

Food consumption choices and climate change

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Summary <p>This report presents the results from an ENTWINED analysis of the climate impact associated with food consumption choices, with special focus on locally produced food. The purpose of the analysis was to analyze and compare the relative climate benefits of locally grown food with other consumption choices available to food consumers, and to propose policies that would enable a reduction in greenhouse gas emissions from food consumption. By constructing different representative consumption bundles (grocery bags), and analyzing emissions of greenhouse gases (GHG) associated with these, we could compare the level of GHG emissions associated with consumption choices. Our results showed inter alia that a vegetarian and seasonally adjusted grocery bag had the lowest emissions of GHG of the bags studied. For non-vegetarian bags, the amount of beef in the bag was very influential for the level of GHG emissions. The impact of locally grown food choices was relatively small, and in one case of the sensitivity analysis negligible. We concluded that from a climate perspective it is more important to focus on <i>what</i> we eat rather than whether it is locally grown, has been transported a long distance, or how the food item was produced.</p> <p>Any development of food & climate policies should be preceded by the development of a standard method for estimating life cycle GHG emissions from food. The cost effectiveness of different dietary choices and policies needs to be assessed. Since dietary shifts imply behavioural changes, the possibility to develop policy packages, including several different types of policies, might be explored.</p>	
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Introduction

The Swedish EPA (2010) calculates that food consumption is associated with some 20% of the Swedish greenhouse gas (GHG) emissions, when measuring emissions from a consumption perspective. In 2006, the Swedish National Food Agency was assigned the responsibility to reduce the environmental impact from food consumption. In 2009, the Swedish National Food Agency together with the Swedish EPA delivered a report with suggestions on environmentally friendly dietary choices to the European Commission. This report was pulled back by the Government Offices after criticism from the European Commission. The report was criticised for containing proposals that could encourage the purchase of Swedish goods at the expense of those from other countries, thus negating the principle of free movement within the common market and therefore a trade restriction. However, the potential negative impact on trade from the proposal was never evaluated and compared with the environmental benefits (Swedish EPA, 2011a; Sveriges Radio Ekot, 2011-09-08). A conflict between environment and trade seemed to have occurred, which made the question of environmental impacts of locally grown food a very interesting topic for the ENTWINED (Environment and Trade in a World of Interdependence) programme.

In 2012, the National Board of Trade published a review of the climate benefit statements often associated with the not fully defined term 'locally grown' food products. The report is focused on the relative climate impact from international transport of food products, and the relation between different stages of the food life cycle and its emissions. The review concludes that the focus on one single stage of the food life cycle as an indicator of climate impact can be misleading. The focus on locally produced food is one indicator considered as misleading from a climate perspective, one of the reasons for this is that there are other factors than transport distance that are important for the climate impact of food transport. Also, from a life cycle perspective there are other factors than transport that contribute to the climate impact from food, where the consumer behaviour is highlighted as potentially important. Transportation of food from store to home and food waste are mentioned as other factors of concern. To reduce GHG emissions from international food transport the review recommends global carbon taxes, and to reduce greenhouse gas emissions from other parts of the food life cycle the review recommends a number of different policy instruments. All in all, a system approach is recommended for a correct estimate of climate impacts from food (National Board of Trade, 2012).

So if it is not a reduction in transport distance by advocating locally grown food that is most important in order to reduce GHG emissions from food consumption, what then should be done? And how? The purpose of this report is to provide policy-relevant input and perspectives to these questions.

The objective of the ENTWINED programme is "to provide scientific knowledge, and to provide tools to support Swedish and other European negotiators and stakeholders in integrating environmental aspects into the international trade regime". This report contributes to this objective by analysing GHG emissions associated with different food consumption choices and by discussing which policies that could promote climate friendly

consumption choices. It was our hypothesis that trade restrictions might be unnecessary as a policy measure to reduce GHG emissions from food consumption in Sweden.

In this report we compare the climate impact of choosing to purchase locally grown food with the climate impact from other types of food consumption and use choices. We also discuss which policies that could promote the most climate friendly consumption in our analysis. The focus of our analysis was on consumption choices as potential measures to reduce GHG emissions from food consumption, since to eat locally grown food is a typical consumption choice, and should be compared with other available consumer choices. In our analysis we considered the consumption conditions in Sweden of today with respect to quantities consumed and GWP emissions associated with consumption. Furthermore, we restricted the analysis to emissions of GHGs. Our results were thereby only applicable to the climate aspects of food consumption.

In order to study climate impacts from different types of food consumption choices we used results from previously performed life cycle analyses (LCA), since this method ensures that all stages of the food life cycle are incorporated in the climate impact assessment. We performed case studies on different consumption bundles, starting with an *Average* grocery bag. This *Average* bag was then modified to represent alternative consumption choices. We included choices such as vegetarian diets, purchase of locally produced food items, a seasonally adapted food bag, but also an all-beef bag. The climate impact from these bags was also compared with the climate impact from home transport by car and by reduced wastage of food. Considering the results from the LCA-analysis, we performed a literature review to identify policy solutions that could be suitable to reduce the climate impact from food consumption.

We used the LCA database developed for the carbon footprint calculator climateaccount.se (IVL, 2009) as basis for our climate impact calculations. The quantities consumed in the *Average* grocery bag and its modifications were approximated from Swedish consumption statistics (Swedish board of Agriculture, 2012a). Climate impact estimates on other choices than grocery bag alterations were based on examples from the literature.

Our key results suggest that:

- To eat a Swedish seasonally adjusted vegetarian diet had the highest potential to be climate friendly.
- The Swedish seasonal aspect could be important for the total climate impact of the grocery bag. The importance of the seasonal aspect for GHG emissions increased in a grocery bag containing relatively low shares or amounts of beef. And in vegetarian grocery bags, the importance of the Swedish seasonal aspect could be high.
- The choice to drive a car to purchase food could be as important as non-vegetarian dietary choices with respect to the climate impact.

A conservative estimation showed that if all Swedes would have eaten a diet corresponding to our *Swedish seasonal vegetarian* grocery bag instead of the *Average* grocery bag, Swedish GHG emissions from food consumption would be ~3.6 million tonnes lower than today.

The total GHG emissions associated with the analysed grocery bags were sensitive to the estimated GWP estimate per kg product for the food categories. But the variance in total GHG emissions associated with a grocery bag was in our data more a result of which food item that was representing the food category than which study the data originated from.

Based on these results and also considering the data used to derive the results we conclude that:

From a climate policy perspective, it can be a good start for policy makers to discuss and try to influence *what* we eat. Hence, focusing on: locally grown food; transport distance of food items to store; or how the food item was produced, may not be necessary initially. It is also important to influence transport from store to home in order to further reduce GHG emissions from the food life cycle.

Policy suggestions:

The development of policies should be preceded by the development of a standard method for estimating life cycle GHG emissions from food, such efforts are currently initiated in the EU Product Environmental Footprint¹. Much of the policies aimed at consumers will be dependent on such a method. The cost effectiveness of different dietary choices and policies needs to be assessed in order to compare food consumption with other sectors where emissions can be reduced, maybe more cost effectively.

Since dietary shifts imply behavioural changes, the possibility to develop policy packages, including several different types of policies, might be explored. Such a policy package could contain: information measures such as voluntary agreements on food exposure in restaurants and stores; economic measures such as increased relative prices of beef; and regulative measures with increased serving of climate friendly food in the public sector restaurants.

¹ http://ec.europa.eu/environment/eussd/smgp/product_footprint.htm

Background

The International Panel for Climate Change (IPCC) considers it *very likely* (to use the IPCC terminology) that cold days and nights have become less frequent while hot days and nights have become more frequent over the past 50 years. Climate change expressed as increased global average temperature is *very likely* due to increased concentrations of GHG in the atmosphere with origin from human activities (anthropogenic) since the mid-20th century. Correspondingly, continued or increased GHG emissions will cause further warming and it is *very likely* that larger changes in the global climate system than the ones observed until now will occur. Climate change has many potential outcomes which lie some years into the future. Extreme weather events such as droughts and floods are expected, increasing sea levels are likely, as well as higher average temperatures etc. The outcomes will vary geographically, but overall there will be quite large changes Bernstein et al. (2007). One of the main pathways taken to reduce the problem with climate change is to reduce GHG emissions.

In Sweden, emissions of GHG have decreased from 72.7 million ton carbon dioxide equivalents (CO_{2e}) in 1990 to 66.2 million tons in 2010 (Swedish EPA, 2012a). However, this reporting of emissions only considers emissions produced within the Swedish borders (production perspective). If changing to the consumption perspective, the Swedish emissions of GHG in 2003 increase from the production perspectives' 76 million tons to 95 million tons (including international transport in contrast to the above mentioned numbers) (Swedish EPA, 2010). Out of these 95 million tons, some 80% are associated with private consumption. And some 25% of these 80% are allocated to the consumption need *eat* as it is called by the Swedish EPA (2010). Basically, in 2003, swedes needed some 20 million ton GHG emissions to supply the food intake (~2 ton per person).

Furthermore, from a consumption perspective it appears as if the Swedish emissions of GHG increase over time rather than decrease. In a recently published report, the Swedish EPA calculates a GHG emission trends associated with Swedish consumption. According to the report, the total emissions associated with Swedish consumption increased from 90 to 98 million tonnes over the period 2000 – 2008, corresponding to an increase of 9%. Some four million tonnes of the increase is considered to be caused by an increased population in Sweden (Swedish EPA, 2013).

This trend is confirmed by other studies, although with slightly different quantitative estimates. In a report for the Nordic Council of Ministers, Glen Peters and Christian Solli calculate the global carbon footprint for the Nordic countries (Peters & Solli, 2010). Their results show increasing GHG emissions for all the Nordic countries from 2001 to 2004. For Sweden, emissions increased from some 96 million tons of GHG in 2001 to 116 million tons in 2004 (see Figure 1). This is in sharp contrast to the Swedish official reporting from the production perspective for the same period (69.7 and 70.1 million tons GHG in 2001 and 2004 respectively) (Peters & Solli, 2010; Swedish EPA, 2012a).

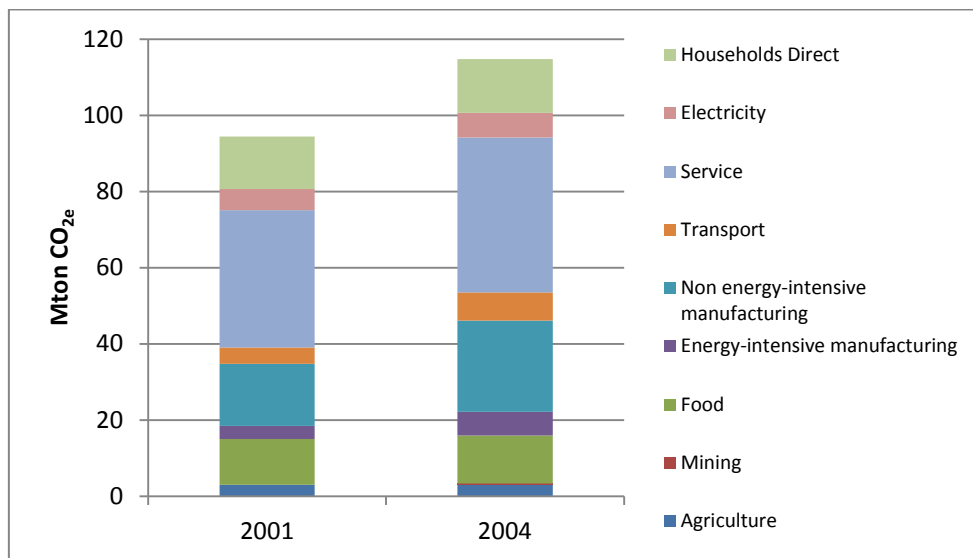


Figure 1: GHG emissions in Sweden from a consumption perspective, Source: Peters & Solli, 2010

The consumption perspective indicates that Swedish GHG emissions are increasing, but in order to make a more detailed analysis of GHG emissions from food, another approach is needed. In this report we chose to use LCA as a method to calculate GHG emissions from food.

The interest for LCA and carbon footprints of food products has been increasing for the last few years, and there have been a large number of studies performed for different types of food products. In Europe, projects at SIK – The Swedish Institute for Food and Biotechnology, the Danish project LCA food and the underlying work of the Ecoinvent database may be mentioned, but there has been many others significant contributors (SIK, 2012; LCA Food, 2012; Ecoinvent Centre, 2007).

The life cycle of a food product can be described in general terms as consisting of the following stages: *agriculture*, *food processing*, *warehouse/retail*, *consumption* (including storage and preparation) and *waste management*; see Figure 2. In-between these life cycle stages are international, regional and local transports, in Figure 2 illustrated by arrows between the stages. In many LCA studies on food products, the full life cycle (“cradle-to-grave”) is often not considered, but instead a “cradle-to-farm gate” or “cradle-to-store” perspective is used. Foster et al. (2006) review the available LCA studies for food and concludes that few studies cover the entire “farm to fork” part of the life cycle. Basically, emissions associated with consumption and waste management are most often omitted from LCA studies on food. One of the reasons for this could be to avoid having to take into account the plethora of possible retail stores, home transports and consumption habits.

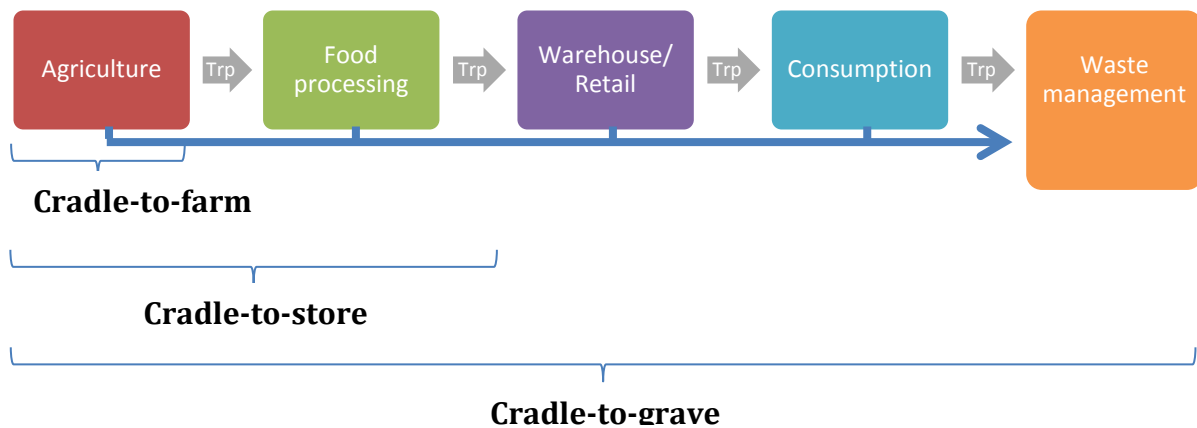


Figure 2: General product system description and the main life cycle stages of a food product. Different scopes may be used in an LCA, depending on the focus in on the agricultural production **system** or the entire life cycle of the food item.

Figure 2 also gives an insight to the challenges to be handled when performing an LCA on food. The consideration of transport within a stage, such as is often the case in the process stage, is difficult to capture. Furthermore, the consideration of GHG emissions from waste needs to be explicitly represented. The waste production, which occurs in all the food chain stages, is in Figure 2 indicated by the blue arrow. Our literature overview showed that the relative importance of the different stages can vary considerably, as is shown in table 1. In the table, the sum of all the individual stages’ contributions to the food chain GHG emissions is larger than 100%. This is because of variations between different food types (ex: vegetables or meat products), food production methods, or degree of refinement in the food product, but also partly due to different analytical approaches in the studies.

Table 1: The food chain stages’ relative importance with respect to GHG emissions

Stage	Low (% of total)	High (% of total)	Source:
Agriculture	14	95	Andersson et al. (1998), Angervall (2008)
Food Processing	<1	65	own estimate, Andersson et al. (1998)
Warehouse / Retail	1	2	Berlin (2010)
Consumption / Use	1	15	Davis (2009)
Transport	5	>75	Lagerberg Fogelberg (2008), DEFRA (2005, 2009)
Waste	3	45	Ventour (2008)

Table 1 motivates the consideration of the full food life cycle when trying to reduce emissions from food and when trying to design successful policies. It also motivates a focus on developing policies that would affect consumption choices, since consumption choices could have an impact on all stages of the life cycle, without singling out any particular stage.

Climate impact from food, a life cycle overview

LCA is a methodology used for quantification of the environmental impact of product life cycles. LCA relates the environmental impacts caused by production (including extraction of raw materials), transports, use and waste management of a product to a “function”, i.e. a desired benefit or usage. The procedure on how to carry out a LCA is described in the ISO 14040 and ISO 14044 standards, but there are several methodological choices that are dependent on the intended goal and scope of the LCA study that can have an effect on the results (ISO 2006a; ISO 2006b).

The Climate Account

The Climate Account² is a web based carbon footprint (climate impact) calculator developed by IVL (IVL Swedish Environmental Research Institute Ltd, 2009). The calculator contains a database of published results and data and use average values of these results and data as input to the calculator. The Climate Account calculator is thereby a meta-analysis version of previous LCA studies. Carbon footprint (climate impact) is in the data expressed by estimating the Global Warming Potential (GWP) associated with emissions of GHGs, mainly carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O). The time frame for the GWP estimates is usually 100 years, but for high GWP estimates for rice, the time span is 20 years. The data on climate impact from food consumption is based on Ahlmén & Persson (2002), Carlsson-Kanyama & Engström (2003), Lagerberg Fogelberg (2008), Ziegler (2008a,b), Lantmännen (2008), Olaussen (2008), Fuentes & Carlsson-Kanyama (2006), Enghardt Barbieri & Lindvall (2003), Williams et al. (2006), Andersson & Ohlsson (1999). The data most often include GHG emission from transport in the food life cycle emission estimates. For the rest of the data it is not specified whether transportation is included or not. In this study we used data from the Climate Account database together with consumption bundles (grocery bags) to calculate the climate impact of different types of food consumption patterns. For comparison we also calculated or highlighted the potential climate impact from home transport by car, reduced wastage of food, and the climate impact from specific food items transported by aviation.

The case studies

The *Average* grocery bag contained 15 kg of food items, where the relative share of the food items was approximated from Swedish food statistics (Swedish board of agriculture 2012a). The data available in the Climate Account data base determined which food items that was included in the *Average* grocery bag. The food items represented in the data base also determined which set of food statistics from Swedish board of agriculture (2012a) that were used to decide the relative shares of food items in our grocery bag, both statistics on direct as well as total consumption was used. The *Vegetarian* grocery bag differed from the *Average* bag by the replacement of 1 unit of meat for 3 units of beans and peas. This substitution was based on the approximate difference in protein content per kg product

² www.climateaccount.se

between yellow peas & brown beans, and meat³. This ratio could have been lower by the use of dried products or by the use of other beans. The *Beef* grocery bag differed from the *Average* grocery bag by only containing beef as representing the food category ‘meat’. The *Swedish seasonal* grocery bag differed from the *Average* bag by an adjusted mix of fruit and vegetables to the Swedish growth season. Rice was replaced by pasta and potatoes. In the *Local* grocery bag we also adjusted the mix of fruit and vegetables but allowed for a longer growth season thanks to the use of heated greenhouses. Rice was replaced by pasta and potatoes. The *Swedish seasonal vegetarian* grocery bag differed from the *Average* bag by the replacement of 1 kg of meat for 3 kg of beans and peas and by adjusting the mix of fruit and vegetables to the Swedish growth season. Rice was replaced by pasta and potatoes. Due to the replacement of rice by equal amounts potatoes and pasta, a small amount of energy was lost compared to the *Average* bag. Table 2 presents the composition of the grocery bags analysed.

Table 2: The food grocery bags in the LCA analysis (kg)

	Average bag / Beef	Swedish seasonal veg.	Veg.	Local	Swedish seasonal
Bread and grain mill products,	2.5	2.5	2.5	2.5	2.5
Pasta and rice	1.4	0.7	1.4	0.7	0.7
Potatoes	1.0	1.8	1.0	1.8	1.8
Fruits and berries	2.2	2.2	2.2	2.2	2.2
Vegetables	1.6	7.1	7.1	1.6	1.6
Fish	0.3	0.3	0.3	0.3	0.3
Meat	1.8	0.0	0.0	1.8	1.8
Milk and milk products	3.5	3.5	3.5	3.5	3.5
Eggs	0.5	0.5	0.5	0.5	0.5
Other products (estimate)	0.3	0.3	0.3	0.3	0.3

As is seen, when aggregated per food category, the *Average* and *Beef* grocery bags are identical. But when disaggregating the most relevant categories it can be shown that there are differences. Differences within a food category are also common for the other grocery bags.

³ <http://www7.slv.se/Naringssok/SokLivsmedel.aspx>

Table 3: Most important relative distribution within specified food categories (kg)

	Average bag	Beef	Swedish seasonal veg.	Veg.	Local	Swedish seasonal
Pasta and rice, out of which:	1.4	1.4	0.7	1.4	0.7	0.7
pasta	0.7	0.7	0.7	0.7	0.7	0.7
rice	0.7	0.7	0.0	0.7	0.0	0.0
Meat, out of which:	1.8	1.8	0.0	0.0	1.8	1.8
Beef & lamb	0.6	1.8	0.0	0.0	0.6	0.6
Pig	0.9	0.0	0.0	0.0	0.9	0.9
Poultry	0.4	0.0	0.0	0.0	0.4	0.4
Vegetables, out of which:	1.6	1.6	7.1	7.1	1.6	1.6
Root vegetables & beans & peas	0.6	0.6	6.5	6.0	0.9	1.0
Other salads	1.0	1.0	0.6	1.0	0.7	0.6

In Table 3 the impact of growth season on the relative share of “root vegetables & beans & peas” and “Other salads” is clarified. The shares in the *Average bag* are derived from the Swedish Board of Agriculture (2012a). These food categories are associated with different GWP estimates. Our best estimate GWP: s used in our calculations is presented in table 4.

Table 4: GWP estimates of different food categories (kg CO₂e / kg product) – best estimate

	Average bag	Beef	Swedish seasonal veg.	Veg.	Local	Swedish seasonal
Bread and grain mill products,	0.5	0.5	0.5	0.5	0.5	0.5
Pasta and rice	1.0	1.0	0.5	1.0	0.5	0.5
Potatoes	0.2	0.2	0.2	0.2	0.2	0.2
Fruits and berries	0.5	0.5	0.3	0.5	0.3	0.3
Vegetables	2.3	2.3	0.5	0.9	1.7	0.4
Fish	3.5	3.5	3.5	3.5	3.5	3.5
Meat	8.8	19.0	-	-	8.8	8.8
Milk and milk products	0.9	0.9	0.9	0.9	0.9	0.9
Eggs	1.0	1.0	1.0	1.0	1.0	1.0
Other products (estimate)	1.1	1.1	1.1	1.1	1.1	1.1

The best estimate GWP was derived as an average value for food items included in the food category. However, when data for a food category was scarce, we selected a representative GWP estimate. Table 4 also show that the shift in food items included within a specific food category affects the GWP estimate for that food category. This can for example be seen for the category ‘Vegetables’, where the GWP estimates varies both according to which types of vegetables that are bought (root vegetables or salad

vegetables), and according production method. The vegetables in the *Local* grocery bag have a lower GWP than the average bag because of the reduced import of exotic vegetables and because of a slightly increased consumption of root vegetables. The type of grocery bag, *Average/Swedish seasonal/Local*, affected the GWP estimate due to changes in production possibilities. As is seen in Table 4, the GWP estimate for meat is identical in the *Average*, the *Local*, and the *Swedish seasonal* bags. The data on GWP estimates in the Climate Account database is already based mainly on Swedish beef, so no adjustment of GWP estimates to represent lower GHG emissions from Swedish beef was possible. Neither could we adjust for the potentially higher GWP estimates from beef production causing land use change as is presented by Cederberg et al. (2011). Generally, for all the food products associated with emissions of methane, the GWP estimate presented in Table 4 can be considered to be underestimated. This is due to the recently highlighted impacts of methane as a short lived climate forcer (Shindell et al., 2012). This impact was not included in the GWP estimates in Table 4.

Home transport

As described above, the transportation from store to home is one aspect where the consumer may reduce the climate impact of food consumption. In this study we use literature review and own calculations based on the composition of the car fleet of today to calculate the climate impact of home transport by car.

Waste

Besides choosing between different types of food, consumers also have other choices that affect the climate impact of their food. One such example is how much food that is wasted in the home. In this study we used literature review and own calculations based on measured amounts of waste and the GHG emissions from waste disposal in order to estimate the climate impact from a reduction in food waste disposal. The potential climate impact from food waste reduction was not included as a part of the climate impact of the grocery bags.

Aviation

Another mode of transport for food is aviation. Aviation is an example of an energy intensive mean of transportation. In this study we combined results from the literature with our own calculations to estimate the added climate impact when food is transported by aviation. The potential climate impact from aviation was not included as a part of the climate impact of the grocery bags.

Most important assumptions

By calculating the climate impact of food consumption choices as the difference between climate impacts of different types of consumption choices we implicitly made the assumption that food consumption choices in Sweden would directly affect production of food.

Analysis of uncertainty in our LCA results

The Climate Account database allows for some illustration of variation in the results. We estimated the variation and robustness of our results by using low, best estimate, and high GWP estimates for the different food categories. Marginal products such as hamburger bread were not included in the range of GWP estimate. The intervals of the variation estimates was, due to the structure of the Climate Account database, mainly a product of different GWP estimates for different food items within a specific food category. The variation range could have been larger if more estimates would have been available. Given the uncertainty in the results we also checked for robustness in our results by performing a literature review to see if our results contradicted or agreed with previous results. This robustness check was a 'light' version of the qualitative assessment of uncertainty used in the working group 3 contributions to the IPCC fourth assessment report (Bernstein et al., 2007).

Deriving policy recommendations from LCA results

There is uncertainty and variation in the results from LCAs studying food consumption and it can be difficult to derive solid policy recommendations from any single study. But consumption of food is responsible for ~20% of the Swedish GHG emissions when measuring emissions from a consumption perspective (Swedish EPA, 2010), and action to reduce GHG emissions are needed to reduce the uncertainty of the future impacts of climate change (World Bank, 2012). Therefore, actions to reduce GHG emissions from food consumption are motivated. Following the precautionary principle (Commission of the European Communities, 2000) we were compelled to propose policy recommendations based on our results, with the aim to allow final consumers to reduce the GHG emissions from food consumption.

Based on the result from our LCA studies, we reviewed policy options that in particular targets consumers. But also producers of food were sometimes within the scope. The suggested policy options were limited to the LCA results with the highest climate impact in our study, and for which relevant literature was available. Moreover, the analysis was limited to actions that can be achieved in Sweden or to some extent in EU, since policy instruments on a global scale were assumed to be more difficult to achieve. The recommendations were preceded by a literature review and mapping of policies in Sweden in the food life cycle, see Appendix 1.

Overall assessment of LCA results

GHG emissions from six different mixes of food purchases (grocery bags) were analysed by using LCA. For comparison we also analysed the impact on GHG emissions of: home transport by car; improved waste management; and energy intensive modes of transportation. The results from our study showed that food consumption choices have a large impact on GHG emissions. Consumer choices related to diets, home transport, waste management all affected national total emissions.

The case study grocery bags

Figure 3 show our best estimate GHG emissions associated with the different grocery bags. The figure provides information on the contributions of different food categories to the total emissions for each grocery bag. The figure also presents variation or uncertainty in the total emissions with the error bars. The range of the error bar was caused by the difference between low and high GWP estimates for the different food categories, often implying that different food types had been included in the food category. The effect on total GHG emissions caused by different food types was often larger than the effect from variation of results from different studies on the same food type. The main exception from this rule was rice, with a GWP estimate ranging from 1.15 – 6.4 kg GHG / kg product. The smaller size of the error bar in the *Swedish seasonal* bag was mainly due to reduced variation in the types of vegetables and fruits consumed.

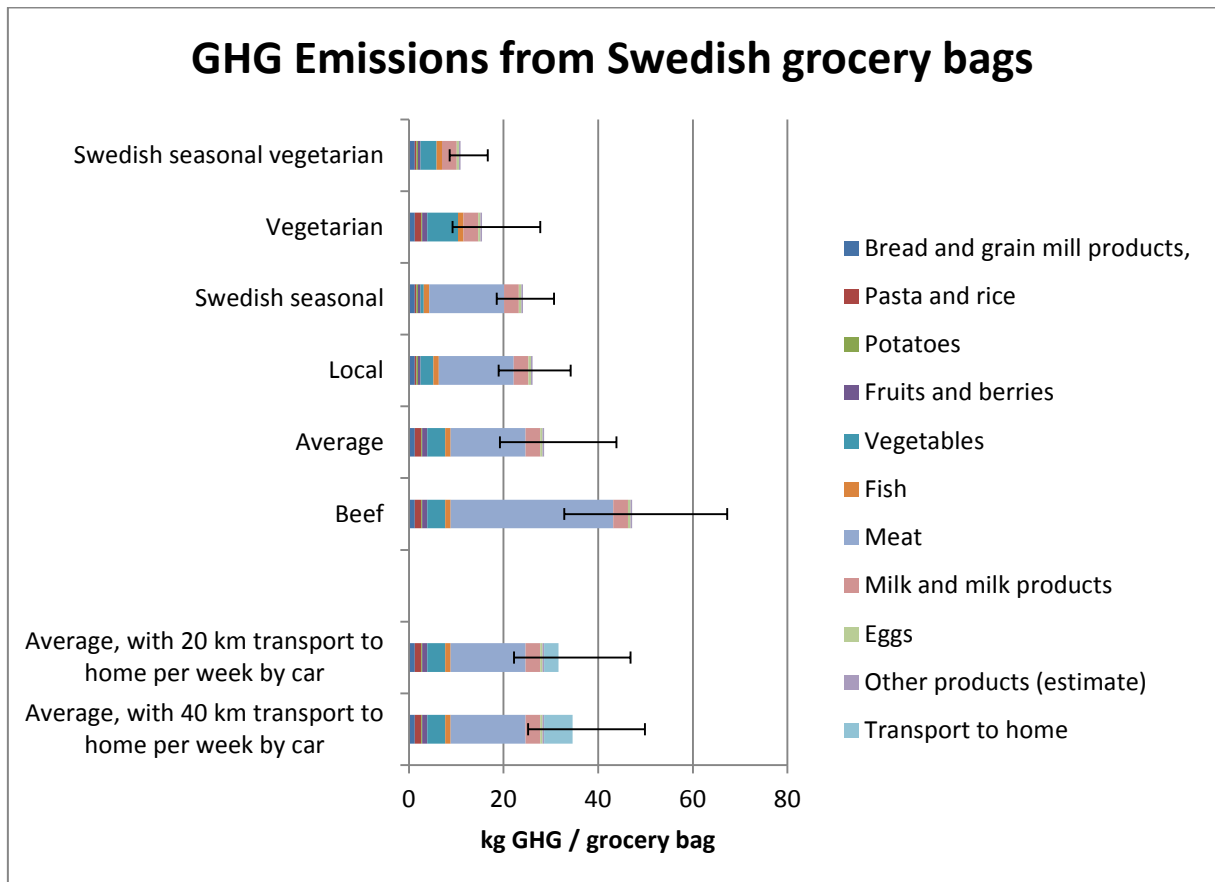


Figure 3: GHG Emissions from Swedish grocery bags, including maximum and minimum GWP estimates.

The two vegetarian grocery bags had the lowest GHG emissions. Of high relevance for the discussion on the climate impact from locally produced food is that when we used the LOW GWP estimate in the GHG emission calculations, the *Average*, *Local*, and *Swedish seasonal* grocery bags were associated with very similar GHG emissions (19.2, 19.0, 18.6 kg CO_{2e} respectively). It is however important to remember that we did not use a ‘local beef’ GWP estimate in the calculations.

Furthermore, the GHG emissions associated with the *Beef* grocery bag clearly showed the importance of beef in the total GHG emissions from Swedish food consumption. The impact on total emissions from home transport by car was comparable with the impact on total emissions from the changing content in the non-vegetarian grocery bags.

Home transport

Sonesson et al. (2005) investigate, with the use of questionnaires and interviews, how selected households in Sweden transport food from the store to their homes. The number of times a store is visited per week and the amount of food purchased each time varies a lot. The conclusion is that an average weekly distance of 28 to 63 km is driven by car to different types of food shops (Sonesson et al. (2005). Assuming a new car in Sweden, which on average emits 142 g CO₂/km according to EEA (2012), this would imply that a

40 km drive to and from the store per week, solely done for this purpose would correspond to almost 6 kg of CO₂ emitted for this trip, and 3 kg CO₂ for 20 km.

Waste

A 2008 study from the UK shows that as much as one third of the food that is purchased is wasted in UK households, and more than half of it is classified as “avoidable waste” (Ventour, 2008). Sonesson et al. (2008) shows that the average kg of wasted food in households correspond to about 2 kg CO_{2e} when it is produced (taking into account all the stages of the food chain). In Sweden, about 239,000 tonnes of avoidable food waste is generated in households every year, corresponding to about 25 kg per person per year excluding beverages other than milk products (Jensen et al., 2011). These tonnes constitute some 35% of the total food waste from the food chain in Sweden 2010. The GHG emissions from avoidable waste then corresponded to 50 kg CO_{2e}. The GHG abatement potential only from an improved household food housekeeping / waste management was not large. These 50 kg CO_{2e} are on the other hand unnecessary emissions.

Aviation

The best available estimate on CO₂ emission factors from food transported by aviation was 0.58 kg CO_{2e}/ton kilometre for long haul flights (DEFRA, 2009). This emission factor imply that one kg of vegetables, transported by aviation from Sub-Saharan Africa to Europe, a trip of approximately 5000 kilometres (Google maps, 2012), will be responsible for air transport emissions of 2.9 kg CO_{2e}. This can be compared with the GHG emissions from beans, where 1 kg of Beans is associated with 0.5 kg of CO_{2e} emissions. Or if compared with our grocery bags, including 1 kg of vegetables transported by aviation in the grocery bag mix would increase emissions of the *Average* bag by some 10%.

All examples

Table 5 shows the same results as in the Figure 3, but with impacts estimated as per cent deviation from the *Average* grocery bag in order to better illustrate the GWP emissions in the HIGH and LOW.

Table 5: Climate impact of consumption choices relative to the *Average bag*

	Impact (%)	Impact (%) low GWP	Impact (%) high GWP
Swedish seasonal vegetarian	-62	-55	-62
Vegetarian	-46	-52	-37
Swedish seasonal	-16	-3	-30
Local	-9	-1	-22
Average bag	0	0	0
Beef	65	71	53
Average, with 20 km transport to home per week by car	10	16	7
Average, with 40 km transport to home per week by car	21	31	14

The table shows more clearly than the figure above that the choice to transport the grocery home by car has an impact on GHG emissions similar to the impact on emissions caused by a vegetarian diet.

In order to enable a comparison of the GHG emissions from the grocery bags with reduced GHG emissions from improved food waste management we nationalised our grocery bag results. The Swedish population was ~9 378 000 in 2010, and the total purchase of food items was ~644 kg per capita in 2010 (Swedish board of agriculture, 2012a). By assuming that the grocery bag covers 50% of the per capita food purchases in Sweden we calculated the impact on national GHG emissions. The results are shown in Table 6. The impact of home transport by car was not aggregated to a Swedish total value due to missing aggregated data.

Table 6: Conservative potential for GHG emission reduction by dietary choices in Sweden, 2010 – best estimate GWP

Grocery bag GHG impact per year in Sweden (deviation from the average grocery bag)	Kg CO _{2e} / cap	Total Sweden [Mton]
Swedish seasonal vegetarian	-379	-3.6
Vegetarian	-283	-2.6
Swedish seasonal	-97	-0.9
Local	-53	-0.5
Improved waste management	-50	-0.5
Average bag	0	0.0
Beef	+398	+3.7

The table above presents conservative estimates for the national impact on emissions associated with the various grocery bags. Our *Average* 15 kg bag per week would constitute 780 kg food per year and person. So to assume that this bag only constitutes 50% of total

consumption is an underestimate, this in turn makes the impact on national emissions to be underestimations.

Sensitivities / central assumptions affecting the results

In the *Local* bag, GHG emissions were reduced because of the increased consumption of Swedish fruits and vegetables and the exclusion of replacement of rice with pasta and potatoes. Although Swedish meat is normally associated with lower GHG emissions than meat from other sources, we chose to be conservative in the *Local* grocery bag in our study and used the same GWP estimates for meat as in the *Average* grocery bag. We were also conservative (or even meat friendly) when using a 3:1 weight ratio in the replacement of meat in the vegetarian grocery bags.

When performing sensitivity analyses we saw that if the climate impact of Swedish beef would be 25% lower than the average beef, then the average climate impact from meat would be reduced from 8.8 kg CO_{2e}/kg meat to 7.2 kg. A pig and poultry meat diet reduced the climate impact of meat from 8.8 kg CO_{2e}/kg meat to 3.8 kg (using a best estimate GWP of 19 kg CO_{2e}/kg meat for beef, 5 for pig (and other categories), and 1.7 for poultry). As an addition, table 7 below shows the sensitivity to meat and beef content of the GHG emissions associated with the *Average* grocery bag for five different cases.

Table 7: Impact on the average grocery bag CO_{2e} emissions from changing meat & beef consumption

Beef & meat sensitivity	CO _{2e} / kg meat	CO _{2e} per bag		
		LOW	Best estimate	HIGH
Average bag	8.8	19	29	44
Av. Bag - Low Swedish beef GWP	7.2	19	26	40
Av. Bag - Low share beef	6.6	17	25	39
Av. Bag - More veg., 1 kg meat	8.8	16	24	39
Av. Bag - More veg., 1 kg meat, low share beef	6.6	14	22	37
Av. Bag - No beef grocery bag	3.8	13	20	32
Swedish Seasonal – Low share beef		16	20	26
Corresponding Vegetarian		10	15	28
Swedish seasonal – More veg., 1 kg meat, low share beef		13	16	20
Corresponding Vegetarian		10	17	30

One implication of this sensitivity was that for some of these special cases, a bag containing meat could imply lower GHG emissions than a vegetarian grocery bag. This situation occurred in our analysis when we compared the GHG emissions from the *Swedish seasonal* grocery bag with the *Vegetarian* grocery bag. If we assumed a low share of beef in the *Swedish seasonal* grocery bag, this bag had lower climate impact than the *Vegetarian* grocery

bag when using high GWP estimates in the GHG calculations. If we assumed both a low amount of meat and a low share of beef in the Swedish seasonal grocery bag, this bag had lower climate impact than the vegetarian grocery bag in calculations based both on the Best- and HIGH GWP estimate. Besides the impact on results of the amount of meat and beef used, the major reason for this situation was the high variation in GWP estimates for rice and the seasonal aspects of vegetables. While the 3 to 1 weight ratio between beans & peas and meat was not as important, the climate impact from consumption of rice and certain off-season fruits and vegetables in the *Vegetarian* grocery bag helped explain why the *Vegetarian* grocery bag could have larger GHG emissions than a *Swedish seasonal* grocery bag.

The best performing grocery bag was the *Swedish seasonal vegetarian* grocery bag. The difference between this bag and the *Vegetarian* grocery bag was that rice was replaced by potatoes and pasta, and that the Swedish growth season determined the choice of vegetables being consumed. The impact of season is also seen in the difference in emissions between the *Swedish seasonal* and the *Local* grocery bag. The GHG emissions from vegetables were 1.7 kg CO_{2e}/kg product in the *Local* grocery bag and only 0.4 in the *Swedish seasonal*. The reason to the difference is that vegetables grown in heated greenhouses were excluded and more root vegetables were consumed in the *Swedish seasonal* grocery bag.

Sensitivities / central assumptions affecting the results

In our case studies, to consume a seasonally adjusted vegetarian diet had the highest potential to be climate friendly.

The Swedish seasonal aspect could be important in grocery bags with low amounts of beef. Given the large amount of meat in our *average* grocery bag, the climate impact of Swedish seasonal aspects seemed low. But in other grocery bags, with lower shares or amounts of beef, the Swedish seasonal aspect turned more and more important, in a sort of inverse proportionality to beef consumption.

The choice to drive a car to purchase food could be as important as non-vegetarian dietary choices with respect to the climate impact.

Discussions

In this report we have compared the climate impact of different food consumption bundles, illustrated as grocery bags, and the climate impact of different use choices. Due to the apparent potential conflict between climate benefits and trade we restricted our analysis so that we only considered climate impacts. We do recognise that there are other important environmental aspects of food consumption such as: pesticide use; Genetically Modified Organisms (GMO), biodiversity issues, animal health, food security, cultural heritage, etc. But these aspects were not possible to include in our analysis.

The most important aspect of our LCA results was that dietary choice determines much of the GHG emissions associated with the grocery bags. This aspect was partly dependent on the data available in our Climate Account database. This implied that GHG emissions from food consumption were lower for vegetarian diets. The best performing grocery bag, *Swedish seasonal vegetarian* had 62% lower emissions than the *Average* bag in our best estimate (55% - 62% for low and high GWP estimates). This suggests that policy development or discussions on what to do about GHG emissions from food consumption doesn't have to focus on aspects such as locally grown food, international transport of food, or specific production methods. Some of these aspects are difficult to draw general conclusions from, and can therefore be misleading as guidelines or indicators. As an example, the aspects of locally produced food and transport distance of food has been shown to be ambiguous. In our literature review we found that the transport contribution to the total life cycle GHG emissions from food often ranges between 5 – 75% of total emissions dependent on food item. The National board of trade presents ranges of 2 – 15% for international transport. Furthermore, Ziegler (2008) and Ziegler et al. (2013) present that transport distance might make a very small change in life cycle GHG emissions of fish, Högberg (2010) shows that tomatoes produced in Sweden can be both better than Dutch but worse than Spanish tomatoes. In some cases, when transporting fresh vegetables with aviation, the transport share of total life cycle emissions can be much higher. Altogether, results from different LCA show that the climate impacts from transportation do not give a coherent picture. Hence, policies focusing on dietary choices may give a more solid climate effect.

In other words, our results suggest that from a climate perspective it can be a good start for policy makers to discuss and try to influence *what* we eat. Hence, focusing on locally grown food, transport distance of food items to store, or how the food item was produced may not be necessary initially. Our results also points at the importance of influencing transport from store to home in order to further reduce GHG emissions from the food life cycle.

Policy instruments that could promote food consumption with lower GHG emissions

Environmental policies can, as policy instruments in general, be categorized in different groups. In this report we categorize environmental policy instruments in the groups: information / voluntary agreements; economic instruments; and legal instruments (regulations). This categorization is for example used by Vedung (1998) and the Swedish Board of Agriculture (2013).

Information as a policy measure is often politically easy to implement to a relatively low cost. One disadvantage with information measures is that it is not guaranteed that the advices are followed. Legal instruments are easy to follow up but controls on compliance of the regulations must be done. Economic instruments aim at considering external costs and influence behaviour through market signals. They can be designed in a variety of ways e.g. increasing prices on goods that are environmental harmful or providing incentives for investments in improved environmental technology. For example economic instruments related to CO₂-intensive home transport of food are supposed to give incentives for consumers to choose less CO₂-intensive transportation. Contrary to legal instruments, where everyone has to comply with the regulation, economic instruments create incentives for actions for those who can reduce emissions at the lowest cost. The policies can either target producers, distributors or consumers. We primarily discuss policies aimed at consumers.

Why policy instruments oriented towards the final consumer instead of the producer?

In this study we focused on food consumption choices and their impact on GHG emissions. There are other aspects than consumption choices that affect emissions in the food life cycle. These aspects are outside the scope of this study but some examples can be found in Swedish board of agriculture (2012c). The background to this report was the debate on the climate aspects of locally grown food. We wanted to complement this debate with more focus on the consumption choice perspective, hence the writing of this report. There is also another reason to focus on consumption choices when considering how to reduce emissions of GHG from food. Using economic instruments to steer towards climate friendly food can either be applied to the emission sources or to emission outputs (products). Most often it is argued that taxations on the emission source are most effective since it directly affects the source. Schmutzler and Goulder (1997) however identify three circumstances when it is more appropriate to impose taxation on the outputs rather than on the sources, namely a) when the cost of monitoring emissions are high b) there are limited options for reducing emissions apart from output reduction and c) there are possibilities for substitutes. Wirsenius et al. (2010) argues that for food these criteria are fulfilled.

General aspects related to the policy suggestions

In our policy literature review we sought to identify best practices available to reduce food consumption emissions via changes in consumption choices. However, our review identified that best practices are scarce, both in Sweden and abroad. A summary of the review is presented in Appendix 1 to this report.

Recent publications already discuss policy options that could be considered when trying to reduce GHG emissions from food consumption (Swedish Board of Agriculture 2012c, 2013; Swedish EPA 2011a). Therefore, none of the policy suggestions presented in this report can be considered as unique. Rather, we have tried to complement the previous reports on the issue. In this section we first present our overall assessment followed by the case specific policy assessment. In this policy literature review we only had the opportunity to review policies promoting dietary changes.

Policies to be considered

During our policy literature review we noticed that two elements seemed to be missing from the discussion on policies that could reduce GHG emissions from food consumption. We also noticed that a reminder could be in place for another important element of the policy discussion. We therefore argue that three general concerns needs to be considered when discussing policies to reduce GHG emissions from food consumption. Following these three, more topic specific policies could also be considered.

General suggestions

Implement policy packages to promote dietary changes

A consumption shift from the *Average* grocery bag to other more climate friendly grocery bags would imply dietary changes, or behavioural changes. The UK Central office of information (2009) presents that effective behavioural change policies must address: individual factors explaining behaviour; social factors explaining behaviour; and environmental factors (both local and wider factors). Our interpretation is that no single type of policy instrument is likely to achieve the desired behavioural change, so a bundle of instruments would be needed. This interpretation is supported by the Swedish EPA (2011a), Gärling & Schuitema (2007) for behavioural change related to transport, and Owens & Driffill (2008) for behavioural change related to energy. The Danish experience of the recently implemented and abandoned fat tax can serve as another motivator for implementing both coercive and non-coercive instruments when trying to reduce GHG emissions from food consumption.

Regulation: Develop a standardised GHG emission calculation for food

Almost all other policy instruments in our review are dependent on information regarding the GHG emissions from a food item (See for example Appendix 1; or Swedish Board of Agriculture 2012c, 2013). As of today there is no internationally accepted standard methodology. Before such a standard is available, no other policy instrument will have any measurable effect since it cannot be tagged to any 'GHG performance'. Having this method would specifically enable an easier process in the efforts to put a climate label on

food. Inspiration can be found in the EU efforts to develop a standard for calculating GHG emissions from renewable fuels (JRC, 2008), and also from the new EU initiative: Product Environmental Footprint⁴. This emission calculation standard could then serve as basis for inter alia climate labelling.

Labelling isn't generally considered as a stand-alone measure to change consumer behaviour (Swedish board of agriculture, 2009a; Nijenhuis et al. 2008). But the consumers with the ambition to make conscious choices should be given the opportunity to do so. However, to analyse a products' GHG emissions often turns out to be complex and time-consuming due to absence of a uniform system and lack of sufficient data (Nijenhuis et al. 2008). As an example the British supermarket chain Tesco announced in 2007 that they would carbon label 70 000 products with their carbon footprint⁵. The project, however, turned out to be too ambitious and the plans were dropped in 2012⁶. Challenges also faced a Swedish project initially aimed at developing a climate label for food (Futerra Sustainability Communications, 2012). Another problem with climate labelling is related to conflicts between different types of targets that can be difficult to sum up (Swedish Environmental Protection Agency, 2007). Altogether it appears as if voluntary efforts to develop GHG emission calculation standards and climate labels are currently underachieving, and it could be worth considering more efforts on a Swedish or a joint EU initiative. The EU Product Environmental Footprint appears promising. The establishment of an accepted methodology for the calculation of GHG emissions from food would enable a range of policy options. This is also an area where further research is needed.

Economic: Establish knowledge on GHG cost efficiency of dietary choices

A missing piece of information in the literature is the production cost of different food items. The only cost estimates we've found are in Wirsenius et al. (2010), and Faber et al. (2012). These studies model impact from carbon or meat taxes. Wirsenius et al. (2010) present that a carbon tax equivalent to € 60 / ton CO₂ would reduce meat consumption in EU with 15%. Based on Wirsenius et al. (2010), The Swedish Board of Agriculture (2012c) argues that a larger decrease in meat consumption would require much higher meat taxes. This suggests that a meat tax in Sweden only could contribute with a limited reduction in GHG emissions from food consumption before the carbon prices is higher than in other sectors.

The production cost is needed in order to estimate the cost efficiency of dietary change policies. The cost efficiency is in turn important since we need to establish whether GHG emissions from food consumption should be targeted with policies before other sources of GHG emissions are targeted. If the carbon price associated with dietary change policy is too high, then society should invest resources in other sectors primarily. The prices in the food market are currently affected by subsidies and taxes, so a standard price survey is not sufficient in this case to analyse the cost efficiency of dietary changes.

⁴ http://ec.europa.eu/environment/eussd/smgp/product_footprint.htm

⁵ <http://www.guardian.co.uk/business/2007/jan/19/ethicalbusiness.supermarkets>

⁶ <http://www.guardian.co.uk/environment/2012/jan/30/tesco-drops-carbon-labelling>

The GHG emissions abatement cost efficiency of the different grocery bags has not been in focus in this study. In the literature we have seen few results indicating any information on the cost efficiency of various options. Wirsenius et al. (2010) and Faber et al. (2012) are the only references we have seen that estimates abatement costs for reducing meat consumption. The Swedish National Institute of Public Health (2009) concludes that environmentally friendly food consumption can save money for the consumer. We have however mentioned the high price elasticity of meat (Swedish Board of agriculture, 2009b) several times. The results from that study encourage the idea to use the price mechanism as a way to reduce emissions from food consumption.

Just to get a grasp of how dietary change could rank on a GHG cost efficiency scale, we performed a quick price survey in our local grocery store and implemented these retail prices on our grocery bags. Although just to be used for indicatory purposes, the survey indicated that our low emission grocery bags are less expensive than the *Average* and *Beef* bags. The indicative GHG abatement cost varied in this survey between -3 to -7 SEK / kg CO_{2e} abated (including taxes & subsidies). The climate friendly grocery bags appeared less expensive than the *Average* bag and the *Beef* bag, which indicated that consumers were not acting as cost minimizing economic agents when shopping food. This was no surprise, but nevertheless supported previous results on the impact of habits on food consumption that has been expressed in Faber et al. (2012), and by the Swedish EPA (2011a). It also confirmed that retail prices for environmentally friendly diets are lower for than for the average food as concluded by the Swedish National Institute of Public Health (2009). More research on the cost efficiency of GHG emissions abatement by changes in consumption choice is needed.

Case specific suggestions

Promote Seasonal vegetarian diets / reduced beef consumption

Our grocery bag with lowest GHG emissions was the *Seasonal vegetarian* grocery bag. Our grocery bag with highest GHG emissions was the *Beef* grocery bag. The following discussion on policies considers suggestions on how to promote a *Seasonal vegetarian* diet, and discourage a *Beef* diet. As mentioned there are other reports covering similar policies, so in this section we highlight what we consider to be high potential policies.

Information / Voluntary agreements

Increased exposure to low-GHG food items in stores and in restaurants

The exposure of food items affects consumption choices (Swedish EPA 2011a, Thaler & Sunstein 2009). As a sort of voluntary agreement between state and companies, retailers and restaurants should be encouraged to adapt the exposure of food items so as to maximise the exposure of low GHG-emission food items.

Advanced consumption guidance:

The Swedish University of Agricultural Sciences recently developed a meat guide (Röös, 2012) in which coloured smileys guide the consumer to which kind of meat (or other protein sources) that should be purchased to be environmentally friendly. Smileys have been shown to affect consumer behaviour in the field of energy efficiency (Thaler & Sunstein, 2009). However, Thaler & Sunstein (2009) also presented that the best

performance was achieved when smileys were paired with information on how well the comparative social group was performing. If a standard for GHG emission calculation methods were to be developed, possibilities for advanced consumption guidance could be within range. This would allow consumers to compare the GHG emissions from their food consumption with the GHG emissions from the average Swede (or friends if you like).

Economic instruments

Increase relative prices of beef

To change the relative prices of beef is appealing as a policy instrument due to the high price sensitivity of beef (Swedish board of agriculture, 2009b). Wirsenius et al (2010) present that a tax on meat should be a cost effective solution to decrease meat consumption. One benefit with a tax on meat is that the import will be covered as well as domestic production and therefore imported meat would not be favoured. A production tax could also lead to carbon leakage and not reduce global GHG emissions, since production would simply move abroad. The Swedish Board on Agriculture (2013) concludes that a carbon tax on consumers can be a realistic alternative, provided that the tax is based on standard calculations on different types of meat products such as beef, poultry and other types of meat. Again, a standard method for GHG emission calculations would be needed.

However, Lower VAT on ecological food has been examined by the Ministry of Finance. The Swedish Environmental Protection Agency (2011a) describes that two main clauses were put forward after this investigation. Due to the so called principle of equal treatment in EC law, Sweden cannot introduce different VAT rates on eco-labelled foods and other products. Moreover, the economic analysis showed that VAT is not the most appropriate environmental policy instrument with regard to for example cost-effectiveness and it is conflicting with the polluter pay principle. And as mentioned, the Swedish Board of Agriculture (2012c) present that a meat tax would have to be high in order to reach a 25% decrease in beef consumption. Also, the use of economic instruments has just recently experienced a draw back in the dismantling of the Danish fat and sugar tax. In 2011 Denmark introduced a tax on saturated fats in oils and certain dairy products with a fat content above what is normal in drinking milk. The purpose was to improve life expectancy by stimulating consumption of more healthy food (Danish Ministry on Taxation, 2010).

Regulation

Climate adapted / Seasonal vegetarian meals in the public sector

Public meals in schools, healthcare and other societal operations can affect the consumption behaviour and provide signals on sustainable food choices (The Swedish Board on Agriculture, 2012c). There are for example municipalities with meat-free days in school, which contributes to reductions in meat consumption. A climate based steering on procurement could also provide incentives for producers to invest in climate adjusted production (The Swedish Board on Agriculture, 2013). Information and education regarding the climate impact from different types of food could help to increase the societal acceptance for such policies.

Uncertainty / Variation of results

The food life cycle for various food items is basically an enormous matrix of potential effects on GHG emissions. In our examples we have highlighted the impacts of heated greenhouses and the transport by aviation or home transport by car as examples of parameters in the food life cycle with large impacts on the GHG emissions from food. We are sure that it would be possible to produce a grocery bag similar to our *Swedish seasonal vegetarian* grocery bag but with much higher GHG emissions than the one we have calculated. There will always be marginal types of production that could have large impacts on the GHG emissions from a specific food item. In this report we tried to cover the uncertainties and variations by showing low, best estimate, and high GWP estimates in our database for the food categories. We also included robustness estimates based on literature reviews as an indication of the plausibility of our results.

Cross-checking of results:

In our quick literature review we found the following studies that present similar results.

Beef / Vegetarian

The negative climate impact of beef is well established. For example Bows et al. (2012); Nijenhuis et al. (2008); Faber et al. (2012); Swedish Board of Agriculture (2009c, 2012, 2013), and the Swedish EPA (2008, 2011a) stress the importance of beef consumption to the GHG emissions from food consumption. Faber et al. (2012) also shows the positive climate impact of a vegetarian diet. However, the Swedish Board of Agriculture (2009c) shows a stronger reduction in GHG emissions when shifting from an average diet to a vegetarian diet than we do in our results. They also present lower impacts on GHG emissions from a seasonally adjusted diet than we do. One reason for this can be the comparatively low share of beef in our grocery bags. We also suspect that we have used higher GWP estimates for fruits and vegetables than the Swedish Board of Agriculture (2009c).

Home transport

The importance of the home transport to the GHG emissions from food consumption is also stressed in Faber et al. (2012).

Aviation

The energy intensity and thereby the large emissions associated with aviation as means of food transport is also expressed in Nijenhuis et al. (2008) and Swedish Board of Agriculture (2009c).

The most important assumptions

In this study we compared the GHG emissions from different food consumption bundles (grocery bags), and then estimated the impact on emissions if consumers were to purchase low emission grocery bags. As we state in this report, this causal link between changes in individual consumption change and adapting production is an assumption. On a larger scale over a couple of years, this assumption is plausible. But in the short run on a local

scale, this link could be weaker. If consumers reduce the demand for a certain food item, the producer always has the option to export products to other markets. Also, if aggregated demand would be reduced, prices could be reduced, leading to a rebound effect on demand.

The composition of the grocery bag

The consumption bundle in the average bag was approximated from Swedish statistics for the year 2010 to represent a Swedish average consumption mix. However, as we showed in our sensitivity analysis, consumers with slightly different consumption mixes can emit much more or much less than our *Average* grocery bag. We did not try to perform ‘real life’ simulations of changes in consumption bundles when shifting away from the *Average* grocery bag. These ‘real life’ changes following for example a shift to a vegetarian diet could change the results somewhat. This could happen if the vegetarian diet included more fish. The *Vegetarian* bag contained milk products, which implied that meat is consumed somewhere in the system, either domestically outside the amounts included in the grocery bag, or exported. The Swedish seasonal aspect implied that the Swedish growth season was affecting the consumption mix of vegetables and fruits. It does however NOT imply that vegetables and fruits origin from Sweden alone.

The GWP estimates

Our GWP estimates originated from other studies, and the uncertainties specified in these studies would therefore apply to our results as well. Apart from this aspect, of highest concern for our results were that the GWP estimate for beef was based on Swedish results only. We could therefore not capture the positive impact on GHG emissions from choosing Swedish beef instead of imported beef in the central analysis, but had to simulate this impact in the sensitivity analysis. Furthermore, the large range in GWP estimates for rice had an impact on the results. This range should be considered with caution since a very small amount of the global rice production is originating from low-emitting rice production (Lagerberg Fogelberg, 2008).

Conclusions and suggestions

The key results from our study were that:

To eat a seasonally adjusted vegetarian diet had the highest potential to be climate friendly.

The Swedish seasonal aspect could be important in grocery bags with low amounts of beef. Given the large amount of beef in our *average* grocery bag, the climate impact of an adjustment to a Swedish growth season was low. But in other grocery bags, with lower shares or amounts of beef, the Swedish seasonal aspect turned more and more important, in a sort of inverse proportionality to beef consumption.

The choice to drive a car to purchase food can be as important as non-vegetarian dietary choices with respect to the climate impact.

Based on these results and considering the data used to derive the results we conclude that policies successfully affecting dietary choices are important to reduce GHG emissions from food consumption. Emphasis on dietary changes might even be sufficient when developing policies aimed at reducing GHG emissions from food consumption, instead of focusing on locally grown food, transport distance of food items to store, or how the food item was produced.

We suggest first of all that efforts should be made to develop a standard methodology for estimating life cycle GHG emissions from consumption of food. Such a standard is an important requisite for many other policy options. Furthermore, knowledge is needed on the production costs of food production and of the cost efficiency of policy options. It is important to establish if dietary changes would be more expensive for society than other options to reduce GHG emissions.

More directly linked to achieving lower GHG emissions from food consumption we suggest that the possibility to develop consumer oriented policy packages should be explored. Such a policy package could contain: information measures such as voluntary agreements on food exposure in restaurants and stores; economic measures such as increased relative prices of beef; and regulative measures with increased serving of climate friendly food in the public sector restaurants.

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APPENDIX 1: GHG Policy instruments

Food & Climate Policies in Sweden along the food chain

This chapter gives an overview of policies aimed at GHG emissions associated with food in Sweden, and in which stage of the food chain these policies can be found. The policy overview does not quantify effects on GHG emissions since no such data was found. Left outside this presentation are policies that can be considered to have indirect effects on GHG emissions from food.

Agriculture

There are relatively few policies directly aimed at decreasing emissions of GHG in the agricultural sector in Sweden today. Several measures have been taken lately from the government to decrease the use of fossil fuels in the agriculture sector, for instance the Swedish Board of Agriculture has been given the task to develop an action program to decrease emissions of GHG from the agricultural sector. The rural development program is a program running 2007-2013 with the overall aim to stimulate sustainable development using support and compensation policy mechanisms.

Up until recently the agriculture sector only paid 21% of the carbon dioxide tax of fuel (used in both machinery and for heating). This share increased to 30% by 2011 and will increase to 60% in 2015, partly since the agriculture sector stands outside of the EU ETS. Berglund et al. (2010) calculates that this will increase the cost with approximately 36 000 SEK per year for a farm with a heating need corresponding to 30 m³ oil. The use of heating oil for heating in the agricultural sector and greenhouses has decreased since 1990. The above mentioned tax exemptions include fuels used in commercial greenhouses, which are also exempted from the energy and carbon dioxide tax with 70%. The carbon tax can be reduced further if it is higher than 1.2% (previously 0.8%) of the sale value of for all manufactured products when 70% of the carbon dioxide tax has been deducted. Artificial fertilizers have a climate impact since the usage demands energy in both manufacturing and transportation. Fertilizers can have a climate effect in other ways as well, for instance, it is common that artificial fertilizers acidify the soil. Taxation on artificial fertilizers was stopped in January 2010.

There are several subsidies paid to the Swedish agriculture sector from EU. The Swedish EPA (2011b) has estimated the total amount of potentially environmentally harmful subsidies in the Swedish agriculture sector, see examples in Farm aid, i.e. support to the farmer regardless the direction of the production or its scope, is since 2010 based on land area owned and used and not on the quantity produced. Farm aid may result in both positive and negative effects on the environment. Regarding internal market support, members of the World Trade Organization (WTO) have undertaken themselves to phase out all international market restrictions (such as tariffs) for agriculture products by the end of 2013.

Table A 1: Examples of Swedish environmentally harmful subsidies in the agriculture sector. Comparing year 2004 and 2009. Source: Swedish EPA, 2011b

Type of subsidy	Million SEK 2004	Million SEK 2009
Export grant	557 (100 % EU)	185 (100% EU)
Intervention support	207 (100% EU)	154 (100% EU)
Farm aid	5315 (year 2005)	6711
Reduced energy tax heating greenhouse and farming	90	100 (2010)
Reduced CO2-tax, heating greenhouse and farming	280	360
Reduced CO2-tax diesel working machines	850	1000

Food processing

This stage in the food life cycle contains all processing steps after the farm and transforming a crop or living animal into a packaged product to be used as a food product. Since this process may demand fossil fuel use, it is indirectly affected by the carbon dioxide tax and the energy tax. Food processing is classified as industrial activities and is therefore exempted from the energy and carbon dioxide tax with 70%. The program for energy efficiency is another policy that affects industries' use of energy.

Warehouse/retail

The current trend in food warehouse/retail is an increased share of cold and frozen food. Around 40-50% of stores' electricity use goes to storage of refrigerated and frozen foods. Warehouses and retailers are energy users and thereby affected by carbon pricing. Except carbon pricing policies, there are few policies aimed at reducing the climate impact from warehouses and retails. Some initiatives do, however, exist. Firms in the food business work together with the Swedish Energy Agency in different projects to increase energy efficiency within food retail. One example is a research project where doors were installed in refrigerators and freezers, which resulted in a decreased electricity use with 6%. Another example is a checklist that has been developed for energy efficiency within the trade sector. The EU Ecodesign directive can also be suspected to have an impact on warehouse/retail energy use in the future.

Consumption

Within EU, energy labels are mandatory for appliances, lights, TVs and more, to help consumers identify products and services that have low environmental impact. Consumers are also affected by energy and carbon dioxide taxes, which influence energy consumption in food processing activities.

A project for climate labelling of food in Sweden started in 2007. Principal funding came from the Swedish Board of Agriculture. From the beginning, one of the primary aims with the project was to develop a system for climate labelling of food. In 2010 that changed to produce a climate certification. The climate certification scheme builds on existing

standards for sustainable food production, currently the Swedish organic label KRAV or the Swedish food quality label Swedish Seal (Svenskt Sigill). No carbon footprint is presented but the criteria are based on a scientific review of studies on climate impact from the food chain.

One information based policy instrument used today related to meat consumption is the so called “plate model”, where consumers are encouraged to eat a diversified diet, with a mix of protein sources, carbohydrate sources and vegetables. Diet advice from an environmental perspective were developed by the Swedish National Food Agency, but was removed due to critique regarding free movement within the common market, since it contained recommendations to eat locally produced food. However, the potential trade-off between free movement and environmental benefits was never evaluated.

EU has import duties on meat, which might have restraining effect on meat consumption. Imported meat to Sweden from the EU is however often considerably cheaper than Swedish meat. Local initiative exists, for instance municipalities with vegetarian days in schools and preschools.

Possible actions to reduce meat consumption are discussed in an evaluation from Swedish Environmental Protection Agency (2011a). For instance, climate adaptation of EU agriculture subsidies, tariffs on imported meat, differentiated VAT, support to product development and an excise tax on meat are discussed. A meat tax has been discussed in Sweden to decrease meat consumption, but no political party is currently pushing the issue.

Waste management

Sweden had an environmental goal to recycle at least 35% of food waste from households, restaurants, caterers and retailers by 2010. Follow ups revealed that this target has not been achieved and the target has been revised to be met 2015 instead (Swedish EPA, 2010). There are a number of policies that municipalities can use to steer waste management in the right direction, such as waste management plans, waste regulations and waste tariffs. Information is also an important tool for changing public behaviour.

In 2000 a tax on landfill waste and a ban of landfilling of combustible waste were introduced. Moreover, to improve resource management and reduce environmental impact it is from 2005 prohibited to dispose organic waste. In 2006, a tax on household waste for incineration was introduced. The purpose of the tax is to increase recycling of plastic, reduce CO₂ emissions and increase cogeneration.

The European Commission has developed a pamphlet, “Stop food waste”, which presents ten tips on how to reduce wastage for households. The Swedish Environmental Protection Agency has developed a waste plan for the period 2012-2017. The waste plan includes five prioritized areas, where waste from households is one. Several information campaigns are going on right now, for instance SaMMA, a Swedish network for authorities, researchers and NGOs and industry that work together to jointly find solutions to contribute to reduction in food waste. It can be about collecting and disseminate information, develop indicators and identify necessary actions.

Transport

Swedish transport climate policies

The transport sector is subject to fuel-taxation. Both the carbon dioxide tax and the energy tax apply to gasoline and diesel. The energy tax on diesel has as previously presented recently been increased, a first step in 2011, the next increase will be in 2013. There are also targeted policies, such as exceptions from the energy and carbon dioxide tax for all biofuels until 2013. Moreover, for passenger cars, the vehicle tax is differentiated based on carbon dioxide emissions per kilometre.

A kilometre tax on trucks has been debated in Sweden but no political decisions have been made.

Since 2012, aviation is included in EU-ETS, increasing the cost for transport to and from EU, which will increase the price for transporting food by air. However, flights into and out of Europe has been excluded from the scheme since November 2012.

Trade policies

WTO's Agriculture Agreement was negotiated 1986-1994 and came into force 1995. The agreement sets limits to what WTO member countries can do in mainly three areas: tariffs, support and export subsidies. Under the agreement, tariff levels for each country on individual products are established. EU already levies the highest allowed tariff for most agriculture products, but also has a number of trade agreements that reduce or remove tariffs on agriculture products with several countries. The commitments under the agreements do, however, still mean relatively high level of support and tariff protection for the agricultural sector. WTO's Agriculture Agreement also includes commitments for future tariff reductions for member countries. The Doha round is the latest round of trade negotiations among the WTO member countries, and aims at achieving reforms of the international trading system through introduction of lower trade barriers and changed trade rules. The negotiations, that started 2001, are still not completed.

Central policies to decrease GHG emissions, with indirect impacts on GHG emissions from food

The CO₂-tax, energy tax and EU-ETS are central economic instruments in the Swedish climate strategy. Other targeted instruments interact with these instruments as technology procurement, information, differentiated vehicle taxes and investment grants (Ministry of the Environment, 2009). Besides Swedish policies, Sweden is affected by a number of EU policies and directives.

The Swedish Carbon dioxide tax and energy tax

The Swedish CO₂-tax was introduced in January 1991. The carbon dioxide tax is levied on fuels for motor driven vehicles per kilo emitted CO₂. The energy tax also applies to fossil fuels and is primarily a fiscal tax with the aim to generate revenue to the state, but has also an effect on fossil fuel usage. The industry is exempted from the energy and CO₂-tax with 70% due to competitiveness of industries on international markets. Other sectors are excluded from the tax as well, such as fuels for heat generation in Combined Heat and Power (CHP) plants, fuels used in the production of electricity and agriculture, forestry and

water activities. The Swedish climate policy decision from 2009 includes new regulations on exceptions from the CO₂-tax for fossil fuel for heating outside the EU-ETS, agriculture, forestry and water management. The exception will be decreased and these sectors will pay 60% of the overall tax level by 2015 with a first step (30%) to 2011, compared to 21% before. The domestic sector and the transport sector pay the full carbon dioxide tax and energy tax.

Sweden's Fifth National Communication on Climate Change (Ministry of the Environment, 2009) includes evaluations of economic policy instruments in Sweden. The report concludes that the energy and carbon dioxide tax have contributed substantially to emissions reductions in the residential-, service-, and district heating sectors in Sweden and have moderated the emission trend in the transport sector. When instruments interact in a sector, it is a complex task to distinguish between individual instrument effects. Other external changes could have had an effect on emissions, such as energy prices or technological development. The total effect of all the instruments introduced since 1990 is estimated to result in decreased emissions with up to 30-35 million tonnes of CO₂ per year during the time period 2010-2020.

On sector level, the emissions from electricity and heating production might have been 70% higher (15 million tonnes in 2007) if keeping the economic policy instruments as they were in 1990⁷. In the residential sector, it is difficult to distinguish between the effects of present-day instruments with 1990 policy instruments. However, the sharpening of policy instruments 1990 has led to increased profitability of investments in fossil free heating, and has consequently contributed to the substantial reduction of emissions in this sector. In the transport sector, emissions have increased despite the introduction of new policies. Without the new policies, the increase would probably have been significantly greater since transport volumes increased more than emissions over the period. The combined effect of the increases in tax on diesel and petrol on emissions since 1990 is estimated to be 1.9 million tonnes CO₂/year in reduced emissions by 2010, and 2.4 million tonnes CO₂/year by 2020, than if the 1990 nominal tax level had been retained.

EU-ETS

In 2005, EU implemented its emissions trading scheme EU-ETS. The EU-ETS is an important part of the EU's decision to reduce emissions 20-30% by 2020 and thus also in the Swedish strategies to reduce climate impacts until 2020. The EU-ETS includes CO₂-emissions from production of electricity, heat, refineries, as well as emissions from large industries, e.g. iron and steel, glass and fibre glass, cement and ceramics, and pulp and paper. The scheme includes only large firms and a few food producers are included. The road & rail & marine transport-, agriculture-, household-, waste management-, and certain energy sectors are not included in the emissions trading system.

⁷ The analysis includes energy tax on electricity, carbon dioxide taxes, permit trading, electricity certificates and targeted support for renewable energy production.

From 2012, EU-ETS includes emissions from aviation, and in 2013 industries' emission of perfluorocarbon and nitrous oxide will be included. This means that food transported by air transport is facing an extra charge since 2012. Because aviation has been included in the system for such a short time, its effects on prices and flight demands cannot be estimated yet. Moreover, flights into and out of Europe has been excluded from the scheme since November 2012. Research done before the introduction of aviation in the EU-ETS has indicated that the effect on prices and flight demand will be small (Belhaj et al., 2007).

Other climate policies

The policy instruments that primarily affect large scale combustion-related emissions from Swedish industries are besides EU-ETS, energy and CO2 taxes, the system of electricity certificates, the program for energy efficiency in energy intensive industries (PFE) and the Swedish Environmental Code. In the domestic sector, there are a number of policy instruments that affect energy use and GHG emissions from residential and commercial buildings. EU's energy efficiency directive was entered into force in October 2012. This brings forward legally binding measures to increase energy efficiency in EU. Information as a policy instrument is an important part of the Swedish climate strategy. Several initiatives on climate information have been conducted in Sweden since 2002. Within the agriculture industries, advice to land owners and farmers is important. Both the Swedish Board of Agriculture and the Swedish Forest Agency have been commissioned to develop targeted information about climate-adapted agriculture and forestry management.

Table A 2: Important policies in the food life cycle, excluding transport (including polices with direct and indirect effects)

	Agriculture	Trp	Food processing	Trp	Warehouse/ Retail	Trp	Consumption	Trp	Waste management
Economic policies	Carbon dioxide tax		Carbon dioxide tax		Carbon dioxide tax		EU tax, meat import		Waste tariffs (municipality level)
	Energy tax		Energy tax		Energy tax				Tax on landfill waste + ban landfill
	Rural development programme, 2007-2013 - targeted interventions		EU ETS		Program for energy efficiency (tax reduction)				
Information / Labelling							EU energy labelling		
							Swedish Board of Agriculture: climate certification		
							Climate labelling of food		

EU directive	Energy efficiency directive	Energy efficiency directive	Energy efficiency directive / Eco design directive	Energy efficiency directive / Eco design directive	Energy efficiency directive
National Political goals					Recycle 35% of food waste 2015
Information/ Research programs	Swedish Board of Agriculture: Action program		Swedish Energy Agency: Research program warehouse storage	"plate model", "meat free Mondays"	Recycling information
					Swedish EPA, Waste plan.
Subsidies	Subsidies, diesel tax, carbon dioxide tax and energy tax EU grants	Subsidies carbon dioxide tax and energy tax			

For the transport activities in the food chain there are other sets of policy instruments affecting the fuel use and thereby the climate impact of transport.

Table A 3: Policies in the transport sector, of relevance for food transport

<i>International transports</i>	<i>Regional/ national transports</i>	<i>Consumer transports</i>
- No fuel tax on bunkers	- No fuel tax on bunkers	- Environmental zones
- EU ETS – air traffic	- EU ETS – air traffic	- CO2 and energy tax on fuel
- Environmental zones	- Environmental zones	- Environmental zones
	- Congestion tax	- Congestion tax
		- Environmental car premium
		- Differentiated vehicle tax

These policies (economic instruments) are not evenly distributed between different transport categories, which can be suspected to have redistribution impacts on food production.

Policy outlook

We made a policy overview identifying if there are policies in other countries that could help reducing GHG emissions from food consumption. The results are presented below.

Food policies in other countries

As a starting point for our overview of available policies that could help to reduce the GHG emissions associated with the food chain we made an international outlook to Denmark, UK, Brazil, and Australia.

Denmark

In 2011 Denmark introduced a tax on saturated fats in oils and certain dairy products (with a fat content above what is normal in drinking milk) with the purpose to improve life expectancy (Danish Ministry on Taxation, 2010). The rate was 16 DKK per kilo saturated fat. The tax aimed at stimulating consumption of more healthy food. From a climate perspective it is hard to say if the tax would stimulate consumption of more environmentally friendly food. Extracted animal fats were included in the tax and animals (cattle & sheep) are emission intensive compared to most other products. To our knowledge, Denmark was the only country with a tax aimed at products with high fat content. However, during the writing of this report it was announced that Denmark in November 2012 abandoned this scheme.

Danish farming has the highest share of organic products in the world; the organic food production share is up to 8% of the total production. The organic products are mainly exported to Germany and Sweden. In the agricultural sector GHG emissions has decreased with 28% from 1990 to 2008 (Danish Agriculture & Food Council, 2011). The driving forces behind this development are mainly combined agricultural approaches, which have led to improved efficiency in production, optimization of breeding and feeding, improved utilization of nitrogen in manure, reduced use of fertilizer and changes in tillage. For example, the improvement in utilization of nitrogen has occurred due to improvements in feed efficiency and stricter legal requirements surrounding animal manure during storage and application (NERI, 2011). Research and development concerning further improvements in the agriculture sector are still being carried out in the Danish agriculture sector to enable future reductions. In 2009, the Danish government introduced a Green Growth plan of EUR 1.8 billion to support green investments in Danish agriculture until 2015 (OECD, 2011).

Emissions reductions in the agriculture sectors in Sweden and Denmark

To analyse the effect on emissions from the Danish policies we gathered data on GHG emissions trend but also on trends in GHG emission intensity for the agricultural sector in Denmark and Sweden. According to data from Eurostat, GHG emissions from the agricultural sector in Denmark have decreased with 8.5% 2000-2010. The corresponding decrease for Sweden is 6.2%.

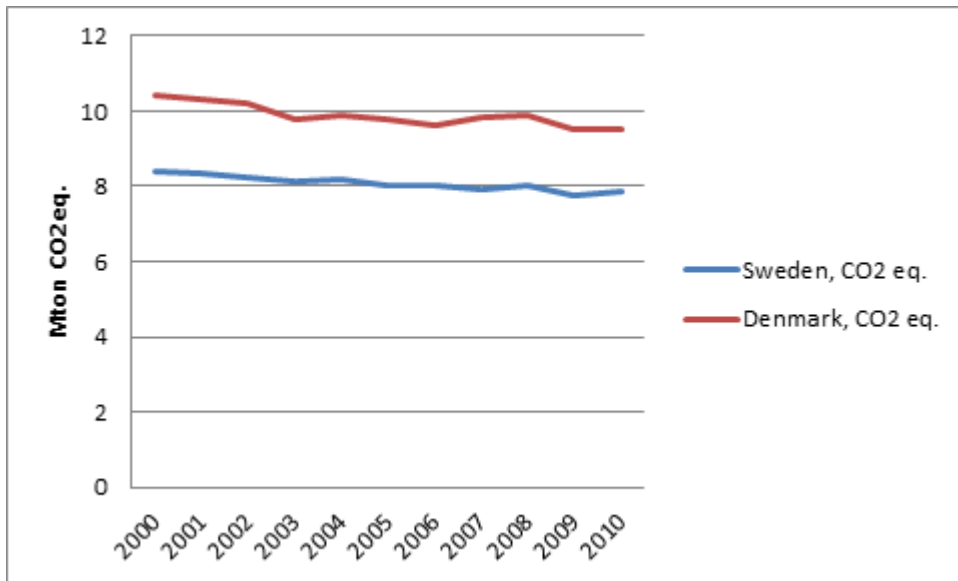


Figure A 1: GHG emission trends in the Danish and Swedish agricultural sector, 2000 - 2010

These emissions are not necessarily a good indicator of the ‘climate performance’ of the agricultural sector, some of the decline can be associated with the European financial crisis. In order to get an indication of whether the agricultural sector performs ‘better’ than Sweden, we analysed the CO₂ intensity by using Eurostat data. As is seen in figure the CO₂ intensity, here measured as CO₂ equivalent per gross value added, is higher in Sweden than Denmark.⁸

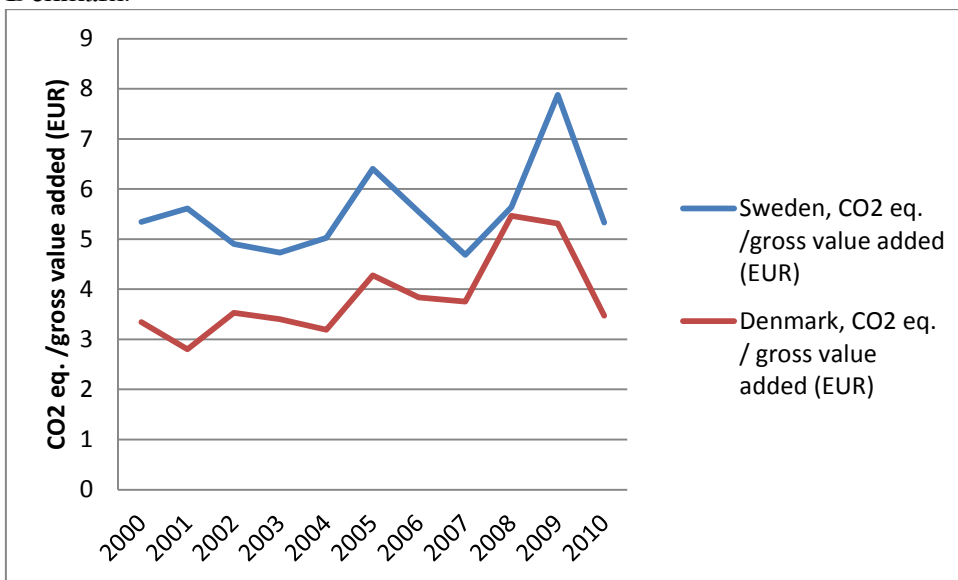


Figure A 2: CO2e intensity in the Danish and Swedish agricultural sector, 2000 - 2010

⁸ Source: Eurostat. Gross value added of the agricultural industry - basic prices. Greenhouse gas emissions by sector (agriculture), 1 000 tonnes of CO₂ equivalent.

As can be seen in figure 8, the climate performance of the agricultural sector show that Sweden normally performs worse than Denmark, but also that no country has declining intensities. An alternative interpretation is that the sector is not performing very well from a climate perspective either in Denmark or Sweden

UK

In the UK, GHG emissions from food make up to 20% of total national emissions, which rises to 30% if land use affected by food is included. Moreover, the stages in the UK food chain contributes to emissions with the following distribution; production and initial processing 34%, manufacturing, distribution, retail and cooking 26% and agriculturally-induced land use change 40% (Sustainable Development Commission, 2011). Policies to reduce emissions from the agriculture sector are mainly of voluntary character. In the 2009 UK Low Carbon Transition Plan⁹, farmers are encouraged to reduce their emissions with at least 6 % by 2020 compared to a BAU scenario, for instance through more efficient use of fertilisers, better management of livestock, reducing the amount of waste sent to landfill, and supporting anaerobic digestion of waste (biogas production).

In Great Britain, a specification for measuring GHG impacts within the food supply chain, i.e. a carbon label for consumers (PAS2050), was developed in the end of last decade. The carbon labelling has been criticized for not affecting consumer choices, but is rather more efficient in addressing other impacts within the food chain (Sustainable Development Commission, 2011). The British supermarket chain Tesco announced in 2007 that it would carbon label 70 000 products with their carbon footprint¹⁰. The project, however, turned out to be too ambitious and the plans were dropped in 2012¹¹.

Brazil

Brazil is a country with large agricultural resources. The agricultural sector accounts for about 6% of GDP, which might seem small, but there is significant value added to this sector, for instance agriculture products represent more than 38% of the country's export. The European Union is the largest market, receiving 29% of total export from Brazil. The level of support to farmers in Brazil is relatively low and limited to certain areas¹². The Ministry of Agriculture produces an annual crop and livestock plan that sets out objectives and support for the year. Price guarantees are used to support production in infant areas, until the infrastructure and activities are in place. Price guarantees are also used to support poorer farmers. The primary aim with this policy is to ensure that purchase prices are compatible with production costs and gives a reasonable profit for farmers. Credit policies are used as an offset to high interest rates in Brazil. The biggest distortion to the market from agriculture polices is due to the requirement that banks are obliged to allocate 29% of

⁹ The UK Low Carbon Transition Plan, published on 15 July 2009, plots how the UK will meet the 34 percent cut in emissions on 1990 levels by 2020.

¹⁰ <http://www.guardian.co.uk/business/2007/jan/19/ethicalbusiness.supermarkets>

¹¹ <http://www.guardian.co.uk/environment/2012/jan/30/tesco-drops-carbon-labelling>

¹² The OECD uses PSE (Producer Support Estimate) as an indicator for monetary transfer from consumers and taxpayers to support agricultural producers. Percentage PSE is the ratio of the PSE to the value of total gross farm receipts, measured by the value of the total farm production plus budgetary support. Brazil's percentage PSE 2008-2010 was 5% which can be compared to EU that 2008-2010 was 22 %.

demand deposits to agriculture lending. Recently, initiative to reduce the environmental impact from the agricultural sector has been introduced. For instance, in 2010 several initiatives were introduced, grouped under the programme for low carbon emissions in agriculture (Programa ABC). Increasingly, Brazil's agricultural support system has environmental and sustainability criteria. A current objective is to reduce dependence on imported fertiliser (OECD, 2011). Since Brazil is one of the world's largest producers of agricultural commodities, the use of fertilizer is substantial and constitutes a large share of the total production cost. The government also supports biofuels through mandatory blending of ethanol with gasoline for transport and gives tax incentives on flexi-fuel cars. Brazil is the world's second largest beef producer and the top exporter in the world. While consumption of beef in Brazil has been relatively stable since 1996, export has increased substantially since then. Cederberg et al. (2011) argue that increased production for export has been the key driver for deforestation in the so-called Legal Amazon Region (LAR) the last decade. The LAR is of growing importance for Brazilian beef production and in 2006, around 25% of Brazil's beef production came from this area. Growth of cattle in the LAR was particularly strong 1996-2006, but since the middle of the last decade, the deforestation rate has decreased. The reduced deforestation rate is a result of campaigns aiming at eliminating illegal operators, pressure on consumers buying beef from these regions and possibly also the economic downturn. Government programs aiming at reducing deforestation in the Amazon have also been launched, for instance the Action Plan for Prevention and Control of the Legal Amazon Deforestation in 2004, and the Sustainable Amazon Plan from 2003. The world consumption of meat is, however, expected to double by 2050, implying a large pressure on meat production in Brazil, and stronger protection of the Amazon will be needed.

Australia

Australia is an important producer and exporter of agricultural products. Shortage of water is a limiting factor in the agricultural sector and a large share of the total water consumption goes to the agricultural sector. Australia is the driest inhabited continent and more recent decline in support has been triggered by droughts. Commodity production in Australia has been very affected by adverse climate conditions since 2010. Agriculture support is mainly provided with budget-financed programmes, but has decreased significantly since the 1980s.

The Australian Government's climate change initiative provides funding to help primary producers adapt and respond to climate change. In 2009 the Government began implementing Caring for our Country, which is a programme to fund environmental management of Australia's natural resources. The Government also has a Drought policy, to prepare farmers and rural communities for future challenges.

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