MISTRA
The Swedish Foundation for
Strategic Environmental Research

Background paper

Food Security and Sustainable Food Systems

Research to support a sustainable, competitive and innovative Swedish food system by 2030

February 2019

Authors:
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Executive Summary

Background

A working group of international experts has been commissioned by Mistra to develop a background report as documentation for Mistra's Board, ahead of a forthcoming decision on whether to call for proposals for a research programme in the area of "Food Security and Sustainable Food Systems"

In this report, food security is framed as an outcome from a sustainable and resilient food system, not with a focus on meeting demand per se, but ensuring health, sustainability, and, if necessary, modifying demand (e.g. changing incentives, via policy, in order to reduce waste, change food environments, and relative food prices) to do so. Food system is here defined as *"encompassing the activities and actors in the production, transport, manufacturing, retailing, consumption, and waste of food, and their impacts on nutrition, health and well-being and the environment"*.

- The failures of our current food system are becoming increasingly recognised. This includes:
- Malnutrition, accelerating obesity and increasing health costs
- Food waste, where it has been estimated that about a third of the world's food grown is lost or wasted.
- Externalisation of environmental impacts, where unsustainable agriculture practices lead to biodiversity loss, degradation of soils and water resources, pollution from agri-chemical use.
- Global GHG emissions, where the food system is estimated to contribute approximately 20–30% of global GHG emissions.

Profound changes in food systems are needed in order to meet the sustainable development goals (SDGs) set by the UN in 2015, and the terms of the Paris Agreement on climate. In a Swedish context, there are a large number of studies and initiatives analysing parts of the Swedish food system, and how these could contribute to a more sustainable food system. There are also an increasing number of innovation efforts on parts of the food chain to make them more sustainable. However, none of the current programmes and initiatives has taken a systemic view looking at how to transform the whole Swedish food system in its totality.

Based on the findings in this background report and stakeholder consultations, the expert group has suggested a set of research question and focus areas for a Mistra Programme on Food Security and Sustainable Food Systems.

The Overarching question

What would a Swedish food system - that is economically, socially, environmentally sustainable, and resilient – look like, and how do we get there?

Research Questions

1. **Making explicit assumptions about the range of plausible futures**

   The world is changing rapidly from environmental, social, technical and geo-political perspectives, with uncertainty about the future becoming a key driver of strategic planning. Scenario analyses are a commonly used tool for decision making under uncertainty, and it could be usefully used to explore a range of alternative future conditions that will shape the Swedish food system, such as changing demographics, robustness of international trade and the architecture of international cooperation, the extent to which society accepts changing diets, ways that demand may change, etc. Development of plausible alternative future conditions can allow the description of different ways that the Swedish food system may deliver healthy diets in a way that is sustainable and resilient. These scenarios can be used to develop a robust research agenda, identify leverage points for intervention, stress-test the development of research questions and so on. Scenarios are, ideally, co-created with a representative set of all actors who are stakeholders in the food system. For each scenario, the implications for a range of social goods can be explored: how does a transformed food system affect, for example, land use, livelihoods, food prices, international competitiveness and soft power?

2. **What are the options for the Swedish agricultural system to be "net-zero" in GHG emissions by 2045 and what are the implications for the food system as a whole?**

   Sweden is making commitments towards becoming an economy with a net positive emission of greenhouse gases, and a "net zero" agricultural sector would be an important factor for decarbonising the economy. What would a "net zero" -carbon agriculture look like within some (or all) of the scenarios described above? Minimising GHG emissions is one aspect of a "sustainable food system" although it is likely to impact on other aspects from environmental (e.g. implications for the intensity of land use), social (e.g. livelihoods, economic competiveness), and spatial perspective (with different regions requiring different future patterns of land management). What are the trade-offs and synergies between these goods and services, and how do they vary across Sweden, if "net-zero" GHG agricultural system was a boundary condition of a food system that provides healthy diets in a sustainable and resilient way?

3. **Identifying the metrics for measuring the performance of the food system against the objectives of delivering healthy diets in a sustainable and resilient way?**

   For managing and describing progress, metrics are key. What "next generation" metrics can be articulated that can incentivise and measure performance from current conditions towards the transformed food system? For example, going beyond agricultural productivity measured in terms of economic gain, or yield, per unit input, towards measuring the performance of the whole food system (such as people fed) minimising the costs of monetized inputs (e.g. fertiliser), environmental impacts (e.g. GHG emissions, impacts on air, water, soil and biodiversity), and health impacts (e.g. healthcare costs associated with malnutrition in all its forms). In other words, metrics for assessing people fed sustainably, equitably, healthily and profitably per unit input. How could such new metrics be adopted by, and influence the decisions of, policy makers, business, consumers and civil society more broadly?

4. **How can the transformation to a sustainable and resilient Swedish food system be enabled and incentivised?**

   Given that (1) and (2) outline potential visions for a transformed Swedish food system, and (3) develops the metrics of progress, what are the pathways by which transformation can be achieved? Answering this question requires identifying the constraints working against change – whether they be technological, social, regulatory or political. Given these constraints, how might they be overcome and an enabling environment be created? Can potential suites of scalable interventions be identified and perhaps piloted in proof of concept applications (e.g. social, technical or regulatory pilot programmes, or "test beds")? How would the interventions create "winners and losers" and who (or where) would these be? How might the transformation affect Sweden's international competitiveness, and broader standing in the world?

   In short, what interventions might shift the food system in the desired directions, with lowest risk, lowest social cost, and highest benefit for Sweden?

Approach and outcome

Research question (1) and (2) outline potential visions for a transformed Swedish food system, (3) develops the metrics of the development and progress, (4) would look at the pathways by which transformation can be achieved. The expectation is that by tackling research questions 1–4, the programme develops a road-map for systemic transformation of the Swedish food system.

1 Background and Mission

According to the statutes of Mistra, research funded by the foundation should "promote the development of strong research environments of the highest international class with importance for Sweden's future competitiveness". The research should find solutions to important environmental problems and enhance the sustainable development of society. The funding call to be developed by Mistra should be based on a background paper and analysis of the current state of the art of research and knowledge needed to support a sustainable, competitive and innovative Swedish food system.

To this end, for the "Food Security and Sustainable Food Systems" topic, Mistra commissioned an expert group of six international senior researchers in the field. These are:

- Adjunct Professor Johan Kuylenstierna (Chairing the Expert Group) *Adjunct Professor at the Stockholm university, Director, Navarino Environmental Observatory (NEO), Vice Chair, Swedish Climate Policy Council*
- Dr. Harry J. Barraza, *Relationship Development Director, LGC, United Kingdom*
- Professor Tim Benton, *Dean of Strategic Research Initiatives, University of Leeds and Distinguished Visiting Fellow, Chatham House, United Kingdom*
- Dr. Ana Frelih Larsen, *Senior Fellow, Coordinator Agriculture & Soil at Ecologic Institute, Berlin, Germany*
- Professor Sirpa Kurppa *Natural Resources Institute Finland (Luke), Bioeconomy and Environment, Sustainability Science and Indicators, Finland*
- Dr. Leslie Lipper *Director of the Independent Science and Partnership Council. Consultative Group on International Agricultural Research (CGIAR), Rome, Italy*

Dr. Ivar Virgin, (Senior Research Fellow, Stockholm Environment Institute), Sweden acted as secretary to the Expert Group. See Appendix A3 for a brief presentation of experts.

The Terms of Reference for the expert group included:

- Briefly describe the Swedish agriculture and food system in an EU and global context,
- Describe the resources, environmental and policy challenges facing society in this area, and the technological and policy developments as well as other trends that are underway in Sweden and the EU to tackle these challenges,
- Outline the current state of knowledge and gaps in the area and provide some examples of current Swedish research, and
- Propose orientation and key components of a new research programme (draft text for the call for proposals).

For a full description of the assignment, See appendix A1.

The expert group met in Stockholm during February 6–8, 2019 to formulate the key findings of the assignment. The group were also assisted in their deliberations through the views and recommendations of a stakeholder workshop organised by Mistra on February 7, 2019 gathering invited representatives of the Swedish Food system stakeholder community (see appendix A2 for participants of this Stakeholder workshop)

This background report should not be read as a thorough assessment of the status of the field. Rather, it strives to go beyond what is already known and to identify relevant and worthwhile future research focus areas and themes for a potential forthcoming Mistra programme on "Food Security and Sustainable Food Systems".

2 Definitions and Concepts of Food Security and Food Systems

Food security can be interpreted in different ways. The most basic interpretation is food security in order to prevent hunger and for providing basic needs, including safe and healthy diets. Food security – supplying "all people at all times" often explicitly s linked to resilience in the face of interruptions; particularly when countries have a heavy reliance on food imports. With a Western, developed world, "just-in-time" food system, one potential route to ensure resilience is through increasing the local self-sufficiency; but other solutions also exist, such as ensuring that trade itself is resilient, or increasing the ability to store food within the country.

A second interpretation of food security is "market-led" food security, where demand needs to be met by markets, irrespective of whether the food is necessary for human health, or has an unsustainable environmental impact.

Sustainable food security is about how to supply diets that are nutritious, acceptable and safe, and produced in a sustainable manner, providing sufficient profits for actors in the food system.

In this report, we frame food security as an outcome from a sustainable and resilient food system, not with a focus on meeting demand per se, but ensuring health, sustainability, and, if necessary, modifying demand (e.g. changing incentives, via policy, in order to reduce waste, change food environments, and relative food prices) to do so.

The concept of a "food system" is increasingly becoming the entry point for analysis and discussions on how to produce sufficient and affordable food and nutritious diets for a growing population in a sustainable way, where "sustainable" is broadly taken to mean that it will not compromise the ability of future generations to meet their own needs (Brundtland, 1987). We define the food system as *"encompassing the activities and actors in the production, transport, manufacturing, retailing, consumption, and waste of food, and their impacts on nutrition, health and well-being and the environment".*

The food system perspective stresses the importance of linkages and feedback loops between food production and consumption, and between human and environmental health, through diets. It recognizes that agriculture is not an end in itself, but the means of producing food (or other produce) for a market. It therefore emphasizes that changes in farming practice can come about directly (e.g. through agricultural innovation) or via markets changing the incentives to grow produce in different ways.

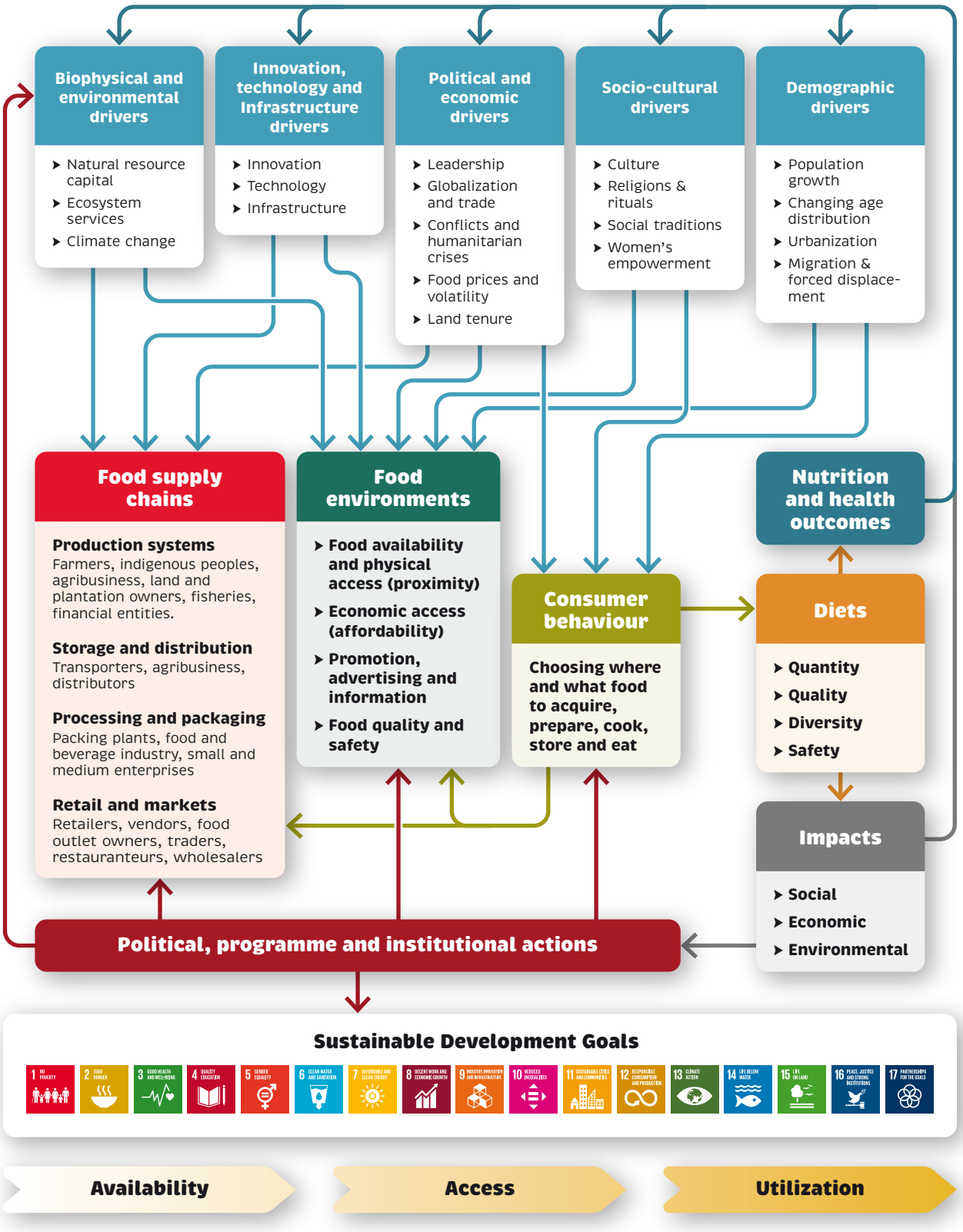


FIGURE 1. A visualisation of a food system and its interconnections.

SOURCE: HLPE. 2017. NUTRITION AND FOOD SYSTEMS. A REPORT BY THE HIGH LEVEL PANEL OF EXPERTS ON FOOD SECURITY AND NUTRITION OF THE COMMITTEE ON WORLD FOOD SECURITY, ROME.

3 Food, Nutrition Security and Agricultural Challenges in a Global and Swedish perspective

3.1 A global perspective

3.1.1 The triple burden of malnutrition

Today global agriculture is more productive and efficient than ever. Since the 1960s global agricultural production has risen enormously. Whilst the global population has risen by 142% between 1961 and 2016, average yields increased by factor of 193% and calorie production by a factor of 217% (FAO, 2018).

Yet, at the heart of this achievement there is a paradox: as the efficiency of production has increased, the efficiency of the food system as a whole – in terms of delivering nutritious food, sustainably and with little waste - has declined. Yield growth and falling food prices have been accompanied by increasing food waste, from the field to the consumer, and a growing burden on human health associated with poor diets and unsustainable environmental degradation.

In spite of the significant progress in reducing global hunger, the world is still far away from a situation of sustainable food security and nutrition for all. Close to 800 million people are chronically undernourished in terms of calorie deficit to meet basic energy needs and 2 billion people suffer from micronutrient deficiency affecting their ability to live a healthy and active life (FAO 2018). The recent trends are worrying since the number of undernourished people in the world increased from 777 million in 2015 to 815 million in 2016. Much of this worsening trend in global hunger is linked to persistent conflicts exacerbated by climate shocks.

At the same time, roughly 1.9 billion people are overweight and obese. The double burden of malnutrition, undernutrition and micronutrient deficiencies (so called “hidden hunger”), and overweight and obesity, contribute to increased susceptibility to infectious and chronic diseases, a growing burden of non-communicable diseases, and therefore premature deaths. Around 44% of 129 countries investigated are struggling with both undernutrition and obesity simultaneously (Haddad et al, 2016).

3.1.2 Meeting SDG targets require major transformations

Will our food systems be able to deliver sustainable and nutritious food to feed a growing global population? This question is key to achieving the Sustainable Development Goals articulated in the 2030 Development Agenda which calls for the eradication of hunger, improvement in natural resource management and human nutrition and health amongst other goals. How much food is needed, what type of food should it be and how should it be produced, processed and distributed are central to current debates on sustainable food systems.

Some estimates of future food demand imply the need for increases of between 60–100% in production (Bruinsma, 2009; Tilman 2011) before 2050. More recent assessments however suggest that to meet the SDG targets for ending hunger and achieving food security and better nutrition (SDG2), it will not be necessary to increase agricultural production by even 50 percent from 2012 to 2050. These SDG targets could be met with a much lower expansion of agricultural output as long as production systems are more sustainable and income and food are more equitably distributed between and within countries (FAO, 2018).

The consensus is that current food systems are capable of producing enough food for a growing population (FAO 2018), but to do so in an inclusive and sustainable manner that will result in improvements in human nutrition will require major transformations, in the way we consume and also produce food (WRI, 2018, Willet et al, 2019). Thus, transforming the food system is the essential key to delivering healthy and sustainable diets and achieve the improvements in health, food and climate security envisioned in the SDGs (Swinburn et al. 2019).

3.1.3 Failing Food systems

Where are the major failures in our current food systems? In the past year a set of major reports from the agricultural, health, and environmental perspectives have outlined the failures of the food system – with a remarkable degree of consistency amongst their findings (WRI, 2018; Willet et al. 2019; Swinburn et al, 2019; EASAC, 2017; IAP, 2018)

3.1.3.1 Unhealthy diets, accelerating obesity and increasing health costs

Dietary-related ill-health is now recognised as the prime global determinant of mortality (Initiatives, 2018; Stanaway et al., 2018). As nations urbanise and incomes rise above poverty level, diets tend to become richer in meat, dairy sugar, fats and refined carbohydrates. Although a rise in consumption of meat and dairy by the wold's poor supplies critical micronutrients, high rates of meat consumption (processed and unprocessed) has been associated increased risks of chronic and damaging diseases including cardiovascular diseases and cancer (Willet et al, 2019). Globally, malnutrition from overconsumption of calories now affects more people than undernutrition, and in 2016, more than 1.9 billion adults were overweight and of these over 650 million were obese (WHO, 2018). The obesity pandemic has immense public health costs and contributes to an increase in the incidence of non-communicable diseases, such as cardiovascular diseases, diabetes, and a range of cancers. By 2025, it is estimated that globally there will be over 700 million people with diabetes (NCD-RisC, 2016).

3.1.3.2 Food waste

It has been estimated that about a third of the world's food grown is lost or wasted, which embeds an enormous amount of energy, water land resources including all the externalities connected to its production. Food loss and waste have many negative economic and environmental impacts (Lipinski et al, 2013). Economically, they represent a wasted investment reducing farmers' incomes and increase consumers' expenses. Environmentally, food loss and waste inflict a host of impacts, including unnecessary greenhouse gas emissions and inefficiently used water and land, which in turn can lead to diminished ecosystems services. Reducing food loss and waste could therefore be one of the leading global strategies for achieving a sustainable food future.

In much of the EU as in North-America, a large proportion of food waste occurs either on farm (where crops that don't meet quality or cosmetic standards can be ploughed back) or else occurs mainly in the downstream part of the food system chain, by retailers, in homes, restaurants and institutions. The collection and analysis of data (Stenmarck, et al, 2016) estimates that for 2012, some to 92 kilograms of household food waste were generated per person and year in the EU-28 (see table 1), which is roughly half of total food waste.

TABLE 1. Estimates of food waste in EU-28 in 2012, includes food and inedible parts associated with food.

Sector	Food waste, million tonnes with 95% CI	Food waste, kg per person/year with 95% CI
Primary production	9.1 ± 1.5	18 ± 3
Processing	16.9 ± 12.7	33 ± 25
Wholesale and retail	4.6 ± 1.2	9 ± 2
Food service	10.5 ± 1.5	21 ± 3
Households	46.5 ± 4. 4	92 ± 9
Total food waste	87.6 ± 13.7	173 ± 27

*Data from the EUFP7 FUSION Programme, (Stenmarck, et al, 2016)

3.1.3.3 Failing natural resource management and the externalisation of environmental impacts

The vast improvements in productivity and food supply we've seen over past decades have come at a high price with severe rates of natural resource degradation as well as environmental damage. Food production is the largest cause of global environmental degradation and currently, policies, institutions and technologies that shape many food systems do not provide incentives for sustainable management of natural resources that provide a wide range of ecosystem services. Rather, they focus on productivity increases at the expense of other ecosystem services such as biodiversity conservation, soil nutrient cycling, carbon sequestration etc. The food system is estimated to contribute approximately 20–30% of global GHG emissions, although there is inherent uncertainty in these estimates (FCRN, 2015). The major sources are from land use change as well as nitrogen fertilizer use. Rice production and livestock production together contribute to as much as 24% of global GHG emissions. Livestock alone contribute 14.5% of human-made GHG emissions. Agriculture also contributes the largest share of global methane and nitrous oxide emissions. Most of agricultural methane emissions result from enteric fermentation during the digestive processes of ruminant animals, and from rice cultivation. Increasingly, reducing emissions from the agricultural sector will become essential to meeting climate targets.

Current incentives for production are based on prices that do not include the costs (or values) of ecosystem services (or the health impacts of consumption). In increasingly globalized systems, long supply chains that reduce transparency can also give rise to social and environmental externalities – e.g. non-equitable and/or environmentally damaging modes of production. Agricultural practices and conversion of natural ecosystems to croplands and pastures is the largest factor causing biodiversity loss and species extinction at globally. Externalisation of costs promotes unsustainable agriculture practices that lead to degradation of soils, nutrient degradation, depletion and degradation of water resources, pollution from agri-chemical use (Pretty et al, 2010).

3.1.4 Increased vulnerability and risks in the current food system

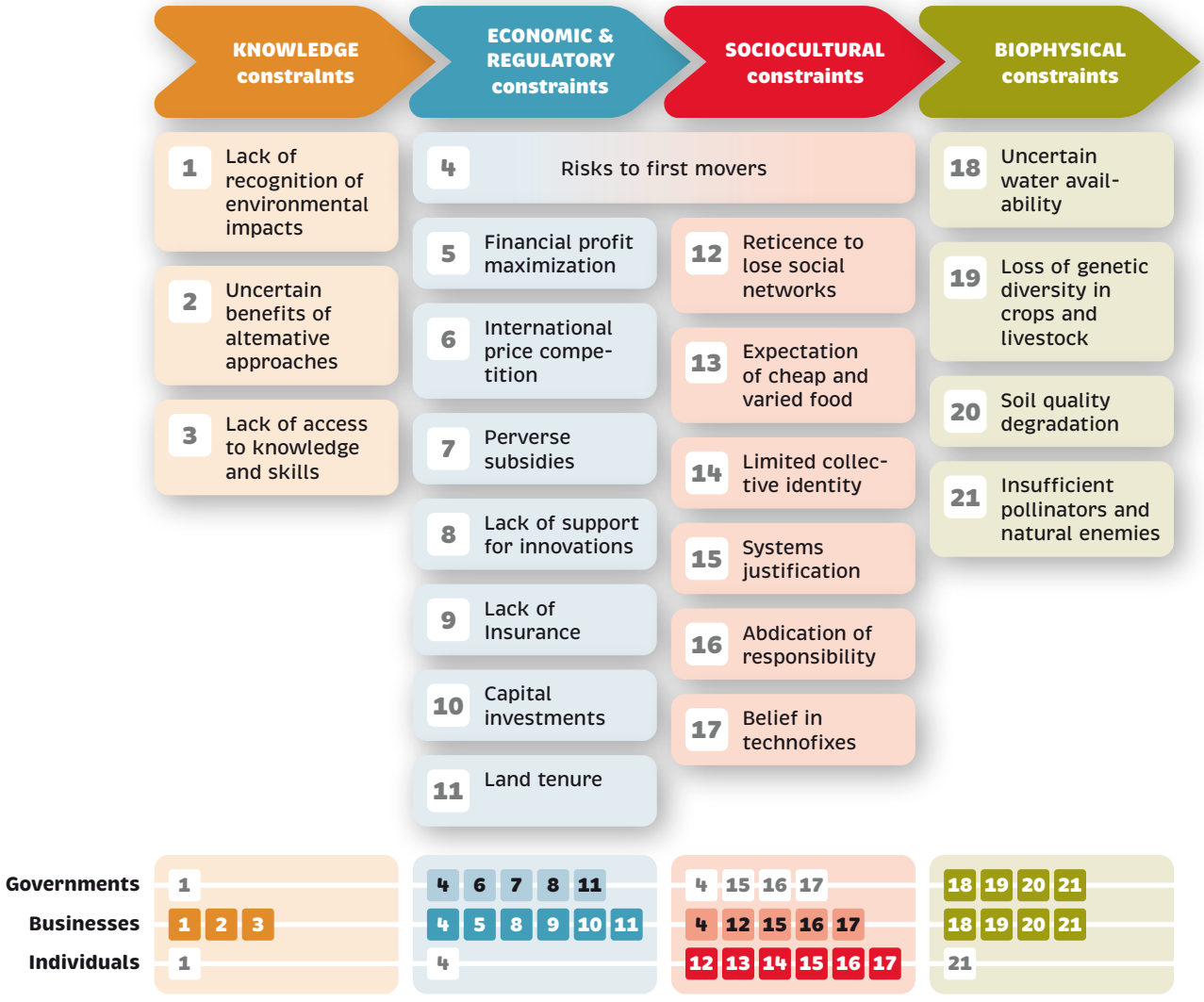
Overall the global food system is highly vulnerable to climate change – through projected changes to agricultural production systems, to potential disruptions in food chains and problems with food safety and storage systems and volatility of food prices.

The current dynamic and complex structures of the global food system also results in increasing vulnerability and risks in the food system. The focus on productivity with associated highly specialized farming, globalization of trade, and complex interdependencies within the system have increased vulnerability of individual actors in the food system to volatile market and climatic / environmental

conditions. For example, decreasing diversity in the farming systems and landscapes tends to be associated with decreased resilience at agricultural holding level (Abson et al, 2013). Globalisation of trade, specialisation and integration of supply chains have also introduced new risks and removed some types of resilience associated with more diversification, resulting in greater potential for cascading effects and amplification of risks in the system. For example, the specialization in livestock production, increased use of prophylactic use of antibiotics in intensive livestock system, coupled with high speed of trade and wide distances have increased the risk of spread of zoonotic diseases, posing risk both to food prices, food security and human health.

Complex transboundary mechanisms amplify the risks in the system. This is expressed by Challinor et al. (2017) "...For example "long-term" climate-induced changes in the global pattern of land-use suitability send price signals that result in unsustainable intensification of land, with the risk of degrading land further. This increases the pressure on the food system which may reduce its resilience, as well as enhancing climate risks through increasing sectoral emissions. With different comparative advantages, the same price signal could simply result in increasing reliance on food imports for any country. Decreased affordability of food, especially for vulnerable groups, can result from short-term food shocks as well as these longer-term changes. The resulting risks to health and nutrition can themselves be compounded by interactions, for example between the natural and built environments resulting in increased risk of plant and animal disease... "

FIGURE 2. Some of the mechanisms locking the food system into its current undesirable state.
SOURCE: FROM OLIVER ET AL, 2018.



3.1.5 Governance failure and lock-ins

The global connectivity and network asymmetry make the governance of the global food system complex. Poor policy responses in one area / locality can result in global impacts, for example via increased food price volatility. The inefficiency of the system in terms of food waste, inequality in food access and nutrition level, as well as health impacts through agro-chemical pollution, or social impacts such as loss of cultural and biological diversity are a symptom of governance failure (IPES-Food, 2018).

Transformation of food systems to more sustainable forms is hampered by several mechanisms that 'lock-in' current states of food systems, including knowledge-based, economic/regulatory, sociocultural and biophysical constraints (Oliver et al. 2018). These main types of constrained are outlined in Figure 2.

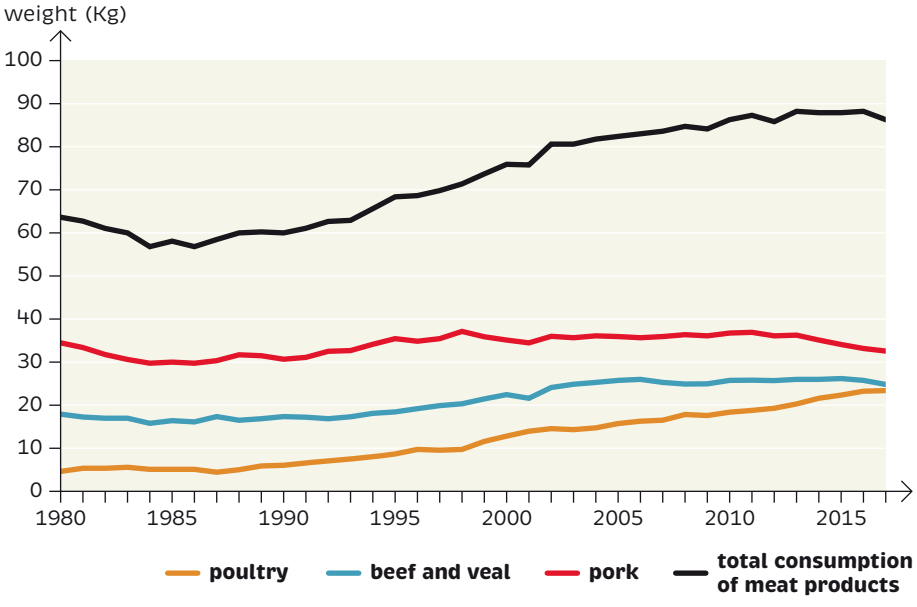
3.2 The Swedish perspective

3.2.1 Swedish food consumption and obesity trends

Swedish consumers are fully connected to a global food market and provided with an abundance of fresh fruits, vegetables and a diversified offering of products in Swedish supermarkets throughout the year. Over the last 50 years, there has been an overall increase in calorie intake per day in Sweden. Some of the consumption trends include a higher consumption of meat, but also vegetables and fruits, and a lower consumption of milk per person.

Food imports have also increased, where animal-based products, such as beef, pork and cheese, have seen large increases (Figure 3 below). The total consumption of meat has increased from 60 to 87 kilograms per capita per year from 1980 to 2015. This is largely due to an increased consumption of beef, pork and poultry. While beef and pork consumption have increased since 1990, the consumption of beef has stagnated in the past 10 years. Poultry consumption has increased by nearly a factor of 4 since 1990. In 2017 the meat consumption per capita actually dropped by 2.6% (2.2 kg) to roughly 85 Kg/person/ year. A survey from 2017 (Axfood, 2017), shows that number of vegetarians in Sweden remains at 6%. Some 40% of survey respondents say they eat vegetarian food at least once a week and almost a quarter (24%) stated that they plan to reduce their meat consumption in 2018. Half of the respondents state that they eat vegetarian food for environmental and climate reasons, while 37% state health as the main reason.

FIGURE 3. Total consumption of different meat products in Sweden from 1980-2015.
SOURCE: JORDBRUKSVERKET 2018A.



As for health, a survey from 2016 showed that 28 percent of women and 42 percent of men were overweight. The prevalence of obesity has increased among adults during the period 2004–2016 and was 15 percent among both women and men in 2016. (Folkhälsomyndigheten, 2018). Obesity is among the main five risk factors in Sweden for healthy years of life being lost.

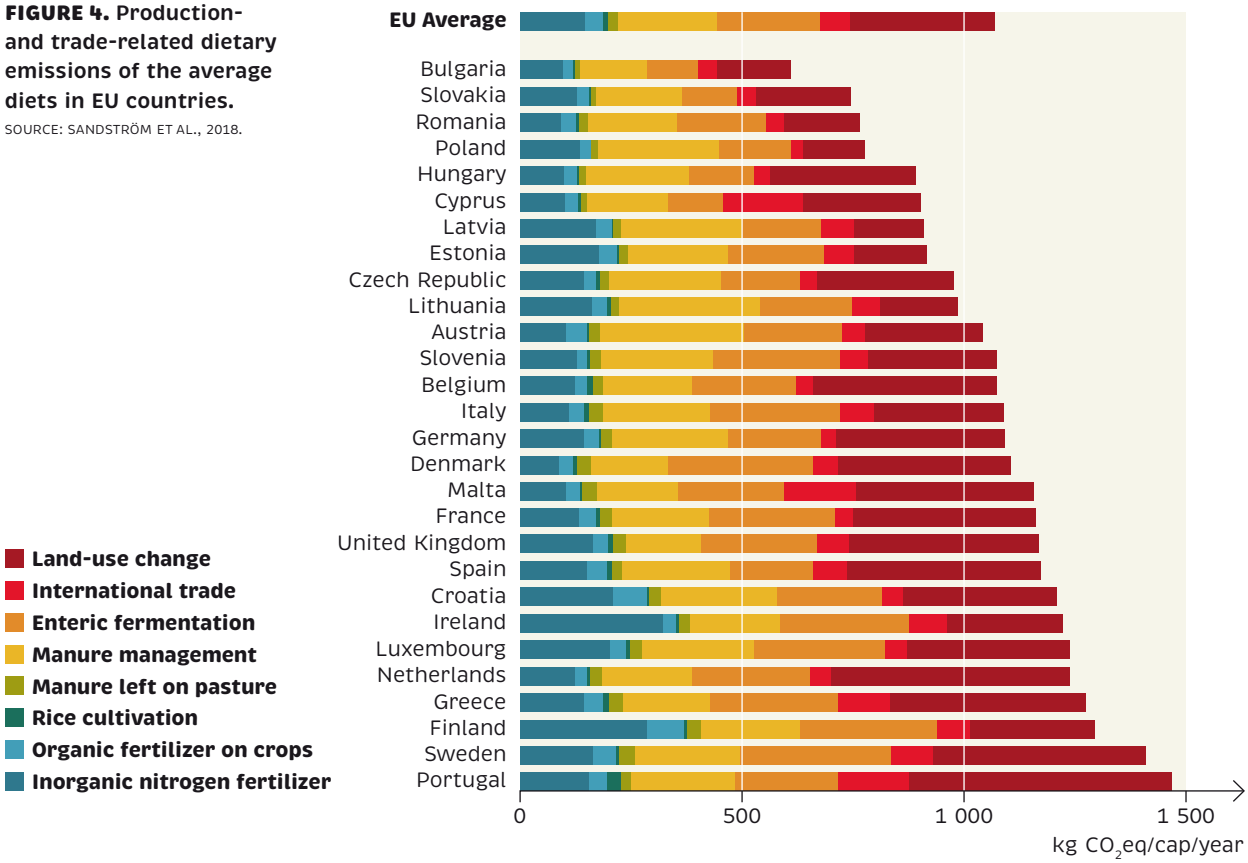
3.2.2 Environmental impact of the Swedish Food System

3.2.2.1 Comparing with an EU average and Swedish food consumption impact outside of Sweden

The environmental impacts of the Swedish food system are in many areas lower than that of EU on average. For example, in a study from 2013 (SMED 2013), it was estimated that nutrient leaching from arable land is Iower in Sweden than in EU, on average, 19 kg Phosphorus(P)-Nitrogen(N) /ha/year for Sweden as compared to 35 Kg P-N/ha/year as an average for EU countries. The same is true for pesticide use, where the use of pesticides per hectare cropland in Sweden is roughly 0.8 kg active ingredients/ha/year in comparison to an EU average of 3.3 kg/ha/year (EFSA, 2017).

Using data from Eurostat, on agricultural GHG emissions as expressed as per tonnes CO_2 equivalents per hectare, Sweden has marginally lower GHG emission 2.1 kg ha/year, as compared to 2.2 kg ha/year as an EU average (Eurostat, 2018a). A study by Sandström et al, (2018) gives a more comprehensive overview of greenhouse gas emissions from Swedish diets. In this study, which includes GHG footprints for food consumption from trade and food import, Sweden has significantly higher GHG emissions, almost 1 500 kg CO_2 equivalents/person/year than an EU average, of approximately 1 100 kg CO_2 equivalents/person/year (see figure 4). This is also corroborated in the research project PRINCE (Policy-Relevant Indicators for National Consumption and Environment), where total greenhouse gas emissions from Swedish food consumption including food import and food produced in Sweden is estimated to roughly 2 000 kg CO_2 equivalents/person/year (Steinbach et al., 2018; Cederberg, 2018)

FIGURE 4. Production- and trade-related dietary emissions of the average diets in EU countries.
SOURCE: SANDSTRÖM ET AL., 2018.



The PRINCE project also visualises the environmental footprint of Swedish food consumption outside of Sweden. In terms of land use, some 3 million ha of crop land, and 1.44 million ha of pasture land were appropriated in 2011 outside of Sweden for food import and consumption in Sweden. This should be seen in relation to the crop land (2.3 Million ha) and pasture land area (0.4 Million ha) used in Sweden. In terms of pesticide use, the differences between pesticide use in Sweden and abroad for producing the food imported to Sweden is large (see table 2 below).

Taken together, this visualises that the environmental impacts in other countries caused by Swedish food import are significantly higher than the environmental impacts from food production in Sweden (Steinbach, et al., 2018; Cederberg, 2018).

TABLE 2 on Pesticide use in Swedish agriculture compared to the use of pesticide abroad to produce Swedish food import.

Type of Pesticide	Total use in Swedish Agriculture (in tons of active ingredients)	Total use for production of food imported to Sweden (in tons of active ingredients)	Percent higher use of pesticides outside of Sweden for food imports
Herbicides	1 232	2 934	240%
Fungicides	317	1 636	520%
Insecticides	28	659	2 400%

SOURCE: CEDERBERG, 2018.

3.2.2.2 Climate change, Greenhouse Gas Emissions trends and Swedish Climate policy goals

Climate changes is expected to have both positive and negative effects on Swedish agriculture. The higher carbon dioxide levels are expected to increase yields by about 5%. The potential to grow more winter crops and crops like corn are also expected to get better. On the other hand, crop conditions can also deteriorate due to increased risks for drought and flooding. This puts greater demands on water infrastructure in agriculture such as ditches, covered ditches, embankments and irrigation dams. Climate change also increases the risk for outbreaks of infectious animal and crops diseases (Roos et al., 2011), mainly due to ecosystem changes and increased presence of insect vectors. Many vector borne diseases are zoonotic, and may spread between animals and humans (Naturvårdsverket, 2017b).

In 2015, emissions from the agricultural sector were about 6.9 Mt CO_2 eq, which equals 12.5% of the total national greenhouse gas emissions (excluding Land Use, Land Use Change and Forestry, LULUCF). About half (51%) of the sector's GHG emissions consisted of N2O, 47% CH_4 and the rest is CO_2. The main sources of greenhouse gas emissions from the agricultural sector are methane emissions from cattle and nitrous oxide emissions from soil and manure, which are almost equal in size (Martin et al, 2016). In 2015, agricultural emissions were about 10% lower compared with 1990. The decrease in emissions from agriculture is explained by a decline in livestock numbers and a decrease in emissions from agricultural soils. The long-term trend is decreasing emissions, although emissions have levelled out over the last few years due to an increased use of fertilisers. Within the Swedish agriculture sector, agricultural soils and enteric fermentation) are the largest GHG emission sources, accounting for 46% and 44%, of GHG emissions respectively.

As shown by Sandström et al, (2018), Steinbach, et al., (2018); Cederberg, (2018), production-based emissions calculated on national production underestimate GHG footprints of the whole food system, and land use change (LUC) emissions related to food imports can be a large source of food systems GHG emissions. As international trade plays an important role in the Swedish food system, dietary GHG emissions accounting should take this into account. However, no standard method exists for accounting land use change emissions, and the various methods result in varying emission factors and therefore greatly impact on the results.

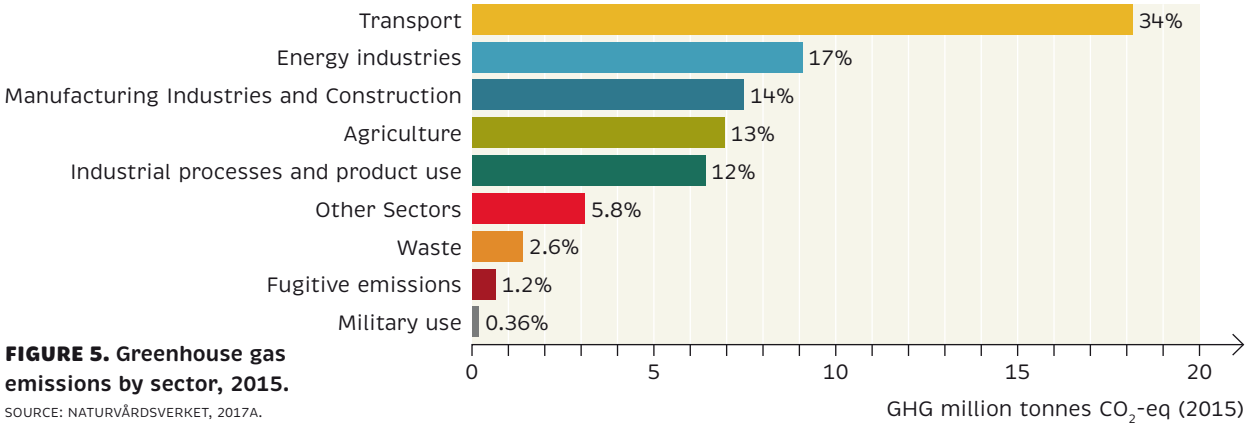


FIGURE 5. Greenhouse gas emissions by sector, 2015.
SOURCE: NATURVÅRDSVERKET, 2017A.

This makes GHG emissions calculations difficult to use in consumer information. Its therefore important that the underlying assumptions behind the accounting schemes are discussed in a transparent and understandable way to guide consumers toward more sustainable consumption choices.

The Swedish Climate policy goals are to become carbon neutral with "zero net" GHG emissions by 2045 and net-positive beyond that year, and all sectors (industry, transport, energy etc) are expected to reduce their GHG emission dramatically. The expectation for reaching the target in the agricultural sector is however lower as it is generally believed that agriculture, among all sectors, will have the greatest difficulties in reaching "net zero" GHG emissions. This is not least due to animal husbandry. However, a "net zero" GHG emissions target in the agricultural sector would be an important driving factor for decarbonising the Swedish economy and for innovation within the sector. Much would therefore be gained if means, tools and pathways for a "net zero" GHG emission agricultural sector were to be developed. In addition, the role of agriculture for other sectors to reach their targets needs to be further analysed, for example the production of biofuels and other bio-based non-food resources.

3.2.2.3 Reducing food waste in Sweden

The food waste at household level in Sweden is 92.8 Kg/person/year and appears to be comparable to an EU average level according to report through the EUFP7 Fusion programme (Stenmarck, et al, 2016). Most of the food waste in Sweden, as in the EU, is generated at the household level.

In response to the need to reduce food waste the Swedish National Food Agency, in collaboration with the Swedish Environmental Protection Agency and the Swedish Board of Agriculture, has developed an action plan "More to do more", in order to reduce food waste throughout the whole food chain including steps and actions in all parts from the farm to the customer. The assignment extends over three years from 2017 to 2019. The action plan contains 42 proposed measures and specified needs as regards investigation, research and innovation (Livsmedelsverket, 2018). There is a Swedish National Target on Food Waste that by 2018 at least 50 percent of food waste from households, institutional kitchens, shops and restaurants must be sorted and treated biologically so that plant nutrients are utilized, with at least 40 percent being treated so that the energy is also utilized.

3.2.3 A potential to produce more?

Currently the Swedish agriculture sector is dominated by dairy/ livestock related production (EU, 2018a). The value of the Swedish export of agricultural and food products has increased since 1996 by roughly 300%, while import increased by some 400% (Cederberg 2018). Sweden has a potential to increase food production and food export (e.g. through increased agriculture and aquaculture production) due to good agricultural conditions with good availability of freshwater, low disease

pressure due to cold winters, and large areas of fertile lands which today are used in a less extensive manner, some being converted into forest areas.

In the light of a changing climate with potentially negative impacts on agricultural production worldwide, Sweden may be one of the few countries that actually are able to increase its production. But this may generate more GHGs and make an ambition to meet a "net zero" target from agriculture more difficult.

At the same time, increasing exports from the rest of the world may cause increased pressure on the environment and the safe operating space. Options for increasing production under different conditions will be key to determine. Such an analysis would require a systemic food system analysis, analysing trade-offs, and impact on factors such as environment, human health, land use, livelihoods, international competitiveness and so forth.

3.2.4 The high costs and profitability challenges of Swedish Agricultural Food Production

Sweden has, by international standards, high taxes on fertilizers, pesticides and CO_2 which, according to many farmers and the largest Swedish farmers organization, LRF, has placed an additional financial burden on Swedish farmers making them less competitive internationally. This has also led to weaker market position for farmers on the Swedish market.

At the same time, LRF, farmers and many Swedish food system actors use a "marketing argument" that Sweden has one of the most environmentally friendly agricultural systems in the world. The LRF slogan, introduced already in 1992, "Swedish farmers towards the world's most environmentally friendly agriculture" has since long been embraced by many Swedish famers and food system actors. Thus, in that sense these fertilizers, pesticides and CO_2 taxes have been helpful. But, profitability margins in the Swedish farming sector has been alarmingly low for many years, and during the period 2000–2017 the average profit margin has been minus 3% (see figure 6).

These low profitability margins are propelling a fast transition to larger, more cost-effective farm units. The low profitability for Swedish famers is worrying in light of an increasing demand for new investments (modern production facilities, new machinery, business development, etc) needed to meet price fluctuations, climate change and increased farm sustainability.

Although the costs of agriculture primary production are generally higher in Sweden, the competitiveness (domestically and/or internationally) may be maintained if consumers of agricultural products are prepared to pay more for products produced in Sweden. As reported by Gullstrand and Hammarlund (2007), there has been an argument that Swedish production is characterised by more environmentally-and animal-friendly methods and a higher level of food security. Consum-

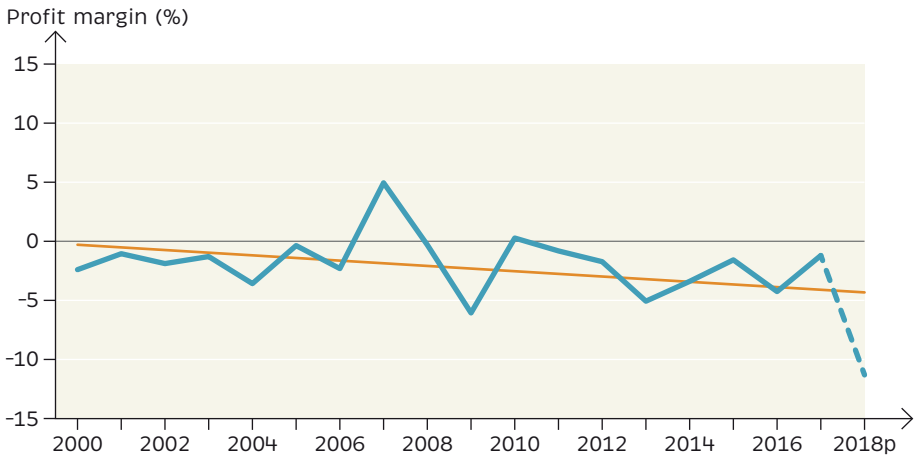


FIGURE 6. The declining rate of profit margins of Swedish farms from 2000 to 2018 (Profit margins after deprecations and salaries to farm owners* as percentage of farm turnover). Only two year with profits between 2000 and 2017.

SOURCE: PICTURE AND DATA FROM OVE KARLSSON; SLU BASED ON DATA FROM JORDBRUKSVERKET: JORDBRUKSSTATISTIKS SAMMANSTÄLLNING 2018, WWW.EKONOMIFAKTA.SE AND OWN CALCULATIONS BY OVE KARLSSON, SLU.

*Farm owner salaries calculated on the basis of an average of 16 400 SEK/month, before taxes.

ers should, at least in theory, therefore be prepared to pay more for Swedish agricultural products. However, their analysis showed that Swedish products in general do not receive higher prices on the European market. In the cases where there is a difference in price, the Swedish products are more often valued lower than other products. On the Swedish market, there is a premium price for Swedish farm produce meeting high environmental and animal-welfare standards. Most of the profit margin for these products is however captured by the retail sector.

3.2.5 Co-creating an agenda for a sustainable Swedish Food System

In a Mistra consultation, a selection of key Swedish Food system stakeholders (see appendix 2) expressed their views on the changes required, and the barriers preventing the development of a more sustainable, productive and resilient Swedish food system. A broad consensus emerged on the need to improve the sustainability of the Swedish food system. However, there are diverging views on what a sustainable food system would look like and the pathways for getting there. The mass of different and often conflicting messages (facts vs opinions) from the scientific community, authorities, industry and civil society influencers about what's sustainable and what's not in the Swedish food system creates confusion and distrust among consumers.

These conflicting views also stifle innovation and action among food producers. In order to address this divergence and create more unity, the participants called for constructive collaborative dialogues and co-creative efforts finding new and more inclusive and effective ways of measuring and communicating progress towards a sustainable and resilient food system. This could include new metrics that apart from conventional ways of measuring productivity, (e.g. food production per unit land, labour, capital, and inputs of fertilizer and pesticide), also incorporate health, environment and social impacts in the measure of progress.

Participants also called for increased efforts to use scientific (including social sciences) and technology advances to achieve systemic change and move towards a more sustainable food system. Increased innovation efforts, supported by an innovation ecosystem, and their functional deployment contributing to new business models strengthening the competitiveness of Swedish farms, value chains and food businesses are equally important.

Agreeing on the need to transform the current Food system, participants also highlighted some of the key barriers to such transformation, including, lack of:

- appropriate infrastructure (e.g., a lock-in in unsustainable production methods or inability to process new types of raw materials and food products),
- economic incentives for large scale transformation (e.g. demand and willingness to pay for healthy, sustainable food still inadequate)
- venture capital (e.g. risk capital driving a systemic change a limiting factor)
- an enabling environment (such as taxes, policies, public procurement, subsidies working against or not effective enough, in driving food system towards sustainability etc.)

To remove barriers and supporting actions and interventions in support of a food system transformation, a broad agreement on transformation pathways and well-anchored food system visions are needed. The participants agreed on the need for interdisciplinary, co-creative, knowledge building processes involving a broad range of food stakeholders in order to develop a vision for what a Swedish food system - that is economically, socially, environmentally sustainable, and resilient – would look like, and how to get there.

Sweden has played a leading role in the EU to decrease the use of antibiotics and improved animal welfare standards in the livestock sector. Overall, the question

is whether the Swedish food system actors can play a constructive role in findings ways to induce a systemic change to, and help transform, current unsustainable food system, mainly linear, fragmented and unsustainable, so that they can become more sustainable and resilient.

3.2.6 Policies shaping the Swedish Food system

Sweden has recently adopted the *National Food Strategy for Sweden – more jobs and sustainable growth throughout the country* (Government bill 2016/17:104). The overall objective of the food strategy is a competitive food supply chain that increases overall food production while achieving the relevant national environmental objectives, aiming to generate growth and employment and contribute to sustainable development throughout the country. The increase in production – of both conventional and organic food – should correspond to consumer demands. An increase in production of food should contribute to a higher level of self-sufficiency. Vulnerability in the food supply chain will be reduced. The Government has in its current action plan and as part of the above food strategy formulated a goal that 30 percent of the Swedish farmland should be ecologically certified, and 60 percent of food consumption procured by public institutions (schools, hospitals etc.) shall consist of certified organic products by 2030.

Since 2018 Sweden also has a climate policy framework with new climate goals, a Climate Law and a climate policy council. The climate policy framework is one of the most important climate policy reforms in Sweden's history providing the long-term ambition and conditions for business and society to implement the transition needed to solve the challenge of climate change. The reform is a key component of Sweden's efforts to comply with the Paris Agreement. The overarching climate goal is that by 2045, Sweden will have net zero emissions of greenhouse gases into the atmosphere and should thereafter achieve negative emissions. Agriculture is the sector that is believed to have the greatest difficulties in reaching a zero net GHG emission targets.

There are two key ways that Swedish agriculture can contribute to climate mitigation and meeting Sweden's targets. On the one hand, agriculture can improve the GHG balance within the sector by moving towards net sink situation where emissions from agriculture are smaller than carbon removals in soils and biomass (greening of) on agricultural land. The "greening of" involves reducing emission intensity of production (g CO_2 eq per unit of output), reduced or changed output (e.g. reducing total emissions from ruminant livestock production), and increasing carbon sequestration in soils and biomass (increasing carbon stock). On the other hand, agriculture can support mitigation in other sectors (greening by), for example, through the production of materials for substitution (e.g. bio-plastics) or biomass / waste for bioenergy, or also by placing of renewable energy sources on agricultural land (e.g. photovoltaics or wind). There are potential trade-offs in greening of and greening by approaches for the Swedish agricultural sector and the food system more broadly that need to be carefully weighed in. However, a third way, that is not recognized by GHG inventories, is to reduce the reliance on overseas' products (e.g. food and feed), by tackling the demand for food, and the amount wasted.

The EU Common Agricultural Policy (CAP) is a key EU policy shaping agricultural production in Sweden, with total allocated EU CAP expenditure for Sweden amounting to 6.8 billion in 2014–2020. The Pillar 1 of the CAP, making up 70% percent of the CAP budget for Sweden, provides direct payments to farmers paid per hectare of land. Since 2015, thirty percent of these are so-called greening payments linked to three environmentally-friendly farming practices: crop diversification, maintaining permanent grassland and dedicating 5% of arable land to environmentally friendly measures (so-called 'ecological focus areas').

All direct payments are subject to the cross-compliance mechanism, which makes receipt of CAP payments conditional upon respect of basic environmental

legislation as well as standards for good agricultural and environmental condition of agricultural land. Rural Development Programmes (RDPs) or Pillar 2 make up for 28% of Sweden's EU CAP allocation. RDPs offer a range of measures to Member States to support environmentally friendly farming practices. Sweden also tops-up the available funding for RDP with additional 5.5 billion Euros of national funds for the period 2014–2020. (EU Factsheet on 2014–2020 Rural Development Programme for Sweden)

Whereas the CAP has gone through several rounds of reforms over the last 15 years there is still significant criticism over its environmental performance (EEA 2017a). Much of this criticism centres around the lack of clearly defined objectives, insufficiently ambitious environmental goals, as well as inadequate monitoring of performance and other issues in policy implementation. For example, the European Court of Auditors has recently found that the greening payments have been largely ineffective and unlikely to offer significant environmental benefits, affecting farming practices only on around 5% of EU farmland (European Court of Auditors, 2017). At the same time, the environmental benefits that can be provided by much more targeted and ambitious Rural Development Programmes are limited by their overall budget and shortcomings in their implementation (European Court of Auditors, 2014).

The new CAP framework beyond 2020 potentially offers a significant opportunity to increase the level of ambitions for agricultural policy. The Commission has proposed a shift from the current compliance system towards a more result focused CAP mechanism by introducing the concept of a 'performance based' delivery model of CAP in order to "to streamline its governance, improve its delivery on EU objectives and to decrease bureaucracy and administrative burden". The new CAP should defer more responsibility to Member States in setting out objectives, targets and enable more flexibility to set up tailor-made, fit-for-purpose solutions at national level. There are risks that in the absence of mandatory targets and without earmarking sufficient support and requirements at EU level, the proposed strategic planning at Member states level could dilute rather than increase environmental ambition. However, the proposed increased flexibility could also pave way for more ambitious national implementation of CAP in Sweden, which would more effectively incentivize farmers and creative solutions to support resilient agricultural production and food system.

The environmental, health, bioeconomy and agricultural policy agendas that influence agricultural, food practices and consumer behaviour in EU are also shaping the Swedish food system. This includes, apart from CAP, the EU Common Fishery Policy, EU Water and Waste Framework Directives, EU Circular Economy and Bioeconomy strategies, and EU trade policies and EU's international commitments (e.g. the SDGs, the Paris climate agreement).

The greening the EU food system needs, apart from a greater EU policy coherence, to also adopt a more systematic approach and actions that address consumption and production simultaneously (EAA, 2017b). A well-funded R&D agenda is crucial to support this transition, defining targets, limits, safe operating boundaries, etc. (Bas-Defossez, et al 2018).

In January 2019 the International Panel of Experts on Sustainable Food Systems called for and set out a way for the development of a governance framework at the EU level for a Common Food Policy for the EU. This reaffirms the increasing awareness and commitment across different scales for a more coordinated and coherent policies to facilitate a food system transformation (IPES-FOOD, 2019).

Box 1. The Swedish Food System

The Swedish Food system is characterized by a decreasing number of farmers, a fragmented food processing sector and a highly concentrated retail sector. In the Swedish food industry, more than 99% of firms are small and medium sized enterprises. The most important sectors within the Swedish food industry are bakeries, meat processing plants, and dairies, with more than 50% of the value of output. There is also dominance of a few large retailer chains. The three largest chains, ICA, Coop and Axfood, together controls over 73 percent of the national food market (Eriksson, 2016). Sweden is also an integral part of the EU food system and internal market with its legal and policy framework. The Swedish agricultural and food producing sector (excluding the restaurant and food retail sector) is a relatively small part of the Swedish economy where the primary sector (agriculture, fishing and aquaculture) accounts for 1.3% of the country's economy compared to 1.5% in EU28, and agriculture 1.9% of its employment (4.3% in EU28), The food processing sector is employing altogether some 240 000 persons which is roughly 2.2% of the Swedish workforce. The farmers' average age is high, 74% are older than 50 years and only 4% of farmers are under 35 (6% in EU28).

Most of Sweden, some 60% of the land, is covered by forests. Consequently, many and almost all farms in the northern part of Sweden combines farming with forestry. Total arable land, about 6.4% of the Swedish land classed as land cultivated with permanent or temporary crops, has decreased slightly, from 2 845 million hectares in 1990 to 2 568 million hectares in 2017. The conditions for crop production display large differences between north and south and roughly 70% of the total cultivated land is found in the fertile plains in the south of Sweden. The average crop yield varies in different parts of Sweden. For example for spring barley the average yield in Skåne, the most southern county, is 6 560 kg/ha and in Norrbotten, a county in the north part of Sweden, 1 330 kg/ha.

There are roughly some 60 000 farms which is half of the number of 1970. The average size of Swedish farms is 45.2 ha compared to 16.1 ha in EU28. Due to extensive land renting practices and a movement towards economy of scale the number of farms less than 100 hectares has decreased, while the number of farms larger than 300 ha have more than doubled since 1999. The same is true for the food production sector, where there the large food producing conglomerates are dominating the Swedish market. There is however, an emerging flora of small-scale farmers and food producing actors focusing on niche markets and selling directly to customers. As for land use trends, the open biodiversity rich grazing areas in Sweden are decreasing due to low and not seldom minimal economic margins in the livestock sector.

Crop production is dominated by cereals and leys, the former mainly being wheat, barley and oats with a total cereal production a normal year roughly around 6 million tonnes, with wheat amounting to roughly 3.3 Million tonnes (Mt). For comparison total grain production in EU28, amounted to some 300 Mt and in United States to some 440 Mt. Animal husbandry has been the dominant line of production and a traditional way of adding value to primary produce. Dairy farming is the largest sector in economic terms responsible for 20 per cent of the value of the Swedish agricultural production. The number of dairy farms has been reduced to 3 600 with an average of 90 cows/herd. Sweden exports a normal year some 2 million tons of grains, mostly unprocessed wheat and imports at the same 700 000 tons of grain products, mostly soya-based feed products. Most of the Swedish food export value comes from processed food products, such as dairy products, seafood, grain, and some 15% of Swedish agroexport is Swedish vodka.

Despite its long coast line and more than 100 000 lakes, Sweden has a relatively small fish and aquaculture sector representing a minor part of Sweden's gross domestic product (GDP), around 0.10%. In 2017, the Swedish fishing fleet consisted of 1 225 registered vessels, landing some 222 300 tonnes of fish (3.4% of total EU landings). The Swedish aquaculture sector is dominated by small enterprises (78% have fewer than 5 employees) producing some 12 800 tons of cultivated fish (mostly trout) and clams, which is roughly 1% of the Norwegian total aquaculture production.

The Swedish self-sufficiency rate for milk is 74%, eggs – 95%, pork – 73%, beef – 50% and the rate has been decreasing over time, where the farm and agroprocessors in Sweden has been pressed by a cheaper import (based on statistic from the Swedish Agricultural Board). Consumption of grain legumes is exceptionally low in the Swedish diet, only 1% of total protein contribution, while meat and milk intake is above the global average. In a potential scenario, developed by Röös et al (2018), where meat consumption in Sweden is reduced by 50% and replaced by domestically grown grain legumes. This transition scenario would increase total area of grain legume cultivation from 2.2% (current level) to 3.2% of Swedish arable land and would potentially reduce the climate impact of the average Swedish diet by 20%.

SOURCES: JORDBRUKSVERKET, 2018; EUROPEAN COMMISSION, 2018A; EUROSTAT. 2018B; SCB, 2017

4 Transitioning to a Sustainable and Resilient Food System in Sweden

At present, Sweden has tremendous potential to transform to a sustainable and resilient food system due to its considerable natural, social and financial resources, as well as recognition amongst a wide range of food system stakeholders that change is needed. What will it take to capture this opportunity and spark the Swedish food system transformation? The key elements emerge from the analysis in previous sections on the failures of the current food system, as well as the characteristics that can be leverage points for change. These are laid out in the following 5 sections.

4.1 A systems approach to sustainable food systems, food and nutrition

Before embarking on any attempt to transform the food system, it is important to adopt a systems approach to analysing problems and their possible solutions. The food system definition demonstrates the importance of seeking sustainability in three dimensions – environmental, economic and social (including people's health relating to diets) – at every stage of a food system, from agricultural production, processing, and retailing, to consumption. Creating the enabling conditions for the shift to more sustainable food systems requires systems-based approaches that consider the range and complexity of interactions and feedback loops prevalent in the system. A systems approach makes explicit the links and interdependencies between food production, distribution, consumption, and nutritional health as well as their relation to the underlying social-economic, biophysical and institutional elements. These are the key factors that ultimately affect the quantity, quality and affordability of food, as well as health, wellbeing and environmental impacts from both production and consumption. The systems approach recognizes the presence of multiple objectives that may give rise to trade-offs. It also explicitly considers interactions between various scales and segments of the food system, which is essential in identifying possible leverage points to facilitate desired changes throughout the food system.

4.2 Which future – and whose vision?

Transforming to a sustainable and resilient food system requires the development of a common vision amongst key stakeholders, as well as considerations of possible changes that might occur in the future that would affect this vision and the means of achieving it. In previous sections of this paper we have outlined various facets of the failures in current food systems, as well as their key drivers. These include socio-economic trends such as demographic transitions and shifts in glob-

al trade policy as well as environmental challenges such as climate change and natural resource degradation. We cannot assume that the trends we have witnessed in the recent past will continue in a linear or predictable fashion – and in fact, we are facing considerable uncertainty in how they may shift in the near future. Taking account of these uncertainties is an essential element of visioning a resilient and sustainable food system, as the nature of a sustainable and resilient food system in Sweden – and the actions needed to achieve it – will vary considerably depending on how the trends of key drivers play out over the future.

A sustainable Swedish food system in a world where global food trade has broken down is likely to be quite different from one in a world with a well-functioning global trade system. For this reason, it is important to develop a clear sense of the uncertainties underlying key threats and opportunities to resilience and sustainability for the Swedish food system, and to consider how these could constitute plausible alternative futures under which transformation should occur. Developing scenarios for these alternative futures and the potential pathways to desired change under varying assumptions is needed to guide development of a robust plan of action. Different stakeholders in the food system will have varying perspectives on the key uncertainties they face, their vision of the desired future food system, and the transition pathway to achieving it. Thus, it is essential to bring them together in a participatory and structured conversation. Addressing the multi-faceted aspects of a sustainable and resilient food system will require the participation of farmers, food processors and industry representatives including those involved in food trade, consumer and civil society groups, as well as stakeholders from the health, environment and climate change communities.

The process of scenario development supports the co-creation of the vision for sustainable food system future for Sweden. It also generates indications of potential transformation pathways and key entry points to achieve change under the different alternative futures.

4.3 In a sustainable and resilient food system, could agriculture play a more important role in meeting Sweden's climate change commitment?

Sweden has committed to ambitious goals for reducing GHG emissions overall, but the agricultural sector has been identified to have specific challenges to contribute to that goal. In the context of shifting to a sustainable and resilient food system, it is worth revisiting the degree to which agriculture could play a more important role, within the context of the overall transformation to a sustainable and resilient food system. Taking a zero net emissions goal by 2045 as a boundary condition for agriculture, what would be the costs and trade-offs with other social goods and services under different scenarios of the future food system? What are possible implications for Swedish diets and consumers? What trade off might there be with other ecosystem services such as biodiversity conservation, soil and water management?

4.4 New metrics needed

Metrics are key to articulating what we mean by success in achieving a sustainable and resilient food system and measuring progress towards achieving it. However, we are still using metrics that are outdated and which give the wrong signals in terms of measuring progress. Food and agricultural policy remains preoccupied with food supply – particularly in terms of agricultural productivity and efficiency, through maximising the growth rate of yields, or more recently in the framing of sustainable intensification Total Factor Productivity Growth (TFP), also described as "growing more with less." TFP measures the efficiency of food production with

respect to the familiar economic inputs of labour, capital, land and chemicals, and fails to capture inputs of natural capital or further costs such as those externalised onto healthcare systems. Therefore, whilst increasing TFP remains the prevailing objective of agricultural policymaking, broader considerations of nutrition, health and the environment essential to the progress in sustainable and resilient food systems are not included.

A better metric would be Total Resource Productivity, or TRP, which extends TFP to include inputs of natural capital (*39*) and so provides a measure of sustainable productivity. Conceptually, such a measure could be further extended to include as inputs other externalised costs such as the health-care costs associated with agricultural production (e.g. via air quality) or from dietary-related ill health, or the costs associated with disposal of food waste and packaging; the outputs, rather than being yield, could be the number of people nourished. This would measure Total System Productivity (TSP).

A food system with high TSP would be sufficiently productive (to meet human nutritional needs) whilst imposing few costs on the environment and society (so being sustainable), and highly efficient at all stages of the food chain so as to minimize waste. It would optimise total resource inputs (direct inputs and indirect inputs from natural capital and health care) relative to the outputs (food utilization). Maximising TSP would maximise the number of people fed healthily and sustainably per unit input (direct and indirect). In other words, it would increase overall systemic efficiency.

Another important aspect to consider in developing new metrics is in relation to performance indicators being developed by Sweden to measure performance in the context of climate change mitigation. This can also be an important means of increasing coordination between climate change and food policy. Developing such metrics and the data needed to support it is no simple task however and requires careful analysis and reflection of the considerable amount of work already ongoing in this area, particularly in relation to SDG indicators.

4.5 Moving forward: building and testing the enabling environment and incentives needed to achieve a sustainable and resilient food system.

How to move forward with on the ground changes in the food system? Section 4.2 suggests that scenarios envisioning a future food system that works for people and the planet might give a starting point for transformation pathways. Government interventions to increase agricultural and dietary diversity and include social and environmental costs in market prices can help enable such a transformation, but do not address the configuration of the food system itself, which is shaped not only by existing policies and institutions, but also by incumbent interests, social norms and cultural values. The literature indicates that systemic transformation often starts from niches – technological, social or institutional innovations that embody new visions for how societal needs can be met. Once these reach a critical mass they become mutually reinforcing and change occurs rapidly. Considering where such niches might emerge in food systems under alternative plausible futures can give indications of potential pathways for transformative change that can be tested in later stages.

Some action areas that have emerged in the context of sustainable food systems that might be relevant in the Swedish case as well are given below, although these are suggestive – not a blueprint for future action.

Increase nutrient density in the food supply. In order to support dietary change, there is a need to re-orient agricultural priorities from producing high quantities of a few crops and uniform food products to producing a greater variety of nutrient

dense and healthy food. Production should focus on a diverse range of nutritious foods from biodiversity-enhancing food production systems rather than increased volume of a few crops, most of which are used for animal production.

Innovation is needed around new food products improving health, and environment, e.g. aqua cultured products, protein crops, algal based food/feed, insects, fungal based food/feed and single cell production systems. Marine harvesting system also needs to change. The global marine harvest contributes only 2% to human food calories (but significantly more in proteins (perhaps up to 15%). Increasing the efficiency of fishery would involve directing capture towards lower trophic levels in the marine food chain.

Change species and systems mix in livestock production systems. There are large differences in efficiency and environmental impact per kg of product between the species, and between production systems within species, e.g. grass fed versus concentrates-fed beef and dairy. Changing species mix, and production systems mix of livestock consumed could therefore bring about significant reduction in some

Change Business models: For food systems to change and be transformed, entrepreneurships, profitability and economic incentives are crucial. Currently the poor profitability of farmers in Sweden and weak incentives for Swedish food system actors to invest in and deploy food system innovations, serves as a barrier for food system change. New Business models, partnerships and an enabling environment for change needs to be developed, linking farmers and agribusiness actors to the expanding market opportunities in a sustainable food system. This would for example include the enabling environment and the business models/cases, to for example;

- convert agricultural and bio-waste to useful products becoming parts of a circular food system
- develop new food products, new plant-based proteins sources, cost effective and sustainable aquaculture system, and meat substitutes based on plant/microbial/ fungal/ insect proteins etc.
- the development of more multifunctional agricultural systems and diverse agrifood systems
- develop ways of selling less for more profit (e.g. by developing premium markets)

Change consumer food choices and diet. Businesses, government and civil society need to move beyond relying solely on education campaigns to shift diets, and instead improve marketing of plant-based foods/dishes. A suite of more sophisticated behaviour-change strategies, including minimising disruption to consumers, selling compelling benefits, maximizing awareness, end evolving social norms has proven successful in shifting consumption patterns in other food and non-food products enabled by digital technologies, a new generation of companies threatens to disrupt conventional food retail with business models that offer new opportunities to improve system efficiency. Meal kit companies offer customers regular deliveries of measured ingredients and recipes according to their dietary preferences, enabling time-poor households to cook meals from whole foods with minimal food waste. Another breed of online retailer is seeking to disintermediate supermarkets by linking consumers to local farmers and food producers, responding to demands for traceability and localism. Blockchain technology will enable businesses to demonstrate provenance and verified sustainability to customers at low cost.

Policy and pricing. Governments, municipalities etc., can support diet shifts through their own food procurement practices, policies and taxes that shape the consumption. Once the qualities and price of nonmeat alternatives rival that of meat, retail level taxes on meat or other animal based-food might become politically acceptable.

5 Swedish Initiatives in Support of a Sustainable Food System

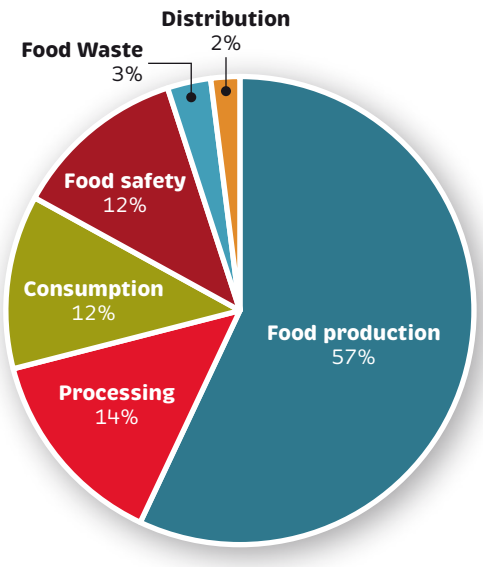
Swedish food system research and innovation initiatives are framed by a large number of regulations and polices. Of relevance for food system research and innovation effort in this context, are the newly adopted *National Food Strategy for Sweden – more jobs and sustainable growth throughout the country* (Government bill 2016/17:104), and the new Swedish *Climate Act*, both described in section 4.2.6 of this report.

There has been significant investment in Swedish food systems research, and research spans over several disciplines involving many Swedish research actors (e.g. SLU, LU,Rise, KI, GU, Chalmers, SU, OrU, Umeå University). In an assessment of Swedish food science research and innovation funding (EU, 2018), it was estimated that throughout the years of 2011–2016, Swedish research funders (Vinnova, Formas, VR) invested roughly 183 Million Euro in Swedish food science research. The funding was allocated as follows: food production (57%), processing (14%), consumption (12%), food safety (12%), food waste (3%) Distribution (2%) (Figure 7 below). As a result, there has been an increased volume of scientific publications, with an average field citation level well above an international average. A large part of the publications are products of international collaboration, which also is a sign of high quality. Some gaps in the conducted research so far is however visible, such as studies on resilience of the food system, or research on transformation pathways to desired goals and how to get there.

Formas, the Swedish Research Council for sustainable development, is funding a long term (10 years) national research programme for food, with its first call in 2017 and with an annual budget of roughly 35 Million SEK. The national research programme is part of the implementation of the above-mentioned National Food Strategy for Sweden, intended to create more jobs and sustainable growth nationwide. This interdisciplinary research program is aimed at strengthening needs-driven research, increasing the focus on product development, innovation, dissemination and commercialisation of research results, as well as raising knowledge levels over the entire food supply chain. The program is basically an umbrella for ongoing and new initiatives, each of them with a shorter time frame than 10 years. In connection to the Programme, Formas is also organising a National Committee Food Science Research (Nationella Kommittén för Livsmedelsforskning). The mandate of this Committee covers the entire food chain, from primary production to consumption, based on the global sustainability goals and the National Food Strategy for Sweden.

Food Science Sweden (FSS) is a national platform aimed at strengthening and visualizing Swedish food science research, gathering the largest players in Swedish food science research – Chalmers, Lund University, SLU, Örebro University and RISE.

FIGURE 7. Allocation of Swedish research funding for different parts of the Food System during 2011–2016.



The FSS platform is also supported by the Swedish Food Federation (Livsmedelsföretagen). The purpose of this initiative is to strengthen Swedish food science research and create improved cooperation between partner organizations, as well as with authorities and the industry.

Swedish Universities and research actors are also active in international relevant food system research efforts. This includes the EAT-LANCET Commissions work on healthy diets from sustainable food systems within planetary boundaries, the SLU Future Food platform, or EU funded initiatives, for example through the Horizon 2020 programme, such as REFRESH. There are also ongoing Mistra Programs of relevance to Food system research.

While Swedish food science research is of high international class, a recent evaluation (Roland Berger, 2018) found the Swedish food innovation less successful. Within the EU, and according to Bloomberg food innovation ranking, Sweden was ranked at 14 in contrast to Swedish forest, car and steel industry, where Sweden was ranked at number 2 in their respective sector ranking. The reasons for this are (i) the large number, 99% of all food firms, are small and medium sized enterprises with limited research and innovation activities (ii) lack of co-ordination in between food system actors (iii) inadequate collaboration between industry and academia (iv). A focus on national niche markets, and limited focus on large global markets (Roland Berger, 2018)

This lack of co-ordination has been recognized by the Swedish government and the food industry through the development of the Sweden Food Arena, a national food industry arena where stakeholders within the food industry can cooperate for an innovative, sustainable and competitive food sector (Tillväxtverket, 2019). The Swedish Agency for Economic and Regional Growth was commissioned to support the establishment of the arena, and activities will be supported and driven by the food industry and its stakeholders. The key tasks of the arena will be to manage and strengthen food industry research and innovation efforts and work towards better cooperation within the food chain, incorporating industry, academia and other stakeholders. The aim of this new initiative, still in its infancy, is to create the conditions for a "world-class Swedish food sector". The arena has begun its work by identifying three areas where there is a need for increased collaboration on research and innovation. These are:

- Health and taste
- Circular food
- Digitalisation and automation

Vinnova is also supporting Food sciences Innovation through its support to the Foodinova Program , creating a virtual National Food Incubator for food, meals, and health(Mat, Måltid, Livsmedel och Hälsa). The Foodinova Program aims at supporting regional food incubators throughout the country, providing incubation and innovation support to companies throughout the food chain, sharing tools, methods, resources through a Digital Innovation Support Toolbox (Krinova, 2019)

In conclusion, there are a large number of studies and initiatives analysing parts of the Swedish food system and how these could contribute to a more sustainable food system. There are also an increasing number of innovation efforts on parts of the food chain to make them more sustainable. *However, none of the current programs and initiatives has taken a systemic view looking how to transform the whole Swedish food system in its totality.* A Mistra Program taking such a systemic view on how to develop a healthy and sustainable Swedish Food system would be most valuable for food system actors in Sweden. Such a Program would support and guide ongoing Swedish food system initiatives, such as the Formas National Research Programme on Food science and the newly formed Sweden Food Arena. A new Mistra Program study would also serve as a guidance internationally on how use a systemic approach to analyse options for, and pathways to a sustainable food system.

6 Suggested Research Focus Areas Related to a Mistra Programme on Food Security and Sustainable Food Systems

6.1 Overarching question

What would a Swedish food system - that is economically, socially, environmentally sustainable, and resilient – look like, and how do we get there?

6.2 Research Questions

1. **Making explicit assumptions about the range of plausible futures**
   The world is changing rapidly from environmental, social, technical and geo-political perspectives, with uncertainty about the future becoming a key driver of strategic planning. Scenario analyses are a commonly used tool for decision making under uncertainty, and it could be usefully used to explore a range of alternative future conditions that will shape the Swedish food system, such as changing demographics, robustness of international trade and the architecture of international cooperation, the extent to which society accepts changing diets, ways that demand may change, etc. Development of plausible alternative future conditions can allow the description of different ways that the Swedish food system may deliver healthy diets in a way that is sustainable and resilient. These scenarios can be used to develop a robust research agenda, identify leverage points for intervention, stress-test the development of research questions and so on. Scenarios are, ideally, co-created with a representative set of all actors who are stakeholders in the food system. For each scenario, the implications for a range of social goods can be explored: how does a transformed food system affect, for example, land use, livelihoods, food prices, international competitiveness and soft power?

2. **What are the options for the Swedish agricultural system to be "net-zero" in GHG emissions by 2045 and what are the implications for the food system as a whole?**
   Sweden is making commitments towards becoming an economy with a net positive emission of greenhouse gases, and a "net zero" agricultural sector would be an important factor for decarbonising the economy. What would a "net zero" -carbon agriculture look like within some (or all) of the scenarios described above? Minimising GHG emissions is one aspect of a "sustainable food system" although it is likely to impact on other aspects from environmental (e.g. implica-

tions for the intensity of land use), social (e.g. livelihoods, economic competiveness), and spatial perspective (with different regions requiring different future patterns of land management). What are the trade-offs and synergies between these goods and services, and how do they vary across Sweden, if "net-zero" GHG agricultural system was a boundary condition of a food system that provides healthy diets in a sustainable and resilient way?

3. **Identifying the metrics for measuring the performance of the food system against the objectives of delivering healthy diets in a sustainable and resilient way?**

   For managing and describing progress, metrics are key. What "next generation" metrics can be articulated that can incentivise and measure performance from current conditions towards the transformed food system? For example, going beyond agricultural productivity measured in terms of economic gain, or yield, per unit input, towards measuring the performance of the whole food system (such as people fed) minimising the costs of monetized inputs (e.g. fertiliser), environmental impacts (e.g. GHG emissions, impacts on air, water, soil and biodiversity), and health impacts (e.g. healthcare costs associated with malnutrition in all its forms). In other words, metrics for assessing people fed sustainably, equitably, healthily and profitably per unit input. How could such new metrics be adopted by, and influence the decisions of, policy makers, business, consumers and civil society more broadly?

4. **How can the transformation to a sustainable and resilient Swedish food system be enabled and incentivised?**

   Given that (1) and (2) outline potential visions for a transformed Swedish food system, and (3) develops the metrics of progress, what are the pathways by which transformation can be achieved? Answering this question requires identifying the constraints working against change – whether they be technological, social, regulatory or political. Given these constraints, how might they be overcome and an enabling environment be created? Can potential suites of scalable interventions be identified and perhaps piloted in proof of concept applications (e.g. social, technical or regulatory pilot programmes, or "test beds")? How would the interventions create "winners and losers" and who (or where) would these be? How might the transformation affect Sweden's international competitiveness, and broader standing in the world?

   In short, what interventions might shift the food system in the desired directions, with lowest risk, lowest social cost, and highest benefit for Sweden?

6.3 Approach and final outcome

Research questions (1) and (2) outline potential visions for a transformed Swedish food system, (3) develops the metrics of the development and progress, (4) would look at the pathways by which transformation can be achieved. The expectation is that by tackling research questions 1–4, the programme develops a road-map for systemic transformation of the Swedish food system.

7 Appendices

A1 Terms of Reference for a Working Group on Food Security and Sustainable Food Systems

Background

A National Food Strategy was adopted by the Swedish Parliament in 2017. The vision of the strategy is that the Swedish food value chain by 2030 will be globally competitive, innovative, sustainable and attractive to operate within. The overall objective is to increase the total Swedish food production while achieving the relevant national environmental objectives. The Government has recently, in August 2018, set up an Expert Panel on Climate Adaptation. Since January 2018 there is also a Climate Policy Council that will give advice to the Government.

Rural areas are essential for supplying our societies with food. This applies especially to primary production, including both agriculture and aquaculture. Urban farming can be a supplement, but since there are not enough space and resources available in the city, urban farming will never replace farming in rural areas.

Nevertheless, many rural communities suffer from a shrinking population and lack of community service and jobs. Incomes are generally lower in rural areas than in cities. Despite the importance of farming, many farmers experience decreased profitability. Some of them have no other choice than to close down their farms. Along with efficiency improvements and less labour intensive farming, this leads to even fewer jobs in the countryside, and in many cases also to loss of farmland and insufficient management of pastures. The consequences for biodiversity are most often negative. With less farmers in Sweden who will supply us with food, and especially with less farmland, we will become even more dependent on import. This may lead to increased uncertainties and risks as well as higher environmental impacts overall.

Extreme weather events, like heat, drought and flooding, seem to occur more often. The food sector needs to take measures to better cope with these events and adapt to a changing climate. Like all sectors of society, the food sector must also transform to cut the emissions of greenhouse gases and become climate neutral, or even climate positive. Biodiversity loss and scarcity of resources, like phosphorus, water and land, are other issues to take into account.

The Common Agricultural Policy (CAP) is the main food policy in the European Union, and thus in Sweden. Under the CAP the EU and the member states provide income support to farmers and compensate them for applying environmentally preferable farming practices. A reformed CAP will enter into force in 2021 or at some point after that. There is also a Common Fishery Policy. The Rural Development Programme for Sweden is supported by the European Structural and Investment Funds and provides funding to community-led local development projects. Since there are many policies and rules that apply to the food sector, there is a need for alignment and simplification of the regulatory framework.

A recent trend is an increased awareness of consumers about the importance of what they eat, i.e. the food quality, both for their personal health and wellbeing, and for the environment and animal welfare. The number of people preferring vegetarian or vegan diet is, for example, increasing as part of this trend. Changes in consumer preferences mean new market segments for the food industry.

Local food and organic food have changed both agricultural practices and the range of food available in regular food stores. The choices consumers make in the supermarket, or by visiting farmers' markets and local producers, have been an important driver. There are also strong movements involving producers of local and/or organic food. In addition, organic farming receive government support, not the least under the CAP.

Despite trends, food choices and culinary preferences are deeply rooted in culture and history and not so easily changed.

A new research programme funded by Mistra

A new research programme should contribute to improving food security, while putting sustainable development, climate mitigation/adaptation and biodiversity in the forefront. The programme should provide scientific evidence for a systemic change, considering what food we should produce, where and how. A new research programme should also contribute to developing the Swedish rural areas and increasing the competiveness of Swedish farms and other food businesses. The profitability of Swedish farms needs to increase, otherwise the necessary investments for the future won't be made. ICT, biotechnology and other new technologies can help achieve the needed change of the food sector.

Focus should be on the Swedish food system but in a European Union context and with a global outlook. The programme should include a long-term vision, adopt a systems approach, and take into account climate and other environmental risks as well as business opportunities. As a point of departure, the whole food supply chain, i.e. from farming and food processing, packaging and distribution, to retail and catering, should be embraced. Approaches to decrease the amounts of food waste and recover nutrients are also of importance, as well as consumer behaviour.

The food industry is global with both large businesses operating at global scale and small businesses, including farmers, operating at local scale. This circumstance should be taken into account. Stakeholders should be involved both in the planning and execution of the programme.

The assignment

A working group comprising international experts will draw up a background report as documentation for Mistra's Board, ahead of a forthcoming decision on whether to call for proposals for a research programme in the area described above.

The assignment includes:

- briefly describing the Swedish agriculture and food system in a global context,
- describing the challenges facing society in this area, and the technological and policy developments as well as other trends that are underway in Sweden and the rest of the EU to tackle these challenges,
- outlining the current state of knowledge in the area and describing the level of Swedish research in comparison, and
- proposing in detail the orientation of a new research programme (draft text for the call for proposals).

A final report must be submitted to Mistra no later than 22 February 2019.

A2 Participants of stakeholder workshop

7 February, 2019, Westmanska palatset, Stockholm

Name	Title	Organization
Agneta Påander	Corporate Responsibility Director	Orkla
Ana Frelih-Larsen	Expert	Mistra Working Group
Anna Wikström	Project Manager	Swedish Agency for Economic and Regional Growth
Annica Sohlström	Director General	National Food Agency
Carolina Sachs	Secretary General	Axfoundation
Charlotta Szczepanowski	Head of Sustainability and Quality	Coop
Charlotte Lorentz Hjorth	CEO	Krinova Incubator and Science Park
Eva Pettersson	Secretary General	The Royal Swedish Academy of Agriculture and Forestry
Gun Olsson	CEO	The Rural Economy and Agricultural Society in Halland
Gunilla Elsässer	Head of Unit 'Food, Climate and Energy'	WWF Sweden
Harry Barraza	Expert	Mistra Working Group
Helena Fredriksson	Head of Research	Lantmännen
Inger Andersson	Chairman	National Committee for Food Science Research
Ivar Virgin	Secretary	Mistra Working Group
Jenny Bergsten	Food Strategist	Region Skåne
Johan Kuylenstierna	Chairman	Mistra Working Group
Katarina Rosenqvist	Senior Consultant Sustainability	Swedish Food Retailers Federation
Kjell Malmlöf	Research Director	Swedish Farmers' Foundation for Agricultural Research
Lena Åsheim	Board Member	Federation of Swedish Farmers – LRF
Leslie Lipper	Expert	Mistra Working Group
Lotta Törner	CEO	Skåne Food Innovation Network
Madeleine Linins-Mörner	Program Director	Axfoundation
Mats Emilsson	CEO	AgroVäst
Pär-Johan Lööf	Innovation Project Manager	Lantmännen
Sara Sundquist	Business Policy Expert	Swedish Food Federation
Sirpa Kurppa	Expert	Mistra Working Group
Thomas Nilsson	Programs Director	Mistra (the Secretariat)
Tim Benton	Expert	Mistra Working Group

A3 The Authors

Short Bios of MISTRA expert group members February 2019

Adjunct Professor Johan Kuylenstierna (Chairing the Expert Group),
Adjunct Professor at the Stockholm university, Director, Navarino Environmental Observatory (NEO), Vice Chair, Swedish Climate Policy Council.

Johan is adjunct professor at the Stockholm university and vice chair of the Swedish Climate Policy Council. He has served as the executive director of the Stockholm Environment Institute, as Chief Technical Advisor of UN-Water, Project Director at the Stockholm International Water Institute, Scientific officer at WMO and Junior Professional Officer at UNDESA. He has also worked as a senior consultant with a focus on sustainability and CSR. He is a member of numerous boards in the public, private and civil society sectors. He has a degree in Earth Sciences and Palaeoclimatology and an honorary doctorate from Stockholm university.

Dr. Ana Frelih Larsen,
Senior Fellow, Coordinator Agriculture & Soil, Ecologic Institute, Berlin, Germany.

Ana is a Senior Fellow at Ecologic Institute in Berlin where she coordinates the Institute's activities on agriculture and soil. Her work over the last 10 years has focused on the evaluation and development of agri-environment policies for climate change mitigation and adaptation in European agriculture. This has involved translating scientific results for policy making, evaluating existing policies for their effectiveness, and working with stakeholders to develop new solutions and policy approaches to improve the environmental performance of agriculture and its resilience against climate change. She has lead and contributed to numerous studies for European and national institutions in the area of Common Agricultural Policy, Water Framework Directive, and Nitrates Directive. Examples of current work include: coordination of a stakeholder engagement process in the development of an international Strategic Research Agenda on soil organic carbon (CIRCASA project); lead on a study supporting the development of sustainable finance taxonomy for agriculture (DG FISMA), and support for the development of an EU carbon farming initiative (DG CLIMA). Ana holds a PhD in Geography from University of Oxford

Professor Tim Benton,
Dean of Strategic Research Initiatives, University of Leeds and Distinguished Visiting Fellow, Chatham House, United Kingdom.

Tim is Dean of Strategic Research Initiatives at the University of Leeds and Distinguished Visiting Fellow at the Energy, Environment and Resources Department at the Royal Institute of International Affairs at Chatham House, UK. From 2011–2016 he was the "Champion" of the UK's Global Food Security programme which was a multi-agency partnership of the UK's public bodies (government departments, devolved governments and research councils) with an interest in the challenges around food. The key role of GFS was to undertake systemic analysis and horizon scanning, in order to identify research priorities to mitigate the challenges of providing sufficient, sustainable and nutritious diets for all. He is a Global Agenda Steward for the World Economic Forum, a lead author for the IPCC Special report on food, land and climate, and co-chair of Foresight4Food, working to align a community of practice on the future of food systems. He has worked with governments and businesses around the world on transforming the food system to deliver better outcomes. He has published over 150 academic papers, many on the topics of agriculture and its sustainability. His particular research interest is currently on food system resilience in the face of climate change.

Dr. Harry J. Barraza,
Relationship Development Director, LGC, United Kingdom.

Harry is currently Relationship Development Director for the UK National Measurement Laboratory – LGC. As a government designated laboratory for chemical and bio measurements, NML-LGC, develops new testing methods and sets standards for agricultural and food sectors - as well in other related industries – including genomics, health, and biosciences. Previously, he was Head of Open Innovation for Arla Foods amba, with a strong focus on collaborative R&D with universities and startups. In this role, he worked closely with academics and other research organisations in Denmark to build research roadmaps impacting the future of primary production and food industry (1). He has also worked with the Swedish Farmers Foundation for Agricultural Research (SLF), to collaboratively develop the framework for a research call linking the concept of sustainable diets in relation to dairy products and production systems (2). Finally, Harry has extensive experience in product innovation and technology transfer in the FMCG industry.

1. *https://foedevarer.di.dk/SiteCollectionDocuments/Foedevarestrategi.pdf*
2. *https://static-lantbruksforskning.s3.amazonaws.com/uploads/attachments/sustainable2018_2.pdf*

Professor Sirpa Kurppa,
Natural Resources Institute Finland (Luke), Bioeconomy and Environment, Sustainability Science and Indicators, Finland.

Sirpa is a Research professor in the Natural Resources Institute Finland (Luke) the group of Sustainability Science and Indicators. Her research topics include sustainability of food production and services, integrated food and environmental policy, integrated product policy, environmental awareness and design, industrial symbiosis and resilience. Her special competences are: agroecology, ecology of food systems, integrated and sustainable food production, environmental assessment, life cycle assessment (LCA) and eco-design. At present, she is a deputy leader of the ScenoProt - Novel protein sources for food security (2015–2021). She has provided expert input into EU Rural Foresight studies and into work of the Committee for the Future of the Finnish Parliament, into the National Food Strategy, into the Strategy for Sustainable Consumption and Production and recently into the working group for the Agenda 2030 for Finland. She attended preparing a proposal on green growth for the Finnish Parliament and preparing the Finnish strategy for bioeconomy, and in 2013–2015 she was a member in the EU Bioeconomy Panel, and from 2014 to 2017 a member of the National Nutrition Council. In EU Susfood ERA net first period she was attending in preparing the SRA for Susfood

Dr. Leslie Lipper,
Director of the Independent Science and Partnership Council. FAO, Rome.

Leslie is a natural resource economist who has worked for over 30 years in the field of sustainable agricultural development. She is currently the Executive Director of the Independent Science and Partnership Council of the CGIAR. She holds a doctorate in Agricultural and Resource Economics from the University of California at Berkeley. For 17 years she directed a program of applied natural resource economics research and policy analysis in support of sustainable agricultural development at the Food and Agriculture Organization of the UN (FAO). She led in the development of the Climate Smart Agriculture concept at FAO and in developing FAO positions in international and national climate change, agriculture and food security policy processes. was a contributing author to the IPCC Fifth Assessment Report WG II chapter on Food Security and Production Systems, and lead author on a 2014 publication in Nature Climate Change on Climate Smart Agriculture.

Dr. Ivar Virgin (Secretary to the Expert Group) ,
Senior Research Fellow, Stockholm Environment Institute (SEI), Sweden.

Ivar has a PhD in biochemistry/gene technology and for the past 25 years he has been working at Stockholm Environment Institute (SEI) mostly doing research on bioscience innovation systems, agricultural development, food security, environmental impact assessments, primarily with a developing country perspective. Ivar is one of the initiators of the two largest bioscience innovation programs in Africa, the BIO-EARN (1999–2010) and BioInnovate(2010-ongoing) focusing on resource efficient, climate smart agricultural production, value chains and waste conversion in East Africa. He is the editor and an author of the Routledge book project Creating Sustainable Bioeconomies: The Bioscience Revolution in Europe and Africa. This book published by Routledge in 2017 deals with the prospects of the Bioeconomy in Africa and Europe and the links between these continents. He is also currently active in and part of the Steering Committee in the Sida supported programme Agriculture for Food Security 2030 (AgriFoSe2030) and engaged in the Swedish International Agriculture Network Initiative(SIANI). Since 2011, he is also a part time famer, running a large farm estate in Västergötland, Sweden. Mariedals Lantbruk AB producing grains on some 350 hectares and forestry products on 420 ha.

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