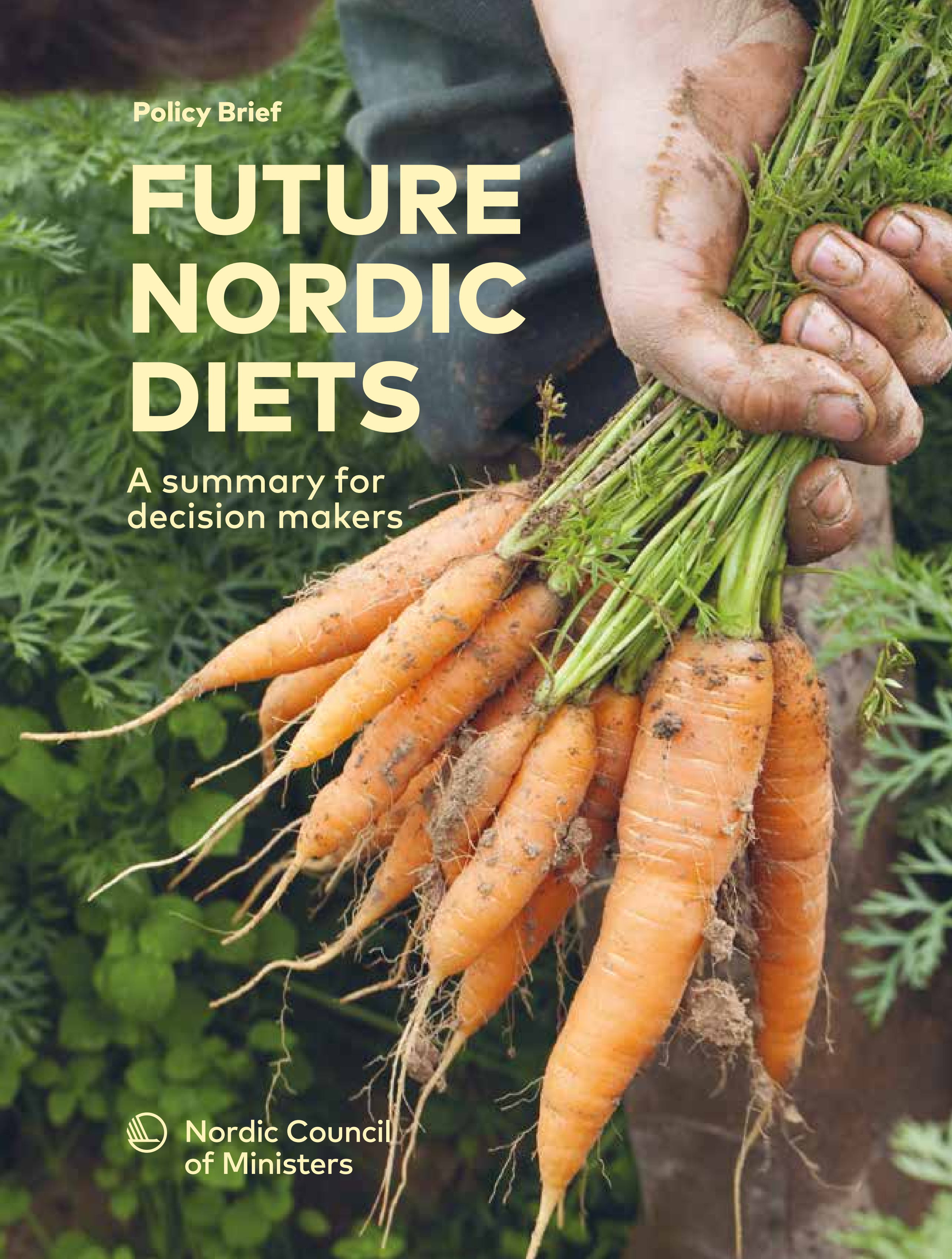

Policy Brief

FUTURE NORDIC DIETS

A summary for decision makers

Nordic Council of Ministers

Policy Brief: Future Nordic Diets. A summary for decision makers
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CONTENTS

KEY MESSAGES

- The four Nordic countries: Denmark, Finland, Norway and Sweden, when seen as a whole, can become **largely self-sufficient by 2030** and even supply food for more people, based on mainly regional, organic production, **if the consumption of animal products is significantly reduced**.
- A low-input agricultural system, in which livestock are mainly fed on grass from semi-natural pastures and on residues from the food industry, **can reduce greenhouse gas emissions and air pollutants significantly**. Though to be compatible with a 1.5°C emission pathway beyond 2030 more measures would be needed.

KEY RESULTS

- The results show that the scenarios, depending on the assumptions made, would be able to produce enough **nutritious food for 31–37 million people** in the Nordic countries. The scenarios would thus be able to support the projected population in 2030, albeit with changes in consumption patterns.

- **Consumption of meat decreased by 81–90 percent** from current consumption levels; substituted by cereals, legumes and vegetable oil. The scenarios also included more vegetables than currently consumed in order to comply with the Nordic nutrition recommendations.

- Estimates of current greenhouse gas emissions from the agricultural production of food consumed in the Nordic countries range between 1,310 and 1,940 kg CO_2-eq per person per year. The greenhouse gas emissions from agricultural production in the scenarios were estimated at **310–700 kg CO_2-eq per diet per year.**

- The total agricultural area needed per diet, including land used abroad for imported food, was **0.23–0.27 hectare per diet**. This can be compared to the planetary boundary for land use change, which states that no more than 15 per cent of global land cover should be converted to cropland. That is 1,951 Mha, which divided by the projected global population in 2030 gives us 0.23 ha per capita.

- Both scenarios would roughly **halve ammonia emissions** from agriculture. As agriculture is responsible for around 90 percent of total national ammonia emissions, these emission cuts would result in significant environmental and health improvements through less nitrogen deposition and lower concentrations of inhalable secondary fine particles.

- The variations between the individual countries in both the diets and the land use per diet are large, reflecting the **big geographical and climatic differences**. For example, the Finnish diets used more than twice as much land as the Danish diets.

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INTRODUCTION

The global food system causes large emissions of greenhouse gases and other pollutants into the environment. Livestock are responsible for a large part of these emissions and take up most of the agricultural land for grazing and feed production, while only making a limited contribution to the global food supply. In the report Future Nordic Diets, we have used an agricultural mass flow model to assess two future food system scenarios for the Nordic countries: Denmark, Finland, Norway and Sweden (hereafter "the Nordic countries"). In these scenarios, livestock feed production competes less with human food production and the majority of food is produced within the Nordic countries using organic farming practices.

- In the first scenario (SY) the number of ruminants was limited to the minimum number needed to graze all semi-natural pastures, while monogastric animals (poultry, pigs and aquaculture fish) were limited to available food processing by-products.

- In the second scenario (EY) the number of ruminants was increased to utilize all ley grown in organic crop rotation and by-product feed for monogastric animals was supplemented with some feed crops grown on arable land. This enabled more food to be produced from Nordic agriculture, thus feeding a larger population.

RECOMMENDATIONS

- A transition towards a more extensive organic farming system of the type described in the scenarios, where livestock feed production competes less with human food production, would result in significantly **lower emissions of greenhouse gases**, acidifying pollutants and eutrophying pollutants. In other words, the opportunity to reduce emissions from food production is around the corner. The knowledge to grow organic food is already there. These farming systems would benefit from further development, but no technical miracles are required.

- Organic farming systems have been observed to have a positive influence on **carbon sequestration** and soil carbon. The drivers for this are not well understood, but crop rotations, increased use of organic amendments such as compost, straw, green manure and deep litter manure, and a larger allocation of biomass to roots in organic systems may all contribute to this. We recommend further exploration into these aspects of organic farming, including the role of grazing animals in farming. This goes hand in hand with the aim of the Paris Agreement to achieve net zero carbon emissions by 2050, which means there is a need to further explore the potential and the best methods for carbon sequestration in agriculture.

- **A holistic perspective** on our food and farming system is necessary if we want to achieve real emission reductions. In this study, we show that a transition to organic and extensive farming is beneficial to the climate, even if the emissions per kilogram of product are equivalent or even higher than for conventional cultivation, since this would go along with changes in our diets. In order for such a perspective to permeate policies and support systems, these need to undergo a profound reformulation, not least the EU's common agricultural policy.

- Efforts need to be made to **promote more sustainable diets**. This can be done through general recommendations, guidelines for public meals, policy decisions within companies and other private institutions that serve food to employees or customers. The results can serve as a basis for such recommendations for sustainable diets. E.g. a reasonable level of meat consumption is one or two servings of meat per week.

- To increase Nordic self-sufficiency towards the levels described in the scenarios, we will need to grow other crops. In particular, **grain legumes and oil crops** need to be more widespread compared to current production in the Nordic countries.

- In order to promote an informed debate on food and agriculture, we want to encourage the **development of more future scenarios for sustainable agriculture**, exploring aspects that we have not included here, e.g. developments in technology and production methods, plant and animal breeding, sustainable fisheries, energy efficiency, innovations in novel food and feed, such as artificial meat, algae or insects. We would also like similar work to be carried out for other regions to increase our knowledge about how local conditions (geology, demography, climate etc.) affect the opportunities for increased regional self-sufficiency.

OUTLINE OF THE TWO SCENARIOS

The current production and consumption of food in the western world is unsustainable. Globally, food systems are estimated to account for almost one third of anthropogenic greenhouse gas emissions, of which agricultural production is responsible for over 80 percent (Vermeulen et al., 2012). More than one third of the world's total arable land is used to grow feed crops for animals and, when pasture land is included, livestock occupies 70 percent of all agricultural land (Foley et al., 2011). A large part of the original energy in animal feed is lost in the metabolic processes of animals (Godfray et al., 2010). If a larger proportion of feed crops were used directly as human food, more food could be made available without the need for more agricultural land (Smith, 2013; Stehfest et al., 2009). If livestock are fed resources that are not in direct competition with human food, livestock production can provide important services to society, and in some cases also to ecosystems (Röös et al., 2016; Schader et al., 2015). For example, the semi-natural pastures in Europe have developed over hundreds of years of human influence through grazing livestock, and today boast a diversity of plant and animal species (Jordbruksverket, 2016). Semi-natural pastures can generally be defined as permanent pastures that have evolved from long-term, low-intensity traditional farming and where no recent reseeding or heavy fertilization have taken place. Grazing animals are needed to preserve the values in these landscapes. Further, by-products from food production, such as low-grade vegetables or residues from vegetable oil production, can be used to feed animals that provide meat and other livestock products to human diets without requiring land for feed production.

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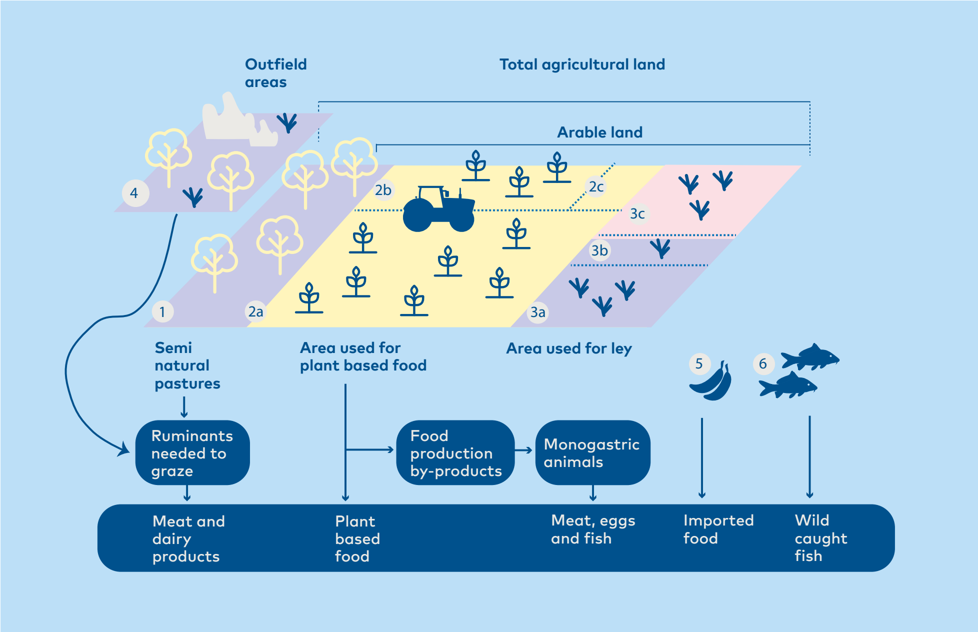

Figure 1: Illustration of the basic rationale used for designing the scenario diets and allocating the available agricultural land to different land uses and activities

In line with this, the project aimed to explore two scenarios for future food systems in the Nordic countries that build on the principle of limiting livestock production to resources that do not compete with human food, as well as organic farming principles (Figure 1):

- the Sufficiency scenario (SY), where the number of ruminant animals (cattle and sheep) is limited to the minimum number of animals needed to graze available semi-natural pastures in each country and where by-products are fed to monogastric animals (poultry, pigs and aquaculture fish) and used to supplement the ruminant feed, and
- the Efficiency scenario (EY), where ruminants graze pastures on arable land to a larger extent, and more grass is used for winter feed in order to make use of the ley that is grown in the crop rotations. Some feed cultivated on arable land may also be included in the feed rations as long as this contributes to the aim of feeding more people from local resources.

1	The amount of semi-natural pastures available for grazing sets a limit on the number of ruminants needed to keep these areas grazed. The ruminants provide meat and dairy products for the diets.
2a	Arable land was allocated to produce most of the plant-based food in the diets. Food processing generates by-products that were used to supplement the ruminant feed and feed monogastric animals (poultry, pigs and aquaculture fish). The monogastric animals provide additional meat, eggs and fish for the diets.
2b	To compensate for the reduced consumption of meat and other animal products, additional arable land was allocated to grow supplementary plant-based food (legumes, cereals and vegetable oil).
2c	In the EY scenario the need for plant-based food is lower. Instead some land was used to grow supplementary animal feed.
3	To provide green manure and pest control, ley was grown for at least two years in a six-year crop cycle. All crops except greenhouse horticulture and fruit orchards were grown in a crop rotation that included ley.
3a	Some ley was allocated to provide winter feed for ruminants and pasture for dairy cows that were assumed to be able to graze semi-natural pastures only to a limited extent.
3b	Slaughter and food waste, manure and, to some extent, straw were used to produce bioenergy for heat, electricity and fuel use on the farms. If additional energy was needed, ley was harvested to produce bioenergy. The digestate was returned to the soils as organic fertilizer.
3c	Ley that was not used for 3a or 3b was not harvested in scenario SY. In scenario EY this land was used to provide more pasture and winter feed for a larger number of ruminants.
4	In the EY scenario, Norwegian outfield areas were also included because of their importance in Norway's animal husbandry. This provided additional pasture for ruminants, especially sheep.
5	Some plant-based food (tropical fruits, nuts, tea and coffee) was imported and included in the diets.
6	A global "fair share" of wild-caught fish was included in the diets.

There were also several normative decisions made by the five NGOs in consultation with the researchers that had implications for the modelled systems:

Normative decisions	**Implications**
1. Diets should seek to resemble current eating patterns and fulfill Nordic Nutrient Recommendations (NNR).	– The Swedish nutrient recommendations translated into food items (SNÖ) was used as the "base-line" diet from which the scenario diets were produced (Enghardt and Lindvall, 2003). – No novel foods (insects, synthetic meat, algae etc.) were included.
2. Future diets should facilitate equitable consumption that is based on local resources, and arable land should primarily be used to grow food for humans, not feed for livestock or bioenergy crops.	– On the available arable land and semi-natural pastures food was produced for as many people as possible. – Arable land was allocated to grow most plant-based food needed for a nutritionally adequate diet (SNÖ). – A global "fair share" of wild-caught fish was included in the diets.
3. The Nordic countries should provide as much food as possible from local production, but be able to import food products that are not possible[a] to produce locally.	– The amount of greenhouse-grown vegetables (cucumbers, lettuce and tomatoes) was reduced by half compared to SNÖ and replaced with vegetables and roots able to grow on open fields. – Tropical fruits, nuts and coffee/tea were imported according to current consumption. Increased consumption of fruits in the scenario diets was covered by local production.
4. The food should be produced in an organic farming system, acknowledging agro-ecological principles.	– At least 33% of arable land in rotation was allocated for ley production (i.e. in a six-year crop rotation ley is grown for two years) to provide green manure. – The frequency of rapeseed and grain legume cultivation was limited to 17% and 10% respectively to avoid build-up of pests and soil-borne pathogens. – Current yield levels were factored using literature values for the yield gap between organic and conventional farming. – Livestock production follows organic practices with respect to time spent on pastures, growth rates, feed, etc.

[a] What can be produced locally is largely dependent on the amount of resources (e.g. working hours, energy, irrigation etc.) one is willing to invest. In this work those products traditionally grown on arable land and in greenhouses in the Nordic countries were considered as possible to produce locally.

5. Food waste should be reduced by half compared to current levels.	– Avoidable food waste in the retail and consumer stage of the food chain is halved compared to current levels.
6. Some land currently used for annual crop production is unsuitable for this and should be left for nature conservation.	– Drained and cultivated peatlands were excluded from the available arable area. – In Denmark, 15% of the arable area was set aside to promote nature conservation.
7. Semi-natural pastures should be grazed by livestock to promote biodiversity and preserve the cultural landscape.	– Ruminants (dairy cattle and sheep) were included in numbers needed to graze all semi-natural pastures. – In the EY scenario, Norwegian outfield areas were also grazed by ruminants.
8. Durable breeds of ruminants should be used to allow grazing of semi-natural and outfield areas in rough terrain.	– A milk yield from dairy cows of 6,000 kg of energy-corrected milk per year was assumed, which is low compared to modern breeds of dairy cows.
9. By-products[b] from food production are best used as feed for livestock.	– Available by-products are fed to livestock and aquaculture, producing meat, eggs, dairy products and fish.
10. Agriculture should be self-sufficient in energy, but should not provide energy for other parts of society.	– Manure, food and slaughter waste were used as substrate in a biogas reactor to produce heat, electricity and, after refining, fuel for agricultural machinery. Some straw was also burned to heat stables and greenhouses. – The digestate and straw ash was applied to the arable land as fertilizers. – If needed, ley was harvested and used as substrate in the biogas reactor.

[b] By-products were defined as leftovers from food production that are unfit or undesirable for human consumption. This includes low-grade potatoes and roots, excess cereal bran, by-products from sugar and vegetable oil production, and fishmeal from gutting and cleaning.

RESULTS

Diets

- In both scenario diets the consumption of meat decreased substantially. Compared to current levels, meat consumption (incl. chicken) decreased on average by 90 percent in SY and 81 percent in EY, to a weekly consumption of 80 and 149 grams respectively. Consumption of fish in both scenario diets was around half of current consumption; around one serving weekly compared to the two servings currently consumed in the Nordic countries. Consumption of milk was slightly less than half of current consumption for SY while it was on the same level as current consumption for the EY scenario.

- To compensate for reduced consumption of animal products, plant-based protein in the form of cereals and legumes increased. For SY the consumption of legumes was about four times the current level, and for EY it increased by 156 percent. Consumption of cereals increased by 67 percent and 51 percent for SY and EY respectively.

- Comparing the different countries, it was noticed that the Norwegian scenario diets were generally higher in meat due to extensive pasture resources, while arable land was limited and crop yields comparably low. However, the Norwegian scenario diets were not able to support the projected population in 2030. At the other end of the spectrum, the Danish diets were lower in meat and milk, since the Danish scenarios were able to support a large population due to high crop yields, while pasture resources were limited, leading to a larger fraction of vegetable products in the diets.

- In total, it would be possible to supply an estimated 30.9 and 37.0 million people respectively with the SY and EY scenario diets. The 2015 population in the Nordic countries totalled 26.2 million and is projected to grow to 28.4 million by 2030. In other words, the scenario diets could feed the Nordic population in 2030 and potentially provide food for an additional 2.5–8.6 million people.

Agricultural production and land use

- The total agricultural area needed per diet including land used abroad for imported food was 0.27 ha per diet for SY and 0.23 ha per diet for EY. This can be compared to the planetary boundary for land use change proposed by (Rockström et al., 2009),

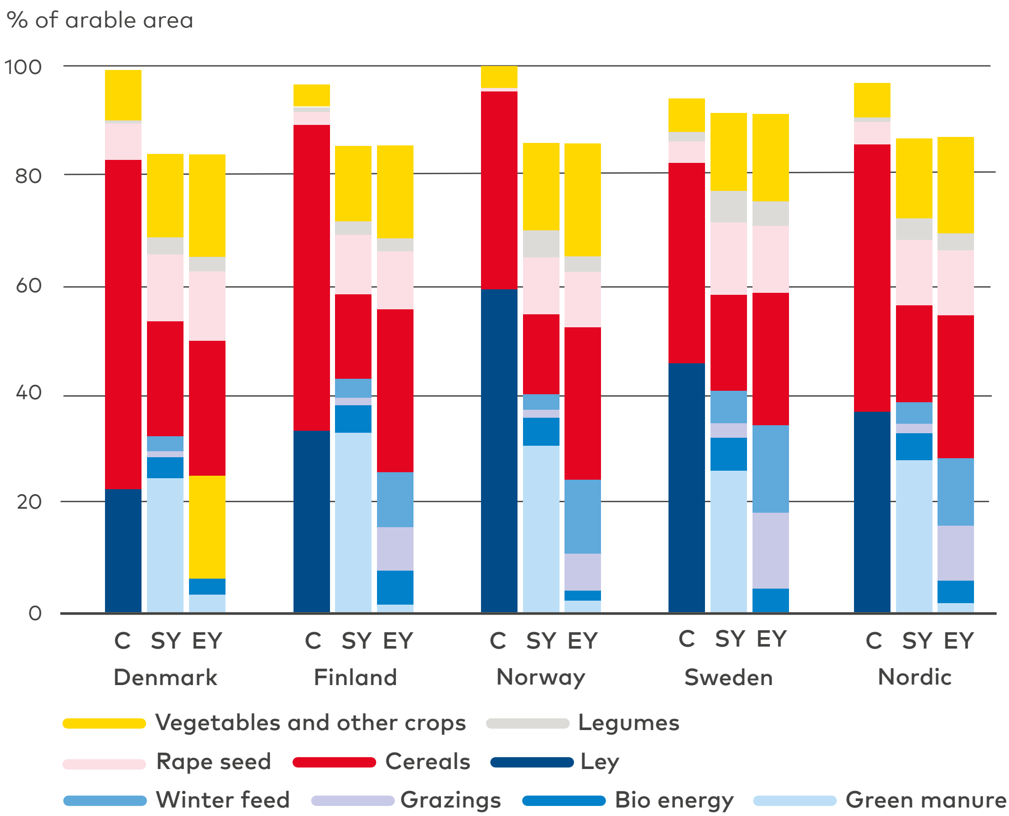

Figure 2. Percent use of arable land for different crops under current land use (C) and for the two scenario diets. The current land use represents current use of arable land in each country and is not directly related to the currently consumed diets.

which states that no more than 15 percent of global land cover should be converted to cropland. This amounts to some 1,951 Mha, divided by the projected global population in 2030 gives us 0.23 ha per person. Hence the EY diet ends up just on the planetary boundary for land use change while the SY diet overshoots the boundary.

- The variation in land use per diet between the individual countries was large. The Finnish diets used more than twice as much land as the Danish diets.

- The results show, somewhat counterintuitively, that a relative increase in arable land allocated to livestock in the EY scenario compared to the SY scenario, had the potential to feed more people from Nordic agriculture.

- In comparison with current land use, a lower proportion of Nordic arable land would be needed for cereal production in the scenario diets (due to less feed production), while higher proportions would be used for grain legumes, rapeseed and other food crops (Figure 2). The proportion of arable land used for ley cultivation would decrease in all countries except in Denmark, where ley cultivation is currently relatively limited, and for the Finnish SY scenario.

Number of animals

- In the SY scenario the number of ruminants was kept at the minimum number required to maintain all semi-natural pastures, resulting in a 74 percent reduction in cattle and a 71 percent reduction in sheep and goats compared to current numbers.

- In the EY scenario, more ruminants were allowed in order to make use of the excess ley for food production. In the Norwegian case, ruminants were also allowed to graze the outfield areas. The total number of ruminants in this scenario increased to almost the same level as current numbers in the Nordic countries, resulting in a 17 percent reduction in cattle and a 35 percent increase in sheep and goats compared to current numbers.

- Poultry and pigs were limited to the number that could be supported with available by-products and, in the EY scenario, some feed grown on arable land. The number of pigs was reduced by 92 percent and 98 percent for SY and EY respectively, while the number of poultry decreased by 84 percent and 50 percent compared to current numbers in the Nordic countries.

- The amount of farmed fish was relatively constant between the two scenarios and around 60 percent lower than currently produced volumes from aquaculture. Around two-thirds of the fish in the diets was supplied from aquaculture while the rest was wild-caught fish. The amount of wild-caught fish corresponded to 7–9 percent of the current volumes landed in the Nordic countries. This resource could arguably provide more food, especially in Norway with its access to large coastal fishing grounds. Incorporating more fish in the diets could potentially increase the number of people who could be supported by the scenario diets. It is however questionable whether the current landed volumes are sustainable, and fish currently caught in international waters can hardly be considered a local resource.

- All scenarios showed a nitrogen (N) and phosphorus (P) deficit that would need to be compensated for by the application of N and P from additional sources. For SY the deficit was 20 kg N and 5 kg P, and for EY it was 28 kg N and 7 kg P per hectare per year. Some of the deficits could thus be compensated for by recirculation of human excreta to the fields. However other sources of nutrients for arable soils would also be needed for the long-term sustainability of the farming system.

Environmental impacts

- The SY and EY scenario diets would give rise to 0.36 and 0.48 ton CO_2-eq per diet and year respectively, mainly comprising methane emissions from ruminant feed digestion and nitrous oxide emissions from soils (Figure 3). The global GHG emission space has been estimated for pathways with a 'likely' chance of staying below 1.5°C global warming compared to preindustrial levels (Sanderson et al., 2016). These pathways require annual GHG emissions to drop to around 27 Gton CO_2-eq (3.2 ton CO_2-eq per person per year) by 2030 and reach 6 Gton CO_2-eq (0.6 ton CO_2-eq per person per year) by 2050, while long-term emissions need to settle at close to zero or net negative emissions. The estimated emissions from agriculture in the scenarios would occupy 11–15 percent of the 2030 emission space and 58–78 percent of the 2050 emission space. Considering that agriculture is presently estimated to account for around 15–25 percent of global emissions (Vermeulen et al., 2012) the scenarios can be considered in line with the pathways in the short term (up until 2030) while deeper reductions would be necessary further on.

- Leaching of nitrogen and phosphorus from arable soils accounted for roughly two thirds of the diet's total eutrophication potential (EP). The remaining third was mainly attributed to ammonia volatilization related to manure management, and for the SY scenario also to ammonia volatilization from non-harvested ley residues. The EP per diet was slightly higher in the SY scenario compared to EY, primarily since the latter scenario provided more diets without using more arable land.

- Volatilization of ammonia was the main contributor to acidification potential (AP) in the scenario diets, accounting for 97 percent of total AP. Fewer animals in SY compared to EY resulted in less volatilization of ammonia from manure. This was however counterbalanced by increased volatilization from crop residues due to extensive areas of ley being used for green manure in the SY scenario.

- Changes in soil carbon stocks were only modelled for Sweden. The model shows a net flux of +110 and -75 kg C per hectare per year over a 100-year time frame compared to business as usual, for SY and EY respectively. The difference is because more ley was left on the fields in the SY scenario. The modelled carbon stock changes in this study did not take into account any increased allocation of biomass to roots in organic agriculture, which may lead to an underestimation of the actual potential.

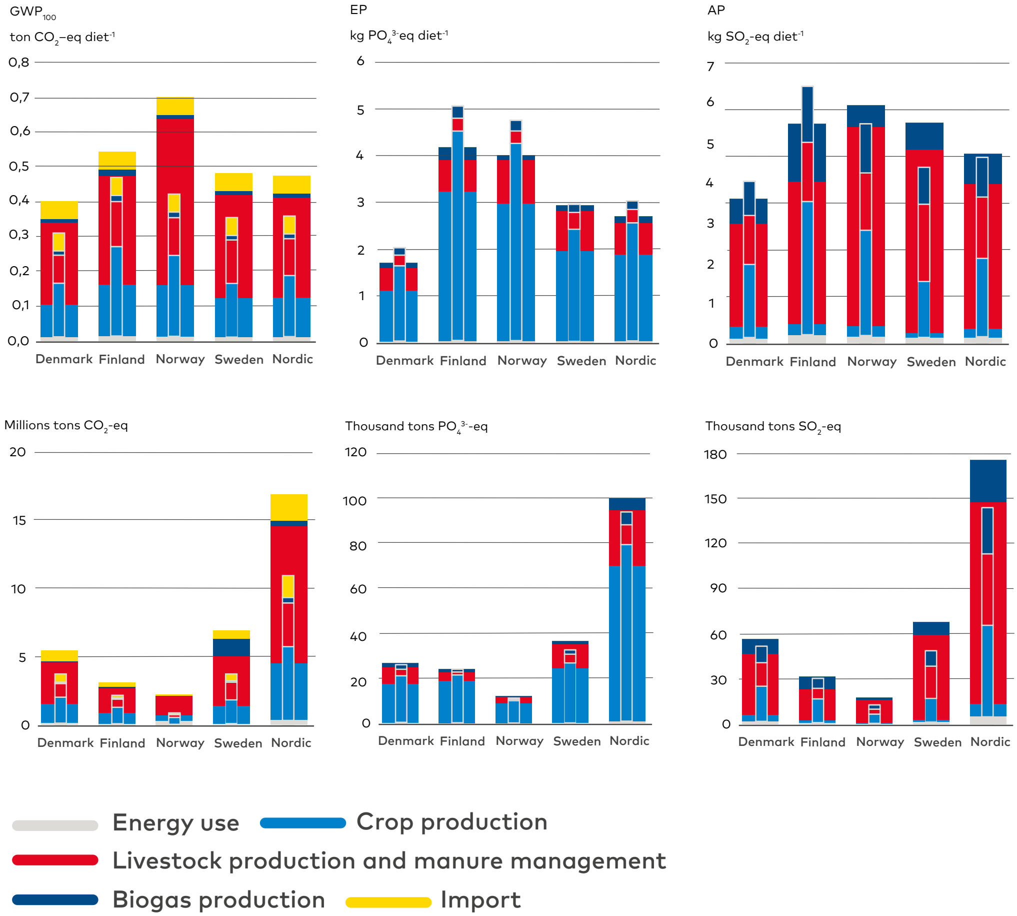

Figure 3. Estimated annual Global Warming Potential (GWP100), Eutrophication Potential (EP) and Acidification Potential (AP) from agricultural production and fisheries fuel consumption for the SY (thin bars) and EY (thick bars) scenario diets. The impacts are divided between imports (yellow), crop production (light blue), livestock production and manure management (red), energy use (grey) and bioenergy production (dark blue). Only GWP100 was estimated for the imported products. The total impacts are largely dependent on the total number of people who could be fed in the different case countries, leading for example to relatively high emissions from the Danish scenarios, since it would be possible to feed substantially more people from Danish resources than the current number of inhabitants.

BACKGROUND

This policy brief constitutes one of the main outputs from the project "Pathways to a Nordic food system that contributes to reduced emissions of greenhouse gases and air pollutants". It summarises some of the main results, conclusions and recommendations of the report "Future Nordic Diets" (Karlsson et. al 2017).

The project was carried out in collaboration with AirClim in Sweden, NOAH and Frie Bønder - Levende Land in Denmark, Suomen luonnonsuojeluliitto in Finland and Norsk Bonde- og Småbrukarlag in Norway, and was funded by the Climate and Air Pollution Group (KOL) under the Nordic Council of Ministers.

The Swedish University of Agricultural Sciences was contracted to do scenario modelling work. They also had the opportunity to contribute additional funds to support the project, including the involvement of Mälardalen University to evaluate the nutritional quality of the diets.


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Farming is the foundation of our food system. While the prerequisite for farming is a clean environment and a diverse nature, agriculture is currently the cause of major environmental problems, including greenhouse gas and nitrogen emissions. The challenge to protect our environment and feed the world sometimes seem insurmountable, but solutions might be just around the corner. This policy brief presents two food system scenarios for Denmark, Finland, Norway and Sweden, where the majority of food is produced within the region using organic farming practices and where livestock is mainly fed on grass and by-products not suitable for human consumption. The results show that we could feed the projected Nordic population in 2030 on organic food, mostly grown within the region, while reducing the climate and nitrogen footprints of our food system.

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