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Sustainable Food System – Targeting Production Methods, Distribution or Food Basket Content?

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1. Introduction

Agriculture is the single most important contributor to the eutrophication of the Baltic Sea. It is responsible for 59% of the anthropogenic nitrogen and 56% of the phosphorous emissions (HELCOM, 2005). A second important source of nutrient emissions is at the other end of the food system – emissions from municipal waste-water treatment plants and from private households. Addressing different aspects of the food system is thus crucial for the Baltic Sea environment. To tackle eutrophication both nitrogen and phosphorous loads should be reduced (MVB, 2005). This can be achieved if emissions from the food system are reduced, e.g. by closing the nutrient cycle from soil to crop and back to agricultural soil (Diaz and Rosenberg, 2008). Granstedt (2000) finds that the high surplus and emissions of nitrate and phosphorous in Swedish agriculture is a consequence of specialized agriculture with its separation of crop and animal production. Similar findings are reported from different parts of Europe (Brower et al., 1995). About 80% of cropland in Sweden is used for fodder production but the animal production is concentrated to a limited number of specialized animal farms. Manure, with its contents of nutrients from the whole agriculture area, is today concentrated on only 20% of the Swedish arable land (Statistics Sweden, 2011). This results in high nutrient surplus and load of nitrogen and phosphorus from these areas. Granstedt (2000) concludes that the emissions can be limited by combining best available agricultural technology with increased recycling of nutrients within the agricultural system trough integration of crop and animal production - ecological recycling agriculture (ERA). This facilitates an efficient use of the plant nutrients in farm yard manure. Other studies of nutrient balances comparing farming systems and lifecycle assessment report similar observations (Halberg, 1999; Myrbeck, 1999; Steinshamn et al., 2004; Uusitalo, 2007). The potential of reduced nutrient emissions trough ERA was confirmed in case studies on local organic farms around the Baltic Sea (Granstedt et al., 2008; Larsson and Granstedt, 2010).

Carlsson-Kanyama (1999) found that greenhouse gas emissions could be reduced by local and organic food production due to shorter transportation. Similar results are reported in a compilation of studies (FiBL, 2006) and in studies of local production and processing in Järna, Sweden (Wallgren, 2008). According to Carlsson-Kanyama et al. (2004) the reductions are not significant unless local distribution becomes more efficient.

1.1 Aim and research questions

The aim of this study was to investigate how much the environmental impacts could be reduced by various changes in the governance of food systems. The main questions investigated were; the importance of food production methods, the importance of transport and processing systems of food, and the impact of different food consumption profiles. By examining this we can also answer what effort would give the most environmental benefits to society. The environmental impacts assessed were potential emissions of nitrogen (risk for eutrophication), global warming impact and use of primary energy in the agricultural production, transporting and processing parts of the food system. To define an alternative food basket and to calculate costs borne by households a consumer survey was carried out. The aim with the survey was to provide information on what a food basket of environmentally concerned residents consists of and costs, in one case study site.

The environmental impact of different food choices has gained increased attention in policy documents. In its "Strategy for sea and coast free from eutrophication" the Swedish Environmental Advisory Council states that major reductions in nitrogen emissions from agriculture are possible with changed consumption profiles (MVB, 2005). Similar recommendations are found in a Government Commission Report on sustainable consumption where increased shares of vegetables as well as local and organic food as means to achieve "sustainable consumption" are discussed (SOU, 2005).

Governance of ecosystems or natural resources is often more efficient if several sectors (horizontal collaboration) and several levels (vertical collaboration) are involved in the process (Low et al., 2003). When addressing the food system different sectors include the production and the consumption sides and levels of decision range from farmers and consumers to municipal and governmental agencies and the EU. Local stakeholder collaboration ensures that several objectives (ecological, social, and economic) are addressed. Such horizontal collaboration involves public agencies as well as NGO:s. Vertical collaboration, or multilevel social networks (Adger et al., 2005) on the other hand, is crucial for enhancing social and ecological resilience (Folke et al., 2005; Dietz et al., 2003). Collaboration and different aspects of institutions in the food sector have been studied by e.g. Carlsson-Kanyama et al. (2004) and Larsson et al. (2007). This paper draws on results obtained in the two EU financed projects BERAS and GEMCONBIO[1].

2. Methodology

Environmental effects of different farming, processing and distribution regimes and different consumption profiles were studied, using primary and secondary data compiled from own studies, literature and official statistics. First we present an overview of the methodology used. More details are given in the following sub-chapters.

Two farming systems, Swedish average 2000-2002 and the system of Ecological Recycling Agriculture (ERA, see Box 1 below) farms 2002-2004 were used for comparison of their respective environmental impacts. Two food consumption profiles (food baskets) were used for comparison of the importance of our choices of food. Data on consumption patterns from a national consumer survey (Swedish Board of Agriculture, 2004) represent the Swedish average food basket. Data obtained in the consumer survey carried out represent an

[1] Baltic Ecological Recycling Ecology and Society, www.jdb.se/beras and Governance and Ecosystem Management for the Conservation of Biodiversity, www.gemconbio.eu.

alternative "eco-local" food basket. Two processing and transportation scenarios were used. "Conventional", mainly large-scale food processing with long-distance transports (data in most cases earlier reported in Carlsson-Kanyama et al. (2004)) and "Local" based on data collected from businesses in Järna, a rural community south of Stockholm.

Four scenarios representing different combinations of agricultural production systems, food consumption profiles, and food processing and transportation systems were combined to answer the research questions. The scenarios are:

1. Conventional scenario – average Swedish food consumption profile, average Swedish agriculture, and conventional food processing and transports.
2. Conventional consumption from ERA farms – average Swedish food consumption profile, ERA farms, and conventional food processing and transports.
3. Local consumption from ERA farms – average Swedish food consumption profile, ERA farms, and local (small-scale) food processing and transports.
4. More vegetarian and local consumption from ERA farms – an alternative food consumption profile (e.g. less and different kinds of meat), ERA farms, and local (small-scale) food processing and transports.

To achieve a match between consumption and production in the second and third scenarios when ERA farms produce the food for the average Swedish food consumption profile it was necessary with the assumption that the consumption volumes of ruminant meat (beef and lamb) and monogastric meat (pork and poultry) can be exchanged depending on the higher share of ruminant meat production on the documented ERA farms.

In all 12 organic, or ERA, farms were studied. The farms were selected to be representative for the main farming conditions and production types in Sweden. They were studied during the years 2002-2004. The studied farms are spread over central and southern Sweden with a concentration (6 out of 12) in the Järna region. Farm characteristics, production data and use of resources were inventoried using interviews and farm accounts. Corresponding data for average Swedish agriculture was obtained from Statistics Sweden (2005).

Ecological Recycling Agriculture (ERA) is a local organic agriculture system based on local and renewable resources. ERA produces food and other agriculture products according to the following basic ecological principles (Granstedt, 2005):

1. Protection of biodiversity.
2. Use of renewable energy.
3. Recycling of plant nutrients.

In consequence with these principles an ERA farm is defined as an organic (ecological) managed farm according the IFOAM standards[2] with no use of neither pesticides nor artificial fertilizers (IFOAM principles 1 and 2) and with the additional condition of a high rate of recycling of nutrients based on organic, integrated crop and animal production. A higher degree of internal recycling within the system enables reduced external input of nitrogen. Nitrogen requirements are covered through biological nitrogen fixation of mainly clover/grass leys. There is only a limited deficit of phosphorus and potassium in the input and output balance according to previous studies

[2] IFOAM, International Federation of Organic Agriculture Movements. The standards are described at www.ifoam.org.

(Granstedt, 2000). The greater part of the minerals is recycled within the farm in the manure. The limited net export of phosphorus and other nutrients seems to be compensated by the weathering processes in most soils and a recycling of food residues could further decrease these losses from the system (Granstedt, 2000; Granstedt and Kjellenberg, 2011). The strive to be self-sufficient in fodder limits the number of animals per hectare. In reality, however, some smaller amounts of imported inputs (seeds, fodder and rock powder for soil improvements) can be necessary depending on variation in yield level between different years. An external fodder rate of a maximum of 15% of total fodder and an animal density of <0.75 animal units/ha were used as criteria for selecting ERA-farms (Granstedt, 2005). An animal unit (au) is defined as one dairy cow, or two young cows, or three sows, or ten fattening pigs, or 100 hens. By following these principles nutrient in manure does not exceed what can be utilised by crops during the crop rotation in the same system. Each single farm does not need to function as a closed system. Farms in the same region with complementing production could cooperate and together function as a recycling farming system in terms of fodder and manure, but regional specialisation of production is problematic. The studies are based on calculated surplus and emissions of reactive nitrogen and surplus of phosphorus compounds from the agriculture–society system according to methods developed by Granstedt (1995; 2000; 2005).

[i]Adapted from Larsson and Granstedt (2010).

Box 1. Principles of ecological recycling agriculture systems[i]

2.1 The consumer survey and calculating an alternative food basket

A consumer case study was carried out in Järna, a community of around 7500 inhabitants. Järna is part of Södertälje municipality, located in Stockholm County. Järna was chosen because there are numerous biodynamic and organic farms and market gardens in the area that serve the local market and a well developed consumer network linked to these farms, i.e. it was possible to find a group of environmentally concerned consumers that was willing to take part in the survey. There are also several food processing industries like a mill and bakery (with both a local and national market), a farm-size dairy and a farmer cooperative selling organic vegetables and meat. For a more detailed presentation of the site see Haden and Helmfrid (2004) and Wallgren (2008).

The families participating in the survey recorded their food purchases for two two-week periods in 2004; one in winter/spring (when local products are scarce) and one in late summer/early autumn (when local products are easy available). The periods were chosen in order to get representative results for the yearly consumption. Information on the amount, price, origin and environmental brand (e.g. Demeter or KRAV)[3] of all food products was recorded either on the detailed receipts or on specified lists supplied. Since the matter of concern in the study was environmental impacts from food and local production, and the studied farms only produce "real food", only these types of products were included in the consumer study. Products such as sugar, candy and beverages were thus not included.

After the recording period, the families were interviewed about their food choices, food consumption and food purchasing habits. The amounts of different products purchased

[3] KRAV is the certifying organisation of organic products in Sweden and Demeter is the equivalent for biodynamic products. See www.krav.se and www.demeter.nu.

during the measured four weeks were then extrapolated to get values for consumption during the whole year. For some comparisons to Swedish average figures, the results for the Järna consumers were also extrapolated to cover meals eaten outside the home, on average 16% of their meals. Apart for content of an alternative food basket the consumer survey also estimated the household cost for this. In all 49 individuals in 15 households took part in the survey. The families were invited to take part in the survey through local food and environment organisations. No formal socio-economic stratification of the families were performed but the general picture obtained during the interviews was that the families well represent the Swedish society. Considering the low number of participants the results obtained is to be considered a special case (scenario 4) and wider implications should be interpreted carefully.

2.2 Calculating agriculture area and environmental impacts of food baskets

The annual environmental impacts of a food basket from ERA farms is calculated from data on consumption (kg per capita and year) of different food product categories, and data on the annual agricultural production (kg per ha). In this study only agriculture land in Sweden was included in the calculations of environmental impacts in terms of nutrient surplus, use of energy and emissions of green house gases. The external fodder including nutrients in imported fodder was however included in the input resources in the nutrient balances.

Products in the food basket were calculated back to the original (primary) amounts of agricultural products produced for human consumption. These included weight of crops harvested for food consumption (kg), living weights for animals going to slaughter (kg) and delivered milk (kg). Calculations for the different products from the average Swedish agriculture and from the ERA agricultures represented by the 12 ERA prototype farms were done using the equation:

$$O = C^{*}cf \tag{1}$$

where C is the amount of a food stuff (kg), cf is a conversion factor for converting a foodstuff back to the weight of the original agricultural product (O). The conversion factors for the different foodstuffs were based on the database FAOSTAT (2004) and complemented with information from Saltå Mill (bread and cereal products) (Gustavsson, 2003) and Svensk Mjölk (dairy products) (Pettersson, 2005). Since the production levels and environmental impacts differed greatly between the farms and farming systems, the original food production in kg was converted to area (ha) in order to get proper results.

The products from the ERA farms included in the food baskets were grouped into seven agricultural categories: Potato products (O_1); Grain products (O_2); Root crops (O_3); Vegetable products (O_4); Milk products (O_5); Meat from ruminant animals (O_6); Meat from monogastric animals (O_7). Characteristic for the Swedish ERA-farms is that they all integrate crop and animal production. However, it was possible to group the farms according to production following four groups with the dominant product named first (bold):

1. **Potatoes,** root crops, vegetable products, bread grain and milk (2 farms)
2. **Milk**, meat and bread grain (6 farms)
3. **Pork**, poultry, egg and cereals (2 farms)
4. **Ruminant meat** and cereals (2 farms)

The farms in group 1 were more diverse and produced a broad spectrum of agricultural products. The farms in group 4 were more specialised and more extensive. To calculate the agriculture area needed and the environmental impacts of food basket scenario 2 and 3 two methods was used:

1. The production (kg per ha) of the products from the four farm groups was combined so they together cover the annual demand of the seven consumption categories in the annual food baskets. The environmental impacts of the food basket were calculated from the average impact of the four farm categories respective.
2. The average production (kg per ha) of products from all the 12 ERA farms was combined so they together cover the annual demand of the seven consumption categories in the annual food baskets. The environmental impacts of the food basket were calculated from the average impact of the all 12 studied ERA farms.

2.2.1 Nutrient surplus

The method for calculating nutrient balances follows those described in Granstedt (2000) and Larsson and Granstedt (2010). The potential emissions of nitrogen were defined as the difference between total input of nitrogen to the farm and the export from the farm in form of agricultural products (meat, milk, grain and horticultural products) (Granstedt et al., 2004). A steady state of the total nitrogen content is assumed. An increased content of Soil Organic Matter (SOM) has however been observed in several studies of organic farms (Granstedt and Kjellenberg, 2008; Hepperly et al., 2006; Mäder et al., 2002) which implies that real losses of nitrogen can be lower than the observed surplus in the nutrient balances.
The potential nitrogen emissions from each farm group as a part of the total load from one food basket was calculated using the equation:

$$A_{i\ \text{N-surplus}} = A_i * A_{i\ \text{N-surplus/ha}} \tag{2}$$

where $A_{i\ \text{N-surplus}}$ is the N-surplus (kg) from the area used for one food basket from farm group i, i=1-4, A_i is the area for farm group i and $A_{i\ \text{N-surplus/ha}}$ is the average N-surplus per ha from the ERA farms included in farm group i.
The nitrogen surplus of one food basket was calculated using the equation:

$$A_{\text{N-surplus}} = \sum_{i=1-4} A_{i\ \text{N-surplus}} + A_{\text{diff N-surplus}} \tag{3}$$

where $A_{\text{N-surplus}}$ is the total N-surplus from the area used for food production per capita (i.e. food basket), and $A_{\text{diff N-surplus}}$ is the summarised residual value of N-surplus for the seven food product categories converted to area (ha). Both primary and official data were used in the calculations. The same procedure was also used for global warming potential and consumption of primary energy resources.

2.2.2 Global warning impact and energy use

The assessment of global warming impact and primary energy use followed the principles of life cycle assessment (LCA) methodology (Lindfors et al., 1995), although a complete LCA was not made due to the complexity of the systems studied. The LCA methodology is primarily designed for assessment of single products, but the structure of the methodology can also be used for larger systems. Here assessments where first made separately for the agriculture, the processing and the transportation systems. There after these results where used in assessment of the scenarios. Compared to a complete LCA the steps being omitted include; the assessment of several impact categories, some minor system parts of the data inventory, and a full description of system borders.

Following the LCA process, a life cycle inventory (LCI) inventorying data concerning direct and indirect energy use and resource consumption were performed in all vital parts of the system under study. For "conventional" agriculture, processing and transportation secondary data were used. For the "alternatives" the 12 ERA farm and food processing and transporting business in the Järna area were used. The data were then grouped into impact categories, where one emission may contribute to several categories. This study assess the impact categories "Global warming impact" and "Use of resources - fossil energy", since these two impacts are closely linked to each other and because they were judged to be the most important ones.

Global warming impact was assessed using global warming potentials (GWP), where all impacting emissions are transformed into CO_2-equivalents. Only direct impacting gases were inventoried, i.e. CO_2, CH_4 and N_2O. The GWP of CH_4 and N_2O correspond to 23 and 296 CO_2-equivalents respectively. Of the different time-spans suggested by IPCC (2001) the 100-year perspective was chosen. The inventory of energy use included two categories of energy carriers – electricity and fossil fuels. These were re-calculated as primary energy, i.e. the energy used was converted to primary energy resource equivalents, measuring the consumption of energy resources in the lifecycle of the energy carriers. Transmission losses in the distribution net (7%), pre-combustion energy consumption for fuels and efficiency in e.g. hydropower and nuclear power are included in the assessment (Lundgren, 1992). This made it possible to compare scenarios and activities using mainly electricity with those using mainly fossil fuels. The results are based on data from the 12 studied Swedish ERA farms. Whether these perform better or worse than other organic farms is not investigated.

3. Results

Environmental impacts of conventional Swedish food production of an average food basket (Scenario 1) is compared with food produced with ERA-methods (Scenario 2); food produced with ERA-methods and processed locally (Scenario 3), and finally with an alternative food basket with less meat and more vegetables produced with ERA-methods and processed locally (Scenario 4). First, the results of the household survey are presented.

3.1 The household survey

When studying the results from the Järna survey there are some evident differences between the consumption patterns of the investigated households and the Swedish average. An average of 73% of the weight for what is considered 'real food' (sugar, candy, beverages etc. not included) was reported as being organic, or ecological, in the alternative food consumption profile, the "eco-local" food basket. In comparison with the national average of 2.2% the figure is very high. Some of the Järna consumers mentioned that they would have bought more eco-food if it was available and not too expensive. The portion of locally produced food purchased by the investigated households was found to be substantial for some product groups, e.g. 56% for cereals and 49% for beef and lamb. On average 33% was reported being local and organic. It is not possible to compare with national averages concerning local food but it is reasonable to assume that the average share is very low.

Other important characteristic for the eco-local food basket were the substantially lower shares of meat and potatoes (75% respectively 57% less) and the higher vegetable consumption (100% more), see Table 1. When looking at more detailed product groups some interesting differences become apparent. Although there is no difference in cereal products as a group it can easily be seen that these households seem to bake more of their bread at home (buy more flour but less bread). They also eat more groats and flakes, which is in accordance with the higher consumption of yoghurt and other fermented dairy products and prefer butter to the more processed margarine.

Product group	Sweden average		Järna survey 2004[i]				
	total[ii]	eco[iii]	total	eco		eco-local[iv]	
	kg	%[v]	kg	kg	%	kg	%
Cereal products	103	1.6	103	81	78	58	56
Potatoes	54	3.3	23	22	96	9	38
Root crops	9	9.9	42	39	92	17	40
Vegetables, veg. products and legumes	58	2.0	98	64	66	29	30
Milk products	168	5.1	199	162	81	72	36
Meat ruminants (beef and lamb)	12		7	5	70	4	49
Meat monogastrics[vii] (pork and poultry)	28	0.8[vi]	2	1	48	1	28
Other meat and mixed meat products	37		5	3	62	2	41
Egg	9	9.7	7	6	88	2	22
Fish and fish products	18	--[viii]	5	0	3	0	0
Fat	13	2.7	15	6	42	0	0
Fruit, berries, nuts and seeds	63	2.6	80	39	48	2	3
Total 'real food', excl. sugar, candy, beverages etc.	572	2.2	584	428	73	194	33

[i] compensated for meals eaten outside home
[ii] Swedish average 2002 (Swedish Board of Agriculture, 2004)
[iii] certified KRAV, and/or Demeter
[iv] produced in Järna district and certified according to KRAV and/or Demeter
[v] % of expenditures per product group
[vi] % of all meat and meat products
[vii] In scenarios 2 and 3, the consumption of ruminant and monogastric meat was swapped in order to fulfill crop rotation demands and a minimum of 40% clover/grass leys in agriculture. Ruminants, beef cattle and sheep, are the only animals that can digest crops like grass and clover. Monogastric animals like pigs and poultry are mainly fed with grain.
[viii] not possible to certify at that time

Table 1. The share of ecological and local food purchases, kg per capita and year, and % of weight.

3.1.1 Household food expenditures

In Järna the investigated households spend more money on food than the average Swedish household. The mean value for food expenditures per household was 5833 €/household/year in the monitored households, while the Swedish average household expenditures was 3376 €, alcoholic beverages and restaurant meals not counted (Statistics

Sweden, 2004). However, when calculated per consumption unit[4] (CU) the difference is smaller, 2600 €/CU/year in Järna compared to 2100 € for the Swedish average CU, 24% higher expenditures. Whether this is a result of these families really giving higher priority to food or a result of the socio-economic status of the studied households was not investigated.

	€/CU	€/person/year	€/household/year
Järna	2584	1800	5833
Swedish average	2084	1600	3376

Table 2. Expenditures on food.

The method used in this consumer survey has some potential limitations. Purchasing patterns may be distorted and no information on the distribution of foods within households is normally obtained (Cameron and van Staveron, 1988). One problem is the possible lack of information about whether a product is never purchased or whether it simply was not purchased during the recorded weeks (Irish, 1982). Bulk purchases make it more difficult to estimate annual food expenditures than if the consumers acquire all or part of their food in relatively small quantities once or several times per week (Pena and Ruiz-Castillo, 1998). However, when the families were interviewed and their purchase diaries and collected receipts checked, information on the above issues was received.

3.2 Nutrient surplus and land use

Table 3 presents base data and the calculated nitrogen surplus in agriculture based on the four production-type groups of ERA farms (potatoes and root crop; milk and meat; pork, poultry and cereal; ruminant and cereal) compared to the average Swedish agriculture, Scenario 1.

The results from scenarios 2 and 3 (conventional consumption from ERA farms and locally produced consumption from ERA farms) are the same because different processing and transport systems have no influence on nutrient surplus in agriculture. The surplus of nitrogen (total and per capita) in the scenario based on ERA-farms, with the same total meat consumption (but with a higher share of ruminant meat), is reduced with 37% compared to the same food being produced by the average Swedish agriculture with the calculation based on the four categories of farms (calculation according method 1 described in 2.2) and 18% compared the average Swedish agriculture with the calculation based on the average surplus on all the 12 Swedish ERA farms (calculation according method 2 described in 2.2). The nitrogen surplus per hectare is also very low in ERA production. This calculation is based on the total farm gate balance including emissions of ammoniac from the animal production[5]. However, scenarios 2 and 3 require having 4.76 million hectares under agriculture production, compared to the 2.45 million hectares arable land of today. This larger

[4] CU = Consumption Unit, a measure that compensates for household structure and the ages of the household members to allow for more relevant comparisons of consumption between different household types.

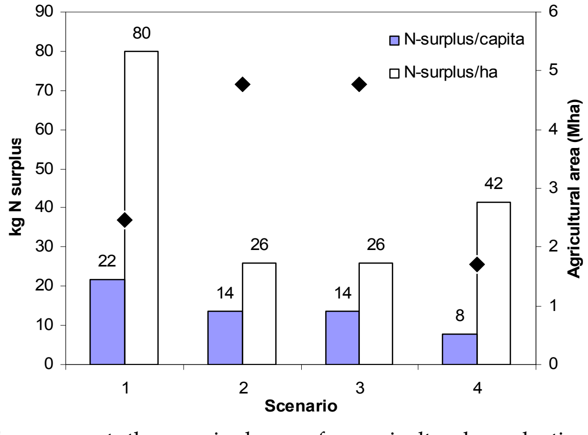
[5] Calculating the nitrogen surplus as field balances would result in greater differences. Field balances, i.e. excluding the emissions from animal production, give 70 – 75 % lower surplus of nitrogen from soil and corresponding losses to the water system compared to the average Swedish agriculture (Granstedt et al., 2008).

area was partly a result of a lower production on organic farms and mainly a result of a higher share of ruminant meat (70% compared to 30% in conventional production) which requires more arable land compared to when producing pork and poultry. In Table 3 both per hectare and per capita figures are presented. The latter figures are the more important ones.
Figure 1 shows the results for nitrogen surplus in diagram form for the sake of comparison to the results presented in the following section (calculated according to method 1).

	Scenario 1. Average Swedish cons. & agri. 2000-02[i]		Scenario 2 and 3. Swedish consumption & ERA farms 2002-04		Scenario 4. Eco-local consumption & ERA farms 2002-04	
		%		%		%
Agriculture area, million ha in Sweden	2.45	100	4.76	194	1.70	69
Agriculture area, ha/capita	0.27	100	0.53	194	0.19	69
N-surplus, kg/capita	22	100	14	63	8	36
(Method 2)	(22)	(100)	(18)	(82)	(10)	(45)
N-surplus, kg/ha	80	100	26	32	42	52
N-surplus, million kg in Sweden	196	100	123	63	71	36

i Adapted from Statistics Sweden (2005). Only arable land in production is counted.

Table 3. Agricultural area required and nitrogen surplus for three scenarios: Swedish average (mainly conventional) agriculture, ERA farms producing the average Swedish food-basket, and ERA farms producing an alternative (ecological and more vegetarian) food-basket. In Scenario 2, 3 and 4 all agricultural production is turned into ERA. Figures within brackets represent are calculated with method 2, see section 2.2. Other results are obtained using method 1.



The black diamonds represent the required area for agricultural production, *million hectares.* 1) Conventional; 2) Conventional consumption from ERA farms; 3) Local consumption from ERA farms; 4) More vegetarian consumption from ERA farms.

Fig. 1. N-surplus in four scenarios, *kg N per capita and kg N per ha.*

Scenario 4 assumes more vegetarian food consumption produced on ERA-farms. In this scenario, the area of agricultural arable land would *decrease* by slightly more than 30% to 1.7 million hectares. And most important, the nitrogen surplus would decrease by 64% or 55% of today's level, depending on if method 1 or 2 is used for calculating the surplus.

3.3 Global warming impact and primary energy resources consumption

Figure 2 and Figure 3 present the results for global warming impact (measured as GWP in CO_2-equivalents) and consumption of primary energy resources (measured in MJ primary energy resources). Here, four scenarios are included as the different systems of processing and transportation are also compared. The trends are similar to those for nitrogen surplus in both cases. However the differences between the scenarios are smaller for the GWP. Changing to ERA-production (Scenario 2) resulted in a 10% reduction in GWP, from 1000 to 900 kg CO_2-equivalents with the calculation based on the four categories of farms (calculation according method 1 described in 2.2). The very low per-hectare results in Scenario 2 and 3 are a result of these scenarios requiring a very large (and unrealistic) area under agriculture production. In Scenario 4 (ERA-production, local processing and distribution and a more vegetarian food profile) the GWP is reduced with 40% compared to Scenario 1.

For the primary energy resources consumption the relation is almost exactly the same as for nitrogen surplus. The use of primary energy for the food consumption is reduced with 44% per capita with the calculation based on the four categories of farms (method 1) with food from ERA agriculture with a traditional diet but with a large part of the monogastric meat replaced by ruminant meat (Scenario 2). Reduced meat consumption with 75%, would reduce the primary energy use with an additional 40%, or in total 67% (Scenario 4).

Processing food locally (and the resulting shorter transports) has some impact on the GWP but almost no impact on the primary energy resources consumption (Scenario 2 vs. Scenario 3). The latter can partly be explained by the choice of energy carriers (fossil fuels vs. electricity) in the food processing industries and by very inefficient meat transports in the studied case.

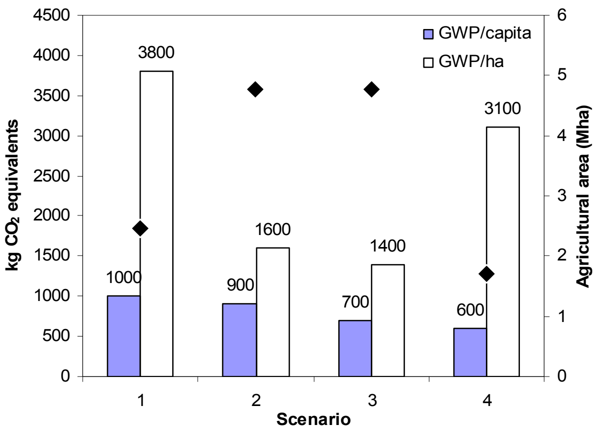


Fig. 2. Global warming potentials in four scenarios, *kg CO_2-equivalents per capita and kg CO_2-equivalents per ha.*

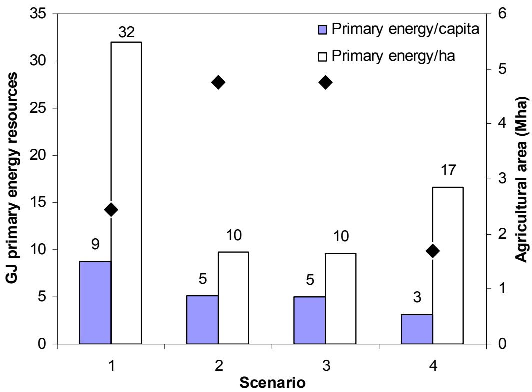


Fig. 3. Consumption of primary energy resources in four scenarios, *GJ primary energy resources per capita and GJ primary energy resources per ha.*

The black diamonds represent the required area for agricultural production, *million hectares.*

4. Discussion

Below environmental and health consequences of different farming regimes and the role of collaboration and consumer demand for sustainable food systems are discussed.

4.1 Environmental aspects of eco-local food systems

According to the Swedish Environmental Advisory Council a diet consisting of two thirds animal products results in four times larger emissions of nitrogen from the agriculture into the water and air compared to a fully vegetarian diet (MVB, 2005). Edman suggests increased shares of local organic food and increased shares of vegetables and a change of meat consumption from monogastric to ruminant meat to reduce the contribution to global warming from the food chain (SOU, 2005). Our study provides results in support of this. The main objective of our consumer survey was to gather data for an environmental impact assessment of an "eco-local" food basket. A food basket consisting of 73% organic food (33% local and organic) and a higher than average proportion of vegetables (100% more) reduced nitrogen surplus with 18 to 37% per capita compared to an average Swedish consumer (Scenario 4 vs. Scenario 1) depending on calculation method used. Thus, not only production methods but also consumption patterns determine the environmental impact.

Simply turning conventional production into a system of ERA without changing consumption patterns would also result in substantial cuts in nutrient emissions. To produce this would however require an additional 2.3 million ha of arable land. This corresponds to a 94% increase and this larger area of arable land is not available in Sweden. Historically the maximum agricultural area in Sweden was about 3.3 million hectares and taking more than this into production again is unlikely. When interpreting the results, it is also important to bear in mind that a large area outside of Sweden is used to produce mainly fodder for the Swedish agriculture. Johansson (2005) finds that 3.74 million hectares are used today for producing food consumed in Sweden. This implies that more than one million hectares are used abroad and that conventional agriculture of today makes use of a larger area than is actually available in Sweden. The ERA-farms are, on the other hand 85 –

100% self supporting with fodder crops. Combining ERA with a more vegetarian food profile (Scenario 4) the acreage needed for food production would decrease from about 2.5 million ha to 1.7 million ha, see Table 3. This opens up for alternative production, e.g. energy, fibre, recreation or export of food products.

What we eat also influences the energy consumed during different stages of the food chain. Generally meat is the most energy demanding food to produce and increased meat consumption is problematic. This is well reflected in a comparison between the different scenarios. Both GWP and consumption of primary energy reduced with a transition towards ERA production (Scenario 2) and with increased vegetable consumption (Scenario 4). If the building up of soil organic matter (Granstedt and Kjellenberg, 2008; Hepperly et al., 2006; Mäder et al., 2002) is considered, green house gas emissions could decrease with 1 500 kg CO_2-equivalents per ha (Granstedt and Kjellenberg, 2011). Following our results some gains were made in terms of GWP by localizing processing and distribution (Scenario 3) but not in terms of primary energy consumption. Pretty et al. (2005) report larger reductions of external effects from localizing production than from switching from conventional to organic production. The referred study was for UK conditions and, in contrast to our study, included a restriction that all food was produced within 20 km of the place of consumption. Other sources, e.g. Sonesson et al. (2010), argue that transportation can be an important contributor to greenhouse gas emissions in the food chain but that the contribution varies a lot. In short, food transports become less efficient the further down the supply chain you get. The last step, consumers' home transports, is the least efficient if cars are used (Sonesson et al., 2010), which often is the case in Sweden (Sonesson et al., 2005). The consumers' transports of food are not included in our study, which could explain the greater importance given to localized production by Pretty et al. (2005). Other potential positive environmental effects of localized production include a reduced need of packaging. Further studies also need to evaluate the reduction of greenhouse gas emissions and other environmental consequences of reduced deforestation in other countries for production of imported fodder and meat products.

By signing the Kyoto protocol Sweden has already agreed to reduce its emissions of CO_2. About 15-20% of the energy consumed is for the transportation of food (SEPA, 1997) and if measures not are taken in agriculture then they have to be taken in other sectors of the economy. There are thus some potential synergy effects of local and organic food production. The relation between distance traveled and emissions of green house gasses is, however, not as clear as one might expect. A study of the Farmer's Market concept (Svenfelt and Carlsson-Kanyama, 2010) shows that, apart from products transported by air, there are no significant difference in energy intensity between food bought at the local Farmer's Market and similar food bought at a supermarket. Although the distance from producer to consumer is much shorter, the transportation to the Farmer's Market is inefficient. Inefficient vehicles are used and there is poor logistics whereas supermarkets are part of an efficient optimized transport system. However, steps could be taken to make transportation more efficient and if the share of locally produced food is increased there is a potential to lower the emissions of CO_2 further through shorter transportation (Carlsson-Kanyama, 1999; Svenfelt and Carlsson-Kanyama, 2010).

Figure 4 presents a summary of the results presented in Figure 1, 2 and 3 showing the relative difference between the environmental impacts in the four scenarios. Scenario 1 (present governance) is set to 1. The dashed bar in Scenario 1 illustrates the 1,3 million ha of agricultural land abroad that Swedish agriculture depends on today.

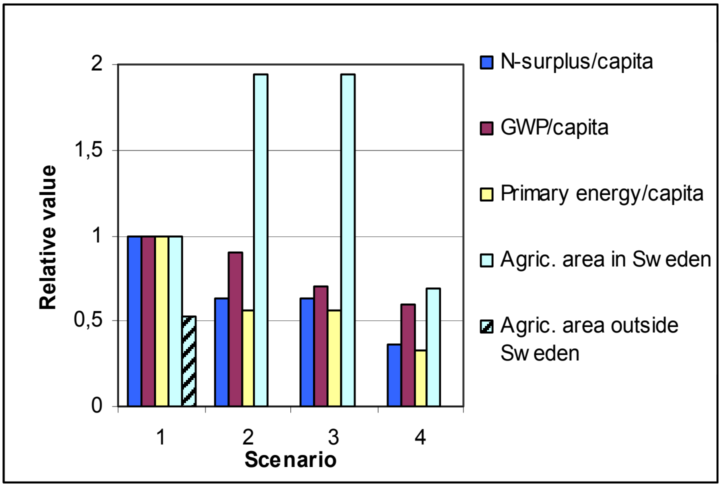


Fig. 4. N-surplus, Global warming potentials and Primary energy resources consumption per capita and required agricultural area in four scenarios, *relative values*.

4.2 Health and sustainable consumption

Our food habits are, unquestionably, important both for our health and for the environment. This is also one of the key issues of Stockholm County Council's S.M.A.R.T. project that gives recommendations for diets that both improve the health as well as decrease environmental impacts (CTN, 2001). New Nordic Nutrition Recommendations (NNR) were approved in August 2004. These are guidelines for the nutritional composition of a healthy diet (NNR, 2004). The NNR do not include instructions for sustainable food choices but such recommendations are available at least in Sweden and in Germany. Some general recommendations include: products produced most nearby when there are equal products; ecological food; less foodstuffs which include few nutrients, e.g. eat fruits instead of sweets (CTN, 2001; SEPA, 1997; 1998; 2000). In Table 4 both nutritional and sustainable food choice recommendations are presented.

The food consumption profile of the studied households seems to follow the diets suggested in the Nordic Nutrition Recommendations (NNR, 2004) and in the S.M.A.R.T. project (CTN, 2001). These households buy a larger share of vegetables (less meat), a larger share of nutritional and storable vegetables (e.g. legumes and root crops) instead of fresh vegetables (e.g. lettuce and cucumbers) during the winter season, less 'empty' calories, more organically produced food and less transported food, compared to the national average food basket. The only large difference is the share of potatoes, see Table 1. The Järna consumers eat substantially less potatoes than the average Swede, while the S.M.A.R.T. project recommends more potatoes. One reason might be recommendations in the anthroposophist nutrient concept – Järna hosts numerous anthroposophist producers and organisations and is considered the anthroposophist capital of the Nordic countries - to minimise intake of solanin producing products like potatoes and tomatoes.

The energy content of consumed (purchased + restaurant meals) 'real' food (excl. sugar, sweets, beverages etc.) was 10.7 MJ/person/day, while the Swedish average 2002 was 10.2

MJ/person/day (Swedish Board of Agriculture, 2004). Thus, we can conclude that our results are in a reasonable range concerning energy content of the purchased food. However, the results are not easily comparable to official statistics due to differences in survey methods.

	Healthy nutrition	**Environmental perspective Sustainable food choices**
Fruit, berries and vegetables	- A high and varied consumption of fruit and vegetables is desirable	- A high and varied consumption of domestic vegetables, fruits and berries in season and foodstuffs grown in the field. - If needed off-season, imported fruits or vegetables grown in the field, giving preference to products grown in a nearby country
Legumes		- More leguminous plants instead of meat
Potatoes	- Traditional use, several nutrients, potatoes have a place in a diet	
Cereals	- An increased consumption of wholegrain cereals is desirable	
Fish	- Regular consumption of fish	
Milk and milk products	- Regular consumption of milk and milk products, mainly low fat products are recommended as a part of balanced diet	
Meat	- Consumption of moderate amounts of meat, preferably lean cuts, is recommended as part of a balanced and varied diet	- Less meat - Choose meat from animals that have grazed on natural pasture, e.g. cattle and lamb. - Eat less chicken and pork.
Edible fats	- Soft or fluid vegetable fats, low in saturated and trans fatty acids, should primarily be chosen	- Butter instead of margarine
Energy-dense and sugar-rich foods	- Food rich in fat and/or refined sugars, such as soft drinks, sweets, snacks and sweet bakery products should be decreased	- Eat less
General		- More locally produced food when this is more eco-efficient. - Ecological food - Eat less foodstuffs which include few nutrients, for example: eat fruits instead of sweets - More easily transported foods, e.g. juice as concentrate instead of ready to drink. - Choose the product produced most nearby when there are equal products.

Table 4. Examples of recommendations. (derived from NNR 2004, CTN 2001, SEPA 1997, 1998, and 2000)

4.3 Collaboration, consumer demand and local development

Sustainability in agriculture from an economic perspective requires high quality food at reasonable price to the consumer (Ministry of Agriculture, 2000; SOU, 2004). What defines "reasonable price" is of course a value issue. In Järna higher prices for local organic food is accompanied with high demand. The higher food expense in the consumer survey is somewhat misleading from a societal perspective. The increased cost reflects lower environmental effects compared to conventional food production and consumption where environmental effects to a large degree are externalized. According to Pretty et al. (2005) substantial reductions in external costs could actually be made by a large scale conversion towards local and organic production, similar to the ERA production studied here.

Ecological food is generally more expensive and on a larger scale, higher food prices might hinder a change of consumption. It could be difficult to convince consumers to increase food expenditure for the sake of the environment only and the consumption pattern found in the survey is not expected at most places. A large scale transformation of Swedish agriculture would probably require the government to intervene. This is similar to what is suggested by Edman (SOU, 2004). To increase local, organic, Swedish food production and consumption Edman suggests that the government should strengthen domestic science subjects at school and provide earmarked funding for buying organic food. Out of all food provided by public institutions 25% ought to be organically certified, according to Edman. In Södertälje municipality 14% of the public procurement of food is organic or biodynamic, which places Södertälje among the top five of all Sweden's 290 municipalities (Södertälje municipality, 2006). This share is meant to increase to 50% in 2020. The policy on public procurement from local organic producers is one example of vertical collaboration which facilitates the high concentration of organic farms in the region. It is a good example of a "policy to help nurture green niches and put incumbent regimes under sustainability pressure" (Smith, 2007, p. 447). The collaboration in local, environmentally friendly food systems is not only vertically anchored. Järna community belongs to Södertälje municipality. The families in the household survey are not an isolated group but part of a well developed network of horizontal collaboration. It corresponds well with the local supermarkets having among the highest proportion of sold organic food in Sweden (Larsson, 2007).

The existence of several actors, at various organisational levels, enhances the diversity of governance options (Hahn et al., 2006). In the case of the local ecological food system in Järna different sectors at several levels are involved which could explain why it is so well developed. Quoting Low and Gleeson (1998, p. 189) on environmental governance: "Think and act, globally and locally". Both households and municipalities use their buying power to stimulate local production and development as well as environmental gains through increased demand of local organic food. The consumers' attitudes revealed in the high share of local and organic food and the tolerance towards higher prices could be described as an informal institution based on trust (Svenfelt and Carlsson-Kanyama, 2010) and common norms (Larsson, 2007). The high level of public procurement and the fact that organic farms can lease municipal land at non-market conditions (Larsson et al., 2007) are results of municipal regulations, i.e. formal institutions. These institutions facilitate in a sustainable governance of the community and the local agriculture.

5. Conclusions

We conclude that a sustainable governance of the food system needs to address consumption profiles as well as production methods, since both cause environmental effects. All examined environmental effects were lower on the studied Ecological Recycling Agriculture farms compared to conventional production. Combining this with changes in our food consumption can further reduce the environmental impact of the food system. If all Swedish food production is altered to ERA this would reduce the surplus of nitrogen with 18-37%. In addition to this, if all Swedes were to change their food profiles towards more organic vegetables and less meat the nitrogen surplus could decrease further. Results from our household survey indicate reductions in the range of 55-64% but the number of observations was limited why this should be seen as a special case.

Changing production methods to ERA would reduce emission of CO_2-equivalents and the consumption of primary energy. Combining ERA with an alternative food basket more is won. A change to ERA would decrease the environmental impacts, even when the food consumption profile remains as the Swedish average of today. The agricultural area needed would, however, increase substantially making a large scale conversion less realistic. If coupled with a changed diet the area needed for food production would decrease with 30%.

The results support other findings that changes in food profiles towards a more vegetarian diet and more organic foods decrease the environmental impacts. This change would have a negative effect in terms of increased food expenditures. The families in the household survey consumed substantially more local and organic products, less meat and more vegetables and they spent 24% more money on food compared to average Swedish consumers. Compared to conventional food production and consumption the environmental costs of eco-local food are however to a larger degree internalized.

In the studied community a local food system characterized by a high share of supply and demand of organic food has evolved. This has been facilitated by horizontal and vertical collaboration – horizontal through a high demand from private consumers coupled with large supply from local producers and vertical in the form of public procurement. However, because of the higher price charged for local and organic food a large scale transformation of Swedish agriculture would probably rely more on governmental intervention since few regions experience as high private and public demand for eco-local food.

The environmental benefits of organic agriculture cannot be fully realized unless food profiles change. For a governmental intervention in the form of e.g. public procurement to have optimal effect it is as important to focus on food content as on production methods. Localized processing is however of less importance in terms of environmental effects.

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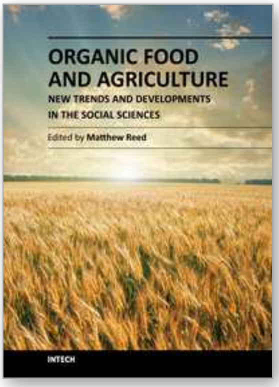

Organic Food and Agriculture - New Trends and Developments in the Social Sciences
Edited by Dr Matthew Reed

ISBN 978-953-307-764-2
Hard cover, 216 pages
Publisher InTech
Published online 05, January, 2012
Published in print edition January, 2012

The global phenomenon of organic food and farming, after three decades of progress, faces new challenges as markets mature and the impacts of the global recession start to change consumers and farmers' expectations. This global survey of the organic food and farming considers how the social sciences have come to understand in what way consumers make their choices as they shop, and how new national markets evolve. It also surveys how established organic sectors in North America and Europe are changing in response to the changes, that in part, the organic movement has created. Moving from a wide range of social science disciplines, methodologies and perspectives, this book represents an excellent starting place for new readers, and offers innovation to those already familiar with the literature.

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