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# ORGANIC AGRICULTURE

## A Strategy for Climate Change Adaptation

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# I. EXECUTIVE SUMMARY

Changing climate patterns have already begun to have considerable impact on agricultural production in many regions. In the near future, shifts in local climatic conditions and the frequency of extreme weather events such as droughts and floods are expected to occur even more frequently, with potentially devastating effects for agricultural yields. Strategies need to be developed to make our food and farming systems more resilient to the effects of climate change. This dossier presents the latest scientific findings to show how organic farming as a holistic sustainable production system can contribute to effective climate change adaptation strategies for the agriculture sector.

The first article by Adrian Müller and Andreas Gattinger demonstrates that farm systems need to become more resilient to climate change impacts such as water stress and increased pest pressure in order to avoid extensive losses in agricultural production. **Organic farming practices are an investment in climate change resilience**. Crop rotation and the use of organic fertilisers contribute to improved soil structures and therefore reduce water erosion due to heavy rain fall, and enhance water supply during dry periods. Furthermore crop and income diversification can help to reduce economic risks for the farmer.

With a focus on **Northern Europe**, Jørgen E. Olesen outlines how changing temperatures and precipitation patterns will impact on farming in the future. Increasing temperatures will lead to the expansion northwards of crops such as grain maize or sunflowers, on the other hand yields for some cereals are expected to decline. Olesen argues that farming systems will need to increase their resilience to climatic extremes. Diverse crop rotations and soils that provide good water supplies during droughts, and rapid water infiltration and drainage during periods of intense rainfall are major parts of any adaptation strategy – as well as characteristic of organic farming systems.

Eduardo Aguilera, Gloria Guzmán and Livia Ortolani describe the impacts of climate change on agriculture in **Mediterranean regions**. A rise in temperatures and drought is expected in this region with many soils extremely vulnerable due to their low organic matter content. Moreover changing climate patterns might lead to the loss of important typical regional production as well as the market opportunities that geographical indications offer farmers. Practices that are common in organic agriculture such as the use of organic fertilisers, cover crops, robust traditional crops and good biodiversity management are the main elements that can help farmers to successfully cope with the changing climate.

In the final article, Antje Kölling and Teresa Elola-Calderón analyse the international and European legal context of climate change adaptation in agriculture, exploring how EU policy frameworks can support the development and expansion of organic systems as effective strategy and solutions to climate adaptation.


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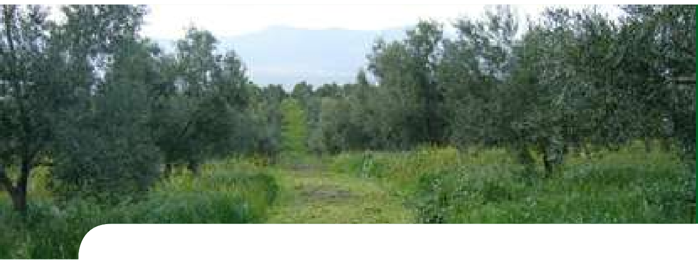


# II. ORGANIC FARMING PRACTICES AND CLIMATE CHANGE ADAPTATION

Adrian Müller, Andreas Gattinger, Research Institute of Organic Agriculture FiBL, Switzerland

## 1. Introduction

The need to adapt to climate change is one of the main challenges facing the future of agriculture. Even if strong and effective mitigation measures were taken, even if greenhouse gas emissions dropped to zero immediately, the climate would continue to change for decades. This is why adaptation is necessary. If global warming can be kept to a moderate level, our need to adapt might primarily reflect gradual changes; but if temperatures rise sharply, adaptation measures will necessarily involve some fundamental transformations in agricultural production. Moreover, as the effects of climate change can vary greatly at local and regional levels, even moderate global warming can trigger fundamental changes in some places.

The main ways in which climate change can affect agriculture are through increased levels of $CO_2$, changing temperatures, climate variability and the frequency of extreme weather events. It can also cause changes in precipitation and transpiration regimes and shifts in crop growing seasons, and it can alter weed, pest and pathogen pressures. Higher $CO_2$ concentrations and a moderate rise in temperature will lead to increased crop yields. However, this positive effect would be cancelled out if the temperature increases by more than 1.5°C. This is very likely to happen, given that huge mitigation efforts would be needed to keep temperature increases even below 2°C (*Rogelj et al., 2011*). Increased variability and frequency of extreme weather events such as droughts or heavy rains also have an adverse effect on agricultural production. With changing precipitation and transpiration regimes, the drier zones of the lower latitudes will generally shift to higher latitudes; precipitation will increase near the equator and in the higher latitudes. Total global precipitation will increase and the current monsoon and El Niño regimes will change. All these changes will, however, be subject to strong regional variability. Climate change will have a big impacts on rainfall patterns, water availability and irrigation needs. The changing climate will likewise cause changes in weed, pest and pathogen pressures. These will manifest themselves as a spread from the lower to mid-latitudes, and pest and disease outbreaks will be reinforced by climatic extremes.

All these influences on agriculture will become clearly apparent in the second half of the 21st century, when the effects will become increasingly negative. The adverse consequences of climate change will emerge earlier and have a stronger impact in the lower latitudes, while mid and higher latitudes will experience less pronounced effects which develop more slowly. More detailed information about the various effects of climate change can be found in *Easterling et al., (2007)*, *Meehl et al., (2007)* and *Rosenzweig and Tubiello (2007)*.

## 2. Adaptation needs

Several key inferences can be made regarding agriculture, based in this understanding of the effects of climate change. As formulated in *Müller et al., (2012, p104)*, for example, "First, impacts vary strongly per region. […] Second, water will be a key issue, in particular due to water scarcity and drought, but also because of extreme precipitation events, waterlogging


**Flower strip besides a cabbage field which provides habitat for beneficial organisms, essential for pollination and disease and pest control of crop plants.**

and flooding. Third, increased weed, pest and disease pressure will challenge agriculture. Fourth, extreme events will put further stress on agricultural production. Fifth, climate variability and the risk in agricultural production will increase". In the light of these increasing uncertainties, adaptation strategies are needed to reduce the risks involved in agriculture. Likewise, it is necessary to promote plant and animal health in response to the increased stress placed upon them. Finally, potentially drastic changes in the climate may force a transition from intensive crop production to extensive grass-based animal husbandry, and could even make agricultural production essentially impossible in certain regions. As such, in certain contexts it might become necessary to consider some fundamental transformations in livelihoods.

Taking steps to diminish the risks that affect agriculture will essentially reduce the otherwise extensive losses in crop harvests or livestock production which are likely to occur. A first strategy is diversified production, which means that each of several production activities contributes only a smaller part of a farm's revenues. If one area of production fails the financial losses will be limited. Diversification of farm production is a concept practised by rural communities in developing countries and emerging economies, and was also the dominant farming model for centuries in Europe. A second strategy is to reduce the financial risk by minimising input costs. Then if crop losses occur, the extent of the financial loss due to unrecoverable investments is lower. A third strategy is to increase resilience to the effects of climate change in individual areas of production, thus mitigating any adverse effects and corresponding losses. Increasing resilience can be achieved, for example, by improving plant and animal health, because healthy organisms are better able to cope with pest and disease pressure and adverse environmental conditions such as heat waves or water shortages. A fourth possible strategy for avoiding existential financial losses through farming is the use of insurance solutions, such as those already widely used today to protect against losses from hail. However, given the increasing risks, the cost of such insurance schemes may become prohibitive. Insurance solutions such as those based on weather indices (deviations from long-term precipitation and temperature averages as recorded in a nearby reference climate monitoring station) are available in a different institutional setting other than agricultural production and we do not address them in this paper.

## 3. The potential of organic agriculture

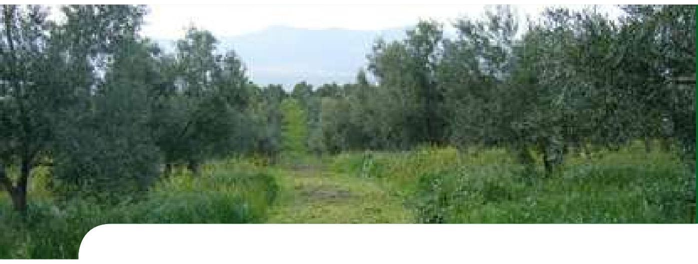
Many of its core characteristics mean organic agriculture is potentially well placed to support the first three adaptation strategies outlined above. Detailed discussions of this can be found in *Müller et al., (2012)*, *El-Hage Scialabba and Müller-Lindenlauf (2010)*, *Niggli (2009)*, *Borron (2006)* and *Milestad and Darnhofer (2003)*. Here we provide a brief overview of their results.

On average, due to crop rotation and organic production practices, rates of biodiversity and crop diversity are higher on organic farms than conventional farms. Set-aside areas and landscape elements such as hedges further increase biodiversity. This diversity in turn improves ecological and economic stability; it reduces pest outbreaks and plant and animal diseases and improves the utilization of nutrients and water (*Smith et al., 2011*).

Organic agriculture uses fewer external inputs, establishes closed nutrient cycles and fosters the optimal use of natural resources, ecosystem services and biological functions, such as predator prey dynamics (*IFOAM EU Group, 2010*). The practice of encouraging such processes with targeted interventions is known as eco-functional intensification (*TP Organics, 2010*). In this way, organic farming responds perfectly to the need for risk-reducing strategies, as it lowers input costs, fosters diversity and invests in healthy organisms. In the long run, this approach increases competitiveness, lowers the risks of incurring debt, and might even protect the livelihoods of small-scale and poorer farmers (*El-Hage Scialabba and Hattam, 2002; Eyhorn, 2007*). An additional financial benefit stems from the price premium for organic products if they are marketed within a certification system.

Furthermore, soil fertility is enhanced as a result of organic agriculture, not only because of the organic fertilizers used, but also the crop rotations involving deep rooting forage legumes which increase and stabilize soil organic matter. This results in significantly enhanced soil organic carbon levels (*Gattinger et al., 2012*) and thus works in synergy with climate change mitigation strategies used in farming, as a form of carbon sequestration. It also contributes to increased water capture and storage capacity (*Reganold et al., 1987*), reduced soil erosion (*Siegrist et al., 1998*) and increased aggregate stability. Moreover, it also stimulates biological activity and raises the diversity of soil life (*Lampkin, 2007; Mäder et al., 2006*). Soils that are rich in organic matter therefore absorb more water during extreme rainfall, reduce surface run-off and erosion, and can sustain a supply of water during dry periods. Consequently, organic agriculture is likely to provide greater resilience in the face of water scarcity and extreme weather events, as well as their consequences such as heavy precipitation, floods and waterlogging (*El-Hage Scialabba and Müller-Lindenlauf, 2010*)

It is important to note that the best practices for farming described above, which produce such a wide range of benefits, are not exclusive to organic agriculture. They are core



elements of organic production, but they can likewise be employed in conventional agriculture. Indeed some of the approaches do feature prominently in more general suggestions for adaptation in agriculture. However, conventional agriculture still generally fails to acknowledge the adaptation value of the systemic view of soil fertility and biodiversity adopted in organic agriculture.

Other adaptation practices such as agro-forestry are not widely used in organic agriculture, but would fit perfectly well in organic production systems. Agro-forestry systems and the use of shade trees can help to mitigate daily temperature peaks and thus improve resilience to heat waves. Such systems also increase the extent of carbon sequestration (*Smith and Olesen, 2010*).

Finally, as a knowledge based system organic agriculture is well placed to use local farmers' knowledge and locally adapted varieties and breeds. It can foster an adaptive and often participative learning approach to the development of crops and practices. These are important sources for greater diversity and adaptation in agriculture.


**Soil profile, with a humus rich top horizon under maize. This soil needs regular organic matter replacement through forage legume cropping, green manure and farmyard manure application because of the pronounced carbon losses associated with maize cropping for silage.**

## 4. Challenges

Because of its complexity, organic agriculture is not a panacea. Organic farming is knowledge intensive, and converting to it involves well organised and high quality training, as well as a supply of information and advisory services.

In developing countries the market structure presents a risk for organic farmers. At present, some regions are strongly export oriented. This mainly involves cash crops so the price premium plays an important role in the farm economy. This can result in a dangerous dependence on the export markets and there is a need for diversification to local markets.

Finally, in some regions the effects of climate change might be so devastating that agriculture has to be completely abandoned. It is very difficult to forecast the local effects of climate change beyond a period of two decades. Thus it is important to consider with caution the possibility that an ideal short term adaptation of agricultural production to the changing climate could lead into a *cul-de-sac* if more fundamental changes become necessary later on.

Time must also be taken now to prepare for the long term changes. In the event that early warning indicators point to the emergence of fundamental difficulties for agriculture in a particular region, income alternatives for the affected population should be considered as early as possible.

## 5. Conclusions

Systemic approaches to soil fertility and biodiversity are one key to the successful adaptation of agriculture. With its core values and characteristics, organic agriculture has already adopted such approaches and therefore represents a promising adaptation strategy. Additional benefits come from the synergies between adaptation and mitigation that can be realised by increasing soil organic matter.

It has been shown that organic agriculture is a promising adaptation strategy. To achieve a broader impact some core practices of organic agriculture, such as the high diversity of crops and practices, and the use of organic fertilizers and legume leys, should also be promoted for use in conventional agriculture without the necessity of full conversion to organic production. If properly applied, planning for climate change adaptation can potentially increase the sustainability of all agriculture by introducing practices such as agro-forestry and the diversification of crop rotations, and by helping to establish healthy soils and diversified production systems, in conventional contexts as well as in organic.

# III. FARM ADAPTATION TO CLIMATE CHANGE IN NORTHERN EUROPE

Jørgen E. Olesen, Aarhus University, Department of Agroecology, Denmark

- In northern Europe climatic warming will increase the range of suitable crops for cultivation.
- A northward expansion of a range of crops has already been noticed, including silage and grain maize, sunflowers and grapevines.
- A warmer climate in northern Europe will be beneficial for warm season crops, but will also cause a decline in yield for some of the cereal and seed crops currently grown.
- The major challenges from climate change are the increasing frequency of extreme weather events, such as heat waves, cold spells, droughts, floods and storms.
- Farming systems will need to consider approaches that increase their resilience to climatic extremes. This will include greater diversity in the crop rotations as well as soils that provide a good water supply during droughts and rapid water infiltration and drainage during periods of intense rainfall.

## 1. Introduction

Since 1901 most of Europe has experienced increases in annual mean surface air temperatures, which amount to 0.9°C for the entire continent (*EEA, 2012*). This warming trend has been much stronger in recent decades, with parts of northern Europe seeing dramatic increases in temperature over the last twenty years. For example, since 2000 the mean temperature in Denmark has been 1.2°C higher than the long-term mean between 1961 and 1990. These temperature trends have been most pronounced in central and north-eastern Europe and in mountainous regions. Temperature variability has also increased, with more warm extremes being observed in particular.

It is not only the temperature that is changing in Europe; there have also been changes in precipitation patterns. Across large parts of northern Europe, the weather has become wetter, while rainfall is decreasing around the Mediterranean. In Denmark, the average winter precipitation has increased by 100 mm over the past 40 years (*Klein Tank et al., 2002*). In other parts of Europe, drought events during spring and early summer are becoming more frequent. The frequency of droughts has increased in large areas of western and eastern Europe, and particularly large increases have been experienced in the Mediterranean region. Rainfall events have also become more intense, even in areas that are getting drier (*Frich et al., 2002*). The weather is therefore becoming more extreme, and all these changes will have a potentially adverse effect on agricultural crop production, although some regions may also benefit from the changes (*Olesen et al., 2011*).

## 2. Extremes are becoming more frequent

For three weeks in August 2002 severe flooding affected parts of Austria, the Czech Republic and Germany. This was caused by heavy rainfall from storms crossing central Europe in early August, which triggered a series of flood waves moving down central European rivers. Climate modelling has shown that global warming is probably linked to a shift towards heavier and more intense summertime precipitation over large parts of Europe (*Christensen and Christensen, 2002*), and such high precipitation events have indeed been observed much more frequently in Europe in recent years. For instance, in 2011 Copenhagen was flooded three times following high rainfall events (*Leonardsen, 2012*), and large losses were also incurred in agricultural areas due to flooding. High intensity rainfall events may occur more frequently in future. This will have consequences for the landscape because one of the main forms of flood protection is to set aside areas of agricultural land to serve as a buffer. During a flood, these agricultural areas are flooded first, destroying the crops but saving the much more valuable infrastructure of the European cities.

In 2003 a severe heat wave lasted from June to mid-August over large parts of Europe, raising summer temperatures by 3 to 5°C. Maximum temperatures of 35 to 40°C were repeatedly recorded in most southern and central European countries. The heat wave was associated with rainfall deficits of up to 300 mm, while the drought and high temperatures caused a decline in crop and livestock production across central and southern Europe valued at 11 billion euros (*Ciais et al., 2005*). Statistically, this heat wave has been shown to be an extremely unlikely event in the current climate. However, it is consistent with the combined increase in mean temperature and

temperature variability resulting from anthropogenic climate change, which is expected towards the end of this century (*Schär et al., 2004*). Since 2003 severe heat waves have had an adverse effect on crop production in western Europe in 2005 and 2006, and in eastern Europe in 2007, 2010 and 2012.


**Drought impacts on wheat field: Soil cracks. Puglia region, Italy, 2011.**

The meteorological records leave no doubt that the weather is becoming more variable with respect to both temperature and rainfall. This also means there are more extremes, in particular more heat waves which are often coupled with droughts, and more intense rainfall events that are often tied to flooding.

## 3. Farmers are adapting to climate change

Even now, farmers are already adapting to the climatic changes. This is quite understandable as farms are constantly experimenting with new cropping techniques, and the most successful of these are quickly shared among the farming community, where agricultural advisors and researchers promote the efficient take-up and dissemination of new findings (*Olesen et al., 2002*).

The consequences of the warming of the European climate can be seen most easily in the extent to which warm season crops are grown. A typical example of this is the cultivation of maize in northern Europe (*Odgaard et al., 2011*). Maize is used in most of north-western Europe for the production of silage as fodder for cows in intensive dairy farming systems. However, until the early 1990's very little silage maize was grown in Britain or Scandinavia as the climate was too cold and the frequency of poor harvests was too high. Since then, the climate has become warmer and now almost all dairy farmers in Denmark base the feeding of their cattle on a diet of maize and grass (Figure 1).

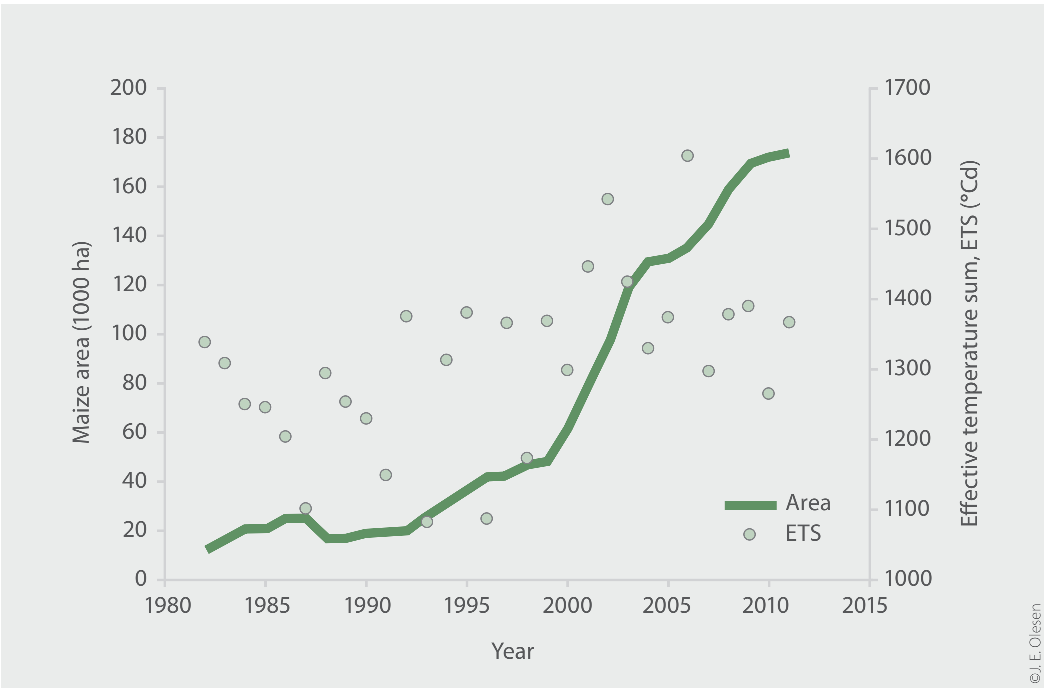



**Figure 1. Area of silage maize in Denmark and the annual effective temperature sum (ETS) above 6°C. The inserted graph shows the relationship between ETS and yield of silage maize using data from Statistics Denmark.**

During the 1990's and early 2000's farmers and agricultural advisors in Denmark did not attribute the increase in the silage maize area to climate change. Instead they argued that new maize cultivars were better adapted to the cool Danish climate, and that this was the reason why farmers chose to grow maize. The real reason was the longer and warmer summers. But even if the farmers were unaware of the real reasons for the change, they still responded appropriately by planting the more productive maize crop rather than fodder beet and whole-cereal crops for silage. Farmers today therefore demonstrate a willingness to adapt quickly to circumstances, including new environmental conditions.

### a) Future climate changes

Recent climate models project that the most extensive warming will occur in eastern Europe during winter, and in western and southern Europe in June, July and August. A very large increase in summer temperatures is projected for the southwestern parts of Europe, possibly exceeding 6°C in areas of France and the Iberian Peninsula by the end of the 21st century (*Christensen et al., 2007*). There is a clear indication that variability in temperature and rainfall may increase considerably over large parts of Europe (*Trnka et al., 2011*). Indeed heat waves and droughts similar to the 2003 situation may become the norm in central and southern Europe by the end of the 21st century.

All the scenarios demonstrate one general trend, namely that the mean annual precipitation increases in northern Europe and decreases further south. Increased winter precipitation is projected for northern and central Europe, whereas summer precipitation will decrease substantially in southern and central Europe, and to a lesser extent also northern Europe. These changes represent more or less a continuation of the trend that has already been observed. There are also clear indications that a more variable climate is to be expected, and thus that extreme weather events will become more frequent.

### b) New crops

Climatic warming will lead to the northward expansion of the cultivable area for cereals such as wheat and maize (*Elsgaard et al., 2012*). For traditional cereal crops like barley and wheat, a rise in temperatures will also lead to a small reduction in yields in areas that currently have cool temperate climates. The warmer temperatures have already been observed to reduce yields of winter wheat in many countries in northern and central Europe (*Brisson et al., 2010*). Drier conditions and increasing temperatures in the Mediterranean region and parts of eastern Europe will lead to larger yield reductions there.

Some crops that at present grow mostly in southern Europe (e.g. maize, sunflower and soybeans) will become more suitable for cultivation further north (*Olesen et al., 2011*). Climate change projections show a 30 to 50% increase in the area suitable for grain maize production in Europe by the end of the 21st century, including Ireland, Scotland, southern Sweden and Finland (*Olesen et al., 2007*).


**Cropping of silage maize and grain maize will expand into large parts of northern Europe with the projected climatic warming.**

Grapevines require relatively high temperatures to grow. A warming climate will therefore expand the suitable areas northwards and eastwards. Meanwhile, in the current wine growing areas the yield variability (fruit production and quality) will become greater than at present, which implies a higher economic risk for the growers. Climatic warming is also likely to reduce the suitability of conditions for today's economically important traditional grape varieties, at least in their current locations.

Other warm season fruits like oranges and kiwis will also spread northwards opening up new opportunities for farmers in central and northern Europe. This will also be the case for vegetable crops, for which both the choice of vegetables grown (e.g. tomatoes and peppers) and the length of the growing season will increase.

## 4. Increasing resilience

The main challenge facing European farmers in the future will be the increased variability of the weather, with greater differences in temperature between seasons and years, and more extreme rainfall patterns that include longer dry spells in the summer, more intense rainfall events and an increased risk of flooding. All this creates new problems for cropping systems. On the one hand the systems must be able to resist or recover from severe heat waves and droughts; on the other they will have to cope with intense rainfalls and waterlogged soils (*Refsgaard et al., 2013*).

Studies of current European farming systems have shown that those which use intensive farming methods with high inputs and monocultures are more vulnerable to climate change than more diverse farming systems using fewer inputs (*Reidsma et al., 2010*). The high vulnerability of intensive cropping systems to increased temperatures and droughts is related to their high water requirements. Higher temperatures mean higher evaporation rates, which means there is a need for soils which ensure an improved water supply for the crops. This can be accomplished in part through better soil management practices that increase the organic matter content of soils, improve their structure and retain surface crop residues that help reduce soil evaporation (*Smith and Olesen, 2010*).

Soils also need to absorb water more effectively during intense rainfall events. To achieve this, it is important to improve soil structures through measures such as cover cropping. At the same time, changes must be introduced at the landscape level, where there is a need for buffer zones to store water before it can be channelled to the streams and rivers and subsequently to the sea (*Ebert et al., 2009*). Adapting to climate change therefore requires a holistic effort involving not only farmers, but also other land holders and society in general. Besides the need to sustain agricultural productivity, these efforts should also consider the need for environmental protection to ensure that nature and biodiversity can also adapt to the changing conditions.

## 5. The role of organic agriculture

Organic agriculture focuses on diversity within the farming system and it aims to maintain healthy and well functioning soils. Both these attributes will contribute to greater resilience in the face of increased climatic variability and more extreme weather (*El-Hage Scialabba and Müller-Lindelauf, 2010*). There is empirical evidence to show that crop yields in low input farming systems are less susceptible to climatic variability than the yields in modern high input systems (*Trnka et al., 2012*). However, the underlying factors that influence these crop responses are still poorly understood.

The diversity of organic farming systems helps increase resilience to climatic variability and extremes in several ways. Organic farms often keep animals, which helps to balance variations in production of cash crops. In terms of productivity, pasture and forage crops that provide feed for ruminant animals often respond differently to extremes than do cereals and seed crops. Nevertheless, in severe droughts all types of crop will suffer. Diversity within the farming systems, as promoted through the use of cover crops, beetle banks, hedgerows, agroforestry systems etc., offers protection from erosion caused by high intensity rainfall. Such measures also provide a degree of ecological buffering to protect against the pests and diseases which might also flourish as a result of climate change (*Olesen et al., 2011*). Introducing trees into the landscape by planting hedgerows or practising agroforestry also helps as it provides shade that moderates the microclimate by reducing high temperatures.

Improving soil organic matter and soil structure helps to reduce the impacts of droughts and high intensity rainfall by improving water infiltration into the soil. Along with this increased rainwater harvest, the water supply to crops also improves due to better soil water retention and root growth.


**Cover crops contribute to climate change resilience in several ways: they improve the structure of soils and thus also their water holding capacity and water infiltration; they reduce the extent of soil erosion; and they reduce nitrate leaching. Denmark, September 2012.**

# IV. ADAPTING TO CLIMATE CHANGE IN THE MEDITERRANEAN REGION: THE POTENTIAL BENEFITS OF ORGANIC AGRICULTURE

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Livia Ortolani, Associazione Italiana per l'Agricoltura Biologica (AIAB), Italy

## 1. Introduction

In many rural Mediterranean areas, agriculture is closely tied to social and economic development. Societies, economies and cultures have evolved in adaptation to the prevailing climatic conditions and weather variability (*Iglesias et al., 2011*). The complex issue today is to define priorities for adaptation strategies.

While the impact of mitigation actions is largely dependent on natural dynamics, adaptation to changing climates is more directly related to local communities. Efforts to adapt must therefore pay special attention to the human dimension. It is important to consider the local context, socio-economic conditions and farm management practices, in order to develop effective adaptation strategies (*Reidsma et al., 2010*). Depending on the local climatic and economic conditions, farmers should take steps each year to adapt to climate change by changing their crop rotations and use of external inputs. These two strategies are both essential elements of organic farming.

The Mediterranean region is one of the so-called climate change hot spots. It is a transition zone between northern Africa and central Europe, where the weather is mild and wet during the winter and hot and dry in the summer. Thus an arid climate with tropical processes interacts with a temperate and rainy climate. Any small shifts in the general circulation dynamics have an immediate effect on the Mediterranean region, causing substantial changes and having a direct impact on farmers' livelihoods (*Giorgi and Lionello, 2008; Schar et al., 2004; Metzger et al., 2006*).

## 2. Climate change impacts on Mediterranean agriculture

Many climate models have been used to simulate the impacts of climate change in Europe at the regional level. Climate models for the Mediterranean region (*Raisanen et al., 2004; Deque et al., 2005; Christensen and Christensen, 2003*) have forecast a rise in temperature and a fall in precipitation that will affect the quality, quantity and management of water resources (*Garcia-Ruiz et al., 2011, Rosenzweig and Tubiello, 1996*). This will have a direct impact on irrigated agriculture, which accounts for more than half of the value of food consumed and exported in the Mediterranean region, even though the irrigated area is just a small fraction of the total agricultural area (*Iglesias et al., 2011*).

Due to high rates of erosion, Mediterranean agro-ecosystems are characterized by a decline in organic matter and the vulnerability of soil organic pools. Moreover, the increased incidence of extreme weather events, such as the heavy and concentrated precipitation that strongly influenced the sowing season in Italy in 2011, has already had an appreciable impact on the annual cereal production (*INEA, 2012*). The different climate change scenarios are all expected to have a more adverse effect on crop yields and to cause a greater risk of yield losses, than will occur in temperate areas (*Ferrara et al., 2010*). The extreme weather events are also causing a rise in cost of insurance, which represents an indirect impact on farmers' incomes.

In Mediterranean areas, as a rule, farmers' incomes are not only directly linked to productivity but also to the capacity to link production to the territory. This regional identity increases the commercial value of high quality agricultural products, which is reflected in the frequent use of geographical indications (PGI and PDO) in these regions. If climate change necessitates a complete shift in cultivation patterns, this could detract from the marketing of typical regional products and thus have a direct impact on local agriculture and farmers' incomes.

## 3. The potential benefits of organic farming for climate change adaptation in the Mediterranean region

The capacity to adapt to the changing climate and extreme weather events by altering farm management practices can significantly reduce the impacts of climate change. Adaptation strategies are therefore a challenge for Mediterranean areas, which are characterized by high vulnerability and a low capacity to adapt (*Metzger et al., 2006*). The acquisition of new management skills and the development of innovation in rural areas can increase farmers' individual coping capacities (*Iglesias et al., 2011*). At the same time, traditional farming systems that have retained the capacity to use and select crop varieties adapted to their local agro-ecosystems are particularly

important for the economic welfare of rural communities. They can add important potential benefits in the context of adaptation. Organic farming can contribute to both mitigation and adaptation in many different ways, such as on the use of organic fertilizers, the diversification of systems and the reduced use of fossil fuel.

### a) Use of organic fertilisers

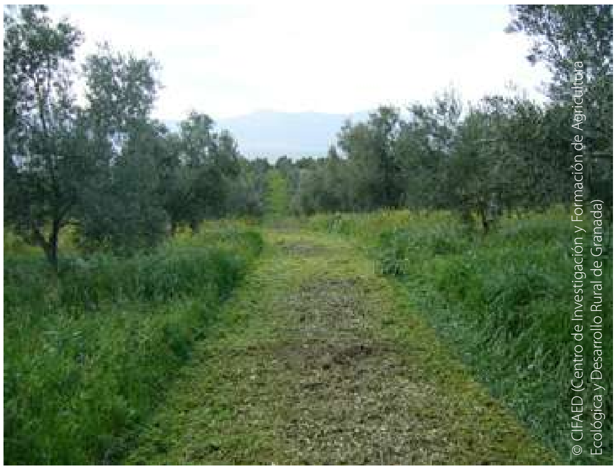
As synthetic fertilisers are prohibited in organic farming, farmers must rely on organic fertilizers. Using such fertilisers means that the soil usually receives more organic material than it does in conventional systems. This promotes the accumulation of organic carbon in the soil, which thus produces a synergy effect for climate change mitigation and adaptation as more atmospheric carbon is sequestered in the form of soil organic matter (SOM). In Mediterranean cropping systems, the average accumulation of soil carbon in organic systems amounts to approximately one tonne of carbon per hectare and year, which is equivalent to 3.7 tonnes of $CO_2$ per hectare and year more than in conventionally managed soils. These carbon sequestration rates depend to a great extent on the quantity and quality of organic matter input. Higher quantities of organic material, especially when applied in the form of compost, lead to higher carbon sequestration rates (*Aguilera et al., 2012a*). Moreover, under Mediterranean conditions organic fertilizers contribute to the reduction of soil emissions and indirect emissions of Nitrous oxide ($N_2O$), which is a powerful greenhouse gas (*Aguilera et al., 2012b*).

High levels of soil organic matter provide a buffer against extreme weather events, because it enhances the water holding and infiltration capacities of the soil, thereby diminishing the risk of yield losses due to droughts or floods. It also helps to stop the advance of desertification, which is an especially serious threat in Mediterranean areas where over 60% of the land is threatened by degradation (*Zalidis et al., 2002*). Furthermore, soils that are rich in organic matter are less vulnerable to erosion (*Lal, 2004*). This is a significant advantage given that the erosion risk is already increasing in countries of the Mediterranean Basin, due to a higher frequency of intensive storms (*Diodato et al., 2011*).

### b) Agro-biodiversity management

Organic farmers usually work with a greater diversity of crops. Crop diversification contributes to the resilience to climate hazards, mainly through better pest control, more efficient use of internal resources and reduced economic risks. Diversification can therefore be considered the key to coping with the climate change. Mediterranean organic farms combine traditionally diversified production, incomes and markets, with innovative management skills (*Kinsella et al., 2006*). Therefore, they provide good models for the development of effective adaptation strategies at the local level.

The use of cover crops for nitrogen fixation and many other functions is common practice in organic farming systems. Cover crops encourage higher levels of biodiversity in the cropping systems (*Cotes et al., 2009*), which contributes to systems' resilience. From a climate change perspective, cover crops provide many other benefits, such as raising the amount of soil organic carbon (*Aguilera et al., 2012a*), drastically reducing the risk of erosion, and enhancing water infiltration capacity. For example, the presence of cover crops in sloping olive groves – a typical crop type in the Mediterranean region – reduces water runoff by 45–95% and soil erosion by 60–98% during the rainy season, compared to olive groves with bare soil. Cover crops in organic olive orchards have been shown to effectively increase water availability in dry periods, provided that they are properly managed (*Guzmán and Foraster, 2011*).




**Mulched organic residues (pruned foliage and cover crops) applied to an organic olive grove. Deifontes, Andalusia, Spain, 2007.**

Local traditional plant varieties and breeds are better adapted to water scarcity and droughts, which have occurred frequently in some Mediterranean areas even before the onset of climate change, and which are now expected to increase in terms of area and duration. As a whole, Mediterranean varieties and breeds represent a huge genetic pool, ideal for sourcing specific adaptations in a context of changing climatic conditions (*Di Falco and Chavas, 2008*). Organic farmers often select, save and re-sow their own seeds, which also contributes to the co-evolution of plant varieties alongside the changes in local climate. Moreover, local varieties of some crops may leave more organic residues in the soil, as is the case, for example, with the local cereal varieties. Although these varieties still produce lower yields than current commercial varieties, the balance might well change with the increasing occurrence of droughts, on the one hand, and with further adaptation, targeted selection and participatory breeding activities on the other.

While diversified hedgerows are not an essential part of organic farms, they tend to be more common on organic farms, where they contribute to an overall ecological concept. Diverse hedgerows provide a refuge for natural pest enemies. The inclusion of woody elements such as hedgerows and trees also helps to increase carbon stocks, both in their own biomass and in the soil, and it enhances other ecosystem services such as water regulation. For example, in an organic farming landscape with a Mediterranean climate in California, riparian and hedgerow habitats with woody vegetation were shown to occupy just six per cent of the total area, but stored 18% of the total carbon; infiltration rates in the riparian corridor were also 230% higher than in the production fields (*Smukler et al., 2010*). Such elements also provide a buffer for variations in the temperature of the soil in the surrounding areas, as has been found in Mediterranean pastures of central Spain (*Sánchez et al., 2010*).

**c) Reduced reliance on fossil fuels**

Organic farms usually consume less fossil fuel, mainly because they avoid the use of synthetic Nitrogen fertilizers, the production of which involves a lot of non-renewable energy. At the same time, unlike in temperate areas, the use of machinery in organic Mediterranean cropping systems is often no higher than in conventional systems (e.g. *Kavargiris et al., 2009, Alonso and Guzmán, 2010*). In a study of 78 Spanish organic farms producing 36 different crop species, *Alonso and Guzmán* (*2010*) found an overall increase in non-renewable energy efficiency and a reduction in its consumption compared to their conventional counterparts. The authors concluded that the non-renewable energy use in Spanish agriculture would be considerably reduced if the area devoted to organic farming increased (on average, 24% less fossil energy is used in organic farms).

Local supply chains receive special support in the context of organic farming and they already belong to the marketing strategies of many organic farms. A local focus can potentially further reduce fossil fuel consumption from transport and the packaging of food.

These savings could make a substantial contribution to climate change mitigation, but will also support adaptation in a situation of increasing global energy scarcity. Oil dependence is higher in Mediterranean countries than in northern European ones (*De Sousa, 2010*). The Mediterranean region is therefore especially vulnerable to possible supply shortages or price hikes caused by peak oil or the projected impacts of climate change on global trade (*Curtis, 2009*). In this respect, there is an urgent need to reduce the dependence of Mediterranean agriculture on fossil fuel. The concepts behind organic farming provide a good framework for achieving this goal.

## 4. Conclusions

To sum up, the Mediterranean region faces a great challenge from climate change, which is predicted to affect agricultural productivity severely. Organic farming is based on the cycling of organic matter and on crop diversification, both of which contribute to the maintenance and improvement of soil fertility as well as the sustainable productivity of agro-ecosystems. These two basic elements, together with the associated savings in fossil fuels, offer broad potential to promote the success of climate change mitigation and adaptation measures in Mediterranean agriculture.


**Organic olive grove with cover crops compared to a conventional grove with bare soil. Deifontes, Andalusia, Spain. 2008.**

# V. TOWARDS A CLIMATE CHANGE ADAPTATION POLICY: A LEGAL AND POLITICAL ANALYSIS

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## 1. Introduction

In 1996 the Intergovernmental Panel on Climate Change (IPCC) defined adaptation as "(…) responses to both the adverse and positive effects of climate change. It refers to any adjustment – whether passive, reactive, or anticipatory – that can respond to anticipated or actual consequences associated with climate change. It thus implicitly recognizes that future climate changes will occur and must be accommodated in policy" (*IPCC, 1996*). For the last two decades policy makers in the field of climate change have neglected adaptation, while instead prioritizing efforts to prevent further increases in the global temperature. As the first effects of climate change are becoming increasingly visible and further impacts are expected, climate change adaptation measures are now raising quickly up the policy agenda.

## 2. Climate adaptation policy in international negotiations: an update

Although the Convention on Climate Change does address the adaptation issue in several of its provisions (*Schipper, 2004*), the ultimate objective of this founding climate text is the stabilization of greenhouse gas (GHG) concentrations in the atmosphere (United Nations Framework Convention on Climate Change (UNFCCC), Article 2).

Adaptation was given rather low importance at the beginning of the international climate change negotiations. There were a number of reasons for this. Firstly, adaptation was perceived as a sign of 'resignation'. Investing in adaptation would imply acceptance that climate change was already happening and that mitigation efforts might fail to fully stop climate change (*Roger et al., 1998*). Secondly, adaptation was perceived as being mainly a form of financial compensation to developing countries, which are considered to be most vulnerable to the adverse effects of climate change (*Damian, 2007*). Thirdly, developing countries were fearful that a broader discussion of adaptation would undermine developed countries' commitments and efforts to mitigate GHG.

Adaptation efforts gained pace in 2007, when the Fourth Assessment Report of the IPCC explained that "more extensive adaptation is required to reduce vulnerability to climate change" (*IPCC, 2007*). The 13$^{th}$ meeting of the Conference of the Parties to the Framework Convention on Climate Change (COP 13, 2007), reacted to these findings with its Bali Action Plan, in which adaptation and mitigation are viewed as equally important. The UNFCCC Copenhagen agreement of 2009 set up a funding scheme (also called Fast-Start Financing) worth 30 billion dollars for the period 2009–2012. The funds are provided by developed countries in order to finance both adaptation and mitigation activities. It is now apparent that, although the pledges made by the industrialized countries almost meet the agreed figure, less than half of the money has so far been committed or allocated to projects, and even less had been disbursed by June 2011 (*Brown et al., 2011*). The outcome of the Doha conference (8 December 2012) upholds the implementation of the Cancun Adaptation Framework, which was adopted in 2010. The Framework involved the creation of the Adaptation Committee and called for the formulation of national adaptation plans by the least developed countries. However, the most significant move on adaptation is the introduction, for the first time, of a legal ruling on "loss and damage from climate change", which would finally force rich polluting nations to compensate developing countries for the harmful effects of climate change. The questions of where the funds will come from and how they should be disbursed in ways that help rural populations reduce their vulnerability and build up their resilience should be answered next year in Warsaw.

## 3. How is the EU tackling climate change adaptation?

One of the objectives of the EU's environmental policies, as outlined in the Treaty on the Functioning of the European Union, is to promote "measures at international level to deal with regional or worldwide environmental problems, and in particular combating climate change" (article 191.1). While the issue of climate change was only given a legal basis with the Lisbon Treaty in 2009, it should be stressed that climate policy competence has been developed *de facto* by the EU since the early 1990s after the signing of the UNFCCC in 1992.

Climate change adaptation emerged as a priority in the 6$^{th}$ Environmental Action Program (EAP), in 2002. Five years later, in 2007 the European Commission published its Green Paper on "Adapting to climate change in Europe – options for EU action". This can be considered a policy response to the floods and the heat waves which hit Europe in 2002 and 2003 respectively. Some 100,000 ha of agricultural land were affected by the major flooding in central Europe in 2002 (*IEEP, et al., 2006*), while the droughts caused by the heat wave of 2003 cost the French agricultural sector around four billion euros worth of damage (*Olesen, et al.,*). Based on the Green Paper, in 2009 the European Commission adopted the White Paper on climate change adaptation (*COM (2009)147*). While this not set out any major actions to take, it does lay the foundation for a future EU Adaptation Strategy to be implemented from 2013 onward. Some potential to increase climate change resilience is also contained in a recent proposal on accounting rules and action plans related to greenhouse gas emissions and their removal through land use activities, land use change and forestry (LULUCF) (*COM (2012)93*), which suggests that "significant co-benefits for biodiversity, soil protection and climate change adaptation can be generated by enhancing and preserving carbon stocks from LULUCF" (*COM (2012)94*).

The adaptation issue has furthermore been addressed, often indirectly, in the following EU sector policies.

**a) The Common Agricultural Policy (CAP)**

Several measures included in the rural development programmes can be considered climate change adaptation measures. In particular, many agro-environmental measures such as organic farming and agro-forestry show considerable potential to contribute to climate change mitigation and adaptation. Environmental protection was introduced as an objective of the CAP in 1992, with the McSharry reform. This was in response to rising public pressure, but was also part of the General Agreement on Tariffs and Trade (GATT) Uruguay round, which required the decoupling of agricultural support from production volumes. The reform laid the basis for today's rural development policy by introducing "accompanying measures". Council regulation (EEC) No 2078/92 introduced support for organic farming (on the basis of *EEC Regulation* 2092/91) and other farming methods beneficial to the environment as an aspect of the CAP. From today's perspective, this support for more diverse and ecological forms of farming can be seen as a first step in the overall support for climate change adaptation.

The Agenda 2000 reform of the CAP recognized the multifunctional character of farming, which delivers not only food, but also landscapes, biodiversity and rural areas. Under this reform, the accompanying measures were transformed into a second pillar of the CAP called the European Agricultural Fund for Rural Development. With the concept of "cross compliance", the 2003 Midterm Review introduced a number of environmental conditions for the receipt of direct payments under the first pillar. While the implementation differed between the various member states and its effectiveness was often doubted, cross compliance did at least introduce the principle of CAP payments being tied to compliance with environmental legislation, and on keeping the land in "good agricultural and environmental condition". Compulsory requirements under this scheme, such as "minimum soil cover" and "retention of landscape features", also play a role in climate change adaptation. With the CAP "Health Check" in 2009, climate change mitigation and adaptation were made key priority objectives of the rural development policy (*Regulation EC/74/2009*).

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The Commission proposals for the CAP 2014–2020 introduced a "greening" component, which also contains potential benefits for climate change adaptation, especially with its requirement for crop diversification. Moreover, the rural development priorities include a shift towards a "climate-resilient economy in the agriculture, food and forestry sectors". Individual measures under for example the articles on "organic farming" and "agro-environment-climate" aim to. However, the effectiveness with which the new CAP targets climate change resilience will depend on the budget negotiations for 2013–2020, and also on the details of any measures concluded after the time of writing this article.

**b) EU Water policy**

The Water Framework Directive (*WFD – 2000/60/EC*) is considered the cornerstone of the European water policy. Although this legal text does not explicitly address climate change, the White Paper on adapting to climate change obliges Member States "to take into account the impacts of climate change" in the elaboration of the river basin management plans (RBMPs) due in 2009. The next generation of plans due in 2015 should be fully "climate-proofed". While most of the countries that have so far adopted RBMPs also included a chapter or a report on climate change and its impacts, Estonia and Latvia excluded climate change issues entirely. Only in some cases (Bulgaria, Germany and the Meuse River Basin District) was climate change mentioned in several chapters (*JRC, 2010*).

## 4. Conclusions

Further action on adaptation has been delayed by the lack of certainty regarding the impacts of climate change, and because of various political and financial hurdles. As neither mitigation nor adaptation can overcome all the impacts of climate change alone (*IPCC, 2007*), efforts in both fields are necessary. To comply with UNFCCC requirements, the EU needs to adopt an ambitious and proactive European strategy for future adaptation, which should also coordinate the national adaptation strategies of the EU-27 (*Council of the European Union, 2012*). It is important that this strategy – which is expected for release in 2013 – and the relevant European sector policies should explicitly recognize the high potential of organic agriculture as a key measure for increasing the climate change resilience of farms and rural economies.

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## Organic Agriculture – A Strategy for Climate Change Adaptation

Changing climate patterns have already begun to have considerable impact on agricultural production in many regions. In the near future, shifts in local climatic conditions and the frequency of extreme weather events such as droughts and floods are expected to occur even more frequently, with potentially devastating effects for agricultural yields. Strategies need to be developed to make our food and farming systems more resilient to the effects of climate change. This dossier presents the latest scientific findings to show how organic farming as a holistic sustainable production system can contribute to effective climate change adaptation strategies for the farm sector.

**IFOAM EU Group – working for organic food and farming in Europe**

The IFOAM EU Group is the European umbrella organisation of organic food and farming, uniting and representing the expertise and interests of around 300 affiliates. The membership of the Group covers the whole organic production chain – farmer organisations, processors, certification bodies, consultants, traders, retailers, and include research institutions as well as consumers.