GUIDE

IFOAM EU GROUP

IFOAM INTERNATIONAL FEDERATION OF ORGANIC AGRICULTURE MOVEMENTS

HIGH SEQUESTRATION

LOW EMISSION

FOOD SECURE FARMING

Organic Agriculture

a Guide to

Climate Change

& Food Security

- *affordable high sequestration practices based on local resources*
- *enables continuous farmer-based adaptation to climate change*
- *ideal for the improvement of the world's 400 million smallholder farms*
- *locally adapted, affordable and people centered*
- *empowers local communities*
- *established practices, systems and markets*
- *experience, practices and expertise to share*

Prepared by

IFOAM definition of organic agriculture

Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved.

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Introduction

Organic agriculture has a significant role to play in addressing two of the world's biggest and most urgent issues: climate change and food security. The aim of this guide is to explain how climate change mitigation and adaptation and food security are inseparable and inherent characteristics of organic agriculture.

As the world's population increases and with it the number of affluent people the demand for food and renewable energy crops will also increase. This combined with the increasing severity and frequency of climate change impacts and the rising price of fossil fuel based chemical fertilizers, herbicides and pesticides will put huge pressure on agricultural production and most significantly on the world's poor. These factors will result in huge increases in the number of hungry people around the world. However current agriculture production is already failing to feed the world's poorest. Despite sufficient food being produced at global level[1] the number of hungry people in the world reached one billion in 2009 for the first time. This figure will continue to increase if 'business as usual' prevails.

Climate change and the global food crisis have put a spotlight on the vulnerability, unsustainability and social inequity of agriculture and food production. There is growing acceptance that policies and practices have failed to feed the world's most vulnerable people, failed to adapt to continuously changing environmental conditions, and failed to protect the very ecosystems that sustain us. Policy makers are now referring to 'soil organic matter', to 'soil carbon,' to 'ecosystem services' and to 'holistic' approaches, all of which are long established core pillars of organic agriculture.

> Organic agriculture enhances biodiversity, protects our fragile soils, improves the nutritional quality of food, ensures high standards of animal welfare and provides increased employment in rural areas. At the same time, organic agriculture reduces green house gas emissions and fossil fuel energy use, cuts nutrient and pesticide pollution and stops potentially harmful pesticide residues entering our food chain. Organic agriculture builds resilient farming systems capable of combating climate change and securing local food supplies and is highly effective in sequestrating carbon.

Organic agriculture is practiced worldwide by 1.2 million producers in 141 countries, with production of organically grown food continuing to steadily increase by at least 15 percent per year. The global market is estimated to be worth approximately US$50 billion per year. While most of the organic markets are in developed countries, developing countries are becoming important suppliers as organic practices are particularly suited for the conditions of their farmers.

Organic agriculture has well established practices that simultaneously mitigate climate change, build resilient farming systems, reduce poverty and improve food security. Organic agriculture emits much lower levels of greenhouse gases (GHG), and quickly, affordably and effectively sequesters carbon in the soil. In addition, organic agriculture makes farms and people more resilient to climate change, mainly due to its water efficiency, resilience to extreme weather events and lower risk of complete crop failure. There is finally, the realisation at the highest political level, that food has to be grown where people live – especially in developing countries where people are most vulnerable to fluctuations in food prices. Organic agriculture puts local adaptation, production and consumption at the heart of its systems, strategies and policies.

Organic agriculture is the most important and widely practiced agro-ecological farming system. It achieves the dual goals of enabling people to flourish while enhancing our eco-systems and their functioning. Organic agriculture has been leading the world in the development of sustainable production systems for over sixty * years and has also pioneered the development of standards, certification systems and markets for sustainable products. Consumers of organic agriculture products recognise the important role organic farmers play in protecting ecosystems and producing healthy chemical-free food. There are now nationally adapted organic agriculture standards in over 40 countries including the USA and Japan as well as three regional standards in the European Union, East Africa and the Pacific.

Organic agriculture has a wealth of production, certification and marketing experience and practices developed over many years in many climatically, topographically and culturally diverse regions of the world. These are available now for integration into international and national climate change and food security policies.

Organic agriculture is widely recognized for its environmental sustainability. A recent study by the Asian Development Bank Institute[2] recommended organic agriculture for its climate-friendly and resilient farming practices. FAO has specified organic agriculture as a promising way for agriculture to mitigate and adapt to climate change[3] and the IPCC's Fourth Assessment Report – without mentioning organic agriculture explicitly - recommended many practices for reducing agricultural emissions already common practice in organic agriculture such as recycling biomass waste as a nutrient source and, integrating crops and animals into a single farm production system.

The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD).

Endorsed by the major UN agencies, an advisory committee made up of representatives from governments, multi-lateral agencies and civil society groups appointed over 400 experts to author the report from developed and developing countries and from agricultural disciplines. Over 800stakeholders identified the key questions to be addressed by the authors at regional workshops. Of key importance to the stakeholders was how agricultural knowledge, science and technology can reshape agricultural production and food systems for reducing hunger and poverty, improving nutrition and human health and facilitating environmentally, socially, equitable and economically sustainable development.

The IAASTD report acknowledged that people have benefited unevenly from the yield increases across regions resulting in inequity in poverty, health, nutrition and trade. This productivity increase has come with many costs including, environmental unsustainability, soil loss and degradation, over-utilization of water, water pollution, habitat and biodiversity loss, global warming and climate change. IAASTD recommended core organic management techniques for successful climate change mitigation and adaptation; including legumes in crop rotations, supporting low-input agriculture, applying water-conserving practices, promoting agro-biodiversity for increased resilience of agricultural systems and the diversification of agriculture[4].

Organic agriculture is a systems approach which combines a range of practices in an optimal and synergistic way. While specific organic agriculture practices can be implemented in conventional agricultural systems, the full combined mitigation and adaptation potential in agriculture is only realised under the systemic approach practiced in organic agriculture. In contrast to other suggestions for increased mitigation in agriculture, or-

* Soil Association is over 60 years old

ganic agriculture optimally integrates mitigation and adaptation. The IPCC also places significant importance on this integration[5].

Redesigning agriculture in an era of climate change entails investing more resources, research and training, the provision of appropriate policy support, including implementing national, regional and international action plans on organic agriculture.

HIGH SEQUESTRATION

The world's soil is a major store of carbon – approximately three times the amount in the air and five times as much as in forests[6]. Soil carbon losses caused by agriculture account for a tenth of total CO_2 emissions attributable to human activity since 1850. However, unlike the carbon released from fossil fuels, the soil carbon store has the potential to be recreated to a substantial degree if appropriate farming practices are adopted. Organic agriculture offers a farming system that can affordably recapture carbon from the air and effectively re-store it in the soil.

The soil sequestration potential of agriculture depends greatly on the initial carbon levels of the soil and management practices including the intensity of organic inputs. On carbon depleted soils, initially high sequestration rates tend to level off after several decades, to eventually reach equilibrium level (up to or over 100 years depending on soils and regions etc), after which no further significant sequestration takes place. In Europe, about half of all the soil carbon that can be sequestered over a 100 year period would occur in the first 20 year period. On the other hand, when starting with very rich soils such as in the conversion of long-term grasslands to croplands, the advantages of organic agriculture are not in net-carbon soil sequestration but rather in minimising the normally huge loss of carbon stored in grassland soils.

Leading organic research institutes in the USA and Europe have rigorous comparative field trials that provide scientific validation of the high sequestration potential of organic agriculture. Some of these trials include almost 30 years of soil carbon sequestration data. These studies show that organic agriculture is highly effective in producing humus in the soil, a stable form of organic carbon.

Table 1 provides an estimation, for illustrative purposes, of the potential additional soil carbon sequestration if the world's agricultural lands were converted to organic agriculture. Depending on the organic agriculture soil management practice implemented and variables such as soil type, climate and initial carbon levels, soil carbon sequestration rates on arable land can range from 200kg to 2000kg of carbon per hectare per year above 'business as usual' conventional agriculture. When different sequestration rates are considered for the world's pasture and permanently cropped lands the percentage of global GHG emissions (49 Gt in 2004) that could be sequestered by a conversion of all agricultural land to organic agriculture would range from 5 to 32% depending on the organic soil management practices implemented. It is important to note the practices implemented will depend on a number of factors including the availability of organic inputs (biomass), the objective (e.g. fertility maintenance versus land regeneration and fertility building), and factors mentioned above such as soil type, climate and the initial carbon levels of the soil.

The mitigation potential of globally applied organic agriculture is therefore highly significant especially in the next 20 to 40 years which is critical in policy terms for delivering major greenhouse gas reductions, transitioning to a low-carbon economy and above all avoiding catastrophic climate change.

Table 1: Estimation of the Carbon Dioxide Sequestration Potential of Agricultural Soils under various Organic Agriculture Management Practices

Note: The numbers represent the additional amount of CO_2eq globally sequestered by organic agriculture compared to 'business-as-usual' conventional agricultural production.

	Extrapolated difference between organically and conventionally managed …			**Potential annual total CO2 sequestration by percentage of total agricultural land converted to organic agriculture in Giga Tonnes (Gt)**			**Percentage of total global GHG emissions**
Organic farming systems with …	… permanent pasture land	… arable land	… permanent crop land	**20%** conversion of all agricultural land to organic agriculture	**50%** conversion of all agricultural land to organic agriculture	**100%** conversion of all agricultural land to organic agriculture	**100%** conversion of all agricultural land to organic agriculture
… good organic practice	100 kg/ha/year	200 kg/ha/year	200 kg/ha/year	0.48 Gt / year	1.20 Gt / year	**2.40 Gt / year**	**5%**
… improved organic practice (e.g. combined with reduced tillage)	100 kg/ha/year	500 kg/ha/year	200 kg/ha/year	0.79 Gt / year	1.98 Gt / year	**3.95 Gt / year**	**8%**
… best organic practice	200 kg/ha/year	1000 kg/ha/year	200 kg/ha/year	1.56 Gt / year	3.90 Gt / year	**7.80 Gt / year**	**14%**
… highest standards for soil fertility building and conservation	400 kg/ha/year	2000 kg/ha/year	200 kg/ha/year	3.10Gt / year	7.75 Gt / year	**15.50 Gt / year**	**32%**

Assumptions:

Total Global Greenhouse Gas Emissions: 49 Gigatonnes (Gt) of CO_2 equivalents per year (2004).

Global area for permanent pastures and grassland: 3.488.000.000 ha

Global area for arable crops: 1.405.000.000 ha

Global area for permant crops (orchards, vineyards, coffee, cocoa, olives, etc.): 130.000.000 ha

Soil Carbon Sequestration Rates in Organic Agriculture

Note: The numbers represent the *additional* amount of CO_2eq sequestered by organic agriculture compared to a business-as-usual conventional agricultural production.

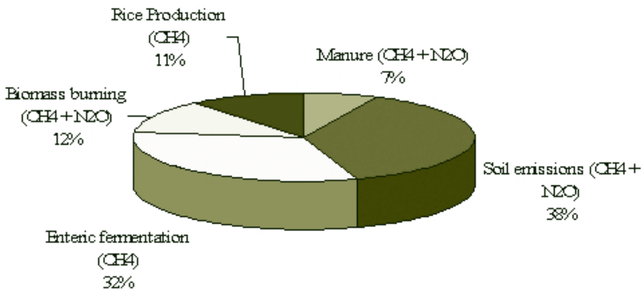
A recent review of 39 comparative studies of soil carbon levels, representing all available soil sampling-based comparative studies, by the Soil Association[47] from many different countries in temperate regions identified that organic agriculture produces much higher soil carbon levels than conventional agriculture. On average the study found that organic **agriculture produces 28% higher levels of soil carbon** compared to non-organic agriculture in Northern Europe, and 20% higher for all countries studied (in Europe, North America and Australasia). This implies that there would be a substantial level of soil carbon sequestration on cultivated land following conversion from conventional to organic agriculture, eg. an **average sequestration rate of 560 kg C/ha/year** for twenty years for the UK and the US was calculated with lower amounts thereafter . The Soil Association report suggested that an **average sequestration rate of 1000 kg C/ha/year** is realistic for organic agriculture when applied to agricultural land globally where composting, agro-forestry and other practices with high sequestration potential are used more widely than in current temperate organic farming systems [6].

Niggli et al [3] based on results and observations of long-term comparative field trials estimated the additional annual soil carbon sequestration for various agricultural production systems (arable, pasture and permanent crops) if their management shifted from conventional to organic production. A soil sequestration rate of **200kg C/ha/year** for arable and permanently cropped land and **100kg C/ha/year** for pastures based on the utilisation of organic inputs such as compost and manure was suggested. On arable land Niggli et al suggested that the figure could be increased to **500 kg C/ha/year** if in addition to organic inputs appropriate tillage was integrated into the rotations of farming systems. Soil carbon sequestration rates of **1000kg**[14] and **2000 kg C/ha/year**[14] above conventional agriculture have been consistently demonstrated in long-term comparative field trials in temperate regions of the USA. These rates are achieved when high levels of cover crops and compost are used in conjunction with appropriate tillage operation.

LOW EMISSION

Conventional agriculture is a major contributor to climate change. According to the IPPC the annual amount of greenhouse gasses (GHG) emitted by the agricultural sector is 10 to 12 % of global emissions. The main GHGs emitted through agriculture accounted for by the IPCC are nitrous oxide (N_2O) and methane (CH_4) - see figure1.

Figure 1: Main sources of agricultural GHG emissions in 2005 according to the IPCCC



The IPCC however does not count the emissions that result from agricultural driven deforestation (i.e. to create more farmland) and the loss of carbon from cropped land due to poor soil management under the agricultural sector. These activities lead to significant CO_2 emissions due to the reduction of above and below ground carbon stocks (trees, plants, roots, soil organic matter etc). In the UK for example large (1.6 million tonnes of carbon per year) ongoing soil carbon losses from the conversion of grassland to arable land are concealed within the Land Use, Land Use Change and Forestry (LULUCF) accounting category rather than acknowledged as farming emissions under the agriculture accounting category[5]. This means that the actual figure for UK agriculture's CO_2 emissions is approximately double the official figure of 1.8 million tonnes of carbon per year[6]. In addition the IPCC guidelines on accounting for soil carbon changes due to agricultural management practices are not being implemented in Europe for example. This means that soil carbon losses resulting from the declining proportion of arable farms that use soil carbon sequestering practices such as temporary grass leys or livestock manure are not being reported[6].

There are also major soil carbon impacts of agricultural systems overseas. Millions of tonnes of carbon are being emitted from the ongoing conversion of habitats, such as the Brazilian savannahs to supply soya for example to intensive livestock operations around the globe and the destruction of rainforest for export beef production. The production and transport of external inputs, such as chemical fertilizer and concentrate feed, also contribute significantly to emissions in the agricultural sector. If all agricultural emissions are factored-in, the contribution of agriculture to global anthropogenic emissions could be as high as 32%[6].

The estimates of N_2O emissions reductions in organic agriculture from replacing chemical nitrogen (N) with organic N and applying this at optimal, lower rates amounts to 1.2 to1.6 Gt CO_2 eq annually. These estimates are based on N_2O contributing 38% of total agricultural non- CO_2 emissions[7], the fact that of all chemical N applied to the soil, 1 to 2% is emitted as N_2O, and the fact that organic agriculture uses 60 to 70% less N input than conventional agriculture[3]. However due to the complexity of farm and field specific variables, such as humidity, temperature, soil pore-size, and the optimal timing and quantity of N applications and various soil management techniques, there is some uncertainty regarding the reliability of potential N_2O emission reduction estimates.

Global adoption of organic agriculture would deliver additional emissions reductions of approximately. 0.6 to 0.7 Gt CO_2 eq through the avoidance of biomass burning (CH_4 and N_2O emissions)[10] and the avoidance of 0.41 Gt CO_2 eq / year emitted from the use of fossil energy consumption for chemical N fertilizer production[9]. In organic agriculture, no chemical fertilizers are used and these emissions are avoided. Nitrogen input in organic agriculture stems from application of manure and compost, or is fixed from the air by leguminous plants.

Finally a switch to a more sustainable diet, one that fits with the productive capacity of sustainable and climate-friendly farming in which excessive production and consumption of meat and meat products, particularly pork and poultry is avoided will significantly reduce GHG emissions associated with feed production and from less intensive livestock production. A diet based on more vegetables, plant based proteins and ruminant (grass fed) livestock products will mitigate global warming, protect biodiversity and habitats that are globally significant carbon sinks and increase food availability for a growing human population[8].

FOOD SECURE FARMING

The soil however is much more than just a place to store carbon. The organic agriculture practices that achieve optimum carbon sequestration also enable farmers to adapt to climate change and build resilient systems. Organically managed soils are rich in soil organic carbon which makes the soil better able to capture and retain water than conventionally managed soils. This means organic agriculture can better secure stable harvests under adverse conditions of water scarcity. Organically managed soils are biologically alive and naturally fertile.

The diversity of crops grown in an organic system, planted at different times in the year make organic agriculture more stable in uncertain weather conditions. Organic agricultural practices build soil, thereby increasing productive land availability while halting and reversing land degradation and erosion. Importantly, organic agriculture approaches are also accessible to small-scale and poor farmers who depend on biodiversity, soil health and locally-available resources for agricultural production.

Organic agriculture is increasingly being recognised for its potential to improve food security and food accessibility. In 2008 UNEP and UNCTAD[9] and the IAASTD report[4] concluded that organic agriculture can increase agricultural productivity, raise incomes and therefore improve food security. The International Fund for Agricultural Development concluded in 2005 that organic agriculture is particularly useful in difficult environments[10]. The 2008 IAASTD report strongly recommended adopting agro-ecological and organic principles, emphasising the need for sustainability through better land, crop and livestock management and increased support to smallholder farmers. It also suggests a participatory process to ensure that science and technology are designed to help small-scale farmers and women farmers in particular. When addressing world agricultural leaders at the World Summit on Food Security in late 2009, US Agriculture Deputy Secretary Kathleen Merrigan called for the importance of organic agriculture and its role in agro-ecology to be elevated within the FAO scope of work.

Table 2: Results from the Meta-Analysis of organic vs. conventional yield comparison studies (Badgley et al. 2007)

Relative organic crop yields, average of studies[11]	
Yields in developed world	92% of conventional
Yields in developing world	180% of conventional
Estimated global food availability before conversion to organic agriculture (Kcal/capita)	
Present global food availability	2786
Estimated global food availability after conversion (Kcal/capita)	
Lower organic yield model estimate	2641
High organic yield model estimate	4381

While average organic yields in temperate zones can be slightly lower than in conventional agriculture, in developing countries and arid regions, in low input situations and under adverse conditions organic agriculture can have considerably higher yields than conventional agriculture[12, 14] Moreover, organic agriculture is acknowledged as being able to contribute to food security[13]. The better performance of organic agriculture compared to conventional agriculture under water limiting conditions highlights the adaptive role of organic agriculture in a changing climate[14]. The close linkage of organic agriculture to natural element cycling enhances long-term sustained productivity compared to many intensive conventional farming systems, where decreasing yields are observed despite high inputs[15, 16].

Farmers in resource-constrained countries traditionally use few external inputs but many of the environmental, social and economic benefits of organic management are hampered by a lack of appropriate agro-ecological knowledge[17]. Organic agriculture empowers local communities to take control of their food production needs by providing affordable, sustainable and locally adapted farming systems. Given its affordability and reliance on local and renewable inputs organic agriculture is readily adoptable by the world's 400 million small (less than 2 ha in size) and relatively poor farms. These small farms are the key to local food security throughout the developing world. Higher and sustainable productivity increases at the small farm level will have a major impact on reducing hunger, improving nutrition and reaching the Millennium Development Goals.

Organic agriculture can transform small farms like no other farming system towards greater productivity by increasing soil fertility and stability, optimizing water use, diversifying crops and incomes, building resilience to climate change, achieving high yields under difficult conditions and creating new local markets. Given the necessary information provision and extension services organic agriculture is an affordable low-risk strategy for smallholders.

Tigray Project

The "Sustainable Development and Ecological Land Management with Farming Communities in Tigray" ('Tigray project') having started in 1996 in four villages, was extended to 165 districts by 2008 and has become the model for Ethiopian agricultural development policy. Outcomes include:

- within a period of 2-3 years, farmers replaced artificial fertilizers completely and relied exclusively on compost, as the positive effects were seen very quickly
- evaluation has shown that the application of compost generally doubled the grain yield compared to the yields from plots with no inputs. In addition, the use of compost also resulted in higher yields than those achieved with chemical fertilizer.
- improved soil quality and hydrological conditions enabled farmers to grow a greater diversity of crops, improving the resilience of the food system, providing better nutrition and new income opportunities
- the improved moisture retention capacities of soil under organic management improved the chances of producing a crop even in drought conditions [18, 19].

Figure 2 shows the differences in average yields of several types of grains. Figure 3 shows the impact of using compost on five different kinds of crops. Both figures show the measured differences between crops grown with the use of chemical fertilizer, the use of compost and no input at all.

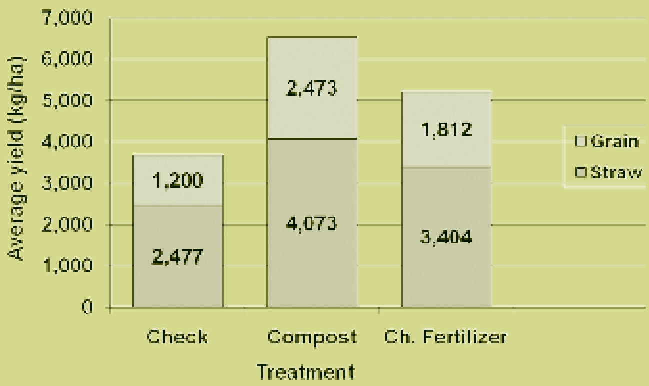


Figure 2: average yield for grain and straw for all crops samples, 2001-2006:

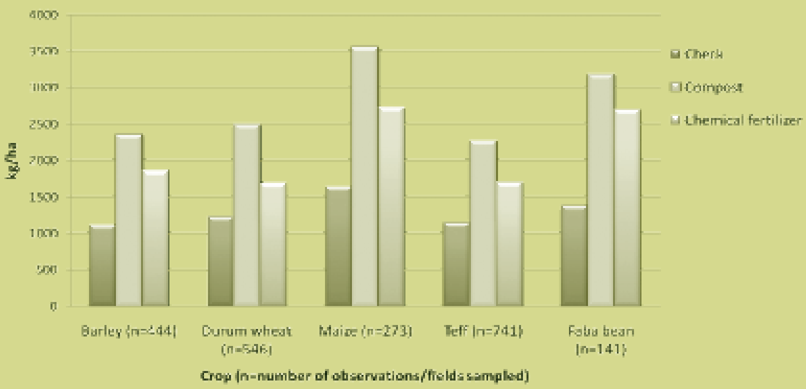


Figure 3: average yield for five different crops, 2000-2006:

Mitigation

The concepts and science underlying the main organic agriculture practices that reduce greenhouse gas (GHG) emissions and sequester CO_2 are outlined in this section. These practices are often relatively easy to implement and deliver good results. High sequestration and low emissions in organic agriculture are not achieved through expensive technology so financial requirements for these mitigation strategies are low. Given the focus on agricultural production, reductions in emissions from the food system beyond the farm gate, including processing, transportation, storage, and distribution are not covered but are also important for climate change mitigation.

Mitigation is primarily achieved through long established and optimized organic farming practices. These practices include enhancing soil biological processes, soil fertility and structure, creating organic matter in forms that are more effective at producing soil carbon, integrating crop and livestock systems, increasing the proportion of vegetation cover which promotes the soil's micro-organisms that stabilize soil carbon and through encouraging and facilitating local production and consumption. The more widespread adoption of organic farming practices and grass-based and mixed farming systems can make a significant contribution to greenhouse gas mitigation. This section explains how these organic practices and principles minimise GHG emissions and maximise carbon sequestration. Many of the practices below fulfil the requirements identified by the IPCC for mitigation in agriculture [5].

Avoidance of chemical fertilizers and herbicides

Conventional agriculture relies on fossil fuel based chemical nitrogen (N) fertilizers and herbicides manufactured in energy intensive factories transported to farms. Chemical (mineral / inorganic) fertilizers release both CO_2 and N_2O during their energy intensive manufacturing process. Organic agriculture replaces highly soluble synthetic chemical nutrients with naturally occurring nutrients in manure, compost, and leguminous plants. Organic crops tend to have deeper and denser roots and scavenge nitrogen and other nutrients more efficiently than non-organic crops. Soil fertility in organic agriculture systems is crucial as active and abundant microflora is required to mineralize organic fertilizers and inputs.

Chemical fertilizers and herbicides inhibit the natural biological activity of the soil that drives the formation of compounds that encase and effectively store carbon. There is some indication that the higher the application of chemical inputs the greater the amount of soil carbon lost as CO_2 as the soil fractions are less stable. This is probably a more significant reason for CO_2 loss in conventional agricultural systems than tillage. However this is only part of the reason that organic agriculture sequesters more CO_2 than conventional systems. Organic agriculture also incorporates significant amounts of organic matter, avoids bare fallows and generally has a higher proportion of grasslands within farming systems[22].

Due to the lower N input in organic agriculture, N_2O emissions are lower than in conventional agriculture. Organic N inputs such as N fixed by legumes and applied through compost and composted manure considerably decreases the concentration of easily available mineral N in soils. As a consequence organic N is released more slowly than chemical N, thus minimizing N_2O emissions. On the other hand, N in manure and in leguminous plant residues can also lead to more N_2O emission as the mineralization of carbon can cause anaerobic/anoxic conditions that promote N_2O emissions.

Building soil carbon and soil fertility

Soil carbon build-up is mainly stimulated by the additional biomass return to the soil from organic fertilizers, which is absent when using chemical fertilizers[23, 24]. Organic agriculture utilizes cover and catch crops, green (legumes) and animal manures, crop residues and compost to build soil organic matter, minimize nutrient loss and maximize productivity. These practices also contribute to the build-up of a healthy soil structure (greater aeration, increased porosity and higher organic matter content), which facilitates the sequestration of carbon and minimizes soil erosion and carbon loss. Compost, followed by farmyard manure and legumes has the most efficient conversion of carbon into soil carbon. In comparison arable crop residues are relatively poor at forming soil carbon which tends to be rapidly mineralised.

Organic agriculture improves the biological conditions for soil carbon accumulation. Biological factors significantly affect the proportion of carbon that is converted to stable soil carbon (humus) thus contributing to increased carbon sequestration in soils. The application of different forms of compost, including composted manure, and the avoidance of chemical inputs stimulates soil microbial processes. Many studies show elevated levels of up to 120% of microbial biomass, microbial enzyme activities, earthworms and soil-dwelling insects in organic agriculture [25, 26, 27, 28, 29]. Soil micro-organisms including fungi and earthworms play a major role in securing carbon by producing polysaccharide gums that glue soil particles together into clusters known as soil aggregates. These aggregates contribute to the stabilization and protection of humus.

Avoiding bare soil

Ensuring the soil is always covered with vegetation prevents the soil from being exposed to processes that accelerate GHG emissions from stored soil carbon. Avoiding bare fallows through the inclusion of catch crops and green manures within organic farming systems retains nutrients for future utilization and avoids the emissions associated with additional nitrogen inputs. Cover vegetation is also important in providing a greater and more continuous supply of the root exudates that support the soil's micro-organisms which build the soil carbon store. Crop residues can also be left on the field as a protective layer for the soil and avoid CH_4 and N_2O emissions caused by the burning of crop residues in conventional agriculture.

Appropriate tillage

Organic agriculture utilizes a range of tillage and soil management techniques to build soil fertility and structure, enhance biological functions and optimize the build-up of carbon in the soil without the need of toxic, fossil fuel intensive inputs. Ploughing is a tillage method used to create a friable and aerated soil for good root growth, to incorporate organic matter into the soil and in organic agriculture it is also used to control weeds. No-till systems were originally developed for arid countries like much of Australia where water conservation is critical and where soils are particularly prone to erosion. No-till systems used in conventional and conservation agriculture are chemical based and require herbicides to kill weeds. Tillage does fracture the soil aggregates that contain soil carbon and therefore exposes the carbon to the processes of mineralization, oxidation and erosion. No-till avoids such damage to the soil carbon structures and therefore contribute to the conservation of soil carbon in the top layers of the soil.

However organic agriculture sequesters significantly more carbon than conventional agriculture regardless of which tillage method is used. Tillage is just one of a number of practices used in organic agriculture that sequesters carbon. No-till is a passive approach to building soil carbon whereas organic agriculture systematically incorporates carbon rich organic matter into the soil. In conventional no-till agriculture, the build-up of soil carbon is usually derived from crop residues and confined to the top soil. The avoidance of chemical agrochemicals that inhibit the formation of humus is another contributing factor to the higher carbon sequestration in organically managed soils. Additionally by aerating the soil, tillage promotes soil microbial activity and root growth and reduces anaerobic soil conditions that can lead to N_2O and CH_4 emissions in undisturbed soils or soils with poor soil structure.

Due to limited available research into the distribution of carbon through soil profiles for both organic and non-organic agriculture it is currently difficult to define accurately the affect of various tillage operations on soil carbon. Conventional no and minimum till may concentrate carbon sequestration in the top soil whereas ploughing, used by both organic and conventional farmers, may redistribute the same carbon throughout the soil profile leading to little changes in overall carbon levels.

Although not yet widely incorporated into rotations both no-till and minimum-till practices are used in organic agriculture. No-till organic farmers roll and crimp cover crops to lay a mat of plant material on the soil surface to suppress weeds, avoid nutrient loss and add carbon to the soil. Organic minimum-till operations however utilize disk and chisel ploughing to maximize soil carbon sequestration and minimize GHG emissions from the soil. Scientific studies both in the USA and Europe have shown that appropriate no-till and minimum till operations can increase soil carbon sequestration in organic agriculture – at least in the upper soil profile. Combing organic agricultural practices therefore with appropriate use of no-till and minimum till has been shown to increase the carbon sequestration performance of organic agriculture still further over conventional agriculture systems. Such systems may be particularly beneficial in drought prone regions where disturbed soils are particularly prone to soil carbon loss.

Further research is needed of reduced tillage in organic agriculture, with care taken to ensure that the full deep soil profile is sampled, that N_2O emissions are measured and that the results are interpreted in the context of the climatic and agricultural conditions of the region and that the viability of the systems are considered[6].

Combining perennial and annual crops

Organic agriculture systems combine different perennial plant species such as trees, shrubs, palms and grasses with different annual crops. Organic agriculture also integrates higher levels of native perennial trees and hedgerows from the surrounding landscape. Plants sequester CO_2 from the atmosphere by pulling it in via photosynthesis. Perennial plants develop their roots and branches over many years to store carbon in the vegetation and soil, annual plants however leave no permanent vegetation and comparatively little soil carbon. There is great potential to improve mitigation by increasing the use of perennials and reducing annual crops, especially those grown to provide concentrated feed for industrial livestock production.

In agro-forestry systems where trees are combined with crop production the potential is even higher for sequestrating carbon. Diverse agro-forestry systems have mostly been developed for the humid tropics but a combination of annual and perennial crops could significantly raise carbon sequestration and food and fuel production in temperate regions. The inclusion of permanent species in tropical farming systems can significantly improve productivity and can encourage farmers to avoid traditional shifting cultivation or slash and burn agriculture and the associated GHG emissions. Combining permanent and annual crop species also enhances the eco-functionality and productivity of the farming system.

Sustainable livestock management

There is debate that the direct GHG emissions from livestock (enteric fermentation, respiration, manure etc) are much higher than estimated by the IPCC. The IPCC also does not include the indirect GHG emissions from meat production as agricultural emissions. When the whole life cycle of the meat production is considered such as the land-use changes linked to animal feed production, slaughtering, processing, refrigeration and transportation the contribution of meat production to climate change is very significant to global warming and climate change. It is estimated that 33% of arable land worldwide is used for producing feed for animals rather than food for humans or for producing plant-based alternatives to fossil fuels. The demand for meat is driving deforestation resulting in huge amounts of CO_2 being released into the atmosphere, the loss of habitats, biodiversity and ecosystems as well as the loss of vegetation capable of sequestering huge amounts of CO_2 annually.

Organic agriculture livestock production emits significantly less GHGs than conventional livestock production. In industrial livestock production animals are raised in factory-like conditions that leads to excessive animal manure production and the need for grain based feed that is often sourced globally. In organic agriculture animals are primarily raised in pastures reducing the need for feed and their manure contributes to the building of soil carbon. Conversion to organic agriculture would result in a much greater percentage of farmland with permanent grass and would therefore significantly increase soil carbon sequestration. Organic agriculture integrates crops and animals in a single farming system (mixed farm) or strives for cooperation between specialized crop and animal farms. This allows efficient feed and manure use and avoids manure oversupply, thus reducing CO_2, N_2O and CH_4 emissions from over-fertilization, storage and dumping. Large-scale animal factories are banned in organic agriculture.

Emissions from more sustainable livestock production as practiced in organic agriculture will decrease available meat due to less intensive production. As meat is a resource-intensive and high GHG emitting product, decreasing meat production can significantly reduce global GHG emissions and release resources for increasing human food production. A dietary transition towards less meat consumption (especially livestock production dependent of feed concentrates) will enable a food system that is better able to mitigate and adapt to climate change and will increase global food security.

Optimal manure management

Improved manure management including distribution systems, such as slurry injections into soils or drag hoses, reduce nutrients losses considerably. Covering manure and slurry storage sites reduces CH_4 emissions. In addition, CH_4 can be captured and used as biogas. Specifically in organic agriculture, manure is often composted. In aerobic composting, assuring sufficient aeration will avoid CH_4 and N_2O emissions. However, decomposition of organic material leads to emissions if it depletes the available oxygen hence the need to optimize aeration in aerobic composting systems. Partial microbial digestion of farmyard manure such as through composting for example promotes its potential to be converted into securer forms of soil carbon.

Improved grassland management

Perennial grasslands are very effective in sequestrating carbon in the soil especially by building up carbon in their root systems. Grasses also have fine root hairs and high mycorrhizal fungal levels which both enhance soil aggregation. Many of the world's arable soils were originally perennial / permanent grasslands with very high carbon contents. The shift from permanent perennial grasslands to annual crops and over-grazing has depleted these grasslands and their ability to sequester carbon and promoted soil erosion. Organic agriculture optimizes the huge soil sequestration capacity of grasslands by:

- increasing the amount of grassland in the farming system (organic red meat production is based on grasslands),
- avoiding the need to convert grasslands into annual crops to produce animal feeds,
- protecting grasslands from over-grazing through reduced stocking rates, and by
- encouraging root growth through the utilization of grass species, including legumes with a variety of rooting depths.

Legumes are strongly promoted on organic grasslands and pastures (grass clover leys), as they increase nitrogen uptake in the soil, raise protein levels in animal feedstuff and avoid the need to purchase animal feed concentrates.

System of Rice Intensification (SRI)

Rice production is a key agricultural emitter of greenhouse gases. Innovative rice production systems based on organic principles of increased root development and increased soil organic matter through decreased flooding offers potential to significantly decrease agricultural CH_4 emissions. For example, through the System of Rice

Intensification (SRI), by planting early, giving seedlings more room, and keeping fields damp but not flooded, farmers can double yield using one tenth as much seed and half as much water. SRI reduces CH_4 emissions by avoiding the need to flood rice fields, and decreases GHG emissions because nitrogen fertilizers are not required. Labor increases while the system is adopted as increased weed management is required, but once the management system has been fully developed labor needs decrease[30].

Local production and consumption

Organic agriculture encourages local production for local consumption of both farm inputs and outputs. This maximizes efficiencies and synergies, reduces emissions from transportation and increase access to local food production and therefore enhances food security. All organic production, distribution and marketing systems should aim to minimize emissions regardless of where production and consumption occurs. International agricultural markets deliver economic benefits to exporting countries but it can also lead to long term negative effects on local food security due to reduced local food accessibility especially for poor people who are most vulnerable to price fluctuations. The promotion of local food production in food insecure regions is critical for increasing food accessibility and also reduces emissions.

Adaptation

Agriculture is highly vulnerable to climate change and our food supply relies on successful adaptation. Adaptation actions include those necessary to restore the resilience of eco-systems and their productivity to enable sustainable economic development. Organic agriculture increases the ability of the farming system to continue functioning when faced with the adverse effects of climate change by increasing resilience within the agro-ecosystem[31, 32]. Organic agriculture creates robust and environmentally benign farming systems that are resilient to temperature extremes, drought and which avoid soil erosion. Organic agriculture also promotes sustainable community based ecosystem management, conservation and restoration activities.

The financial requirements of organic agriculture for adaptation are low. Additional costs mainly come from information provision, education and extension services. Organic agriculture however offers innovative farmer based group systems that facilitate best practice knowledge exchange in a systematic and cost free manner. This is particularly important for the empowerment of vulnerable and poor people in rural populations that rely on agriculture for their livelihoods. This section explains key organic principles that help farmers and communities adapt to climate change. Organic agriculture fulfils many of the requirements identified for successful adaptation strategies[33].

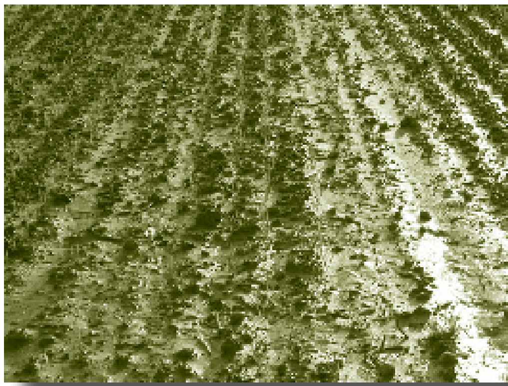
Preventing and reversing soil erosion and restoring degraded land

Worldwide two billion hectares or 38% of agricultural land is significantly degraded, resulting in the breakdown of agro-ecological functions, poor crop yields, land abandonment and deforestation[12]. Agricultural erosion through overuse, undernourishment and chemical inputs has damaged the natural, healthy and helpful biological activity in the soil that underpins the soils capacity to continuously regenerate. Biologically alive soils are crucial in the adaptation of agriculture to climate change, providing sufficient nutrients for plant production, achieving high yields in times of water scarcity and preventing and reversing soil erosion.

Organic practices that contribute to the mitigation of global warming also increase soil health: use of organic instead of chemical fertilizer; cover crops, catch crops, green manure; composting; appropriate tillage; and the integration of perennials and trees into the farming system. Healthy soils have higher organic matter contents and greater biological activity which improves soil structure and stability. The organic management of soils is a highly effective tool to regenerate degraded land. By increasing the soil organic matter content, organic agriculture is able to build up soil carbon and soil fertility from low levels and bring severely degraded land back into production.

Drought and flooding resilience and water use efficiency

The majority of the world's farmers rely on rain-fed agriculture. In the wake of climate change, rainfall is predicted to become more unreliable and to come in more intense events. It is critical that farming systems can capture water and store it in the soil for later use. Organic agriculture systems, capture, store and use water more efficiently due to better soil structure and higher levels of humus and other organic matter compounds with sponge-like properties (humus can store approximately 30 times its weight in water so that rain and irrigation water are not lost through leaching and evaporation). Organic matter also enhances drainage in soils, significantly reducing the risks from water-logging and surface-water flooding[2,34]. Water capture in organic fields can also be 100% higher than in conventional fields during torrential rains[35]. Under organic agriculture the soil organic matter captures and retains more water in the crop root zone. Organic agriculture practices that preserve soil fertility and maintain or increase organic matter can reduce the negative effects of drought while increasing productivity[2,24] and also reduce irrigation needs. Other practices such as crop residue retention, mulching and agro-forestry, conserve soil moisture and protect crops against microclimate extremes.



Side by side comparative non-organic and organic trials illustrate the superior performance of soil management practices in organic agriculture

Resilient crops

Building healthy soils is the basis for growing healthy resilient plants that are better able to withstand environmental pressures such as increased water scarcity and pest and disease pressure. Organic agriculture strengthens the immune systems of plants and thus the defence and self-healing capacities of crops against pests and diseases. Plants that obtain their nutrients through natural biological processes are more resilient to environmental stress than crops that obtain their primary nutrition artificially through highly soluble chemical fertilizers. This is mainly achieved through optimal soil and water management, the building of soil structure and fertility and the choice of locally adapted robust crop varieties. In addition organic crops tend to have longer and denser roots that are able to seek out water reserves deeper in the soil profile and which are also more resilient to desiccation.

Agro-genetic biodiversity

Organic agriculture has a big role to play in protecting the world's agricultural genetic resources (e.g. crop and farm animal species and varieties). Organic agriculture encourages the use of locally adapted varieties and decentralized participatory breeding programs especially in-situ (on-farm) based conservation, breeding and production. In-situ approaches maintain varieties for future needs while allowing them to continuously adapt to environmental pressures such as climate change. Our agro-genetic diversity is a critical resource in the effective ongoing adaptation to continuous changes in climate.

Diversification

A science based on uniformity is no longer appropriate for solving our farming problems. Climate change and increasing vulnerability to environmental and economic variability requires a science based on diversity to manage risks and cope with uncertainties. Diversification is a fundamental aspect of organic agriculture. Resiliency to climate disasters is closely linked to farm biodiversity. Practices that enhance biodiversity allow farms to mimic natural ecological processes, enabling them to better respond to change and reduce risk. Biologically diverse organic farms that optimize ecological functionality avoid the build-up of disease and pest levels and are more resilient to other environmental pressures. Crop diversity (both temporal and spatial) provides a variety of rooting depths that enhance soil stability and structure, improves nutrient and water use, and contributes to a stabilized microclimate. Farmers who increase inter-specific diversity via organic agriculture suffer less damage compared to conventional farmers planting monocultures[2, 21, 22, 36]. The diversity of landscapes, farming activities and crops is greatly enhanced in organic agriculture resulting in farming systems that are resilient to the adverse effects of climate change. The robust and resilient nature of organic agriculture systems also helps to protect sequestrated carbon from climatic disturbances increasing the permanence of sequestration.

Local farmer knowledge

Most of the worlds farmers are smallholders and many are women. Organic agriculture encourages the use of local and indigenous farmer knowledge and observation techniques and recognizes the critical role of women throughout the entire food chain, as farmers, consumers and mothers. Their agricultural systems have attracted little attention from research and development and are usually assumed to be inherently unproductive. However smallholder farmers throughout the world have developed a multitude of practices and innovations that should be seen for what they are; the basis for any realistic development – including productivity improvements. Indigenous and traditional knowledge are key sources of information on adaptive capacity, centered on the selective, experimental and resilient capabilities of farmers[2, 3, 21, 24, 25]. Organic agriculture strengthens the rich ecological knowledge of the world's smallholder farmers resulting in enhanced productivity, greater resilience and resource efficiency, and improved access to food and income.

Export promotion of Organic Products from East Africa

Commenced in 1997 the "Export promotion of Organic Products from East Africa" ('EPOPA project) has now enhanced the livelihoods of approximately 110,000 farms in Uganda. It has helped build a self-sustaining organic supply chain that continues to expand and benefit even more farmers. Outcomes include:

- Producers gained access to higher value markets and could provide their families with a richer and more varied diet.
- Organic management of cash crops increased the opportunities for subsistence production through organic agriculture practices such as inter-cropping.
- Organic agricultural techniques learned through the project were transferred to the production of subsistence crops, improving productivity and local food security.
- Income from higher value markets was used to improve the overall productivity of the farm, benefiting both cash - and subsistence crops[20, 21].

Food Security, Poverty Alleviation & Health

There is a combination of reasons for rising global hunger including; market rather than people focused agricultural policies, poverty, lack of food sovereignty [**], climate change, degraded and unproductive farming systems and the destruction of ecosystems and their services. Fundamentally the lack of knowledge of affordable, sustainable, resilient and productive farming systems that put the needs of local people and ecosystems first is missing. The World Development Report 2008[37] stressed the important role of agriculture as a development tool in the world's poorest countries to increase incomes, reduce poverty and food insecurity. Organic agriculture can help put the needs of the most vulnerable first and break the cycle of poverty. It is best practice for achieving food security through the support of the world's smallholder farms that make up 90% of all farms worldwide.

People before commodities

Food accessibility in the developing world is tied closely to local food production[38, 39] (FAO 2008, Bruinsma 2009). However in many developing countries investment in the agricultural sector has focused largely on export crops to generate foreign exchange, rather than producing crops for local consumption. With twenty-five percent of people in developing countries living on less than US$1.25 per day[40] this policy has forced many countries to rely on continued low international food prices to meet national food demand. The IAASTD report confirmed that this strategy has failed and led to rural poverty, under-employment, food shortages and social unrest[3].

Highly mechanized, capital and chemical intensive farms often mass-produce commodities that are important food crops. These commodities, instead of providing core human nutritional needs, often become ingredients for other industrial systems such as intensive livestock (meat), highly processed food products, and renewable energy feedstock affordable only by affluent consumers. Organic agriculture not only avoids monocultures and industrial farming but encourages the integration of the needs of local communities in organic farming systems. Crop rotations can be designed to increase income and self-sufficiency through the integration of cash crops, goods for bartering and energy and a diverse range of food crops including for self-consumption.

Lower costs, less debt and reduced financial risks

The 2009 World Summit on Food Security officially recognised people's right to food. Seventy-five percent of the world's one billion hungry people live in rural regions of developing countries where in theory access to food should be easier[41]. However many of these people are unable to afford the necessary means for effective and resilient productive farming. Organic agriculture minimizes the financial and resource barriers to farming and therefore enhances people's access to local food. Input costs in organic agriculture are much lower as it avoids costly external inputs such as chemical fertilizers, pesticides and fuel. Lower costs reduce financial risk, avoids the need for credit and subsequent indebtedness. As fossil fuel prices rise the cost of external chemical inputs will rise further, making reliance on these inputs increasingly risky. Organic agriculture also reduces risk by increasing the diversity of food and income sources and therefore reduces the risks associated with the failure of a particular crop. The high diversity of organic agriculture leads to greater ecological and economic stability through optimized ecological balance and risk-spreading.

[**] The ability to either purchase and / or produce ones own food including access to resources such as fertile land and water.

Eco-functional intensification

Conventional agriculture intensifies production by increasing external inputs such as chemical fertilizers, pesticides, water, hybrid and genetically modified seeds and in the case of animal production: feed concentrates and pharmaceutical drugs. Eco-functionally intensified production systems enable more food to be produced without compromising the quality of the environment and our food. In organic agriculture eco-functional intensification is achieved by higher inputs of knowledge, observation skills and agro-ecological methods to intensify the beneficial effects of eco-system functions including, biodiversity and soil fertility, minimizing loses from material cycles and utilizing the self-regulating mechanisms of biological systems to achieve stable farming systems.

Best practice food security

A major barrier to food security and accessibility in the developing world is lack of adoption of affordable, productive and resilient farming systems by many of the world's 1.5 billion smallholder farmers. These farmers produce on approximately 400 million small (less than 2ha) and marginal (less than 1 ha) farms and form the backbone of local food security throughout the developing world[17]. Many of these farms are relatively poor and unproductive and highly vulnerable to climate change. Optimizing productivity and building resilience of these farms is critical for improving local food security and accessibility. Local food production in smallholder farms can often be increased significantly through improving the use of locally available resources and agro-ecological methods for soil fertility building and pest prevention. Eco-functional intensification increases productivity and enhances food security especially in challenging environments such as water scarce regions.

> The Executive Director of the United Nations Environment Program (UNEP) and the Secretary General of the United Nations Conference on Trade and Development (UNCTAD concluded in their 2008 joint study that „organic agriculture can be more conducive to food security than most conventional systems, and .. it is more likely to be sustainable in the long term."[12].

Knowledge based income creation and the green economy

Organic agriculture is optimized through the effective adaption to local conditions and opportunities. These include climate, topography, biodiversity, ecosystem health, local and traditional farming system knowledge and the entrepreneurial and innovative spirit of local communities. Organic agriculture does not rely on externally imposed and controlled one-size-fits-all formulas. Rather it empowers local communities to develop their food and farming systems and generate wealth through production and value-adding. Realizing the optimization of organic agriculture, including sequestration and eco-intensification potential, is dependent on the expansion and dissemination of ecosystem oriented research, knowledge, and technology.

Organic agriculture, if adopted widely, will require a new breed of professional agronomists capable of unlocking the innovation and entrepreneurial spirit of local people, enhancing local food accessibility, building resilient farming systems, protecting local ecosystems and facilitating access to appropriate micro-financing to stimulate value-adding activities. Providers of research, extension and training will therefore need to have expert knowledge of local conditions and optimize the participation of local farmers and communities in capacity building programs, including participative seeds and animal breeding programs. If governments embrace the shift towards a knowledge based economy organic agriculture can contribute not only to the rapid mitigation of global warming but also to a green economy that secures access to food for all, protects our ecosystems and brings sustainable growth and better quality lives to us all.

Local research capacity required to realize the full benefits of organic agriculture

The Organic Research Centres Alliance (ORCA) is a proposed consortium of research institutions working together throughout the developing world. It is a joint initiative of the Food and Agriculture Organization of the United Nations (FAO), the Swiss Research Institute of Organic Agriculture (FiBL) and the Danish International Centre for Research in Organic Food Systems (ICROFS). Each centre will consist of a network of core organic research institutions, non-organic research institutions that undertake complementary research on low-input systems and ecology; farmers' organizations and grassroots organic movements that steer agenda setting and technology development.

The ultimate objective of the alliance is to ensure that the environmental, economic, and social benefits accruing from organic research are shared worldwide and beyond the organic community, as a contribution to sustainable agriculture and poverty alleviation. The centers will be "institutions without walls", formed through alliances between producers and scientists, as well as partnerships between institutions in developing and developed countries. The alliance intends to internationally network and strengthen existing institutions and empower them to become centers of excellence in trans-disciplinary and participatory organic agriculture research. The centers will draw heavily on traditional knowledge, improve it with scientific investigation and share it widely.

Social innovation and capacity building

Organic agriculture has spearheaded the expansion of many innovative local production and marketing systems including community supported agriculture, urban agriculture and direct marketing initiatives such as 'box schemes'. Organic agriculture builds the social capital of rural areas: being knowledge-intensive, rather than capital and resource-intensive, it utilizes traditional knowledge and promotes farmer-to-farmer exchange. Participatory Guarantee Systems (PGS) programs enable small-holder farmers selling directly to the community to guarantee the authenticity of each others organic production systems, develop markets and share knowledge. Hugely successful in Latin America and India these local initiatives eliminate external (third-party) certification costs and facilitate the uptake of sustainable, affordable and resilient farming systems that build the capacity of local people to respond to climate change and food security.

High yields in tough conditions

In developing countries yields often rise on organic farms as the unfavourable conditions often respond positively to organic agriculture practices. Organic agriculture captures and stores more water and achieves higher yields under water stress and on degraded land compared to conventional agriculture. Organic agriculture builds soil fertility and structure and is more efficient in using resources, including well adapted local resources such as local seed varieties, which are often limited in areas with extreme poverty and food insecurity. The eco-functional intensification of organic agriculture systems increases productivity and enhances food security especially in challenging environments. A UN study of 114 projects in 24 African countries found that yields on farms using organic or near organic practices more than doubled with yield increases of 128% in east Africa[12].

Long-term sustainability

Supply of chemical nitrogen (N) fertilizer is unsustainable and supply of chemical phosphorous (P) fertilizer is limited. Chemical N is manufactured with high energy use, currently from fossil fuels of which supplies are rapidly diminishing. Conventional agriculture relies on phosphorous that is directly sourced from non-renewable and rapidly declining deposits. Chemical N and chemical P underpin conventional agriculture but they are not sustainable long-term options for maintaining crop yields and driving world food production. Fossil fuel prices are expected to rise considerably in the future especially as supplies become increasingly scarce. Global agriculture will need to switch to sustainable fertilizers which are renewable, available locally and which do not rely on high energy use. External, non-renewable inputs of P can also be necessary on organic farms depending on site characteristics. However due to the P from organic fertilizers such as compost and manure, the need for non-renewable P is much lower than in conventional agriculture. Organic agriculture also promotes soil biological processes that enhance P-uptake.

Avoidance of toxins and pharmaceutical drugs

Organically produced foods have lower levels of pesticides and veterinary drug residues and, in many cases, lower nitrate content"[42]. Chemically based pesticides and herbicides are prohibited in organic agriculture. Farmers, farming families, communities, farm animals, native animals and insects, water bodies, foods and ecosystems are therefore sparred exposure to these very toxic compounds. According to the World Bank up to 5 million farm workers are estimated to suffer pesticide poisoning each year and at least 20,000 die annually from exposure[43]. Many of these farm workers are in developing countries where safety guidelines and equipment are less available and where chemicals that are banned in many developed countries are still routinely marketed.

Hormones, antibiotics and similar drugs are restricted in organic farming worldwide to ensure that organic food is as free as possible from antibiotic-resistant bacteria which can pass from farm animals to humans and cause serious infections which do not respond to normal antibiotic treatment. Use of such substances to increase growth rates in farm animals, milk yields in dairy cows and egg production in poultry is entirely prohibited in organic agriculture. In exceptional circumstances organic agriculture in some countries may permit the use of pharmaceutical drugs to treat, or prevent ill health, though with strict limitations. Limitations include much longer withdrawal periods than practiced in non-organic agriculture. Livestock health is improved in organic agriculture due to reduced stress and disease levels in animals, friendly husbandry conditions, adequate space per animal, adequate combination of indoor and outdoor space and adequate feed.

Nutrition

Comparative studies[44, 45] have shown a higher content of beneficial, health-promoting secondary plant compounds in organic produce. Phyto-chemicals produced by plants, such as vitamins and anti-oxidants (e.g. carotenoids and flavonoids) are associated with the prevention of disease in humans. Crops under organic production are less "pushed" or "forced" than in conventional agriculture, their growth is generally slower, resulting in the plants having sufficient time to synthesize their vital components. Produce raised with high water and chemical fertilizers and pesticide inputs[46] have been shown to causes a dilution effect. The "dilution effect" is triggered by high levels of nitrogen and rapid plant growth, especially in the absence of pest pressure. For example tomatoes grown on fields that have been organically managed for several years exhibit much higher flavonoid concentrations than in conventional crops. This also applies for animal products. In certain countries growth can be hastened through inclusion of hormones in the feed of conventionally raised livestock. The effect of these hormones is known to increase the weight of meat produced per calorie of food ingested, primarily through the retention of water in the flesh. Increased levels of secondary plant compounds can contribute to improved community resilience to disease and reduce reliance on health care interventions. The prevalence of disease is expected to increase due to global warming with the poor most likely to be hit the hardest and also the least able to respond effectively due to lack of resources.

Biodiversity and ecosystem protection

Organic agriculture removes artificial boundaries between farms and landscapes and therefore provides important linkages, such as wildlife corridors, between disparate natural habitats. Organic farming systems are seen as an integral part of the wider ecosystem - the protection and enhancement of the ecosystem at the landscape level provides benefits in the form of ecosystem services at the farm level. As a consequence organic farms have higher quantities of native landscape and a greater diversity of plant species, beneficial insects and wildlife growing and living on and near the farm. Through optimising the application of fertilizers, organic agriculture also avoids eutrophication of water bodies caused by oversupply of highly soluble fertilizers, manure and slurry. Eutrophication can lead to severe reductions in water quality, fish, and other animal populations as experienced in the large dead zones in the Gulf of Mexico[3]. Organic agriculture can halt and reverse soil erosion and desertification and regenerate degraded land to highly productive levels while breathing new life into local ecosystems and their functioning. Organic agriculture is therefore an ideal tool for the world's 1.5 billion smallholder farmers that not only produce the bulk of the world's food, but are perhaps our most important biodiversity and ecosystem stewards.

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IFOAM position on the full diversity of organic agriculture

Any system using the methods of organic agriculture and being based on the Principles of Organic Agriculture is regarded by IFOAM as 'organic agriculture' and any farmer practicing such a system can be called an 'organic farmer'. Organic agriculture brings valuable contributions to the farmer and to society outside the market place. IFOAM supports the adoption of organic agriculture regardless of whether the products are marketed as organic or not.

IFOAM regards third party certification as a reliable tool for guaranteeing the organic status of a product, and one that appears to be most relevant in an anonymous market. But IFOAM does not see this as 'universal' and not the only tool to describe organic agriculture. Apart from third party certification there are other methods of organic quality assurance for the market place. These can be in the form of self-declarations or participatory guarantee systems. There are also situations where the relation between the consumer and the producers are strong enough to serve as a sufficient trust building mechanism, and no other verification is needed.

IFOAM principles of organic agriculture

Health

Organic Agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.

Ecology

Organic Agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.

Fairness

Organic Agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities

Care

Organic Agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment.

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IFOAM'S MISSION IS LEADING, UNITING AND ASSISTING THE ORGANIC MOVEMENT IN ITS FULL DIVERSITY. OUR GOAL IS THE WORLDWIDE ADOPTION OF ECOLOGICALLY, SOCIALLY AND ECONOMICALLY SOUND SYSTEMS THAT ARE BASED ON THE PRINCIPLES OF ORGANIC AGRICULTURE.

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