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Organic Trade

ORGANIC FARMING AND CLIMATE CHANGE

Monograph

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Study focusing on organic agriculture and mitigation and adaptation to predictable and unpredictable impacts of climate change - looks at the general contribution of agriculture to climate change; discusses the considerable potential of organic agriculture for reducing emissions of greenhouse gases, and its contribution to sequestration of CO_2 in the soil; outlines weaknesses of organic agriculture in the context of climate change; discusses the inclusion of organic agriculture in voluntary CO_2 emissions markets; includes bibliography, and a list of useful links (pp. 24-27).

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Research Institute of Organic Agriculture FiBL

The Research Institute of Organic Agriculture FiBL, Frick (Switzerland), FiBL Germany and FiBL Austria are centres for research and consultancy on organic agriculture.

FiBL Frick was founded in 1973. The close links between different fields of research and the rapid transfer of knowledge from research to advisory work and agricultural practice are FiBL's strengths. FiBL Frick employs over 100 members of staff with a volume of project funding totalling some € 10 million in the year 2006.

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Alongside practical research, high priority is given to transferring knowledge into agricultural practice through advisory work, training courses and expert reports as well as various modern methods of documentation (magazines, data sheets, reference books and Internet).

Numerous FiBL projects in Eastern Europe, India, Latin America and Africa promote the development of organic research services as well as advisory and certification services.

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Foreword

Climate change is the defining challenge for human development and ecological well being in the 21st century.

The OECD and Stern Review project that if no action is taken, concentrations of greenhouse gases in the atmosphere could reach 2 ºC higher than their pre-industrial levels by 2035-2050. The consequences of a 2 ºC temperature rise are grave for potentially millions of people through death, injury and dislocation from flooding, fire and disease, adverse effects on water quality, species extinction and reduced agricultural yields.

Inaction on greenhouse gas emission reductions risks even higher temperature rises. The Stern Review says that inaction means there is a 50% chance of a rise by 5 ºC. This is a temperature rise equivalent to a change in temperature from the last ice age to today and is described by the Review as “very dangerous indeed”.

Agriculture is both affected by climate change but also contributes to it. As a sector, agriculture must therefore both adapt to changes and offers options for mitigation i.e. reducing greenhouse gas emissions and store carbon.

Agricultural land use contributes to 12% of global greenhouse gas emissions. This figure is rising. As demand for food increases, farmers are clearing new land resulting in deforestation, tilling of pasture and soil degradation. This activity opens carbon sinks and so releases greenhouse gases.

Agriculture must also adapt to changes in climate in order to provide food security. Rising temperatures and decreasing water availability are reducing yields particularly in developing countries where agriculture is vital for the food security of these populations. Extreme weather events such as droughts and floods are making cropping and animal production even more prone to failure.

The objective of the study is to explore the mitigation and adaptation potential of organic agriculture. It examines organic agriculture’s performance on greenhouse gas emissions and carbon sequestration. With respect to adaptation, the study discusses how organic farming systems utilize traditional skills and knowledge, manage with weather extremes, and enhance productivity and resilience.

The weaknesses of organic agriculture are examined with respect to productivity and reliance on livestock.

The study is based on a comprehensive review of peer reviewed scientific literature. It concludes that organic agriculture has much to offer in both mitigation of climate change through its emphasis on closed nutrient cycles and is a particularly resilient and productive system for adaptation strategies.

The study raises the issue of whether organic agriculture should be eligible for carbon credits under voluntary carbon offsetting markets and the Clean Development Mechanism. On the basis of the findings of this study, organic agriculture may well serve as a “quick win” policy option to store carbon and reduce emissions.

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Introduction

Climate change will dramatically alter global food production. The inequity in food supply between industrialized and developing countries is expected to increase, as the 40 poorest countries in the tropical and subtropical zones will suffer most, both from droughts and periodic floods.

Agriculture is not only affected by climate change but also contributes to it. Ten to twelve percent of global greenhouse gas emissions are due to human food production. In addition, intensive agriculture has led to deforestation, overgrazing and widespread use of practices that result in soil degradation. These changes in land use contribute considerably to global CO_2 emissions. Sustainable agriculture and food supply systems are thus more urgently needed than ever before. They must boost the capacity of agricultural production to adapt to more unpredictable and extreme weather conditions such as droughts and floods, reduce greenhouse gas emissions in primary food production and halt or reverse carbon losses in soils.

Organic agriculture is claimed to be the most sustainable approach in food production. It emphasizes recycling techniques and low external input and high output strategies. It is based on enhancing soil fertility and diversity at all levels and makes soils less susceptible to erosion. In this publication, organic farming and food systems are evaluated in the context of climate change scenarios. As simple answers cannot be given to such a complex and global problem, it is equally important to highlight recommendations for future development and research requirements in organic agriculture.

Organic farming links productivity with ecology and creates livelihoods in rural areas: it is a surprisingly multifaceted option.

1. Agriculture as Cause and Victim of Climate Change

Chapter key points

- Agriculture contributes substantially to climate change via emissions of methane and nitrous oxides.
- Emissions of greenhouse gases from agriculture are expected to increase considerably unless action is taken.
- Climate change is expected to change agricultural production dramatically.

The current change in global climate is a phenomenon that is largely due to the burning of fossil energy (coal, oil, natural gas) and to the mineralization of organic matter as a result of land use. These processes have been caused by mankind's exploitation of fossil resources, clearing of natural vegetation and use of these soils for arable cropping.

These activities have primarily led to a measurable increase in the carbon dioxide (CO_2) content of the atmosphere, an increase which results in global warming, as CO_2 hinders the reflection of sunlight back into space, and thus more of it is trapped in the Earth's atmosphere. Molecules of methane (CH_4) and nitrous oxide (N_2O) have a similar, but far greater effect: the global warming potential of methane is twenty times that of $CO_{2,}$ while that of nitrous dioxide is as much as 300 times greater. IPCC has published greenhouse gas emissions classified by different sectors as shown in figure 1. When calculating the climate impact of a certain production type it is always a question, where to put the cut-off points of a particular system. For instance, agricultural emissions as shown in figure 1 do not comprise emissions from fertilizer production, which are counted under 'industry'. This needs to be taken into account when comparing farming systems. When considering the total food chain from the farm to the consumer, emissions from all the other sectors need to be included. Thus, the greenhouse gas emissions from all sectors related to agriculture may potentially sum up to 25-30% of all GHG emissions.

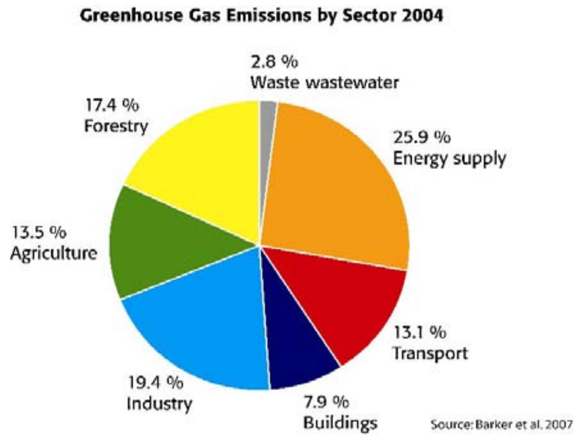

Figure 1: Greenhouse gas emissions (CO_2, CH_4 and N_20 converted to CO_2 equivalents) by sector in 2004 (Barker et al., 2007).[1]

1.1 Greenhouse gases emitted by the agricultural sector

According to the Intergovernmental Panel on Climate Change (IPPC), the annual amount of greenhouse gases emitted by the agricultural sector is estimated at between 5.1 and 6.1 gigatonnes CO_2 equivalents[2] in 2005 (Barker et al., 2007). This represents approximately 10–12% of total greenhouse gas emissions.

Of these emissions, methane accounts for 3.3 Gt equivalents and nitrous oxide for 2.8 Gt CO_2 equivalents annually, while net emissions of CO_2, at only 0.04 Gt CO_2 equivalents per year, are small.

Agriculture is the main emitter of nitrous oxides and methane according to current practice and knowledge.

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[1] Note to figure 1, (= Figure TS.2a from the technical summary of the Working Group III Report "Mitigation of Climate Change"; Barker et al. 2007)

- Energy Supply: Excluding refineries, coke ovens etc., which are included in industry.
- Transport: Including international transport (bunkers), excluding fisheries. Excluding offroad agricultural and forestry vehicles and machinery.
- Residential and commercial buildings: Including traditional biomass use. Emissions in Chapter 6 are also reported on the basis of end-use allocation (including the sector’s share in emissions caused by centralized electricity generation) so that any mitigation achievements in the sector resulting from lower electricity use are credited to the sector.
- Industry: Including refineries, coke ovens etc. Emissions reported in Chapter 7 are also reported on the basis of end-use allocation (including the sector’s share in emissions caused by centralized electricity generation) so that any mitigation achievements in the sector resulting from lower electricity use are credited to the sector.
- Agriculture: Including agricultural waste burning and savannah burning (non-CO_2). CO_2 emissions and/or removals from agricultural soils are not estimated in this database.
- Forestry: Data include CO_2 emissions from deforestation, CO_2 emissions from decay (decomposition) of above-ground biomass that remains after logging and deforestation, and CO_2 from peat fires and decay of drained peat soils.
- Waste and wastewater: Includes landfill CH_4, wastewater CH_4 and N_2O, and CO2 from waste incineration (fossil carbon only).

[2] Carbon dioxide equivalent, CO_2eq, is an internationally accepted measure that expresses the amount of global warming of greenhouse gases (GHGs) in terms of the amount of carbon dioxide (CO_2) that would have the same global warming potential. Examples of such GHGs are methane and nitrous oxide.

Emissions of nitrous oxide originate mainly from:

- high soluble nitrogen levels in the soil from synthetic and organic nitrogen sources (fertilizers).
- animal housing and manure management.

The main sources of methane emissions are:

- enteric fermentation[3] by ruminants (e.g. cows, sheep, goats).
- anaerobic turnover in rice paddies.
- manure handling.
- compaction of soils resulting from the use of heavy machinery.
- biomass burning, e.g. from slash-and-burn agriculture, emits both methane and nitrous oxide.

Vegetation – together with the soil ecosystem as the place for decomposition – generates large fluxes of carbon dioxide (CO_2) both to and from the atmosphere[4]. According to the Intergovernmental Panel on Climate Change (IPPC), this flux is nearly balanced in agriculture with a net emission of 0.04 Gt CO_2 equivalents per year, and represents less than 1% of global anthropogenic CO_2 emissions (Smith et al. 2007).

Substantial emissions of CO_2 from soils, however, originate from land-use changes such as deforestation (not counted under the agricultural sector by IPCC). On the other hand, reforestation and afforestation are considered sinks for CO_2.

By sequestering carbon dioxide in the soil, agriculture may contribute to the carbon cycle in a positive way. Whether the balance is positive or negative depends to a large extent on the cut-off points for the comparison (for instance if the fertilizer industry is included or not) as well as the management and farming practices applied. Agriculture has the potential to be a considerable CO_2 sink, if good farming practices, like organic farming, are employed.

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[3] Methane is emitted as a by-product of the normal livestock digestive process, in which microbes resident in the animal's digestive system ferment the feed consumed by the animal. This fermentation process, also known as enteric fermentation, produces methane as a by-product.

[4] Carbon in its gaseous form plays a key role in climate change. Carbonates are relatively stable forms of carbon present in rocks and sediments that may dissolve in water, where the resulting concentration of carbonic acid is regulated by a complex temperature and pH-dependent equilibrium with atmospheric CO_2. The most important form of carbon, however, is as a constituent of all organic compounds in the plant and animal world. Plants and some micro-organisms assimilate CO_2 and form compounds that are the basis of human and animal nutrition. Organic carbon is the energy source for almost all forms of life. In the process of using this energy, organic compounds are converted back into their mineral elements and this process produces CO_2.

Thus, the energy of organically fixed carbon is used in natural systems as well as in man-made technologies and industry. Whereas in natural systems assimilation and decomposition are nearly balanced, the burning of fossil resourceS is not counterbalanced by a process that points in the opposite direction. Land-use change means primarily deforestation and cultivation of land, giving rise to a significant decrease in the living biomass and historically grown humus content of soils – a process that can be reversed only slowly.

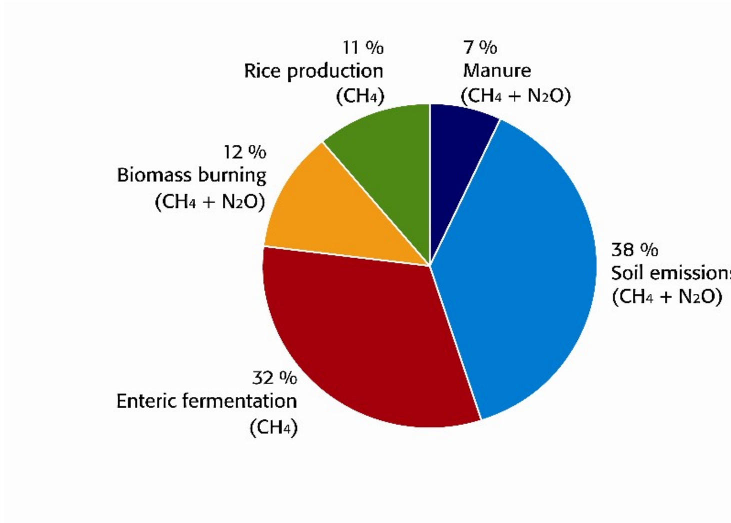

Figure 2: Main sources of greenhouse gas emissions in the agricultural sector in 2005 (Smith et al., 2007)

1.2 Further increase in emissions expected unless agricultural practices change

Predictions concerning the future global trends for greenhouse gas emissions from agriculture largely depend on physical and economic parameters that have a strong influence on total emissions. These parameters include: cost of fuel, economic development, evolution of livestock numbers, increase in productivity, new technology, availability of water, deforestation, and consumer attitudes and diet (Smith et al. 2007).

According to current projections, total greenhouse gas emissions from agriculture are expected to reach 8.3 Gt CO_2 equivalents per year in 2030, compared to the current level of approximately 6 Gt CO_2 equivalents annually (Smith et al. 2007).

1.3 Higher risks due to more unpredictable weather

Current scientific models predict substantial environmental changes caused by increased emission of greenhouse gases. These changes will affect agriculture both in positive and negative ways. The forecast increase in global temperature of between 1.4°C and 5.8°C will result in alterations in precipitation patterns (Smith et al. 2007).

Extreme weather events (droughts, floods) are expected to occur more frequently. Seasonal variations in weather events may pose risks to traditional methods of crop production either due to water constraints or surplus of water and erosion. Soil stability will become crucial in order to store water in the soil profile, to resist severe weather events and minimize soil losses.

Vulnerable regions such as tropical and subtropical areas and high mountain regions are expected to suffer most from climate change.

1.4 Measures proposed by IPCC to mitigate the global warming impact of agriculture

The Intergovernmental Panel on Climate Change IPPC has suggested a range of measures for mitigating greenhouse gas emissions from agricultural ecosystems (Smith et al. 2007). According to Barker et al. (2007), sink enhancement (carbon sequestration) will contribute most to mitigation in this context. Prominent mitigation options in agriculture according to IPCC (Barker et al. 2007; Smith et al, 2007) include improved cropland management (including nutrient management, tillage/residue management and water management), improved grazing land management (e.g. grazing intensity, nutrient management) and the restoration of degraded soils.

2. The Potential of Organic Farming to Mitigate Climate Change

Chapter key points

- Organic agriculture has considerable potential for reducing emissions of greenhouse gases.
- Organic agriculture techniques can contribute significantly to sequestration of CO_2 in the soil.

Agriculture can help to mitigate climate change by a) reducing emissions of greenhouse gases (GHGs) and b) by sequestering CO_2 from the atmosphere in the soil. The potential of organic agriculture for both effects is high, as data gained from modelling both long-term field trials and pilot farms show.

2.1 Reduction of greenhouse gas emissions

2.1.1 Organic farming has lower global warming potential

The global warming potential (GWP) of agricultural activities can be defined as greenhouse gas (GHG) emissions in CO_2 equivalents per unit land area or per unit product.

The global warming potential of organic farming systems is considerably smaller than that of conventional or integrated systems when calculated per land area. This difference declines, however, when calculated per product unit, as conventional yields are higher than organic yields in temperate climates (Badgley et al. 2007). Under dry conditions or water constraints, organic agriculture may outperform conventional agriculture, both per crop area and per harvested crop unit.

Figure 3 shows the results of comparative studies on the global warming potential of organic and conventional production. Organic farms do not only produce cash crops, but they use arable fields for temporary grass-clover (ley-farming) and fodder production for livestock. A part of the grass-clover yields and nutrients is used to fertilize arable crops and soils. Depending on the methodology and the calculations used, the results can differ substantially:

- In the two long term comparison experiments with arable rotations in Switzerland, the DOK trial (Mäder et al., 2002) and the Burgrain experiment (Nemecek et al., 2005), the global warming potential of all crops was reduced by 18% in the organic plots. A reduction of warming potential has also been found in Dutch dairy farms and in some vegetable crops.

- In contrast, no difference or higher emissions for organic crops were modeled for the experimental farm in Scheyern (Bavaria, Germany), for 18 Bavarian commercial crop farms and for most of the vegetable crops from model farms in the Netherlands.

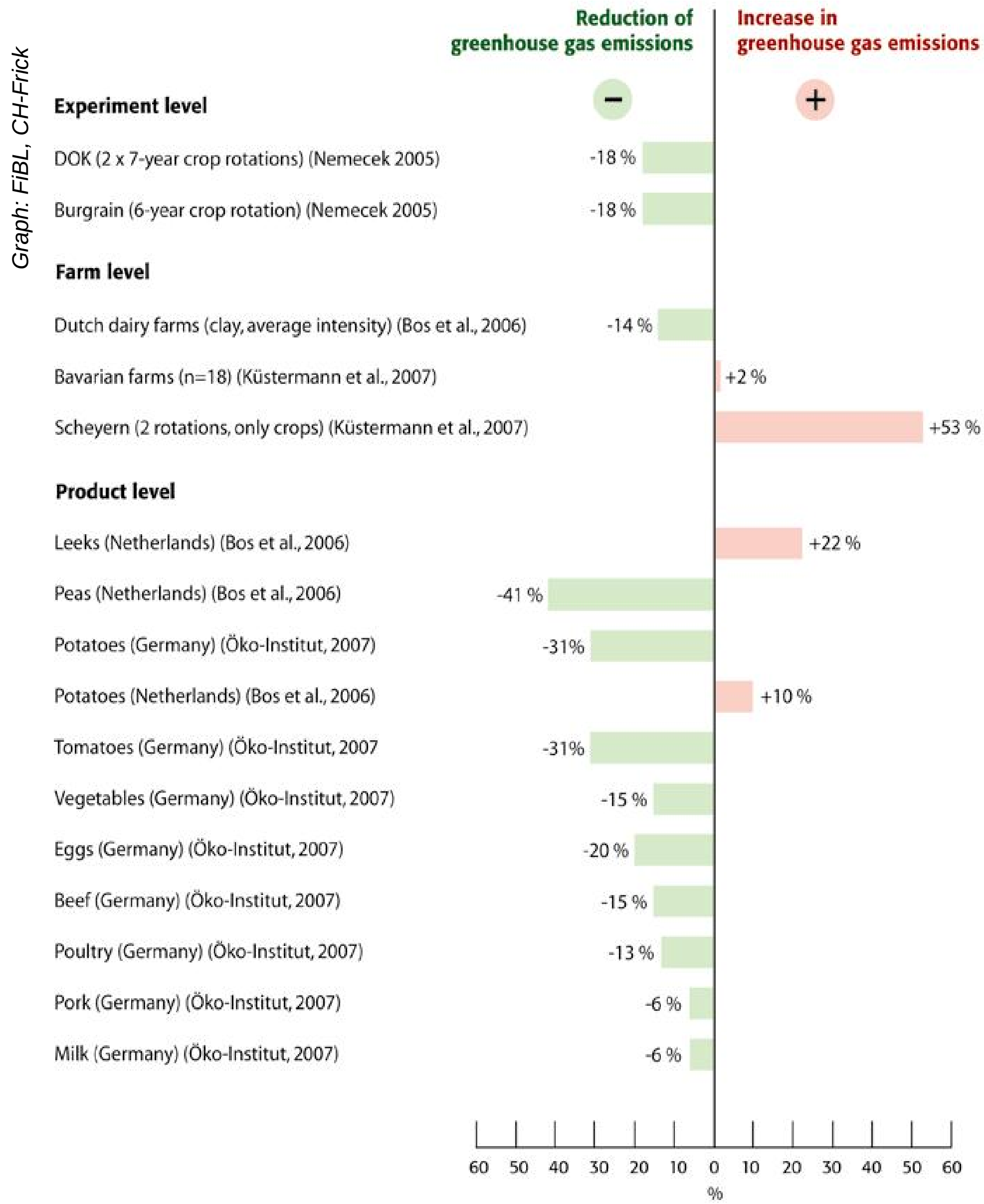

Figure 3: Relative global warming potential of organic agriculture compared to conventional agriculture (basis: grams CO_2 equivalents per kg product). At the experiment and farm level, all crops in a rotation were compared.

When losses and gains of soil carbon stocks (mineralization or sequestration) are considered in the calculations, the global warming potential is considerably reduced for organic agriculture as shown in recent studies (Figure 4):

- Scheyern experimental farm: decrease of 80% (crops only, Küstermann et al., 2007).
- Bavarian survey of 18 commercial farms: 26% (Küstermann et al., 2007).
- Station experiment in Michigan: 64% (Robertson et al., 2000).

Graph: FiBL, CH-Frick

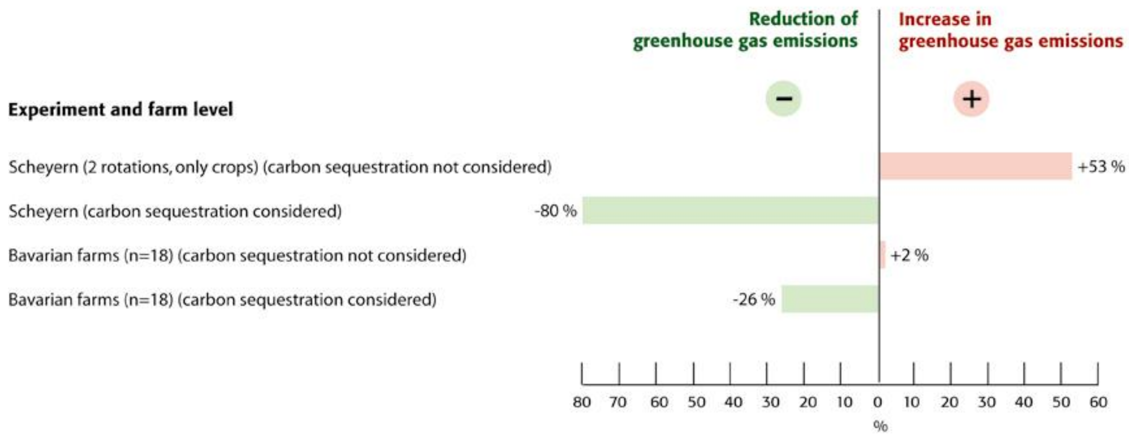

Figure 4: Relative global warming potential of organic agriculture relative to conventional agriculture with and without consideration of CO_2 sequestration (basis: grams CO_2 equivalents per kg product; (Küstermann et al., 2007).

2.1.2 The role of nitrogen and N_2O

Synthetic nitrogen fertilizers as a major contributor to global warming

The global warming potential of conventional agriculture is strongly affected by the use of synthetic nitrogen fertilizers and by high nitrogen concentrations in soils. Global nitrogen fertilizer consumption (produced by fossil energy) in 2005 was 90.86 million tonnes (IFA, 2007; http://www.fertilizer.org/). It takes approximately 90 million tonnes of fossil fuel (diesel equivalents) to produce this nitrogen fertilizer[5]. This is about 1% of global fossil energy consumption. In the UK, a 100-hectare stockless arable farm consumes on average 17,000 litres of fossil fuel annually through fertilizer inputs (Cormack, 2000).

Graph: FiBL, CH-Frick

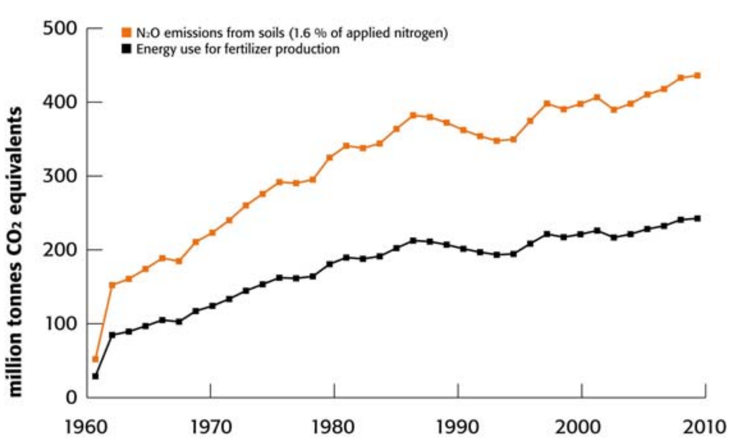

Figure 5: Energy used for production of synthetic fertilizers and emissions of nitrous oxide (N_2O) from soils[6] after application of fertilizer (in million tons CO_2 equivalent), based on data from the International Fertilizer Industry Association IFA (http://www.fertilizer.org/).

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[5] Modern industry uses 28 MJ / kg of ammonia under optimum conditions, but older technology may still use higher amounts of energy for fertilizer production (Gerlagh and van Dril 1999). The best technology available currently uses 0.76 litres of diesel equivalents, older technology between 1 and 1.5 litres to produce one kg of nitrogen fertilizer

[6] A fixed factor of 1.6% of the applied N is used to calculate N_2O emissions, since the data on N_2O emissions from soils is relatively poor.. Gerlagh and van Dril (1999) add another 1.4% for N2O emitted in the process of fertilizer production, when ammonia is converted to nitric acid, adding a substantial amount to the total emissions of the fertilizer industry.

Organic agriculture: Self-sufficient in nitrogen

Organic agriculture, in contrast, is self-sufficient in nitrogen. Mixed organic farms practice highly efficient recycling of manures from livestock and of crop residues by composting. Leguminous crops deliver additional nitrogen in sufficient quantities (on stockless organic farms this is the main source). Badgley et al. (2007) calculated the potential nitrogen production by leguminous plants via intercropping and off-season cropping to be 154 million tonnes, a potential which exceeds the nitrogen production from fossil fuel by far and which is not fully exploited by conventional farming techniques.

Photo: Andreas Fliessbach, FiBL, CH-Frick

Figure 6: Legumes – The fertilizer plants of organic farming. Organic farming uses leguminous crops as a catch crop, for under-sowing or as green manure, thus fixing nitrogen from the air.

Organic agriculture: Reduced emissions of nitrous oxide

Emissions of nitrous oxide are directly linked to the concentration of easily available mineral nitrogen in soils. High emission rates are detected directly after fertilization and are highly variable. Denitrification[7] is additionally enhanced in compacted soils. According to IPCC, 1.6% of nitrogen fertilizer applied is emitted as nitrous oxide.

In organic agriculture, the ban of mineral nitrogen and the reduced livestock units per hectare considerably reduce the concentration of easily available mineral nitrogen in soils and thus N_2O emissions.

Furthermore, these factors add to lower emissions of nitrous oxide:

- Diversified crop rotations with green manure improve soil structure and diminish emissions of nitrous oxide.
- Soils managed organically are more aerated and have significantly lower mobile nitrogen concentrations. Both factors reduce emissions of nitrous oxides.

In the study by Petersen et al (2006), lower emission rates for organic compared to conventional farming were found for five European countries. In a long-term study in southern Germany, Flessa et al. (2002) also found reduced nitrous oxide emission rates in the organic farm, although yield-related emissions were not reduced.

[7] Denitrification is the process of transformation of nitrate and nitrite into elementary nitrogen (N_2).

Integration of livestock and crop production: An important contribution to mitigation

The on-farm use of farmyard manure – a practice increasingly abandoned in conventional production – needs to be reconsidered in the light of climate change. While conventional stockless arable farms use synthetic nitrogen fertilizers, manure and slurry from dairy, beef, or from non-ruminant farms have become an environmental problem. In these livestock operations, nutrients are available in excess and overfertilization occurs. Emissions of CO_2, nitrous oxide and methane are likely to be very high and water pollution may occur when manure is treated as waste and not as recycled as a valuable fertilizer in the crops.

Integration of livestock and arable production, the rule on organic farms, can thus reduce the global warming potential of food production. This fact is not calculated correctly in most global warming potential models, however, as livestock production is generally considered separately from crop systems.

Nitrogen efficiency as a key factor for the reduction of greenhouse gases

Greenhouse gas emissions at farm level may be related either to the farm's nitrogen surplus or to the farm's nitrogen efficiency, as demonstrated by a scientific model of greenhouse gas emissions from European conventional and organic dairy farms (Olesen et al., 2006). Farm nitrogen surplus can therefore be a good proxy for greenhouse gas emissions per unit of land. Since organic crop systems are limited by the availability of nitrogen, they aim to balance their nitrogen inputs and outputs and their nitrogen efficiency. Their greenhouse gas emissions are thus lower than those of conventional farming systems.

2.1.3 Methane emissions

Methane accounts for about 14% of the greenhouse gas emissions (Barker et al., 2007). Two-thirds of this are of anthropogenic origin and mainly from agriculture. Methane emissions stem to a large extent from enteric fermentation and manure management and in consequence are directly proportional to livestock numbers. Avoidance of methane emissions of anthropogenic origin and especially of agricultural origin is of particular importance for mitigation. Organic agriculture has an important, though not always superior, impact on reduction as livestock numbers are limited in organic farms (Weiske et al., 2006;Olesen et al., 2006; Kotschi & Müller-Sämann, 2004).

The data available on methane emissions from livestock is limited, especially with respect to the reduction of GHG emissions from ruminants and manure heaps. Some authors suggest high energy feedstuff to reduce methane emissions from ruminants (Beauchemin and McGinn, 2005), but the ruminants' unique ability to digest roughage from pastures would then not be used. Furthermore, meat and milk would be produced with arable crops (concentrates) where mineral nitrogen is an important CO_2 emitter, and competition to human nutrition might become a problem.

Longevity of animals on organic farms contributes to reduction of methane emissions

Organic cattle husbandry contributes positively to reducing methane emissions by aiming towards animal longevity (Kotschi and Müller-Sämann, 2004). The ratio between the unproductive phase of young cattle and the productive phase of dairy cows is favourable in organic systems because, calculated on the basis of the total lifespan of organic dairy cows, less methane is emitted. On the other hand, lower milk yields of organic cows caused by a higher proportion of roughage in the diet, might increase methane emissions per yield unit. A model calculation of the best yield-methane emission rate at different diets (roughage versus concentrates) is missing. The slightly reduced yields of organic farms might be nearer the optimum than conventional dairy production.

Photo: Silvia Ivemeyer, FiBL, CH-Frick

Figure 7: Since ruminants are able to utilize plant material that other animals cannot, they are essential livestock for extensively grazed systems.

Composting and biogas production as measures for mitigating climate change

Composting and biogas production are often suggested as measures for mitigating climate change. In the context of climate change, the benefits of aerobic fermentation of manure by means of composting are ambiguous, as a shift from anaerobic to aerobic storage of manure can reduce methane emissions, but will increase emissions of nitrous oxide by a factor of 10 (Kotschi and Müller-Sämann 2004). A very promising option, however, is controlled anaerobic digestion of manure and waste combined with biogas production. While this option is not restricted to organic production methods, organic agriculture has been at the forefront of biogas production systems for decades. Attention must be paid however to the economic viability of biogas production systems.

Methane emissions from organic rice production and from ruminants: Improved techniques needed

Methane emissions from organic rice production and ruminant production do not differ substantially from those of conventional production. Better rice production practices in organic and conventional agriculture, such as avoiding continuous flooding or choosing low methane-emitting varieties (Smith and Conen, 2004) could enhance reduction of methane emissions. The multi-target approach of organic farmers and the fact that they are often more highly skilled could enhance implementation of improved production techniques.

2.2 Organic farming sequesters CO_2 in the soil

2.2.1 Soil erosion results in loss of soil carbon

Arable cropland and permanent pastures lose soil carbon through mineralization, erosion (water and wind-driven) and overgrazing. Global arable land loss is estimated at 12 million hectares per year, which is 0.8% of the global cropland area (1513 million hectares) (Pimentel et al., 1995). This rapid loss is confirmed by experimental data from Bellamy et al. (2005) in England and Wales. Between 1978 and 2003, they found carbon losses in 92% of 6000 soil samples. Annual CO_2 emissions from intensively cropped soils were equivalent to 8% of national industrial CO_2 emissions.

Photo: Andreas Fliessbach
FiBL, CH-Frick

Figure 8: The better drainage and water-holding capacity of organic soils reduces the risk of drought and soil erosion (the DOK long-term system comparison in Switzerland. Left: organic field; Right: field with mineral fertilizer).

If agricultural practices remain unchanged, the loss of organic carbon in typical arable soils will continue and eventually reach a new steady state at a low level. The application of improved agricultural techniques (e.g. organic farming, conservation tillage, agroforestry), however, stops soil erosion (Bellamy et al., 2005) and converts carbon losses into gains. Consequently, considerable amounts of CO_2 may be removed from the atmosphere.

2.2.2 Organic land management: Carbon gains

Organic land management may help to stop soil erosion and convert carbon losses into gains (Reganold et al., 1987), particularly due to:

- the use of green and animal manure.
- soil fertility-conserving crop rotations with intercropping and cover cropping.
- composting techniques.

2.2.3 Higher soil organic matter content in organic farming

Farm comparison and long-term field trials show that organically managed soils have significantly higher organic matter content. It is estimated that, under Northern European conditions, conversion from conventional to organic farming would result in an increase of soil organic matter of 100 to 400 kg per hectare annually during the first 50 years. After 100 years, a steady state, i.e. a stable level of soil organic matter, would be reached (Foereid and Høgh-Jensen 2004).

2.2.4 Carbon sequestration rates on organic farms

Under 'real' conditions in long-term experiments, or in farm-level comparisons, carbon sequestration rates vary considerably.

Trial	**Variant**	**Result**

DOK[8] trial, Switzerland, data for 1978-1998 (Fließbach et al., 2007)	Biodynamic with composted farmyard manure	Level of soil organic matter remains stable
	Conventional stockless (mineral fertilizer only)	Decrease in soil organic matter: 191 kg per hectare compared to the biodynamic variant (=-13%)
Bavarian organic farms, Germany (Küstermann et al., 2007)		Sequestration rates of 110 to 396 kilograms per hectare and year
		Fields managed with integrated pest control: loss of 249 and 55 kg carbon respectively
Rodale experiment, US (Pimentel et al., 2005)	Manure-based organic system	Soil carbon increase 981 kilograms per hectare
	Legume-based organic system	Soil carbon increase 574 kg per hectare
9 farming system trials in the US (Marriott and Wander 2006)		Soil organic carbon concentrations 14% higher in organic than in conventional systems

Organic versus conventional soil conservation strategies: No-tillage and minimum-tillage cropping

In the past decade, agricultural techniques have been developed to maintain soil fertility and soil quality. By reducing the intensity of tillage, soil conservation can be improved, and water and wind erosion can be considerably reduced (Holland 2004).

- Robertson et al. (2000) compared the greenhouse warming potentials (GWP: including carbon sequestration, agronomic inputs and trace gas emissions) of conventionally tilled, no till and organic farming systems in the Mid Western US and found none of these agricultural systems to be climate neutral. Whereas no-till reduced the GWP of conventional tillage by 88%, organic production with legume cover was only 64% lower than conventional tillage.
- In a nine-year system comparison experiment in Beltsville (Maryland, USA), it was shown that the organic farming approach provided excellent soil fertility building and was superior to conventional no-tillage techniques, despite the use of a plough (Teasdale et al., 2007).

No-tillage cropping is mainly practised on stockless farms, which leads to highly specialized farms – either crops or animals – and excess manure on the animal farms becomes an environmental problem. Nitrate excess in the soil triggers emissions of nitrous oxide, as well as nitrate leaching and phosphorus run-off. The organic approach involving local recycling and nutrient use in a mixed-farm approach offers many ecological benefits.

In very fragile soils, it is nonetheless recommended to use minimum-tillage techniques in organic farming as well. Several research projects in different parts of the world are working on such systems. For instance, in Switzerland a long-term trial was recently started that analyses the effect of reduced tillage on crop yields and weed infestation (Berner et al., 2005). Similar research projects are running at Bonn University in Germany. Technically, there is no inherent incompatibility between organic and minimum-tillage cropping.

[8] The DOK trial in Switzerland has been running since 1978. In this trial, biodynamic (D) is compared with organic (O) and conventional (K) production (Mäder et al. 2002).

2.2.5 Agroforestry, Permaculture, Polyculture

Agroforestry is a management system that integrates perennial and annual crops in a two-canopy or multi-canopy production system. This guarantees better exploitation of light, water and soil nutrients and protects soil more effectively from erosion and leaching. It leads to a more diversified and sustainable production system than many treeless alternatives and provides increased social, economic and environmental benefits for land users (Sanchez et al. in Kotschi and Müller-Sämann, 2004). In the humid tropics, agroforestry is seen as viable alternative to slash-and-burn agriculture.

Photo: Lukas Kilcher, FiBL, CH-Frick

Figure 9: Agroforestry system in Cuba: agroforestry systems integrate perennial and annual crops in a two-canopy or multi-canopy production system.

The CO_2 sequestration potential of agroforestry in the short and medium term is mainly above ground. The additional carbon in the standing vegetation may increase by 50 tonnes per hectare; in the soil by an additional 7 tonnes per hectare. These increases were measured 20 to 25 years after recultivation of previously cleared forests. (Palm et al., 2000, cited in Kotschi and Müller-Sämann, 2004).

Even though agroforestry is neither restricted nor exclusive to organic agriculture, organic principles suit it very well. Consequently, organic agriculture could play a role in the development of agroforestry systems and combining these two systems is a potential solution for reducing greenhouse gases, sequestering carbon dioxide and increasing the productivity of agro-ecosystems.

2.3 Mitigation potential of organic agriculture beyond purely agricultural practices

2.3.1 Changing consumer behaviour and diet

The greatest potential for reducing greenhouse gas emissions from agriculture would be to change consumer behaviour. Production of meat requires inputs that are seven times as high as the inputs needed to produce the same quantity of non-meat calories. Organic agriculture aims at precisely this goal: consumption of less-processed products and increased consumption of products like cereals, potatoes, pulses and oils.

Greenhouse gas emissions are highest in beef production (CO_2 equivalents per kg meat are higher than 10,000 g), followed by pork, poultry and egg production (2,000 to 3,000 g CO_2 equivalents per kg) and milk (approximately 1000 g CO_2 equivalents per kg). Emissions from production of plant foods are generally below 500 g CO_2 equivalents per kg (Bos et al. 2007; Nemecek 2006, Ökoinstitut 2007, Küstermann et al. 2007).

Although ruminants (cattle, sheep, goats) are major methane emitters, they are crucial to global food security as they tap into an area of 3,432 million hectares worldwide that is not suitable for crop production. These animals carry bacteria in their rumen that make plant material digestible, that other animals are hardly able to use, but unfortunately this fermentative process is also emitting methane.

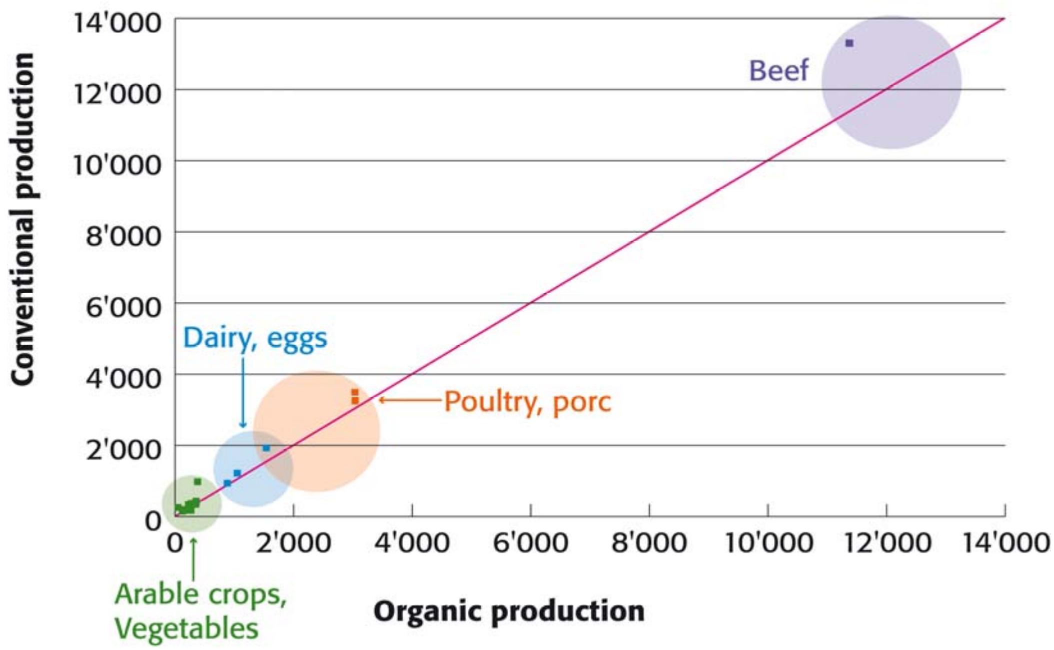

Figure 10: Greenhouse gas emissions (g CO2 equivalents per kg) for various agricultural products. The major reduction of emissions could be reached by reducing meat consumption. In human diets the differences between organic and conventional production are of minor relevance (above the red line: organic performs better, below the line conventional performs better.

2.3.2 Stopping deforestation

In organic farming, preparation of the land by burning vegetation is restricted to a minimum (International Federation of Organic Agriculture Movements, 2006). Organic farming thus contributes to halting deforestation with its highly negative impact on climate change. Often, the opposite argument has been made, as organic agriculture usually needs more land to produce the same amount of food as by conventional farming. This might be compensated by the potential of organic agriculture for aiding reclamation and making use of degraded land due to its favorable effects on soil fertility and soil organic matter. In addition careful land use and management as in organic farming enhances environmental security and will help to stop losses of fertile arable land not only by erosion.

3. Does Organic Farming have Greater Potential to Adapt to Climate Change?

Chapter key points

Organic systems are highly adaptive to climate change due to

- the application of traditional skills and farmers' knowledge,
- soil fertility-building techniques and
- a high degree of diversity

Agricultural production in most parts of the world will face less predictable weather conditions than mankind experienced during the intensification of agriculture over the last century. Weather extremes will become predominant. Resilience and adaptiveness are new requirements gaining importance for innovation in agriculture.

The Intergovernmental Panel on Climate Change (IPPC) defines adaptation to climate change as 'adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities'.[9]

3.1 Traditional skills and knowledge as a key to adaptation to climate change

Traditional skills and knowledge have been neglected in intensive agriculture, although they are now being partially recaptured by integrated pest management. Organic agriculture, on the other hand, has always been based on practical farming skills, observation, personal experience and intuition. Knowledge and experience replaces or reduces reliance on inputs. This knowledge is important for manipulating complex agro-ecosystems, for breeding locally adjusted seeds and livestock, and for producing on-farm fertilizers (compost, manure, green manure) and inexpensive nature-derived pesticides. Such knowledge has also been described as a 'reservoir of adaptations' (Tengo and Belfrages, 2004).

3.2 Organically managed soils are better adapted to weather extremes

Farming practices such as organic agriculture that preserve soil fertility and maintain or even increase organic matter in soils are in a good position to maintain productivity in the event of drought, irregular rainfall events with floods, and rising temperatures.

Soils under organic management retain significantly more rainwater thanks to the 'sponge properties' of organic matter.

- These 'sponge properties' were described for heavy loamy soils in a temperate climate in Switzerland where soil structure stability was 20–40% higher in organically managed soils than in conventional soils (Mäder et al., 2002).
- The amount of water percolating through the top 36 cm was 15–20% greater in the organic systems of the Rodale farming systems trial compared to conventional systems. The organic soils held 816,000 litres per ha in the upper 15 cm of soil. This water res-

[9] Cited in 'Gateway to the UN System's Work on Climate Change' http://www.un.org/climatechange/background/living.shtml

ervoir was likely the reason for higher yields of corn and soybean in dry years (Pimentel et al., 2005).

- It was found that water capture in organic plots was twice as high as in conventional plots during torrential rains (Lotter et al. (2003). This significantly reduced the risk of floods, an effect that could be very important if organic agriculture were practised on much larger areas.

3.3 Enhancing productivity of degraded soils by building soil fertility

Experience with degraded soils of the arid tropics have shown that agricultural productivity can be enhanced using soil fertility building techniques. In the Tigray province of Ethiopia, one of the most degraded parts of the country, agricultural productivity was enhanced by soil fertility techniques such as compost application and introduction of leguminous plants into the crop sequence. By restoring soil fertility, yields were increased to a much greater extent both at farm and regional level than by using bought mineral fertilizers (Edwards, 2007). This large-scale experiment underlines the importance of organic matter and soil fertility for ensuring productivity in dry regions and partly explains the surprisingly high yields from organic crops found by Badgley et al. (2007).

3.4 Diversity enhances farm resilience

An additional strength of organic farming systems is their diversity – including the diversity of crops, fields, rotations, landscapes and farm activities (mix of various farm enterprises). The high level of diversity of organic farms provides many ecological services that significantly enhance farm resilience (Bengtsson et al., 2005; Hole et al., 2005).

Positive effects of enhanced biodiversity on pest prevention have been shown by several authors (Zehnder et al., 2007; Wyss et al., 2005; Pfiffner et al., 2003). Similar effects of diversified agro-ecosystems on diseases and better utilization of soil nutrients and water are likely to occur (Altieri et al., 2005).

4. What are the Weaknesses of Organic Agriculture in the Context of Climate Change?

Chapter key points

- CO_2 emissions per unit of organic crop do not always meet expectations.
- Organic manure management techniques need improvement.
- These issues underscore the research and development needs in organic agriculture.

4.1 Criticism No. 1: Organic farming is less productive

4.1.1 Agronomically difficult crops as a challenge

One major criticism of organic agriculture is that productivity is lower compared to intensive conventional agriculture. Under geoclimatic conditions that allow for a very high yield, in the case of some crops the relative advantage of organic agriculture in terms of energy consumption per land area compared to conventional production may switch to the contrary when calculated on the basis of crop or livestock yield. This is particularly true in the case of highly demanding crops such as potatoes, grapes fruits and horticultural crops especially from greenhouse production (Nemecek et al. 2005, Bos et al 2006, Comrack 2003). Pest, disease and weed management problems relating to these crops have not yet been resolved satisfactorily. Consequently, the yield for these crops is too low and the energy input, even though relatively low on a land area basis, becomes relatively high when applied to a crop unit. With more research into organic agriculture, however, progress may be expected in this field.

4.1.2 Better technology transfer could improve organic yields

The productivity of organic agriculture is often underestimated by many scientists and policy-makers. Organic agriculture represents a very productive food supply system that relies on recycling strategies. Badgley et al. (2007) modelled the yields stated in 293 on-farm and on-station publications and concluded that, compared to high-input agriculture in developed countries, the average yields in organic crop and livestock production are 92% of those in conventional agriculture.

	CH	AT	DE	IT	FR
Wheat	64-75	62-67	58-63	78-98	44-55
Barley	65-84	58-70	62-68	55-94	70-80
Oats	73-94	56-75		88	
Grain maize	85-88		70	55-93	66-80
Oilseeds	83	78-88	60-67	48-50	67-80
Potatoes	62-68	39-54	54-69	62-99	68-79

Table 1: Organic crop yields as a percentage of conventional reference yields (for Switzerland: LBL 2005; other countries: Offermann and Nieberg, 2000)

As scientific progress in conventional agriculture has accelerated in recent years, if we look only at the most recent data and at selected countries in temperate climate zones, yield differences as obtained from official databases are generally higher (Table 1). In the case of wheat, for example, organic yields vary between 58% (lowest figure for Germany) and 98% (highest figure for Italy) of those of the conventional pair. This rather wide range of yields measured by farm surveys indicates that yields on organic farms might be improved considerably, e.g. by better technology transfer from research to practice.

4.1.3 Organic farming performs better under water constraints

Interestingly, yields from organic agriculture under conditions where water is limited during the growing period, and under subsistence farming, are equal or significantly higher than those from conventional agriculture. A comparison of 133 studies from developing countries concluded that organic plant and livestock yields were 80% higher than their conventional counterparts (for crops only the increase in yield was by 74%) (Badgley et al., 2007).

In temperate climate zones higher yields for maize and soya were registered in organically managed fields in dry seasons (Hepperly et al., 2005). The available data indicates that the technique inherent to organic farming of investing in soil fertility by means of green manure, leguminous intercropping, composting and recycling of livestock manure could contribute considerably to global food productivity. Further improvements in manure storage and application techniques are also required, however, in organic systems in order to reduce nitrous oxide and methane emissions.

4.2 Criticism No. 2: High dependency on nutrients derived from livestock

Some critics are concerned about the dependency of organic cropping upon nutrients deriving from livestock. This criticism, however, underestimates manure as a valuable and potentially useful resource. Moreover, this is not a relevant weakness since the numbers of animals kept in agriculture depends mainly on consumer demand.

In order to reduce greenhouse gas emissions, efficient and direct recycling of manure and slurry is the best option, since it avoids long-distance transport and consumption of energy for synthetic fertilizer production. The combination of crop and livestock production is currently the most efficient way of bringing organic ‘waste’ from livestock production back into the carbon stock of the soils and use it as a locally available resource for crop fertilization and enhancing soil quality.

When integrated into arable farming systems, ruminants exploit leguminous crops and inter-crops that are needed to produce nitrogen, provide soil cover and capture soluble nutrients, building up soil fertility and soil structure.

From the point of view of integrating ecology and sustainable resource use, the combination of organic cropping with livestock production is undoubtedly a strong point.

4.3 More funding is needed for research on organic farming

As 99 % of the world’s public and private research funds have focussed on optimizing conventional and integrated food and farming systems during the last decades, major progress and solutions can be expected as a result of agro-ecological and animal welfare research activities.

5. Look: Climate credit for organic farming?

Chapter key points

- Sequestration of CO_2 in soils is excluded from the Clean Development Mechanism (CDM), although it could take effect quickly, is very cost-effective and would promote rural development.
- Organic agriculture should be included in voluntary CO_2 emissions markets.

Agriculture, both organic and conventional, has the potential to make a cost-effective contribution to mitigation (Smith et al., 2007). The Intergovernmental Panel on Climate Change (IPCC) estimates that agricultural greenhouse gas mitigation options are cost-competitive with non-agricultural options in achieving long-term climate objectives.

5.1 Special benefits of organic agriculture

Within agriculture, organic agriculture holds an especially favourable position, since it realizes mitigation and sequestration of CO_2 in an efficient way. Compared to other agricultural systems, organic farming is a well-defined system that is already based on certification and that could easily be extended to meet the standards of CDM. Organic production has great mitigation and adaptation potential, particularly with regard to soil organic matter fixation, soil fertility and water-holding capacity, increasing yields in areas with medium to low-input agriculture and in agroforestry, and by enhancing farmers' adaptive capacity. Paying farmers for carbon sequestration may be considered a win-win-win situation as a) CO_2 is removed from the atmosphere (mitigation), b) higher organic matter levels in soil enhance their resilience (adaptation) and c) improved soil organic matter levels lead to better crop yield (production).

Improvement is needed, however, with regard to yields and methane emissions. Organic agriculture, with its holistic multi-target approach, offers further relevant advantages with regard to lifestyle changes, for example, primarily in developed countries. Its numerous co-benefits could greatly assist the development of rural societies in southern countries (see also Smith et al., 2007).

It would benefit the cause if agriculture, and in particular organic agriculture, could be included as a high-benefit / low-cost CO_2 reduction system in the next climate agreement, negotiations on which, referred to as the 'post 2012 negotiations', are about to begin.

5.2 CO_2 sequestration excluded from the Clean Development Mechanism

Agriculture, however, and organic agriculture in particular, are barely able to benefit from climate credits, of which the Clean Development Mechanism (CDM) is the most popular. Even though agriculture could apply for CDM credits for reduction of methane through biogas installations for example, the single most important measure in terms of greenhouse gas reduction, sequestration of CO_2 in soils, is excluded from the CDM mechanism.

Likewise, the 'gold standard' launched by the World Wide Fund for Nature (WWF) formally excludes agricultural CO_2 sequestration sinks from eligibility for carbon credits. For both organizations, the reason is that agricultural CO_2 sinks are considered to be temporary in nature only. Once CO_2 has been sequestered, a change in land use poses the risk that a substantial amount of CO_2 will be released back into the atmosphere. The logic of this perception leads to a situation where only afforestation or reforestation projects are supported. Organic mixed farms, especially when good compost is used, tend to build up organic matter with a higher proportion of stabile fractions (Fließbach/Mäder 2000). Therefore, quitting organic farming might not lead to a faster release of CO_2 than cutting a tree plantation.

5.3 Benefits of CO_2 sequestration acknowledged by IPCC

The Intergovernmental Panel on Climate Change (IPCC) and other authors, however, state that CO_2 sequestration in agricultural systems, agroforestry, improved land-use systems or reclamation of degraded soils for cultivation have many benefits.

The most important of these benefits are:

- the fact that sequestration could take effect very quickly – buying us time, as is noted often, since initial sequestration peaks can be reached after 5 to 10 years.
- CO_2 sequestration in agriculture is very cost-effective and, as a result of its co-benefits, would also greatly assist rural development.

5.4 Voluntary CO2 emissions markets

Due to these incontestable benefits, voluntary CO_2 emissions markets have emerged.

The best known of these are probably:

- the World Bank's BioCarbonFund
- the Chicago Climate Exchange (CCX)
- the European Climate Exchange (ECX)

Emission certificates are traded at prices that are currently lower than those suggested by IPCC (20 USD) so as to achieve a substantial contribution. Because the market is voluntary, it lacks the security of the 'official' Kyoto Protocol and is consequently somewhat speculative in nature.

Strict and technically sound guidelines for the execution of voluntary carbon reduction projects will greatly assist the standardized implementation of voluntary carbon CO_2 projects. This will increase projects' credibility, transparency as well as traceability and tradability. Standards like those of the Voluntary Carbon Standard (VCS) published in November 2007 use the existing Clean Development Mechanism methodology where possible, but they broaden the scope by including additional methods as well as land-use systems to reduce or capture CO_2.

6. Conclusions

6.1 Benefits of organic farming

The benefits of organic farming regarding climate change can be summarized as follows:

- Organic agriculture has considerable potential for reducing emissions of greenhouse gases.
- Organic agriculture in general requires less fossil fuel per hectare and kg of produce due to the avoidance of synthetic fertilizers. Organic agriculture aims at improving soil fertility and nitrogen supply by using leguminous crops, crop residues and cover crops.
- The enhanced soil fertility leads to a stabilization of soil organic matter and in many cases to a sequestration of carbon dioxide into the soils.
- This in turn increases the soil's water retention capacity, thus contributing to better adaptation of organic agriculture under unpredictable climatic conditions with higher temperatures and uncertain precipitation levels. Organic production methods emphasizing soil carbon retention are most likely to withstand climatic challenges particularly in those countries most vulnerable to increased climate change. Soil erosion, an important source of CO_2 losses, is effectively reduced by organic agriculture.
- Organic agriculture can contribute substantially to agro forestry production systems.
- Organic systems are highly adaptive to climate change due to the application of traditional skills and farmers' knowledge, soil fertility-building techniques and a high degree of diversity.

6.2 Weaknesses of organic farming and research requirements

This paper recognizes that organic agriculture also has weaknesses, mainly related to productivity and yield losses in some crops and production areas. Such issues highlight the need for research. Total European research funding for organic agriculture currently represents less than 1% of the total food and agriculture research budget. In order to improve organic agriculture's performance and to allow more assistance to be provided to organic agriculture projects in low-input or developing countries, where CO_2 mitigation would be most beneficial, more research is needed in the following areas:

- Soil fertility management, crop growth and health.
- Better exploitation of leguminous plants in improved crop sequences.
- Habitat management with improved manipulation and exploitation of diversity at all levels.
- Crop breeding programmes focusing on the adaptability of plants to low-input situations in soils, on weed competition, and on pest and disease tolerance.
- Improved plant protection techniques and compounds from natural sources.

- Breeding strategies and programmes for adaptability to management and environmental stress situations in organic livestock production.
- Reduced tillage organic systems.

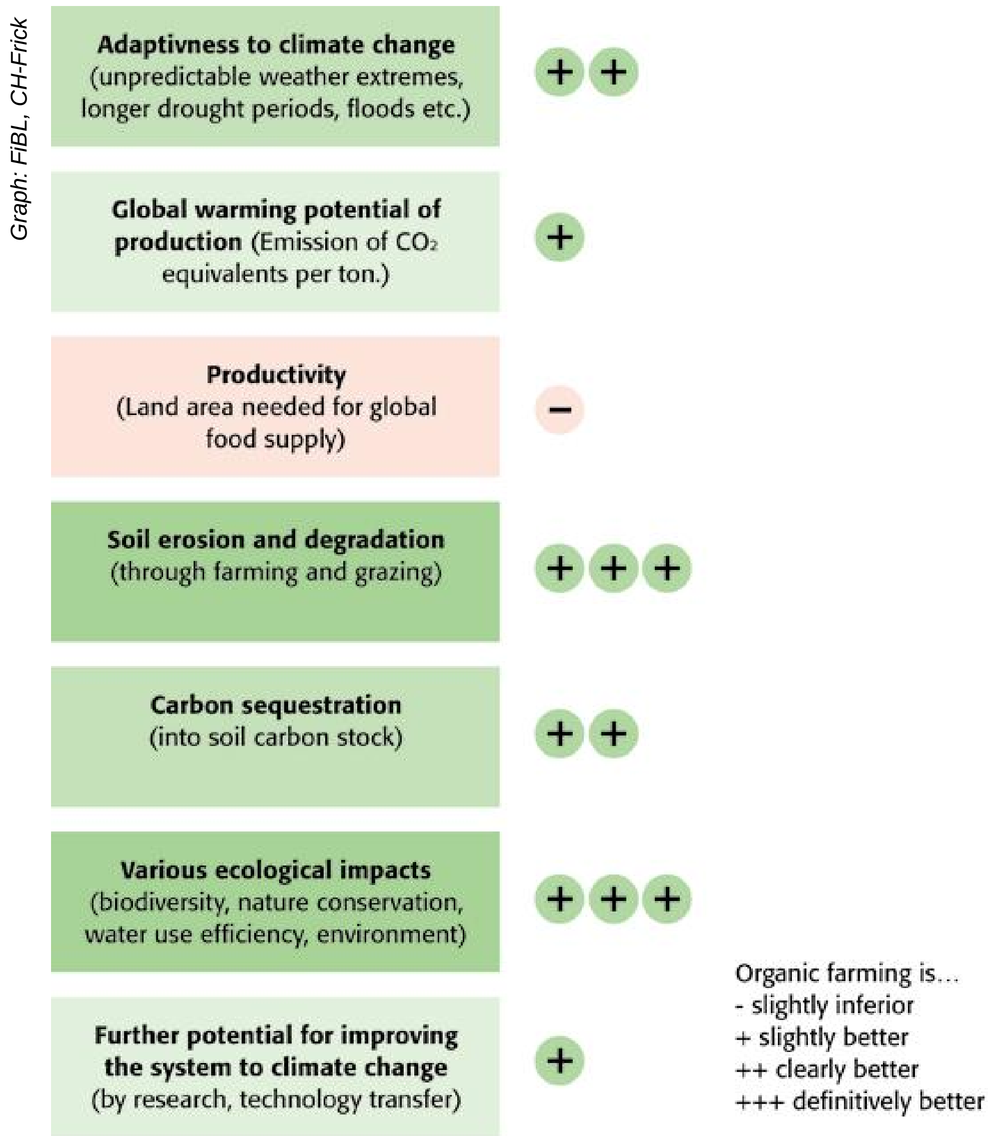

Figure 6: Performance of organic agriculture compared to conventional agriculture in the context of climate change.

In spite of these weaknesses, organic agriculture is so far the most promising approach for mitigation and adaptation to climate change. Organic agriculture represents a positive example of how farmers can help mitigate climate change and adapt to its predictable and unpredictable impacts. It can serve as a benchmark for allocating development resources to climate change adaptation, or to measure progress in implementing climate-related multilateral environmental agreements.

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8. Links

- **Intergovernmental Panel on Climate Change (IPPC)**

  The Intergovernmental Panel on Climate Change was established by the World Meteorological Organization (WMP) and the United Nations Environment Programme (UNEP) to assess scientific, technical and socio-economic information relevant for the understanding of climate change, its potential impacts and options for adaptation and mitigation. Website: http://www.ipcc.ch/

  The reports of Working Group III, which assesses options for limiting greenhouse gas emissions and otherwise mitigating climate change are available at http://www.mnp.nl/ipcc/

  The Working Group III Report 'Mitigation of Climate Change' for the Fourth Assessment Report 'Climate Change 2007', can be downloaded from:
  http://www.mnp.nl/ipcc/pages_media/AR4-chapters.html

- **Clean Development Mechanism (CDM)**

  The Clean Development Mechanism (CDM) is an arrangement under the Kyoto Protocol allowing industrialized countries with a greenhouse gas reduction commitment (called Annex 1 countries) to invest in projects that reduce emissions in developing countries as an alternative to more expensive emission reductions in their own countries. The most important factor in a carbon project is establishing that it would not have occurred without the additional incentive provided by emission reduction credits.
  Website:http://unfccc.int/kyoto_protocol/mechanisms/clean_development_mechanism/items/2718.php

- **World Wide Fund for Nature (WWF): Gold Standard**

  Initiated by the World Wide Fund for Nature and others. This standard for Clean Development Mechanism projects was launched in 2003 after wide-ranging stakeholder consultation among key actors of the carbon market as well as governments. The Gold Standard Foundation offers a quality label for renewable energy and energy efficiency projects with sustainable development benefits. Website: http://www.cdmgoldstandard.org/

- **Voluntary Carbon Standard (VCS)**

  The VCS Program provides a global standard and program for approval of credible voluntary offsets. VCS 2007 was released on 19 November 2007. Detailed information is available at the website http://www.v-c-s.org.

- **International Federation of Organic Agriculture Movements (IFOAM)**

  IFOAM is the worldwide umbrella organization for the organic movement, uniting more than 750 member organizations in 108 countries. IFOAM actively participates in international agricultural and environmental negotiations with the United Nations and multilateral institutions to further the interests of the organic agricultural movement worldwide. Website: www.ifoam.org.
  Information from IFOAM related to climate change is available here: http://www.ifoam.org/press/positions/Climate_study_green_house-gasses.html

ITC: The Development Partner for Export Success

ITC mission

ITC enables small business export success in developing countries by providing, with partners, trade development solutions to the private sector, trade support institutions and policymakers.

ITC's strategic objectives

- **Enterprises:** Strengthen the international competitiveness of enterprises.
- **Trade support institutions:** Develop the capacity of trade service providers to support businesses.
- **Policymakers:** Support policymakers in integrating the business sector into the global economy.

International Trade Centre
UNCTAD/WTO

A joint technical cooperation agency of UNCTAD and WTO for business aspects of trade development

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