Organic agriculture and its benefits for climate and biodiversity

Summary

Changing the way we produce food can make a big difference in mitigating climate change, can help farmers to adapt and to become more resilient, and can contribute to biodiversity protection. Organic farming offers a systemic approach for reducing greenhouse gas emissions (GHG) and increasing soil carbon sequestration while sustaining healthy soils and protecting biodiversity.

Organic consumes less energy and reduces GHG emissions

- Instead of being dependent on external fossil-fuel intensive fertilizer or pesticide inputs, organic farming relies on establishing closed nutrient cycles and minimizing nitrogen losses. This can reduce global agricultural GHG emissions by around 20%.
- Refraining from synthetic fertilizer use reduces nitrous oxide emissions from soil by 40% per hectare in organic systems.
- Animals in organic systems have access to free range areas, are allowed to graze as much as possible and 60% of the feed has to come from the farm or the same region. The reduced number of animals and grassland-based systems reduce emissions and improve carbon stocks in soil.
- Organic agriculture often uses improved manure management such as manure composting which can reduce nitrous oxide and methane emissions from manure by 50% and 70% respectively.
- Organic agriculture has a higher energy efficiency and a lower energy use per hectare. It consumes around 15% less energy per unit produced compared to conventional agriculture

Organic sequesters and stores more carbon

Many common practices in organic farming, such as crop rotations including legumes or reduced tillage, help to improve soil quality and fertility and contribute significantly to higher soil organic carbon stocks of up to additional 3.5±1.1 tonnes of carbon per hectare compared to land under conventional management.

Organic protects species and habitat diversity

The prohibition of synthetic fertilizers and pesticides and biodiversity-enhancing practices, such as diverse crop rotations with legumes, landscape elements or reduced tillage, lead to on average 30% more species and 50% more individuals in organically managed areas.

Organic supports ecosystem functions

Organic farming promotes soil health and reduces soil erosion by 22%. It protects water bodies by reducing nitrate leaching by 28-39%. Organic has a positive impact on crop pollination and increases natural pest control.

Organic increases the resilience of farming systems

The improved soil structure in organic farming reduces erosion, supports plant health and makes organic more resilient to changing weather conditions. Organic farming does not rely on synthetic fertilizers and pesticides, which makes the organic system less dependent to external inputs. The enhanced biodiversity in organic systems favours stable yields during drought periods and adaptation to future environmental conditions.

Policy recommendations

- Adopt a systemic approach to reduce negative environmental impacts from food production.
- Carbon farming has to take a holistic and multi-dimensional approach, to deliver on climate mitigation, adaptation, biodiversity and other environmental objectives.
- Ensure that the CAP Strategic Plans are ambitious and contribute fairly to the target of 25% of EU agricultural land under organic management by 2030 as stated in the Farm to Fork and Biodiversity Strategies.
- Strengthen the support, through relevant “on top” agri-environmental-climate schemes and advisory services, for sustainable farming practices that provide public goods and support the transition towards agroecology.
- Ensure a good representation of organic in upcoming research programmes to further improve the environmental benefits of organic farming.

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Introduction

Climate change and its consequences pose a severe threat to our agricultural systems and food production as such and it is one of the biggest challenges we face today. According to the IPCC the last decade already experienced a global surface temperature increase above 1°C, compared to 1850-1900, while warming over land is generally higher than over the ocean. Furthermore, an increase in frequency and intensity of climate and weather extremes like heatwaves, heavy precipitation and droughts can be observed and have a big impact on agricultural production.[1] Time is very limited to still steer the wheel around but changing the way we produce food can make a big difference in mitigating climate change and helping farmers to adapt and become more resilient. The 2022 IPCC report on mitigation states that agriculture and other land use can help removing and storing carbon; they can however not compensate for delayed emissions reductions in other sectors.[2] Organic farming holds a big potential in reducing GHG emissions and increasing soil carbon sequestration while sustaining healthy soils and protecting biodiversity and ecosystem functions.

Agriculture contributes directly to around 10% of the EU GHG emissions, and more than 80% of these are methane emissions from livestock production due to enteric fermentation and nitrous oxides emissions from soils.[3] However, when all emissions linked to food production are taken into account, it is estimated that they are responsible for up to 21-37% of global emissions.[4] Besides direct agricultural emissions this concerns emissions linked to the production of feed and its impact on deforestation, and emissions linked to the production of inputs such as synthetic fertilisers. Around 80% of agriculture land is used for animal production as grazing land or arable land for feed production while producing only 18% of the world's calories supply and less than 40% of the global protein supply.[5] Moreover, changes in land use including agriculture are one of the main drivers for biodiversity loss.[6]

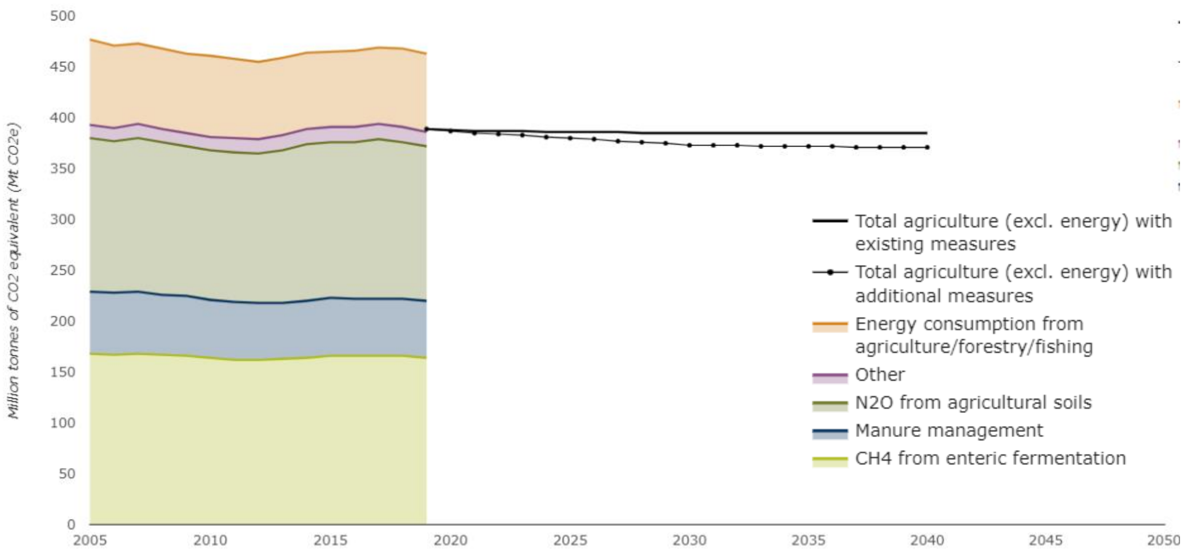

Figure 1 EU agricultural emissions by source and projected emissions (Source: EEA[3])

Climate change and most of its consequences like temperature increase or increased extreme weather events pose an adverse effect on biodiversity and conversely, changes in biodiversity affect the climate system through impacts on the nitrogen, carbon and water cycle. Climate change impacts habitats and behaviour of species, including their growth and geographical distribution, and many species are not able to keep up with the pace of change. Preserving biodiversity and intact and healthy ecosystems are necessary to succeed in climate protection and adaptation to the consequences of climate change. Healthy ecosystems can contribute to carbon

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sequestration, they are less susceptible to the negative consequences of climate change and they can mitigate impacts of droughts, storms and flooding. Intact ecosystems ensure the provision of nature's contribution to people such as clean water or healthy soil.[7,8]

The joint IPBES/IPCC report from 2021 states that "Safeguarding nature and ensuring a stable climate are thus vital to support people's good quality of life." Although there is a growing understanding and recognition of the interconnection between climate change and biodiversity loss and the common drivers they share, it is still all too often looked at from a single perspective and addressed separately. This segregated approach, however, will fail to point to solutions encompassing multiple benefits and lead to solutions that are not optimal for either problem. In the worst case maximising one aspect might lead to action counteracting the other objective and trade-offs with other aspects of sustainability.[7]

The impact of agricultural practices, food waste and diets must all be considered if we are to understand how food and farming can positively contribute to biodiversity protection, climate change mitigation and adaptation while providing healthy diets for all. It is key to consider climate and biodiversity as part of the same complex problem to maximize the benefits of solutions and focus on multi-objective approaches.[7] Land management must ensure that biodiversity is preserved within the agricultural landscape, pollution from pesticides and fertilisers is reduced and climate change is curbed. Agriculture is a crucial lever for all of this.

Organic farming offers a way of approaching these challenges taking their complexity into account and promoting a systemic approach, which is essential to reduce GHG emissions, help the agricultural sector to adapt to climate change and to support healthy ecosystems. Having a holistic view is intrinsic to the concept of the organic movement that made it its overarching goal to create sustainable food systems for healthy farms, healthy people and a healthy planet. Increased conversion to organic agriculture can contribute to the reduction of greenhouse gas emissions, while also bringing important benefits, such as improved system resilience to the effects of climate change, maintaining biodiversity on farmland, conserving soil fertility, reducing eutrophication and water pollution, and improving food security and farmers' sovereignty.[9] It is crucial to take a food systems view, focusing not only on mitigation in agricultural production, but considering also consumption patterns, as well as optimal resource use. Organic agriculture, combined with reduced concentrated feed and animal products, and the reduction of food waste enables sustainable and climate-friendly agricultural production and food system. The 2022 IPCC report states that agroecological practices support food security, health and well-being, biodiversity and ecosystem services.[10]

The Organic Regulation is the baseline for the benefits that organic farming provides. Several rules have direct and indirect impact on biodiversity, responsible use of energy, soil and its organic matter content and GHG emissions.[11] In many instances the environmental and climate performance of organic farmers goes beyond the organic regulation and therefore additional and optimised practices and resulting benefits should be rewarded and incentivized by the EU and Member States through on-top agri-environment-climate measures to further enhance the delivery of public goods. However, in only a few countries have options for agri-environment-climate measures been developed to capitalise specifically on the baseline of organic farming standards.[12]

The multiple benefits of organic farming

Organic consumes less energy and reduces GHG emissions

Organic management shows a positive impact on soil-based greenhouse gas emissions. On average the climate protection performance of organic results in 1082 kg CO_2 eq per hectare and year, due to lower GHG emissions and increased carbon sequestration in soils.[13]

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- **Lower emissions due to prohibition of synthetic fertilizers use**
  The production, transportation and use of fossil fuel-based fertilizers require large energy inputs and significantly contribute to GHG emissions from agriculture. Since synthetic fertilizers are prohibited in organic agriculture and consequently the emissions associated with it are absent the GHG emissions of organic farming are significantly reduced. Studies show that the emission reduction potential by an absence of synthetic fertilizer use is around 20% of the global annual agricultural GHG emissions.[14] Instead of being dependent on external fertilizer inputs, organic farming relies on seeking to close nutrient cycles through natural fixation of nitrogen, the recycling of organic manures and minimizing nitrogen losses. This helps to optimise available nutrients resulting in generally lower nitrogen levels on organic farms.

- **Lower nitrous oxide emissions from soil**
  The use of synthetic fertilizer also contributes to other agricultural emissions, namely nitrous oxide. While nitrous oxide from soils can be released in all farming systems to some extent, the application of synthetic fertilizer increases the emission on site.[13] Studies show a reduction of 40% less nitrous oxide emissions per hectare for organic systems.[15] Nitrous oxide is another major direct GHG emission in agriculture and a reduction of nitrogen application rates is therefore an effective way to reduce emissions.

- **No production of plant protections chemicals**
  The production of pesticides requires a considerable amount of energy, even though it makes up only a fraction of the energy needed for fertiliser production. Estimates of the total GHG emissions, however, vary widely.[16] Since the use of synthetic plant protection agrochemicals is prohibited in organic farming, the emissions associated with their production are thus avoided.

- **Reduced emissions from livestock**
  Besides nitrous oxide emissions, methane from enteric fermentation makes up most of the GHG emissions from agriculture. Considering it being the main share of agricultural emissions, it is a key area to look for emission reduction in the sector. Organic farming sets clear rules on how many animals are allowed per hectare with the objective of not exceeding the holding capacity of the land. A reduced number of animals lowers the emissions connected with synthetic fertiliser in particular as well as manure management, reduces the nitrogen application rate and avoids over-fertilization of land. 42% of organic land are pastures and meadows mostly used for grazing organic livestock[17]; animals in organic systems are kept outside and allowed to graze as much as possible. The EU organic regulation requires 60% of the feed to come from the farm or the same region. This feed composition reduces imports of concentrated feed from outside the EU, where land use changes to produce feed contribute to the global GHG emissions. Using cows with an increased lifespan or breeds of cattle that provide both milk and meat are other measures to decrease the emission per unit product in dairy production and are well suited to organic farming systems.[18]

- **Improved manure management**
  Manure management accounts for around 15% of the agricultural GHG emissions.[3] Improved techniques, such as manure composting is often used in organic agriculture and it can reduce nitrous oxide by 50% and methane emissions by 70%.[9] Reducing emissions from manure management aims for limiting the anaerobic generation of methane or using closed storage to capture methane and use it for instance as biogas. However, in order for biogas production to be sustainable and not negate its benefits through indirect land use changes, it has to exploit waste and residues and not rely on the large-scale cultivation of energy crops (e.g. maize).[19]

- **Lower energy input of organic production**
  Organic agriculture bases its production on on-farm processes instead of being dependent on external energy inputs. Nitrogen fixating legumes, such as clover grass leys, and the use of organic manure to recycle nutrients help to build up soil fertility.[13] Overall, organic agriculture shows a lower energy use per hectare and per unit product. Studies suggests that around 15% less energy are consumed in organic

agriculture per unit produced.[20] A study in Switzerland shows, that even though organic farming uses sometimes more machinery and performs more mechanical weeding, the energy demand per hectare was between 22% and 35% lower per year than conventional farming and per kg harvested dry matter it ranged from 2% to 17% lower energy demand.[21]

Organic sequesters and stores more carbon

Soil organic matter content in arable soils has been declining across the EU, the main drivers being land management and climate.[22] Many common practices of organic farming help to improve soil quality and fertility and contribute significantly to higher soil organic carbon sequestration compared to land under conventional management. The use of organic fertilizer like composted waste from livestock husbandry, improved crop varieties, crop rotations including legumes, reduced tillage and planting of cover crops contribute to the increased carbon storage. A global analysis shows higher soil organic carbon stocks in land under organic management compared to land under conventional management (by 3.5±1.1 tonnes of carbon per hectare) and to higher annual sequestration rates (up to 0.5±0.2 tonnes of carbon per hectare and year).[23] An analysis across Europe shows that reduced tillage under organic farming clearly increases the soil organic carbon content in the surface layer by more than 20% compared to ploughing[24]. Studies conducted in Switzerland show an increase in topsoil organic carbon by 25% with conversion to reduced tillage.[25] Besides climate mitigation, a high humus content also contributes to increased water infiltration and retention, hence reduces erosion and generally improves plant health.[26,27] However, carbon is not only stored in soils, but it can also be sequestered by landscape elements like hedgerows.[i]

SOLMACC – towards greater climate change mitigation and adaptation

SOLMACC (Strategies for Organic and Low input farming to Mitigate and Adapt to Climate Change) was an EU project that demonstrated that farming can be climate-friendly by applying a combination of optimised organic farming practices to respond to climate change. Across Europe, 12 demonstration farms changed their farming practices over the course of five years under close scientific monitoring and supervision. The practices were linked to optimised on-farm nutrient management, optimised crop rotation, optimised tillage system and agroforestry. The farms mainly reduced their on-farm GHG emissions following the adoption of new practices, increased biodiversity and they were able to improve the soil quality. The yields of the participating farms even increased in some cases.

Organic farming protects species and habitat diversity at the field and farm scale

The positive effect of organic farming systems on flora and fauna compared to conventional systems has been demonstrated in numerous studies. [28,29] This is the case for both on individual fields and at farm level and above and below-ground biodiversity. Organically managed areas have on average 30% more species and 50% more individuals.[30,31,32] The strongest positive effect of organic farming on biodiversity is seen in one-year arable crops, followed by special crops (viticulture, orchards), with the smallest effects having been demonstrated in grassland. However, there is yet only a small number of studies focussing on the impact of organic grassland management. A study from Germany noted that plant species numbers in organic and extensive conventional systems were slightly higher than in intensively managed permanent grassland.[33] Organic farming can also support rare insects and spiders and increasing their abundance by 55% and their diversity by 27% compared to conventional farming. Furthermore, rare plant species of open arable land are found in higher diversity and densities on organic farms.[34] It has been shown that organic farming has a positive impact on the diversity and density of pollinators, beneficial insects, plants, the density of destroyers and the diversity of herbivores.[3028,31] Several studies show that organic farming promotes species diversity, the number of individuals and the reproduction rates of wild bees.[35,36]

[i] Even though not part of the EU organic regulation, several private labels include the preservation and construction of landscape elements (e.g. Naturland) which also have a positive impact on biodiversity.

Besides a greater diversity in species, organic farms also provide more diverse habitats. Comparisons of organic farms with conventional farms in Switzerland, Denmark and the UK show that the proportion of semi-natural areas on organic farms is higher than on conventional farms.[37,38,39,40] In many cases, organic farms have smaller field sizes, a higher diversity of farmland and a more varied land use. Organic farming has the potential to promote biodiversity not only locally, but also at the landscape level. In cleared landscapes, organic areas cannot realise their potential for biodiversity.[36,41,42,43] With growing proportions of organic areas in the landscape, the positive effects on biodiversity also continue to increase.[44,45,46,47]

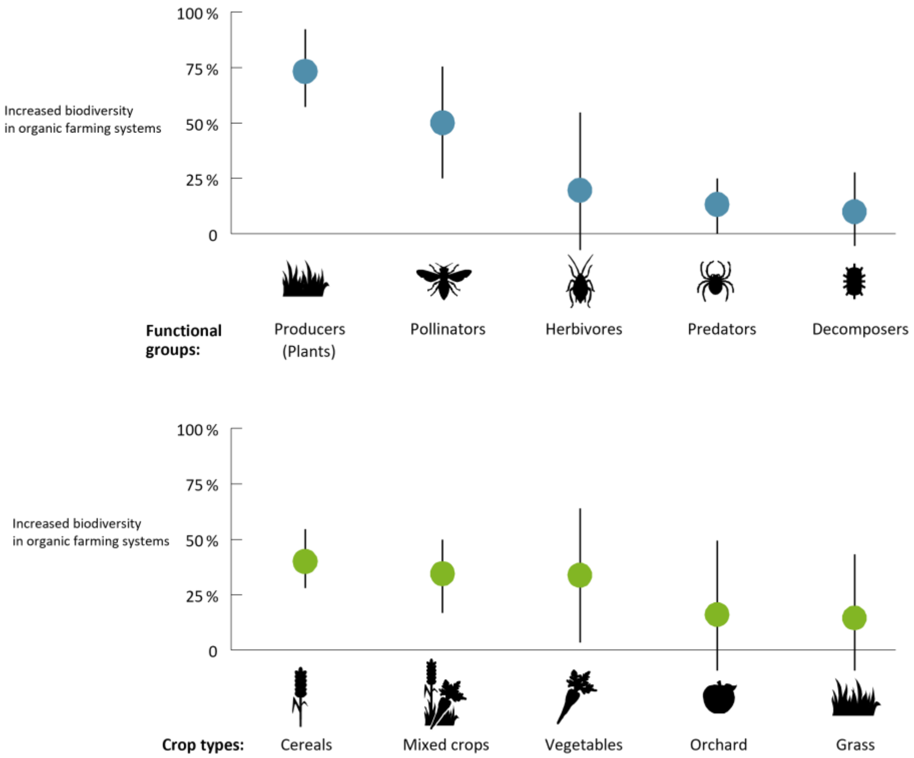

Figure 2 Differences of biodiversity on organic systems compared to conventional farms (Figure adapted from Figure 1 in Tuck et al. 2014[32])

Organic supports ecosystem functions

Biodiversity is an important basis for the functioning of many ecosystem processes and functions. The positive impact of organic farming on crop pollination increases fruit yield and reduces loss due to misshapen fruit.[48] Organic cultivation increases natural pest control in various cases compared to conventional cultivation.[32]

Soil health is the foundation of organic farming and several features that can be observed in soils under organic management, such as an improved soil structure, contribute to soil erosion prevention and flood protection. Organic soils have better soil aggregate stability due to their higher humus content and a higher water infiltration rate of 137%.[49,13] Thus, organic soils are better protected against erosion resulting from heavy precipitation. A reduction of soil erosion and soil loss was identified to be -22% and -26% respectively in organic farming.[13] Soils from organic farming mineralise 30% more nitrogen from a green manure during drought than soils from conventional farming.[50] The rich biodiversity in soils under organic management result in an active soil life and a diverse fungal fauna can reduce pathogens in soils.[28,51] Organic farming has a big potential in protecting ground- and surface water. The contamination of water bodies through fertilizers or pesticides is expected to be lower. Nitrate leaching was shown to be reduced by 28-39% in organically farmed systems.[13] In addition, the avoidance of pesticides has a positive impact on water resources since the input of these substances with a potential toxicity and detrimental effects on the environment are restricted. The restricted use of veterinary drugs in livestock systems has a lower negative impact on water resources too.[13]

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Furthermore, the reduced use of synthetic fertilizers and pesticides limits the negative impact of agricultural practices on air quality. Organic farming reduces emissions of ammonia, particulate matter, oxides of nitrogen, carbon and sulphur, as well as volatile organic compounds and pathogens, which all have adverse effects on human health.[9] [52]

Liivimaa Lihaveis – organic grass-fed beef enhancing biodiversity


©Liivimaa Lihaveis

The Baltic grasslands are very diverse and contain more than 70 species per square meter. A collective farmer initiative of Estonian organic beef farmers founded the NGO Liivimaa Lihaveis and developed an organic grass-fed beef quality scheme aiming to give more added-value to their products. The management of biodiversity rich semi-natural grassland enhances and maintains diverse and plentiful species and habitats while contributing to carbon sequestration. The scheme ensures high animal welfare practices on the farms, and it helps to maintain active and socially resilient communities in rural Estonia.

Organic increases the resilience of farming systems

Consequences of climate change such as more intense and frequent heatwaves, heavy precipitation, droughts and other extreme weather events, can already be observed today and will certainly increase in the future. Agricultural production will have to adapt to these conditions to withstand the additional pressure of pests, diseases and climate variability to ensure resilient food systems. Organic farms often cultivate a higher crop diversity, locally adapted species and sustain more biodiversity in and around their production area. The importance of soil health, building up soil organic matter and promoting a soil rich in beneficial microorganisms allows a higher water capture and retention capacity, reduces erosion, supports plant health and makes organic more resilient to changing weather conditions. The fact that organic farming uses legumes for nitrogen fixation and organic manure and does not rely on synthetic fertilizer, makes the organic system also less dependent to external inputs of non-renewable resources which are often fossil-fuel intensive. The sustainable use of resources, diversification of production systems and the capacity for self-organisation and innovation are essential for socio-economic resilience.

Resilience and adaptability to adverse climate conditions such as extreme weather events and other environmental stressors is enhanced by species and habitat diversity.[53] Crops in organically managed systems can produce higher yields under very dry conditions than comparable crops in conventional management. For example, as shown in studies the yield of organic maize was 137% and the yield of organic soy was 196% relative to conventional management during drought periods.[54] The positive impact of biodiversity can also be seen in species-rich meadows, which are more stable in terms of yield during dry periods and have a longer growing season.[55] Genetic diversity ensures adaptation to future environmental conditions and the structurally rich and heterogeneous landscape promotes the mobility and migration of fauna to new more suitable locations.

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Table 1 Contribution of organic production rules to environmental and climate benefits

Production rules Article numbers refer to Council Regulation (EC) 834/2007 [A] and Commission Regulation (EC) 889/2008 [B]	**Respect natures systems/ cycles**	**Contribute to bio-diversity**	**Make responsible use of natural resources**			
			Energy	**Water**	**Soil**	**Air & climate**
Prohibitions [A: 4 (a) iii and (c)]						
No mineral nitrogen fertilisers [A: 12.1 (e)]	√	√	√	√	√	√
No herbicides, only authorised products can be used [A: 12 (h), B: Annex II]	√	√	√	√	√	√
No landless livestock production [B: 16]	√		√			√
No hydroponic production [B: 4]	√			√	√	
No use of GMOs [A: 9]	√					
Strict control of external inputs [A: 4 (b)], minimisation of the use of non-renewable resources [A: 5 (b)] and recycling of wastes and by-products [A: 5 (c)]						
Only permitted fertilisers : low-soluble mineral fertiliser [A: 4 (b) iii] and soil conditioners when need proven [B: 3, Annex I]	√	√			√	
Only authorised plant protection products when established threat [A: 12.1 (h), B: Annex II]	√	√			√	√
Feed primarily from holding or same region (with exceptions) [A: 14.1 (d)]	√		√			
Stocking density and use of livestock manure restricted to maximum of 170 kg N/ha and year [B: 3 &15.1]	√	√	√	√	√	√
Obligations to use good husbandry practises and prevention [A: 4 (a) iv and 5)						
Multiannual crop rotation including legumes and other green manures [A: 12.1 (b)]	√	√	√	√	√	
Tillage and cultivation practices that maintains organic matter, and protects soil [A: 12.1 (a)]	√	√	√	√	√	
Maintain crop health through prevention (natural enemies, the choice of species and varieties, crop rotation) cultivation techniques and thermal processes [A: 12.1 (g)]	√	√	√		√	
Number of livestock limited to minimise overgrazing, poaching, soil erosion or pollution [A: 14.1 (b) iv]	√	√		√	√	√
Preference for inputs from organic origin (Art 4b with exceptions (Art 4d))						
Manage entire holding organically (with exceptions) [A: 11]	√	√	√	√	√	√
Only organic seed (with exceptions) [A: 12.1]	√					
Only organic feed (with 5 % exceptional rule for monogastrics) [A: 14 (d) ii]	√					

Source: Own analysis based on the Regulations (EC) 834/2007 and (EC) 889/2008 and scientific literature.

Source: European Commission DG AGRI, 2014. Evaluation of the EU legislation on organic farming: study report. Sanders, J.(editor)[11]

Additional agroecological practices with multiple benefits

Even though organic agriculture already contributes to climate and biodiversity protection (see Table 1), there are several additional and optimised farming practices that can be applied on an organic farm. Such practices include agroforestry, with a high potential to sequester atmospheric carbon, and optimised on-farm nutrient recycling, like composting manure and crops residues to close nutrient cycles and reduce GHG emissions. Furthermore, optimised crop rotations, such as the introduction of grain and forage legumes to support soil fertility, nitrogen fixation and carbon sequestration and optimised tillage systems, like reducing the frequency or depth of tillage or apply no-till can improve the beneficial effect of organic farming even further.[56] Other management practices that go in line with the principles of organic farming and that hold benefits for the climate and biodiversity are using appropriate breeds, grassland management and the construction of landscape elements like hedgerows which can sequester additional carbon and are habitats for many species.

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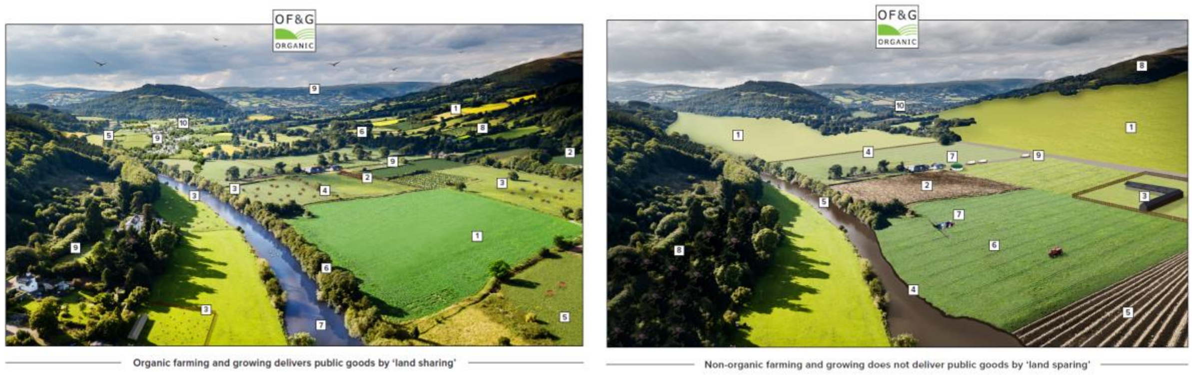
Biodiverse landscapes delivering public goods

The combination of beneficial practices in organic farming for climate and biodiversity in a systems-based approach provides synergies with the potential for greater impacts. Agricultural management and biodiversity enhancement is designed to mutually benefit each other. Organic farming and the benefits associated with its practices, show how a land sharing approach can be used in a constructive way, alternatively to a separation of intensive agriculture low in biodiversity with negative impacts on ecosystem functions and land set aside for nature (see Figure 3). While some species need undisturbed natural habitats, there are several key species, such as farmland birds and arable wildflowers, that have adapted to agricultural systems and thrived within them. A further intensification of agricultural activities would negatively impact these farming-adapted species. Lower intensity, land-sharing approaches such as organic farming, may be better suited to support farmland biodiversity and they play an important role in the mix of approaches, including nature restoration, to deliver on biodiversity protection objectives.[12]



1. Diversity and crop rotations
2. Recycling nutrients, soil health & fertility and building soil carbon
3. Grass-based animal production
4. High animal welfare
5. Unimproved grassland
6. Hedges and field margins for wildlife
7. Reduced pollution and GHG emissions per acre
8. Trees and permanent crops
9. Connecting consumers with their food
10. Increased employment and vibrant rural communities

1. Uniformity and monoculture
2. Open nutrient cycle
3. Intensive livestock production
4. Less hedgerows and wildlife corridors
5. Soil erosion
6. Use of fossil fuel based inputs
7. Increased pollution and GHG emissions per acre
8. Poorer land marginalised 'for nature'
9. Increased transport
10. Low employment

Figure 3 Organic farming and the public goods it delivers compared to non-organic farming (Source: OF&G Organic)

In organic farming, yields per area are on average 20% lower.[57,58,59,60] However, it has been shown that closing the yield gap between organic and conventional farming may be a matter of time and yields approached those of conventional systems after 10-13 years, while at the same time requiring no synthetic nitrogen inputs.[62] Observations from the UK have shown that organic wheat yields are similar to conventional wheat yields in the 1970s. For conventional yields to grow more synthetic nitrogen is required.[61] Organic farming can lead to a greater spatial stability of biotic and abiotic soil processes and improved soil structure and thus secure yields in the longer term.[62] Another factor that reduces the yield gap and gains importance in the light of climate adaption, is the resilience of organically managed systems to extreme weather conditions, such as droughts.[54] Moreover, agricultural diversification practices such as multi-cropping and crop rotations have the potential to substantially reduce the yield gap and as research is advancing and the understanding of organic agricultural practices increases, the yield gap between organic and conventional production is likely to decrease as well.[57]

However, to counterbalance possible lower yields, an increase in organic has to go alongside changes in food consumption, such as reducing food waste and shift to more plant-based diets. The fact that organic farming is less dependent on external inputs allows a greater sovereignty, with more control over the agricultural production processes and the associated costs. It empowers farmers by creating agricultural systems that are more resilient towards the impacts of climate change and by reducing their dependence on external inputs. The yield levels under conventional farming can only be sustained with the additional input of external products, such as synthetic fertilizer and pesticides.

Systemic approach is needed

A systemic approach is needed to establish sustainable synergies between different land use purposes such as food production, biodiversity protection and climate benefits. A 'sustainable intensification' agenda, which aims to increase production with fewer inputs, and therefore free land for nature conservation, focuses on partial technical solutions which do not halt farm expansion, concentration and specialisation dynamics which are often major drivers of biodiversity loss and land degradation.[63] According to the study of IDDRI it is possible for a European agriculture based entirely on agro-ecological practices to provide a balanced diet for all Europeans by 2050.[63] Among others, a reduced consumption of animal products and therefore reduction of number of farm animals and substantial reduction in food waste make it possible to combine nature conservation with high agro-biodiversity. A combination of extensive herbivore systems and diversified organic cropping systems allows ambitious biodiversity protection, while reducing GHG emissions.

The sometimes lower yields in organic agriculture lead to a higher GHG intensity per unit product, even if the emissions are lower when considered per area. Some studies, for example from Austria, show however that products have on average 25% lower GHG emissions per kg of product in organic production compared to conventional production.[64] However, focussing on efficiency only is partly misleading and does not take yield stability over time, resilience and other environmental impacts such as nitrate leaching into groundwater, air pollution, soil health or biodiversity loss into account, often consequences of intensifying food yield beyond sustainable limits. Organic farming tends to perform better when it comes to environmental parameters measured per unit area (Figure 4).[65] Many impacts on the environment and ecosystem are mainly relevant within their ecosystem boundaries which requires a focus on performance not only per unit product but also per agricultural land area. A comprehensive system approach is needed to address all challenges such as maintaining soil fertility, nutrient recycling and ecosystem contributions.[66] Current agricultural practices should not negatively impact the long-term sustainable land use and future yields.

Furthermore, it is important to keep in mind that in Europe an estimated 20% of the food produced ends up being wasted.[67] At the same time the consumption of red meat exceeds recommendations for a healthy diet whereas much of the agricultural land in Europe is dedicated to livestock, due to feed production. Organic farming with grassland-based livestock production and adequate stocking rates does not only address nitrate loss into groundwater but also contributes to animal welfare. The grassland-based system allows the use of grassland areas which are unsuitable for crop production and reduces pressure on cropland. The reduced numbers of animals in organic farming in relation to the available agricultural land area and the regional feed go hand-in-hand with improved environmental indicators, animal welfare, lower GHG emissions and carbon storage whereas intensive livestock production based on imported feed may have negative effects both in Europe and in the feed producing country. What is needed is therefore not just a focus on production volumes but on how we can use the available resources more efficiently, through improved distribution, reduction of food waste and healthy and sustainable diets.

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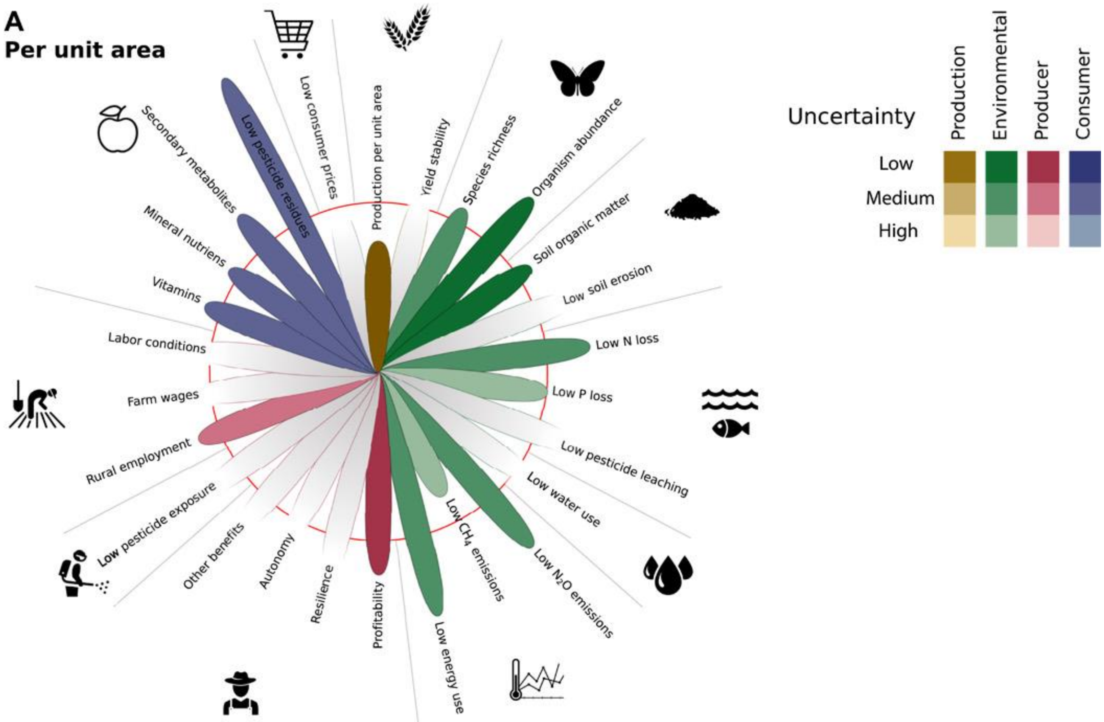

Figure 4 Average performance per unit area of organic agriculture relative to conventional agriculture (indicated by the red circle; larger petals represent superior organic performance). Source: Seufert and Ramankutty (2017)[68]

The way forward

A historic lack of scientific support which still continues today, leaves organic farming potential for improvement. Advancing research, improving crop varieties adapted to organic management and addressing other yield-limiting factors such as pest control, could contribute to an increased productivity of organic farming. The organic movement is constantly improving its practices to contribute to climate mitigation, adaptation and biodiversity protection. Focusing on best practices could further enhance the multiple benefits of organic. Successful knowledge transfer will be important including an adequate communication of research findings together with their translation into practice.[69]

Organic farming offers various benefits and potential solutions to reduce the climate impact of food production, support sustainable production in a changing climate while promoting biodiversity at field, farm and landscape level. It offers a way to provide sustainable and healthy diets in the long term not exceeding planetary boundaries.

Policy recommendations

- **Adopt a systemic approach to reduce negative environmental impacts from food production**
  Organic farming has a systemic approach that reduces the environmental impact compared to conventional farming. Increasing land under organic farming can contribute to climate mitigation, improve the resilience of farming systems, contributing to soil health and preserving or improving biodiversity.

- **Carbon farming has to take a holistic and multi-dimensional approach**
  The European Commission presented the “Sustainable Carbon Cycles” communication, which addresses how to increase carbon sequestration and to scale up carbon farming as a business model. It is essential that carbon farming not only delivers on increased carbon sequestration, but ensures at the same time benefits for climate adaptation, biodiversity, and other environmental objectives. The multiple benefits

of organic farming should be recognized and to avoid trade-offs, clear environmental and biodiversity safeguards are needed.

- **Ensure coherence with the CAP Strategic Plans and the 25% organic target**
  Ensure that the strategic plans submitted by the Member States are ambitious and contribute to the significant development of organic farming in the EU to reach the target of 25% of agricultural land under organic management by 2030 as stated in the Farm to Fork and Biodiversity Strategies.

- **Strengthen the support for sustainable farming practices that provide public goods and transition towards agroecology**
  Funds should be provided for scaling up organic farming systems. To maximise the environmental and climate potential of organic farming beyond the scope of organic standards, the EU must ensure that Member States prioritise organic farming under “on-top” agri-environmental-climate schemes targeted at climate mitigation, adaptation and other environmental goals (in addition to organic farming payments). For example, access to relevant schemes can further improve biodiversity and climate performance through supporting the active management of hedgerows, field boundaries and margins, birds and other endangered species as well as carbon sequestration. Training and extension work on agroecological practices should be integrated into education programmes. Adequate and tailored advisory, knowledge sharing and training that address sustainable land management in a systemic way to reduce all negative impacts from agriculture should further support the needed transition and shift in practices.

- **Research that further improves organic farming**
  Ensure a good representation of organic in the upcoming Horizon Europe work programme and support setting up a network of organic living labs that contribute to climate and biodiversity protection.

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