Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

**EPOK – Centre for
Organic Food and Farming**

Organic Production and Climate Change

– from a Swedish perspective

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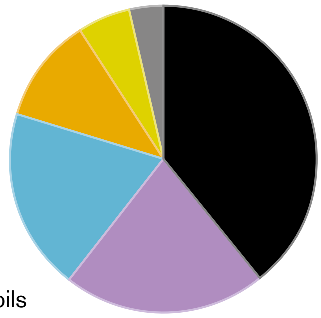
Organic production and climate change

To mitigate climate change, major decreases in emissions are needed in the near future. All sectors must contribute. Emissions of greenhouse gases from agriculture are dominated by methane and nitrous oxide, and not by carbon dioxide as in the energy and transport sector. When nitrogen is added to soil in the form of mineral fertiliser, animal manure or plant residues, a small proportion of the nitrogen is lost as nitrous oxide. Ruminants emit methane that is formed as a by-product of their feed digestion process. Considerable emissions also occur from Sweden's carbon-rich organic soils in the form of carbon dioxide and nitrous oxide (Figure 1). These three dominant sources of emissions, which account for 75 percent for all emissions from Swedish agriculture, are difficult to control because they are driven by natural biological processes. For other sources of emissions, such as gaseous losses from the storage and spreading of manure, carbon dioxide from fossil fuels and imported feed, new methods and alternative systems that decrease emissions are available. Agriculture has the potential not only to decrease its own emissions, but also to contribute to changes in the rest of society through production of bioenergy and sequestration of carbon in soil. Many of the climate challenges facing organic agriculture are shared by all other types of agriculture. However, organic production is based on a number of principles expressed in standards and regulations which create specific preconditions for the potential of organic agriculture to decrease its greenhouse gas emissions. Important areas as regards the climate impact of organic agriculture in a Swedish perspective are summarised below.

"To mitigate climate change, major decreases in emissions are needed in the near future"

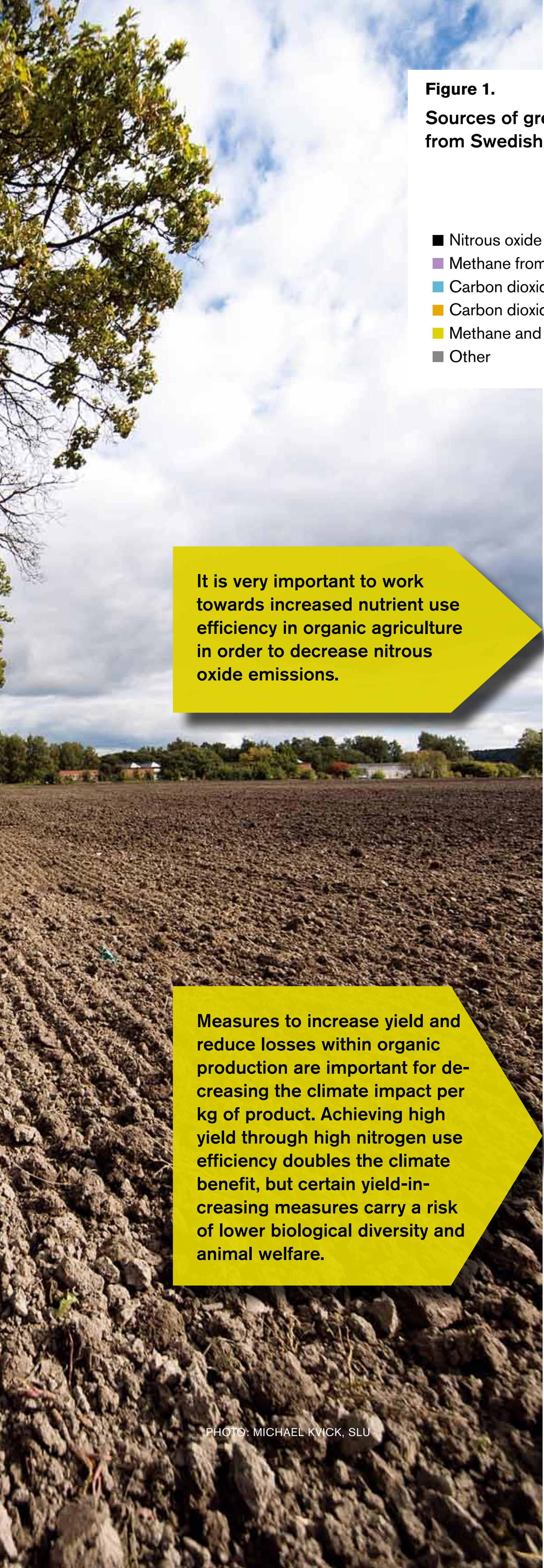
Figure 1.

Sources of greenhouse gas emissions from Swedish agriculture



- Nitrous oxide from soil
- Methane from livestock
- Carbon dioxide from carbon-rich organic soils
- Carbon dioxide from engines and heating
- Methane and nitrous oxide from storage and spreading of fertilizer
- Other

Source: Swedish Board of Agriculture.



It is very important to work towards increased nutrient use efficiency in organic agriculture in order to decrease nitrous oxide emissions.

Measures to increase yield and reduce losses within organic production are important for decreasing the climate impact per kg of product. Achieving high yield through high nitrogen use efficiency doubles the climate benefit, but certain yield-increasing measures carry a risk of lower biological diversity and animal welfare.

PHOTO: MICHAEL KVICK, SLU

Nitrogen use efficiency

Nitrous oxide emissions from soil arise from the biological processes that take place when plant-available nitrogen is present in the soil. Nitrogen is supplied in large amounts in agriculture through fertilisation, feed imports, nitrogen-fixing plants and atmospheric deposition. Losses of nitrogen cause climate impacts and eutrophication. Organic farms generally have a lower nitrogen surplus per hectare (nitrogen supplied minus nitrogen removed in animal and vegetable products) than conventional farms, but their nitrogen use efficiency (kg nitrogen removed per kg nitrogen added) is often at the same level (dairy farms) or lower (arable farms). The lower nitrogen surplus lowers the risk of nitrous oxide emissions per hectare, but for low nitrous oxide emissions per kg product, high nitrogen use efficiency is required.

Higher yields

Decreasing the climate impact per kg of food produced is largely a question of increased efficiency, in other words high yield in relation to the amount of resources used, especially land and nitrogen. The climate impact from organic products can be decreased by increasing the yield, so that the emissions per hectare can be allocated to a larger amount of products. If this can be achieved through improving the nitrogen use efficiency the climate benefit is doubled, since the risk of nitrous oxide emissions is also decreased. However, if the yield is increased through structural changes, such as larger fields, altered crop rotations or more weed-free crops, there is a risk of an associated decrease in the positive effects of organic agriculture on biological diversity. If animals produce at a high rate because they are healthy, this is positive for both the animals and the climate. However, increasing the intensity of animal production can bring about a decline in animal welfare. Reducing losses at all stages is also very important, since food which is produced but never consumed makes a quite unnecessary contribution to the climate impact.

The large amount of ley grown in organic agriculture helps to retain and sequester carbon in agricultural soils and thus decreases the climate impact. However, a very high level of sequestration is required to compensate for the greenhouse gas emissions from ruminants. If some of the ley forage is used for bioenergy, the climate benefit is potentially large.

PHOTO: ISTOCKPHOTO.COM

Research and development are needed to design production systems that produce benefits for society with lower demands on land and other finite resources. Use of local resources such as pasture, local forage crops, by-products, waste and surplus heat should be optimised in order to decrease the pressure on agricultural land world-wide.

PHOTO: PELLE FREDRIKSSON

More carbon in the soil

If more carbon is added to the soil than is lost, the soil binds in this carbon and gives a positive effect on the climate, since carbon dioxide is removed from the atmosphere and the carbon is transformed into more stable forms in the soil. The soil thus becomes a carbon sink. Whether the soil acts as a carbon sink or a carbon source is determined by the initial amount of carbon in the soil, the amount of carbon added in the form of roots, plant residues, manure and other organic material, and the temperature, water content and form of tillage used. Organically managed soils generally contain more carbon than conventionally managed soils. This is due to the large proportion of ley in organic production and to the greater use of manure. It is positive for organic agriculture to use conventional manure and other organic fertilisers originating from conventional agriculture if this decreases the total amount of nitrogen fertiliser on the conventional farms. However, the manure would have contributed to carbon sequestration on the conventional farms too, so the question is whether this benefit can be attributed to organic agriculture. In order to retain and store carbon in the soil, however, it is good to follow the regulations that apply within organic production, which require ley in the crop rotation and a high proportion of forage in the diet of ruminants.

Resource-efficient systems

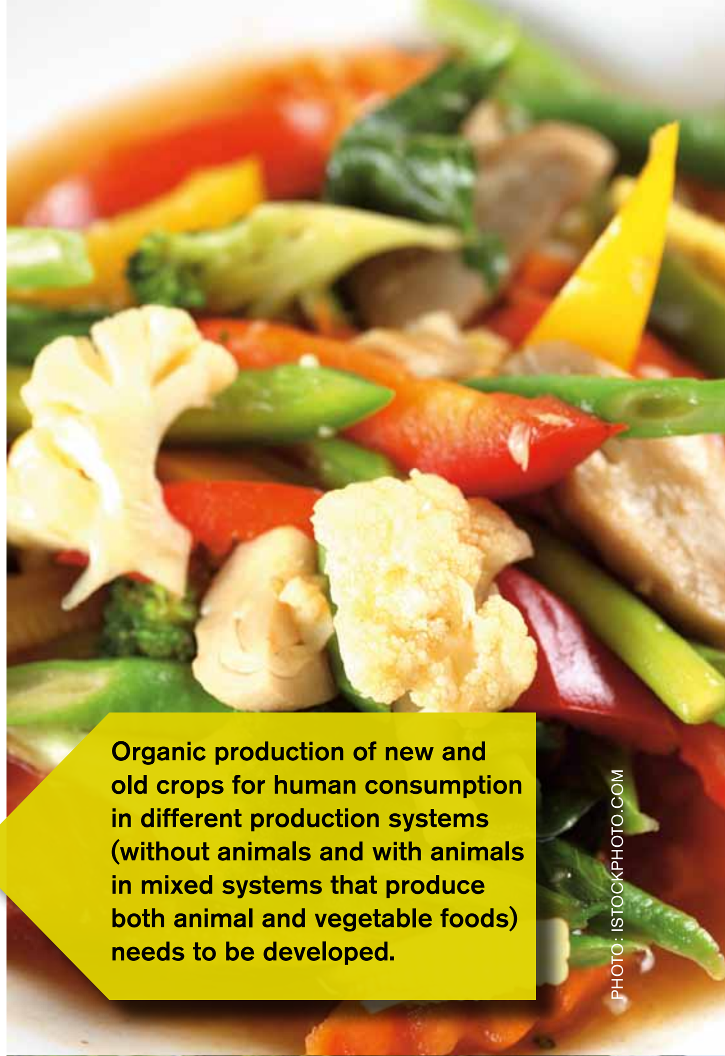
Greenhouse gas emissions from energy use within agriculture are small, both in relation to emissions from the total energy sector and in relation to total greenhouse gas emissions from agriculture. Agriculture can be self-sufficient in energy without needing to set aside extensive areas for energy production. Organic agriculture can contribute to supplying energy to society, and thereby lower greenhouse gas emissions, through various types of bioenergy production. The climate benefit of biogas production from manure can be doubled if the greenhouse gas emissions from manure handling decrease at the same time as renewable energy is produced. However, bioenergy production from crops grown on arable land competes with production of food and feed. Organic agriculture often requires a larger area than conventional agriculture to produce the same amount of food or energy, since the yield levels are generally lower and land also needs to be set aside for fixing nitrogen. The trend in area of cultivated land in Sweden is declining, but new agricultural land is being taken into use in other countries, resulting in very large greenhouse gas emissions and loss of biological diversity.

A more vegetable-based diet

Methane from ruminant digestion and nitrous oxide from soil caused by nitrogen fertilisation are the greatest sources of greenhouse gas emissions from agriculture. Organic agriculture in Sweden is currently dominated by animal production based on ruminants. Methane emissions can be decreased through efficient production systems with well-adjusted diets and where healthy animals grow and produce well. If organic agriculture could also produce more vegetable food products (plus pigs and poultry fed on domestic feedstuffs), those eating Swedish organic food would substantially decrease their climate impact, since greenhouse gas emissions are considerably lower for vegetables than for animal food products.

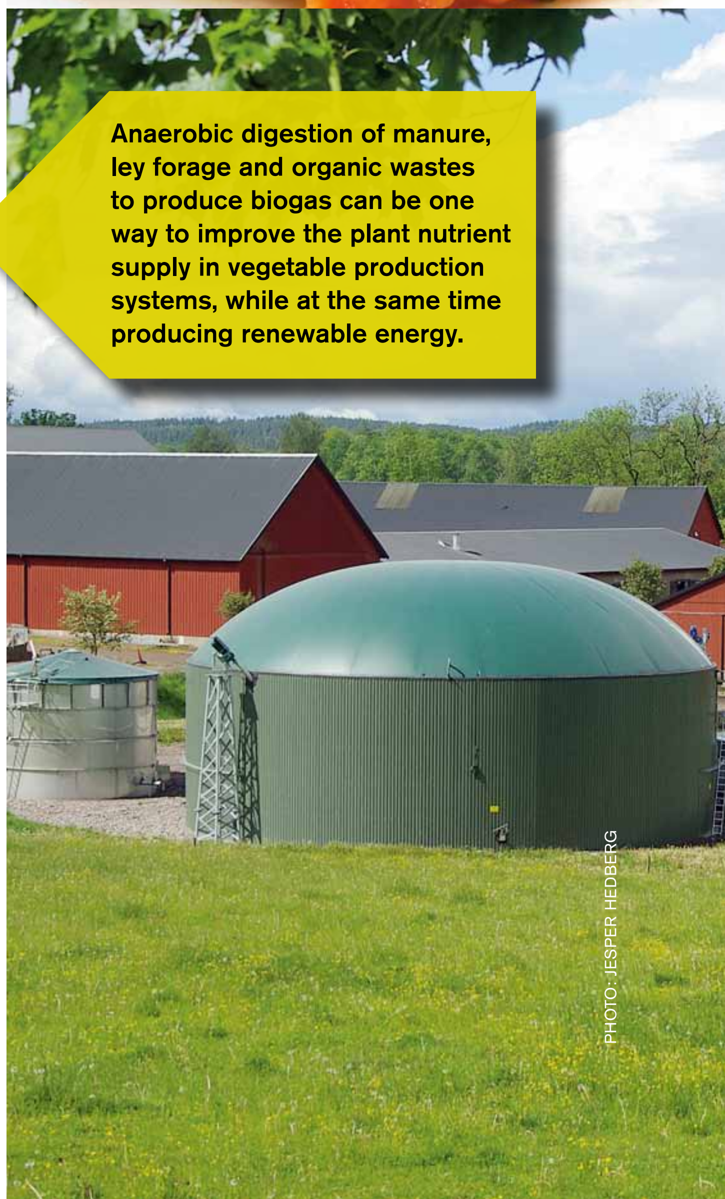
Climate benefits of bioenergy

High-yielding production systems require less land to produce the same amount of food than systems with lower yield. If the 'leftover' land in the intensive system is used to produce biomass that replaces fossil fuel, this is a major climate benefit. However, while in theory producing food more intensively means that more land is left over for bioenergy production, in practice it will not necessarily be used for bioenergy. This is determined by factors such as subsidies and raw material prices on the global market. If wheat prices are high, more wheat will be produced if the soil is suitable for that, rather than for example energy forest or energy grass. If the primary aim is to mitigate the climate impact, it is at present better to produce bioenergy than food on a piece of land since the bioenergy can replace fossil fuel. However, bioenergy production from agriculture can only replace a small proportion of all the fossil energy used, and agricultural land is needed for food production. This means that a balancing act is required to determine how much energy, feed, food and other products agricultural land should supply.



Organic production of new and old crops for human consumption in different production systems (without animals and with animals in mixed systems that produce both animal and vegetable foods) needs to be developed.

PHOTO: ISTOCKPHOTO.COM



Anaerobic digestion of manure, ley forage and organic wastes to produce biogas can be one way to improve the plant nutrient supply in vegetable production systems, while at the same time producing renewable energy.

PHOTO: JESPER HEDBERG

Organic and conventional production – pluses and minuses for the climate

It is very difficult to draw general conclusions on the climate impact of organic production compared with conventional. However, in very simplified terms, current knowledge on these production systems under Swedish conditions can be summarised as follows:

1. *Climate impact per hectare – advantage organic.*
2. *Climate impact per kg product – very wide variation for different products, but generally a draw.*
3. *Climate impact per kg product with carbon sequestration included, on condition that the carbon remains in the soil – advantage organic for animal products, unclear for vegetables.*
4. *Climate impact per kg product considering the amount of land used and with bioenergy to replace fossil fuel being produced on the land left over – advantage conventional.*

A relatively large amount of research has been done on the comparisons in points 1 and 2, so these results can be regarded as fairly reliable. Only a few studies are available on points 3 and 4 and the comparisons are much more complex, so these conclusions should be applied with great caution. The potential for carbon sequestration varies greatly between soils, so for this it is very difficult to make general statements.

Challenges on the way to a lower climate impact

The challenges we face lie not only within the natural sciences. Much knowledge and technology are available for decreasing greenhouse gas emissions today, but economic and social factors prevent their wider application. Research in the natural sciences needs to be integrated and complemented with research in the social sciences. In order to work successfully on lowering the climate impact of Swedish food consumption and to stake out a path towards sustainable agriculture, a value-based discussion is needed on what Swedish agricultural land should be used for and the role organic production should fill in future agriculture.

In addition, there are other important natural science aspects of climate that should be considered in the creation of sustainable agricultural systems:

- Extensive agriculture without pesticides promotes biological diversity and decreases the spread of toxic substances in the environment, while agriculture with high yield levels and efficient use of nitrogen can supply products with a lower climate impact. Is there a golden middle path or is coexistence of both systems the best option?
- The long-term fertility of the soil is an important sustainability issue. How is it affected by short-term and long-term measures to decrease the climate impact?
- Climate-optimised systems for animal production affect animal management. What is the animal welfare situation in such systems?
- The price of fossil fuel and other raw materials is rising. How can production be adjusted to decreasing availability of fossil fuels and other finite resources?
- Agricultural land is a finite resource. In the future, there will be increasing demands on the land to produce food for a growing population, but also energy and other raw materials. What systems can optimally utilise local resources such as pasture (not suitable for growing crops) and waste products?
- Conditions for plant growth are changing in Sweden and world-wide with increasing air temperature. How will agriculture be affected by future climate change and how do we design robust systems that can tolerate the predicted changes?

Many of the questions listed above are still unanswered. Many questions are common to both organic and conventional agriculture. Research is underway in many areas, but there is also a need for more dialogue, a discussion on ethical aspects and a greater degree of interdisciplinary research efforts. At the same time, mitigating negative climate impacts is quite literally a hot topic. We must act on the knowledge available now. This brochure, and the detailed report on which it is based, have hopefully helped to formulate what we know already and to identify areas that are still unclear.

PHOTO: ISTOCKPHOTO.COM

This folder is a short version of a knowledge synthesis on climate impact from organic farming and how to mitigate climate change in organic agriculture. The knowledge synthesis is only available in Swedish.

EPOK – Centre for Organic Food and Farming at the Swedish University of Agricultural Sciences (SLU) works with collaboration, coordination and information on organic agriculture research in a Swedish, Nordic and international perspective.

EPOK is a resource for the entire SLU for external communication and to coordinate and initiate research and education.

www.slu.se/epok

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SLU

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