and public affairs manager is part of the programme leadership group.
- A young researcher network. Funds were allocated for coordination of a young researcher network and for activities within the network. The network is open to all young researchers in the programme and to young researchers in closely related projects.
- Three implementation projects, focusing on increasing practical collaboration between researchers and societal partners.
- Three additional research projects:

  Expert forecasting of Swedish food system actor preferences. The aim is to elicit incentivised beliefs of food system actors about one another to learn about actors possible misperceptions about others' beliefs. The project is initiated by WP7.

  Understanding a changing risk landscape for the Swedish food system in the Anthropocene. The aim is to increase the understanding about the new risk landscape following multiple crises such as the Covid-19 pandemic, the Russian invasion of Ukraine and food price inflation. The project is initiated by WP2, 3 and 6.

  Participatory scenario development for future Swedish food production systems – an addendum to the scenario development and modelling in Mistra Food Futures. The aim is to co-create alternative concrete pathways for different types of future Swedish production systems that fit the scenarios developed in Mistra Food Futures, and to provide quantitative inputs for biophysical modelling in WP5. The project is initiated by WP3 and 5.

- An internal research conference among Mistra Food Futures researchers. The conference took place March 12th – 13th 2024 and spurred much needed scientific discussions among all researchers involved in the programme.
- A seminar with representatives of the EU commission to introduce the programme to commission representatives.
- A whole day meeting with representatives from the Formas funded research centres SustAinimal, FINEST, Blue Food and Pan Sweden to discuss concrete future collaborations among the research centres and Mistra Food Futures.
- A seminar at the Almedalen event in 2024, in collaboration with SLU Future Food.
- Funds to develop a programme overarching conceptual framework based on the overall programme design.
- An 'end of phase one/start of phase two' conference, entitled Food Forward, to discuss programme key findings with programme partners and beyond and how the programme contributes with solutions needed for a more sustainable and resilient food system.

7. Moving forward

Since the original design of Mistra Food Futures took place in 2019, the surrounding environment has gone through significant and much unexpected changes: the Covid-19 pandemic, the Russian full-scale invasion of Ukraine and the significant price inflation we have witnessed over the last few years. While it is becoming even more evident in everyday life that climate change is happening, this means that a sustainability transition of the food system needs to happen at the same time that society goes through other crises which at least in the short-term will to most people appear more pressing. Preparing the programme for the second phase, we therefore widened the scope of the programme, to encompass how food system transformation towards sustainability and resilience can happen at the same time as food preparedness is improved. In the second phase, the programme will also take a more pronounced global perspective, by building on our work regarding territorial and consumption impacts and interdependencies (30,58).

Beyond this, Mistra Food Futures phase two is designed around a set of eight WPs, one focused on overall programme organisation, leadership, communication and dissemination, six focusing on thematic research questions and one focused on designing and implementing a **transition lab** aiming at strengthening the transition capabilities of societal partners and beyond. The research-focused WPs are designed to focus on i) advancing future

pathways for food systems, designing future **indicators** and evaluating how indicators can help food system transition, evaluating **measures** for net-zero agricultural systems, evaluating models for sustainable agricultural **systems** and food systems beyond agriculture, investigating how national and international **policy** can function as levers or barriers for change and suggest solutions for barriers, and finally to analyse the industrial **organisation** of the food value chain impacts on resilience and sustainability transition.

Furthermore, the programme phase two is designed to feature a long-term perspective towards 2045, advance system modelling capacity and further advancing implementation. Finally, the programme phase two will be organised around the Mistra Food Futures academy, which will train the future food system researchers and provide a working structure for trans- and interdisciplinary collaboration as well as for maintaining the programme after phase two has ended.

For details about the second phase and for a full record of programme publications, we refer to the programme website: https://mistrafoodfutures.se/en/

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MISTRA
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