By Jørgen E. Olesen

Climate-friendly food

The greatest potential for reducing the impact of climate change on the production and consumption of food is expected to lie in influencing consumers' choice of food products

Climate change is without doubt one of the greatest challenges mankind has ever faced. This is not least due to the enormous consequences that climate change will have for the world's ecosystems and for our living conditions. At the same time, climate change is a colossal political problem, in which the world's democracies run the risk not being able to carry out the decisions that have to be made.

The political and democratic problem builds on the very limited understanding that there is a connection between emissions of greenhouse gases, climate change and their impact on the living conditions of individual people.

In reality, there is both a spatial and a temporal separation between emissions and effects. The world's industrialised countries, which emit by far the largest amount of greenhouse gases, are in the first instance the least vulnerable to the effects of climate change. In addition, serious effects will first occur much later (decades to centuries) than the emissions. Therefore it can be very difficult to generate popular backing for serious initiatives against emissions of greenhouse gases.

Agriculture and food production play an important role in this connection due to the importance of climate change for agriculture's production basis and because it is one of the sectors emitting most greenhouse gases. For agriculture, the climate challenge is therefore double – it must both adapt to the changes and at the same time reduce its emissions of greenhouse gases.

Agriculture's emissions

Agricultural production results in emissions of methane (CH_4) and laughing gas (N_2O), which contribute to the man-made greenhouse effect. The greenhouse effects of methane and laughing gas are 23 and 296 times more powerful respectively than the effect of carbon dioxide (CO_2). CO_2 from biological processes is neutral in relation to the greenhouse gas effect, but changes in land use in forestry and agriculture as well as between them can impact on the storage of carbon in the soil and thus on the balance between bound and atmospheric CO_2. Further, agriculture has an energy consumption (direct and indirect) that also contributes to CO_2 emission. In part this can be compensated for through the use of biomass for energy production.

On a global scale, the overall emissions from agriculture are estimated at 17-32 per cent of the total emissions. A very great proportion of these emissions is related to livestock production. The great uncertainty is especially connected with the emissions resulting from clearing woods and cultivating the soil.

In Denmark, agriculture's emissions amount to about 16 per cent of the national emissions of greenhouse gases. Emissions of methane and laughing gas from Danish agriculture fell by 26 per cent in the period from 1990 to 2006. The fall is especially due to smaller cattle herds and a considerable increase in agriculture's nitrogen efficiency as a result of the implementation of the aquatic environment plans.

For Denmark, the EU's new proposal for an energy and climate directive means:

- An increase in renewable energy's share of energy supply from 10 to 30 per cent by

2020

- A 20 per cent reduction in CO_2 emissions in 2020, compared with 2005, from sectors (including agriculture) that are not subject to quotas, and
- 10 per cent of the transport sector's energy consumptions must come from biofuels in 2020. This obviously implies both challenges and opportunities for agriculture.

Methane

Methane is formed through the decomposition of organic substances under completely oxygen-free conditions, such as those found in animals' digestive systems and in environments that are permanently waterlogged. Ruminants' digestion is the greatest single source of methane in agriculture.

There are also good conditions for methane production in liquid manure tanks, depending on the composition of the liquid manure and on the temperature in the tank. Methane oxidation can occur in the floating membrane and this is estimated to reduce methane emissions by about 10 per cent. Re-establishing wetlands can increase methane emissions because the changed water level distorts the balance between methane production and methane oxidation.

Methane from animals' digestion can be reduced by changed feed or through the use of methane-inhibiting substances. However, this has a number of undesired side-effects. On the other hand, there are a large number of possibilities for reducing emissions of methane and laughing gas from animal manure. The treatment of liquid manure in joint biogas plants in particular has a potential for considerable reductions in emissions.

There are also possibilities through new technological initiatives, including more frequent sluicing out of liquid manure to storage, acidification of the liquid manure and the establishment of floating membranes and permanent covers on the liquid manure tanks. Finally, there are possibilities for reduction through e.g. burning hard animal manure or air-tight coverage of hard fertilizer.

Laughing gas

Laughing gas in soil is primarily formed as an intermediate product in the bacterial nitrogen cycle. The formation can occur through the nitrification of ammonia to nitrate or through the denitrification of nitrate to free nitrogen (N_2). The processes in the nitrogen cycle are influenced by a number of conditions in the soil, such as accessibility of oxygen and organic substances, the soil's pH and the moisture content.

Laughing gas emissions occur especially from soil and manure stores. In addition, there is an emission added to the amount of nitrogen that is lost from the agricultural cycle through ammonia evaporation and nitrate leaching, as these losses are transformed in other eco-systems with emissions of laughing gas as a result.

Emissions of laughing gas can be reduced by cutting the use of nitrogen fertilizers and by reducing losses through ammonia evaporation and nitrate leaching. An increased utilisation of nitrogen in particular results in a reduction of laughing gas emissions.

Other options are to introduce a cultivation practice that has a documented effect in reducing laughing gas emissions from a given quantity of applied nitrogen fertilizer, e.g. with shared manuring, by avoiding nitrate-rich fertilizers in the spring, by not using commercial fertilizers at the same time as livestock manure, by using nitrification inhibitors in the fertilizer and by treating liquid manure in biogas plants.

Carbon in soil
The amount of carbon (C) in agricultural systems comprises primarily C in the soil's organic substances. In particular, the carbon content in agricultural soil can be influenced through the addition of crop residue and animal manure.
In addition, the intensity with which the soil is worked plays a role for carbon storage. Direct sowing will thus lead to an accumulation of carbon compared with traditional ploughing. The increase in the soil's carbon store is especially large under grass fields and a part of the carbon storage occurs under the ploughed layer. Re-establishing wetlands on organic soil would be particularly effective in increasing CO_2 storage as it would stop the decomposition of organic substances in this humus-rich soil and, under certain circumstances, would increase the recycling of plant remains.

The impact of food products on the climate
European studies have shown that the overall consumption of food products, beverages, tobacco and other stimulants amounts to 22-31 per cent of the EU's total contribution to greenhouse gas emissions. Meat and meat products are the foodstuffs that have the greatest impact on the climate, followed by the dairy products milk, cheese and butter (see the table). The lowest impact on the climate is from vegetable food products.
Agricultural production is the link in the production chain which for all food products causes the greatest emission of greenhouse gases, while, on the other hand, only a small part of the emissions come from manufacturing, packaging and transport.
It is therefore in agricultural production where initiatives to support a climate-friendly agriculture should primarily be directed. Life-cycle analyses of food product systems show that the annual emission of a milk cow is about 14 ton CO_2 equivalents per hectare, from a sow with her production of porkers about 7.5 ton CO_2 equivalents, and from plant cultivation about 3.5 ton CO_2 equivalents. An analysis of available initiatives for reducing emissions shows that the realistic potential for emissions reduction at present in Danish agriculture is about 15, 20 and 30 per cent for livestock, pig and crop cultivation respectively.
The greatest potential for reducing the climate impact of production and consumption of foodstuffs must be expected to lie in influencing consumers' choice of foodstuffs, so they tend to a greater extent to choose the climate-friendly foodstuffs based on plant products (flour, bread, meal) and outdoor vegetables and less of the animal foodstuffs that have a large climate impact (especially meat, milk and other dairy products, as well as eggs). At the same time, this will be in line with general dietary advice about a sound and balanced diet.
The challenge will be to support a situation where production and consumption of foodstuffs has the least possible impact on the climate. As a food exporting country, we are forced to realise that climate documentation will be one of the competitive parameters of the future, either directly through a system of labelling the climate impact of foodstuffs or indirectly by central players in the foodstuffs industry and retailers making climate-related demands on their products.

Bioenergy's contribution
Agriculture today contributes with about 24 PJ of biomass to energy, equalling about 3 per cent of Denmark's total energy supply. Analyses have shown that an increased exploitation of residual products such as liquid manure and straw can result in two to three times as much bioenergy from agriculture. If, in addition, we change 15 per cent of the corn-growing area to energy crops, then the supply of bioenergy from agriculture can be almost five times higher.

There are considerable uncertainties involved in calculating the overall impact of increased bioenergy utilisation on greenhouse gas emissions, as there is great uncertainty about the precise quantification of how this would affect the soil's carbon pool. In addition, the type of energy crops that would be chosen for cultivation will have great importance, as cultivating annual crops will generally reduce the soil's carbon pool, while cultivation of perennial crops can be expected to increase the soil's carbon pool.

Increased biomass production will also be able to raise the extent of other environmental problems. This can happen for example if fallow areas are recultivated with annual crops that contribute to higher use of pesticides and loss of nutrients. The opposite can also be the case, however – e.g. when changing from grain production on environmentally sensitive areas to perennial energy crops with lower loss of nutrients and low pesticide consumption.

What can be done?

Achieving a considerable reduction in the climate impact of food production demands initiatives in many areas. There is a need to reduce emissions in primary production. Here it is especially important to continue to increase nitrogen efficiency in production at the same time as the amount of carbon in cultivated soil is kept unchanged or even built up. There is also a need for increasing the utilisation of biomass for energy, but this should occur without it affecting foodstuff production and other considerations towards the environment. Here it is in particular the possibility of increased exploitation of waste and residual products and the cultivation of perennial energy crops.

This demands new motivation for promoting a development that ensures both a reduction in emissions and an increased utilisation of biomass. There is a need for both research and innovation to ensure that it is the correct solutions that are chosen and that they are sufficiently cost-effective. This should be supplemented by various initiatives towards the primary operations. Some of the elements that can be considered are:

- A ban on operating practices that are especially CO_2-emissive (e.g. cultivation of carbon-rich lowlands)
- Economic subsidies for establishing and operating CO_2-friendly technologies (e.g. biogas and direct sowing)
- Economic subsidies for CO_2-friendly operations based on an overall operating accounting system for greenhouse gas emissions, where there are comparisons with typical figures for the relevant production type
- Taxation of methane and laughing gas emissions from the individual farms, e.g. based on the size and extent of the livestock production and the farm's nitrogen surplus

As it will be seen from the above, there are too few possibilities with the current technology for limiting agriculture's greenhouse gas emissions. A responsibility lies with the consumer to choose climate-friendly food. Taxation of the particularly climate-hostile foodstuffs, such as meat, milk, cheese and eggs, would be the most effective means. The proceeds from such taxation could suitably be used to reduce the price of fruit and vegetables. There would also be considerable health benefits.

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