# Fact Sheet

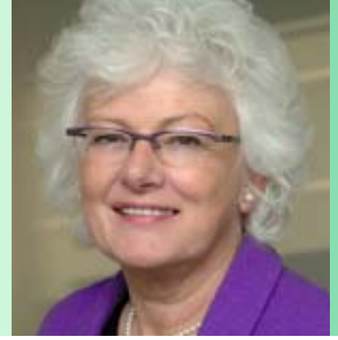
European Commission
Agriculture and Rural Development


# CLIMATE CHANGE: THE CHALLENGES FOR AGRICULTURE

## Contents







## Foreword

I am delighted to introduce this important fact sheet as it explains the complex relationship between agriculture and climate change and the positive efforts the EU is making in the farming sector to address the problem.

As individuals we are all experiencing more variable climatic conditions. You can imagine that farmers, who are so dependent on the vagaries of the weather, are more conscious of this than most. It seems that we now have a very solid body of evidence about climate change – it is happening and it will hit home in the European Union (EU). As it does so, European agriculture will feel the full force. A decrease in average annual rainfall will be a serious problem in many regions. Over the whole EU we can expect more sudden heat-waves, more sudden storms, more sudden floods.

There could be some winners. Yields in some northern regions of Europe could increase, for example. On the other hand there will certainly be losers. Many southern European countries already have difficulty providing enough water for their farmers, who in some cases account for around half of national water consumption – and the droughts that we foresee will make the situation much worse. At the same time, pests will proliferate, and forests are already becoming more susceptible to fires.

Of course, farmers have known the weather as both friend and foe since farming began. They are used to expecting the unexpected. But there are limits to what they can cope with – particularly at a time when they are also under increasing commercial pressure.

The EU has taken the issue seriously for a long time. We have been in the front line of the international battle for hearts and minds – to make people see the dangers, and to persuade our partners to join with us in taking action. So far, EU policy on climate change has emphasised mitigation. Farming is also involved in the fight against climate change; the EU agriculture sector has already made progress in reducing its gas emissions. However, the urgency of the climate challenge requires that we maintain our efforts in this area – and even step them up. Mitigation alone is not enough. It's time to adapt.

Thankfully, in the area of agricultural policy, we are not starting from scratch. The Common Agricultural Policy already has building blocks in place which should make it easier to adapt to climate change. Regulation also has its place. Farmers must already follow quite a number of environmental rules. Perhaps more rules will be needed; but I believe that, wherever possible, we should give farmers positive incentives – incentives to adapt their farm structures and production methods, and to continue providing environmental services. In addition, we must take a closer look at possible tools for managing risks and crises.

So, please read on to see how successfully dealing with climate change is critical to the future of European agriculture and how farming well can help reduce the impact of climate change.

**Mariann Fischer Boel**
**Commissioner for Agriculture and Rural Development**


## 1. Introduction

Climate change is now recognised as one of the most serious challenges facing the world – its people, the environment and its economies. There is now clear scientific evidence that the high concentration of greenhouse gases (GHGs) in the atmosphere is causing global warming. While the world has experienced climatic changes before, the issue we now face involves human influence. It is a challenge that must and can be dealt with.

It is believed that most global warming we can now observe is attributable to emissions of GHGs that result from human activities, in particular land use changes such as deforestation, and the burning of fossil fuels (coal, oil and gas).

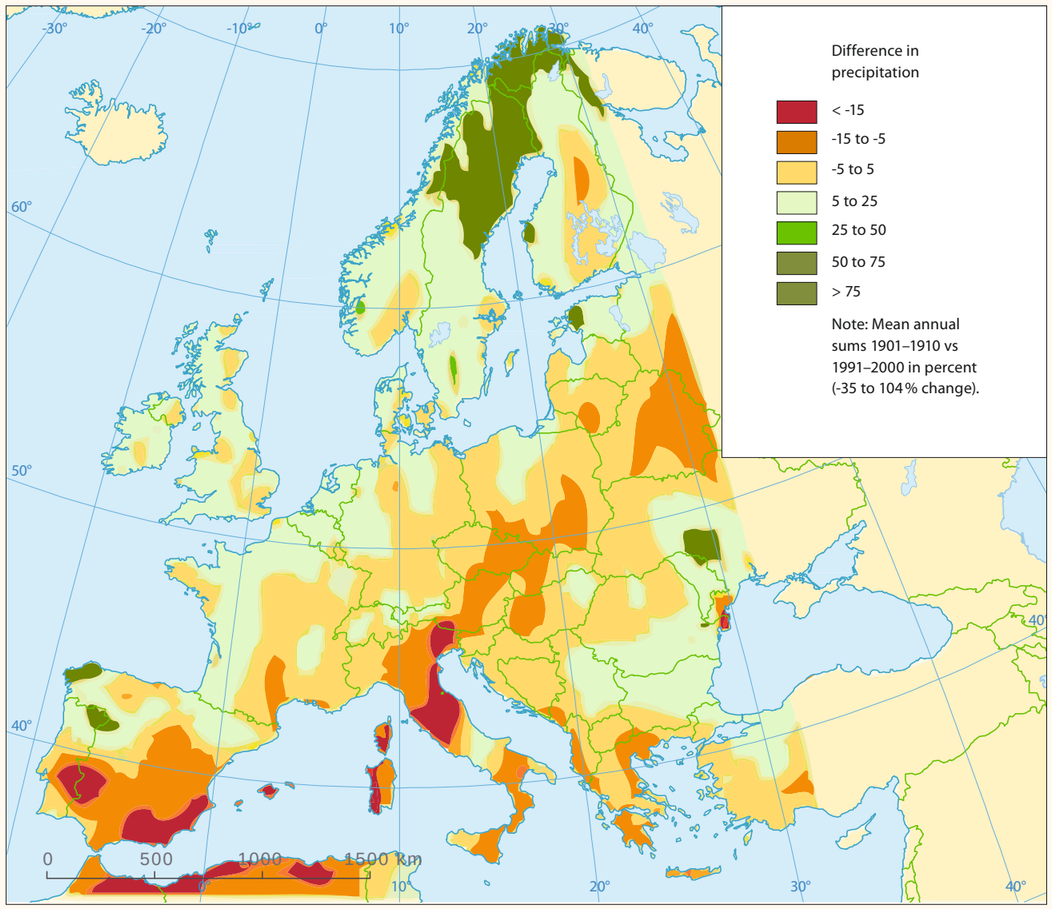
Europe has warmed by almost 1 °C in the past century, faster than the global average. Climatic conditions have become more variable. Rainfall and snowfall have significantly increased in northern Europe, while rainfall has fallen considerably and droughts are more frequently experienced over southern Europe (see Figure I). Temperatures have become more extreme (for example the record-breaking 2003 summer heat wave) and floods more common. While individual weather events cannot be attributed to a single cause, statistical analyses show that the risk of such events has already increased considerably as a consequence of climate change. Economic losses due to weather-related disasters have increased considerably in recent years.

Due to its wide range of effects climate change will, in the medium to long run, change the context of policy making profoundly. Climate change presents a double challenge today: how to cut the emissions of gases responsible for warming (known as mitigation); and how to adapt to current and future climate change in order to lessen the adverse impacts it will have on us – adaptation.

The changing climate is also a major challenge for agriculture and agricultural policy-making. This fact sheet explains how European Union (EU) agriculture is affected by, and influences, global warming and how the sector and EU agricultural policy can address the double challenge of reducing emissions while at the same time adapting to projected impacts of climate change.




**Figure I. Trend in mean annual rainfall (1900–1998) – Mediterranean region**




Source: European Environment Agency (EEA), Technical report N° 7/2005 – 'Vulnerability and adaptation to climate change in Europe, based on M. Hulme (1999) – an historical monthly precipitation dataset for global land areas from 1900 to 1998' (http://reports.eea.europa.eu/technical_report_2005_1207_144937/en)

## 2. Climate change is happening

There is now little doubt that climate change is happening. "Most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations. The observed widespread warming of the atmosphere and ocean, together with ice mass loss, support the conclusion that it is very likely that it is not due to known natural causes alone". These are some of the conclusions of the latest report of the Intergovernmental Panel on Climate Change (IPCC)[1], which gathers the leading authorities on the subject at international level and has recently been awarded with the Nobel Peace Price[2] for its efforts to build up and disseminate greater knowledge about climate change. Countries and individuals that hitherto did not acknowledge the extent of the climate change problem have now formally agreed that it exists and needs to be addressed.


[1] See: http://www.ipcc.ch 'Climate Change 2007: The Physical Science Basis, Summary for Policymakers'
[2] Together with former US Vice-President Al Gore

### Box 1. Climate change forecasts

**The term climate change is generally used to describe human influences on the climate. The most significant threat is the emission of greenhouse gases (GHGs), which contribute to the 'greenhouse effect'. The greenhouse effect is a natural mechanism essential to life on Earth, but human activity has altered the balance in the mechanism. Radiant energy emitted by the sun comes through the Earth's atmosphere and warms its surface. This heat then radiates back into the atmosphere, but some of the sun's heat is absorbed in the atmosphere by gases. With increasing concentration of GHGs, this effect is amplified, thus increasing the Earth's temperature.**

**The Intergovernmental Panel on Climate Change (IPCC) set up by the United Nations in 1998 brings together the world's leading experts to produce assessments of the state of Earth's climate system. Its reports provide comprehensive, up-to-date assessments of the current state of knowledge on climate change. The IPCC's 'Fourth Assessment Report' was published in autumn 2007.**

**Global climate models, which reproduce the functioning of the atmosphere and oceans, are used together with emission scenarios to estimate future changes in climate patterns. The scenarios cover the main driving forces for future gas emissions such as economic development, and population trends. The latest IPCC report states incontestably that the process of climate change is happening in all continents and oceans, in particular over land and in the high northern latitudes.**

**The IPCC is very confident that most of the observed increase in temperature is a result of the increasing concentration of GHGs in the atmosphere due to human activities. These activities include, in particular, the burning of fossil fuels and deforestation both of which cause emissions of carbon dioxide ($CO_2$) – the main gas responsible for climate change – as well as other GHGs, such as methane ($CH_4$) and nitrous oxide ($N_2O$). As much as 25% of all global GHG emissions can be attributed to land use changes, among which tropical deforestation is the most prominent. In Europe energy and transport are the biggest sources of such emissions. Since the beginning of the industrial era (around the mid 18th Century), $CO_2$ and $CH_4$ concentrations have significantly increased. Even if emissions stop today, these climate changes would continue for many decades due to the historical build up of the gases in the atmosphere.**

### What the experts say

An increase in global temperature of almost 0.8 °C in the last 150 years has been observed. While this does not yet seem dramatic, the trend has already had a significant influence on many physical and biological systems (water, habitats, health) over the last three decades. International researchers agree that climate change impacts will become progressively more severe throughout the world, although there is still uncertainty over the magnitude and speed of those impacts.

The IPCC foresees that continued GHG emissions will cause further rapid warming during the 21st Century, inducing changes in the global climate system that are very likely to be more significant than those observed during the 20th Century. It is estimated that, without more global action to limit emissions, global surface temperatures might have risen to between 1.1 °C and 6.4 °C[3] by the end of the 21st Century, although the temperature increase is more likely to be in the range of 1.8 °C to 4.0 °C (about 0.2 °C per decade). In Europe the largest temperature increases have occurred, and are projected to be, in southern Europe. The range of projections is due to uncertainties in the physical climate models, and to the unpredictability of future emissions, which are dependent on factors such as technological change and human population growth.

### International and EU efforts against climate change

Climate change is a global problem requiring global solutions. International collective action has been taken since the early 1990s, with the EU taking the lead. The EU played a key role in the development of the United Nations Framework Convention on Climate Change (UNFCCC), and its Kyoto Protocol, which sets legally binding targets for industrialised countries to reduce emissions of GHGs by 5 % by 2012. The EU accepted a higher commitment: the 15 older Member States[4] undertook to cut these emissions by 8 %. Member States that joined the EU from 2004 have reduction targets of between 6 % (Hungary, Poland) and 8 % (Czech Republic, Slovakia, Slovenia, the Baltic countries, Romania and Bulgaria). Cyprus and Malta do not have Kyoto targets.

In early 2007 EU heads of government went further, making a firm, independent commitment to reduce GHG emissions by 20 % by 2020 (compared to 1990 levels)[5]. In the ongoing international negotiations, the EU is pursuing the objective of a 30 % reduction in emissions by all industrialised countries by 2020 and the involvement of developing countries, which currently do not have reduction commitments. The EU believes broader, more ambitious targets are needed to prevent global temperatures rising more than 2 °C above pre-industrial levels, to avoid major environmental, economic and social impacts.

### Reducing emissions is not the only aim

EU policies on climate change have concentrated on the reduction of GHG emissions. But these efforts on their own may not be enough to avoid the impacts of changing climatic conditions. While mitigation is needed to prevent avoidable climate change, adaptation is necessary to cope with impacts that are unavoidable due to past emissions. The Commission's recent Green Paper (June 2007)[6] sets out options for EU action to help the process of adaptation to climate change (for example, by the construction of flood walls, development of drought tolerant crops, and selection of forestry species and practices less vulnerable to storms and fires). Adaptation efforts need to be stepped up at all levels and in all sectors and need to be coordinated at EU level. The Green Paper explores the role of EU policies – including agricultural policy – in improving Europe's resilience to climate change impacts and calls for a broad debate on adaptation. It will be followed by a White Paper in 2008 with more concrete options for adaptation.

### Preparing climate change policy after 2012

An EU priority is to advance negotiations for a future global and comprehensive climate change framework. International discussions on new targets have already started at the Conference of the parties of the UNFCCC and the Kyoto Protocol (Montreal 2005 and Nairobi 2006). The aim of the talks is to reach a comprehensive, global agreement for the period beyond 2012 when the current Kyoto targets expire. An important landmark was the meeting of the parties in December 2007 in Bali, the launch of formal negotiations. The objective is to reach an agreement on a renewed international framework by 2009.

[3] This range reflects uncertainty about the precise figures

[4] Prior to the 2004 and 2007 EU enlargements that brought about the accession of a further 12 countries

[5] COM(2007) 2 final, Commission Communication 'Limiting Global Climate Change to 2 degrees Celsius – The way ahead for 2020 and beyond'

[6] COM(2007) 354 final, Green Paper 'Adapting to climate change in Europe – options for EU action'





## 3. The twin climate change challenges for agriculture

Agriculture needs to address the double challenge of reducing its GHG emissions while at the same time adapting to projected impacts of climate change. Agriculture releases GHGs into the atmosphere, though on a smaller scale than other economic sectors. Agriculture can also help provide solutions to the EU's overall climate change challenges.

**Reducing farming emissions**

Agriculture is an important source of two powerful greenhouse gases: nitrous oxide ($N_2O$) and methane ($CH_4$) (see figure II):

- $N_2O$ is released to the atmosphere mainly due to the microbial transformation of nitrogen fertilisers in soils; the generation of $N_2O$ represents over half the total emissions from agriculture;
- $CH_4$ emissions come mainly from intestinal fermentation by ruminant animals (enteric fermentation)[7];
- Both $N_2O$ and $CH_4$ emissions are produced from manure storage – decomposition of stored manure in oxygen-deprived conditions[8] – and spreading on farmland.

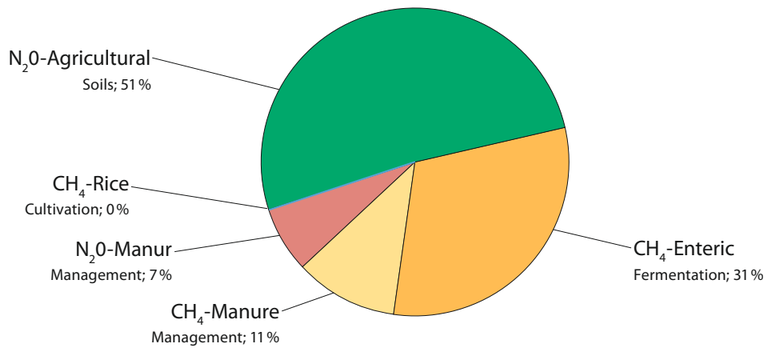
Agriculture hardly emits carbon dioxide ($CO_2$) – the most widespread GHG in the atmosphere (see box on measuring emissions). On the contrary, agricultural lands, which occupy over half of the EU's territory, hold large carbon reserves that help reduce $CO_2$ in the atmosphere.

The changing climate is also a major challenge for agriculture and agricultural policy-making. This fact sheet explains how European Union (EU) agriculture is affected by, and influences, global warming and how the sector and EU agricultural policy can address the double challenge of reducing emissions while at the same time adapting to projected impacts of climate change.

**Adapting to climate change risks**

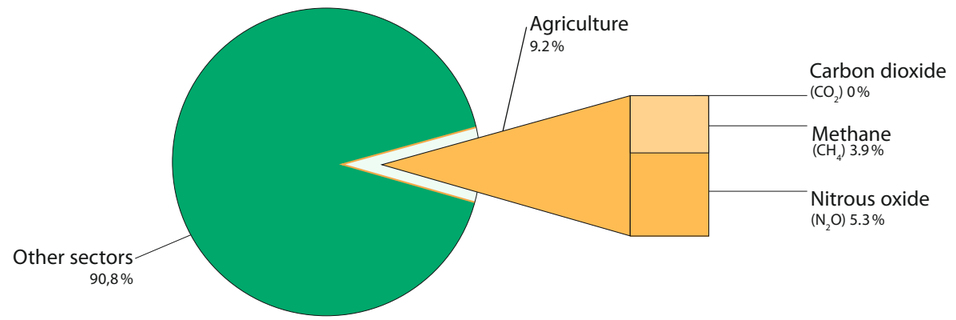
Climate change affects many economic sectors, and agriculture is one of the most exposed, as farming activities directly depend on climatic factors. Access to natural resources (soil, air and water) is crucial to agricultural sustainability. This is important to everyone in Europe as farmland, woods and forest cover approximately 90 % of EU's land surface. Climatic variability year-by-year is one of the main causes of variability in crop yields and the inherent risks of farming. Farming is thus in the front line of the battle against climate change impacts. Adaptation is as a critical challenge for agriculture and rural areas.

**Figure II. Breakdown of agricultural GHG emissions (EU-27[9]) – 2005**




Source: Commission DG Agriculture elaboration based on EEA data[10]

**Figure III. Share of agricultural sector in total GHG emissions – 2005 (EU-27)**





[7] Ruminants (cows, sheep, buffalo) produce significant amounts of methane as part of their normal digestive process. The bacteria present in the rumen of these animals convert fibrous feeds into products that can be digested and used by the animals, but this microbial process also produces methane

[8] Also known as anaerobic conditions – these anaerobic conditions often occur when large numbers of animals are managed in confined areas (e.g. dairy farms, beef production units, and pig and poultry farms)

[9] The EU of 27 Member States following the accession of Bulgaria and Romania in January 2007

[10] See: http://www.eea.europa.eu/themes/agriculture/indicators

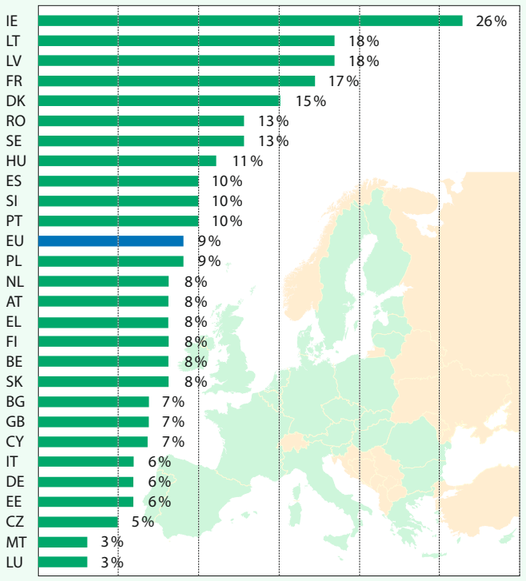


## 4. How agriculture influences climate change

**Agricultural GHG emissions**

The EU-27 agriculture sector released nearly 475 million tonnes of $CO_2$-equivalent[11] of greenhouse gases in 2005. This represents about 9 % of total EU GHG emissions (against 11 % in 1990), making agriculture the third largest emitter sector[12] (see figure III). Approximately 5 % of total emissions is $N_2O$*, from application of organic and mineral nitrogen fertilisers to soils, and nearly 4 % is $CH_4$, mainly from the digestion processes of ruminant animals and, to a lesser extent, from manure storage. In the EU the influence of agriculture on emissions is limited and diminishing. Further efforts by the agriculture sector should reap the reward of additional reductions in emissions. Behind this overall picture, individual Member States have widely varying situations (figure IV.). In 2005 the share of emissions from agriculture was higher than the EU average in Ireland (26 %), Latvia and Lithuania (both 18 %), France (17 %), Denmark (15 %), Sweden and Romania (13 %), Hungary (11 %), Spain, Slovenia and Portugal (all 10 %). This is largely due to the relative importance of their agricultural sectors – the share of farming in the Member States' total emissions depends on the size and structure of the sector relative to the size of other emitting sectors. The role of agriculture as a source of GHG also varies significantly depending on different farming practices (e. g. whether farming is livestock or crop dominant, intensive or extensive, etc.) and diverse environmental and climatic conditions, such as soil characteristics and temperature.

**Figure IV. Share of agriculture sector in total GHG emissions (by EU-27 Member State) – 2005**




Source: EEA

[11] Methane and nitrous oxide emissions are usually accounted in $CO_2$ equivalents ($CO_2$-equ) as these gases have differing global warming potential and lifetime permanence in the atmosphere than $CO_2$. Warming potential is usually calculated taking $CO_2$ as a basis and over 100 years. For example, methane, the second most important greenhouse gas after $CO_2$, is about 21 times more effective in trapping heat in the atmosphere than $CO_2$. Therefore one tonne of $CH_4$ is equivalent to 23 tonnes of $CO_2$-equ

[12] Detailed information on agricultural GHG emissions can be obtained in the EEA Technical report No 7/2007 – Annual European Community greenhouse gas inventory 1990–2005 and inventory report 2007 (http://reports.eea.europa.eu/technical_report_2007_7/en)

* $N_2O$ has 296 times the warming potential of $CO_2$



**Agriculture's emissions are declining in the EU**

The story is more positive than it first seems. Total EU agricultural emissions actually fell by 20 % in the period 1990–2005, mainly due to changed farming techniques and fewer livestock. EU-15 agricultural GHG emissions have fallen by 11 %; emissions in the 12 new Member States (post-2004) were cut by 45 % in the same period mostly due to the restructuring of agriculture in these countries during the 1990s. This compares to the global situation where farming emissions have risen by nearly 17 %, due mainly to increases in developing countries.

The reduction of farming emissions is much higher than the overall reduction in emissions in all EU sectors of about 8 %. Agriculture has therefore made a significant contribution to the achievement of the Kyoto protocol commitment. Despite this encouraging trend, agriculture is still responsible for most $CH_4$ and $N_2O$ emissions. Recent studies have pointed out the significant contribution that livestock makes to climate change. A report from the Food and Agriculture Organization of the United Nations[13] concludes that livestock is responsible (globally) for 18 % of harmful gas emissions, a higher share than transport. The estimate is made using a different methodology than the standard accounting of emissions, and considers the entire commodity chain from the cultivation and production of feed to marketing of animal products. And the study is not focused on the EU only. Nevertheless, the spotlight is on emissions generated at farm level, as the gases emitted from the rest of the commodity chain are estimated to be relatively low.

[13] 'Livestock long shadow: environmental issues and options'. See: http://www.fao.org/newsroom/en/news/2006/1000448/index.html

### Box 2. Measuring agricultural emissions – the need for caution with data

**Emissions worldwide are calculated by sector using standard IPCC methodologies for GHG inventories. All EU Member States are signatories of the United Nations Framework Convention on Climate Change, and report their GHG emissions annually according to the common reporting framework.**

**The Agriculture' inventory includes methane ($CH_4$) and nitrous oxide emissions ($N_2O$). Both gases are normally accounted in $CO_2$ equivalents as this is a way of harmonising their different global warming potential. Emissions of $CO_2$ from the energy use of agricultural machinery, buildings and farm operations, are not accounted in the 'agriculture' category but are included in the 'energy' inventory. The sequestration of carbon in agricultural soils and crops is not accounted under the 'agriculture' category either but reported under the 'Land Use, land use changes and forestry' category.**

**Measuring emissions from agriculture is thus more difficult than from industrial activities due to the complex biological and ecological processes involved in gaseous releases from agricultural systems. The methodology for accounting emissions combines the use of country-specific activity data (such as animal numbers, crop area, fertiliser use) and standard emission factors (e. g. $CH_4$ per animal). For example, the amount of $CH_4$ emitted by the digestion processes of ruminants is calculated as the number of animals multiplied by an emission rate per animal. These emission factors are uncertain, hide important sources of spatial variability and do not take full account of the many mitigation responses observed in the farming sector. For instance, emissions data only reflect changes in the amounts of fertilisers applied, but not the changes in application techniques or fertiliser formulations. The resulting figures thus do not accurately reflect agricultural emissions as too many uncertain factors are included. Monitoring methodologies thus need refinement to more accurately reflect agricultural emissions.**

The issue is made more complex due to variations in livestock systems (different feeding systems and usage of land) and the diversity of products that result from livestock production processes. The European Commission is planning to carry out a specific study to quantify the overall emissions of the EU livestock sector.

**Improvements due to the increased efficiency of farming techniques**

The trends in reduced agricultural emissions are largely the result of improvements in the efficiency of farming practices (for example enhanced fertiliser application techniques and improved manure storage), the implementation of the Nitrates Directive (involving voluntary and compulsory requirements on use and management of manure) and encouragement from the Common Agricultural Policy (CAP), for example the linking of direct aid payments for farmers to the fulfilment of environmental conditions.

Within the period 1990–2005, large reductions occurred in the greatest sources of farming emissions: methane from ruminants and nitrous oxide from soils. Methane emissions from livestock fell (by over 20%) primarily as a result of a severe drop in cattle numbers (see figure VI). All Member States, except Portugal and Spain, reduced their emissions from ruminant enteric fermentation, in particular the newer Member States. Methane from manure management was also reduced, by 9%, with the greatest mitigation improvements in the newer Member States.

Nitrous oxide emissions from soils were reduced by 21% in the same period, mainly due to less use of organic and synthetic nitrogen fertilisers (see figure VI). Emissions declined in most Member States. Reductions of about 50% occurred in several newer Member States (e.g. Bulgaria, the Czech Republic, Estonia, Latvia, Lithuania and Slovakia). The UK, Denmark, Greece, Finland and Germany also significantly cut their emissions, by around 20%.

In the EU, there are no specific emission reduction targets for agriculture or its major gas emissions, methane and nitrous oxide. However, several Member States have specific emission reduction plans targeted at agriculture and are using a wide range of instruments to mitigate farm emissions.

**Agriculture will cut its emissions further**

Emissions from agriculture (EU-27) are projected to decrease further – by 23% by 2010 (15% in the EU-15) compared to 1990[14] – due to the continuing effects of the 2003 CAP reform (see section on EU policies) and other environmental legislation (see Box 3). This trend also reflects the continuing decline in cattle numbers and more efficient fertiliser application. Other economic sectors are also expected to decrease their emissions, but to a lesser extent than agriculture. The EU is the only world region where agricultural emissions are expected to decrease as substantial rises are expected in developing countries due to economic development and growing demand for meat and dairy products.

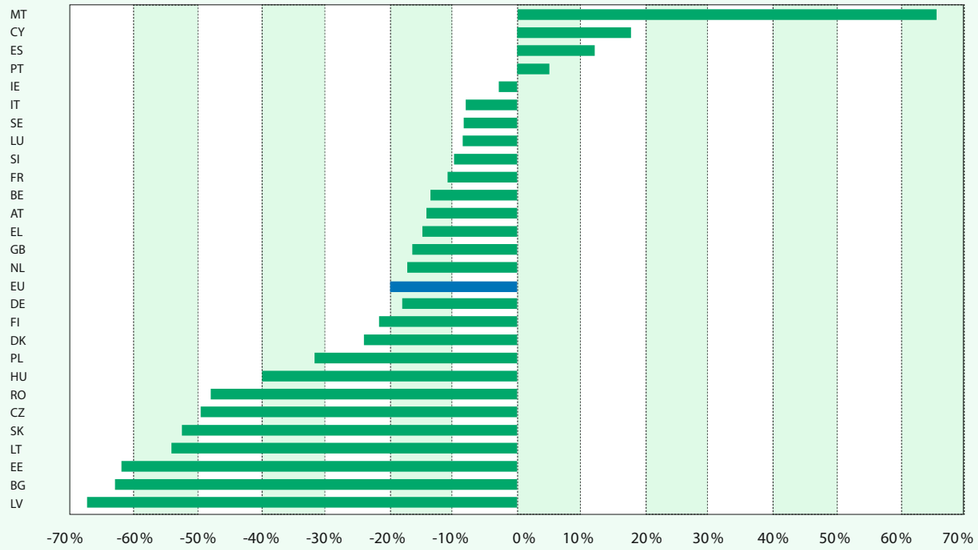
**Less methane – the decline in livestock numbers is playing an important role**

The anticipated decrease in cattle numbers and improvements in productivity are likely to contribute to a continuing decline in $CH_4$ emissions. Substantial falls in emissions are expected from an anticipated reduction in the EU's dairy cow herd in the coming years (as dairy cows produce a large proportion of methane emissions). Changes in livestock nutrition, such as use of certain forage species and specific dietary additives, are cost-effective options to reduce methane offering high potential for development.

[14] The projection is based on Member States' estimates that take into account all existing domestic policies and measures. By 2010, total EU-27 GHG emissions are projected to be about 11% below base-year levels (usually 1990) if the additional measures planned both at EU and Member State level are implemented

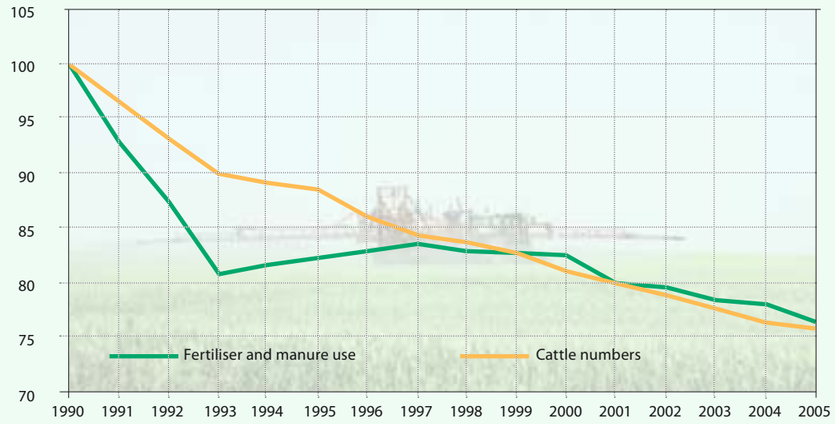


**Figure V. Change in total emissions of $CH_4$ and $N_2O$ (1000 tonnes $CO_2$ equivalent) from agriculture – 1990–2005 (EU-27)**




% change 1990–2005: total $CH_4$ and $N_2O$ emissions  Source: EEA, Agri-environmental indicators

**Figure VI. Trends in cattle numbers and nitrogenous fertiliser use 1990–2005 (indexed relative to 1990 levels) – EU-25[15]**




Source: Commission DG Agriculture elaboration based on EEA data (agri-environmental indicators)[16]

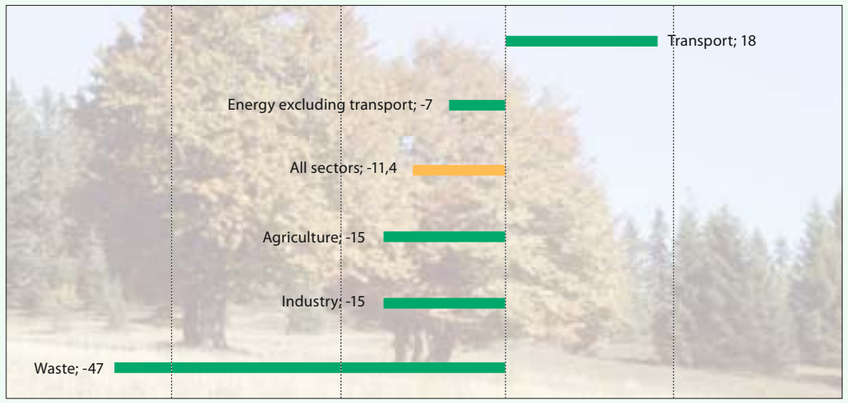
[15] EU of 25 Member States prior to the accession of Bulgaria and Romania in January 2007

[16] See: http://www.eea.europa.eu/themes/agriculture/indicators

**Lower nitrous oxide emissions – improved fertilisation methods**

The main reasons for the past decline in $N_2O$ are decreases in nitrogen fertiliser use, by 25 % over the last twenty years, and reductions in manure application. The European Fertilizer Manufacturers Association projects a further overall decline in nitrogen fertiliser use in EU-15[17]. In EU-10[18] consumption will slightly increase, particularly in Poland, driven by projected rises in cereals production. Despite this, by 2015 EU-25 nitrogen use should be 27 % lower than in 1986 when nitrogen consumption peaked.

**Figure VII. Projected agricultural emission trends to 2010 (EU-15)**




% change

Source: Communication from the Commission on progress towards achieving Kyoto objectives (in preparation)

[17] EFMA (2006): Forecast of food, farming and fertiliser use in the European Union 2006–2016
[18] The 10 Member States that joined the EU in May 2004



## 5. How EU policies can help reduce emissions

**Development of EU policies is contributing to reducing emissions**

Unlike other industries, gas releases in agriculture cannot be controlled by pressing switches on a machine. The most sustainable approach is for agriculture to deliver a range of environmental outcomes while remaining a viable competitive sector, bringing economic and social benefits. Measures that contribute to cutting GHG emissions from farming do not thus result from a specific climate change policy but are driven by general agricultural and environmental policy aimed at long-term sustainability.

**The CAP plays a strong part**

A number of steps have already been taken to integrate climate change concerns into the CAP – a lead has been taken at EU level in successive reforms over recent years. For example, the 2003 CAP reform shifted the financial support to farmers towards direct aids decoupled from production (i.e. not linked to quantities produced) with the effect of reducing incentives to intensive production[19]. This 'decoupled' support comes with clear obligations on farmers to manage their land in sustainable ways. 'Cross-compliance' links direct payments to farmers to their respect of environmental and other legislation set at EU level. Beneficiaries of direct payments must also maintain agricultural land in good agricultural and environmental condition. Member States lay down the conditions for this – these include on-farm obligations, such as soil practices that help maintain soil organic matter and protection of permanent pastures, which help enhance the carbon sink[20] capacity of soils.

There is also a range of rural development measures (under the so-called 'Second Pillar' of the CAP) that can contribute to mitigation, such as aid to modernise farms (e.g. via energy efficient equipment and buildings), training and advisory services, and support for biogas. Particularly relevant are agri-environmental measures. By offering compensation for the extra costs incurred by farmers who voluntarily contribute to the protection of environment, agri-environmental schemes have significant potential to stimulate adoption of measures to curb emissions and enhance carbon sinks. The Commission encourages Member States to include measures to tackle gas emissions when designing and implementing their rural development programmes, as climate change is one of the key priority areas defined in the EU's strategic guidelines for rural development policy[21]. Future development of the CAP should provide opportunities to enhance existing instruments to combat climate change.

**Environmental legislation plays its role**

While many climate change problems linked to agriculture are being addressed by developments in farming structures and management techniques, this is taking place within a regulatory environment that sets limits on some practices. Various items of EU legislation contribute greatly to mitigating climate change, for example the Nitrates Directive (see environmental legislation box).

[19] See: http://ec.europa.eu/agriculture/index_en.htm for more information
[20] Carbon sinks are forests and other ecosystems that absorb carbon, thereby removing it from the atmosphere and offsetting $CO_2$ emissions
[21] Council Decision 2006/144/EC of 20 February 2006 (OJ L 55, 25.2.2006)

## Box 3. Environmental legislation

**The following are examples of environmental legislation which, although not addressing climate change directly, are relevant to the avoidance of GHG emissions in the agricultural sector:**

**Nitrates Directive (Council Directive 91/676 of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources, OJ L 375 of 31.12.1991) – the Directive has two main objectives: to reduce water pollution by nitrates from agricultural sources and to prevent further pollution. The Directive is managed by Member States and involves: monitoring of water quality in relation to agriculture; designation of nitrate vulnerable zones; establishment of (voluntary) codes of good agricultural practice and of (obligatory) measures to be implemented in Action Programmes for the nitrate vulnerable zones. Several Member States have designated their whole territory as vulnerable to nitrate pollution. For these zones, the Directive also establishes a maximum limit of nitrogen from livestock manure that can be applied per hectare: 170 kg N/ha per year. Codes of good agricultural practice cover such activities as application periods, fertiliser use near watercourses and on slopes, manure storage and spreading methods and crop rotation and other land management measures.**

**Integrated Pollution Prevention and Control (IPPC) Directive (Council Directive 96/61 of 24 September 1996 concerning integrated pollution prevention and control, OJ L 257, 10.10.1996) – the Directive aims at minimizing environmental pollution and nuisance from large operations/installations. The IPPC Directive covers livestock farms with more than 2 000 fattening pigs and/or more than 750 sows and/or more than 40 000 chickens. Measures that must be applied on those farms are mainly aimed at reducing ammonia emissions (e.g. covered storage of animal manure, improved housing systems, air purification, manure handling and treatment, low-emission manure application). Ammonia is not a greenhouse gas, but the measures concerning manure treatment also influence methane and nitrous oxide emissions. In 2006, the Commission launched a review process of the IPPC Directive that aims to improve its implementation further.**

**National Emission Ceilings Directive (NEC) (Directive 2001/81 of 23 October 2001 on national emission ceilings for certain atmospheric pollutants, OJ L 309, 27.11.2001) – the NEC Directive, operates within the EU's overall air quality policy, and sets upper limits for each Member State for the total emissions in 2010 of the four pollutants responsible for acidification, eutrophication and ground-level ozone pollution (which includes ammonia). It is left largely to the Member States to decide which measures to take in order to comply. Member States are obliged to draw up national programmes to demonstrate how they will meet the national emission ceilings by 2010.**

**Water Framework Directive (WFD) (Directive 2000/60 of 23 October 2000 establishing a framework for Community action in the field of water policy, OJ L 327, 21.12.2000) – the overall objective of the WFD is to establish a framework for the protection of all waters (surface water and groundwater), in particular to prevent further deterioration and to protect the status of ecosystems and wetlands and to promote sustainable water use, and to contribute to mitigating the effects of floods and droughts. Member States are responsible for the designation of river basins and the preparation of river basin management plans, including programmes of measures. WFD is also a tool to address pressures from farming activities on water quality and quantity, with a link to climate change mitigation and adaptation.**

**Soil Framework Directive (proposed). Soil performs many functions, including that of a carbon sink. It therefore contributes to climate change mitigation. The EU is trying to improve soil protection and has proposed a regulatory framework. Member States' obligations under the proposed Directive are to identify (within five years) areas at risk of soil degradation, to specify (within seven years) risk reduction targets for these areas and to establish programmes of measures, which have to be put in place within eight years from adoption of the Directive. The proposed Directive is in the EU decision-making process. The Directive will allow Member States to set acceptable levels of soil erosion (for example), within the overall objectives of the Directive.**




## 6. How agriculture is affected by climate change

### Climate change affects agriculture globally

The IPCC assessment report[22] (recently made public) foresees that even small amounts of global warming will reduce crop yields and trigger higher yield variability in low-latitude world regions. Negative effects on agricultural yields will be exacerbated by more frequent extreme weather events. Smallholders and subsistence farmers will be particularly affected as they also have less capacity and means to adapt. This is expected to increase the risk of famine; the additional number of people at risk could rise to several hundred million. At higher latitudes (e.g. the north of the northern hemisphere), crop productivity is projected to increase for moderate temperature increases (below 3 °C) and decrease beyond that.

### EU agriculture is affected too

Climate change is also a real concern for EU farming. Agriculture will face many challenges over the coming decades, such as increasing international competition, further liberalisation of trade policy and further declines in the rural population in many regions. Climate change adds to these pressures.

It is true that some of the projected climate change impacts could be beneficial for farming in certain European regions, mostly northern areas, but most impacts are likely to be adverse and occur in regions already under pressure due to socio-economic and other environmental factors, such as water scarcity. This uneven effect of global warming is expected to amplify regional differences in Europe's agricultural conditions, with a higher risk of land abandonment and regional marginalisation in some parts of the EU, and could exacerbate economic disparities between European rural regions.

### Key climate change concerns for European agriculture

Although there are important regional variations in the expected climatic conditions, over the 21st Century predicted impacts can be summarised as milder and wetter winters, hotter and drier summers and more frequent and intense extreme weather events. Figures VIII and IX show the simulated temperature and rainfall variations across the EU by the end of the century. The projections are based on one socio-economic scenario foreseeing increased emissions from today's levels. Temperature projections indicate significant warming, particularly in the Iberian Peninsula and central south-eastern European regions, in the future. Although, rainfall projections are even more uncertain than those on temperature, the trends towards a decrease of precipitation in the southern EU can already be observed.

Extreme weather conditions, and to a lesser extent changes in annual and seasonal precipitation and their interaction with temperature, are likely to have most serious consequences for agriculture in the short to medium term. The most severe effects from changes in the mean temperature and rainfall may not be felt until 2050, but significant adverse impacts are expected earlier from extreme climate events, such as prolonged heatwaves, droughts and floods. These extreme weather conditions are projected to become more severe, to occur more frequently and in more parts of the EU, and are likely to increase the incidence of crop failures.

Impacts may also come from the effects of climate change on soil fertility, such as an increased vulnerability of soil organic matter and the risk of soil erosion due to rising temperatures and higher occurrence of droughts and rainfall. Despite uncertainties about precise impacts, recent studies show the importance of identifying potential synergies between land and soil management practices, linking issues of carbon sequestration, emissions of greenhouse gases, and long-term sustainability of farming systems.

[22] W.E. Easterling, P.K. Aggarwal, P. Batima, K.M. Brander, L. Erda, S.M. Howden, A. Kirilenko, J. Morton, J.-F. Soussana, J. Schmidhuber and F.N. Tubiello, 2007: 'Food, fibre and forest products. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change'

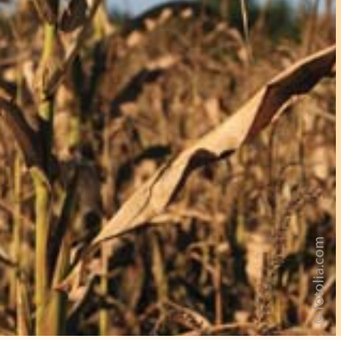
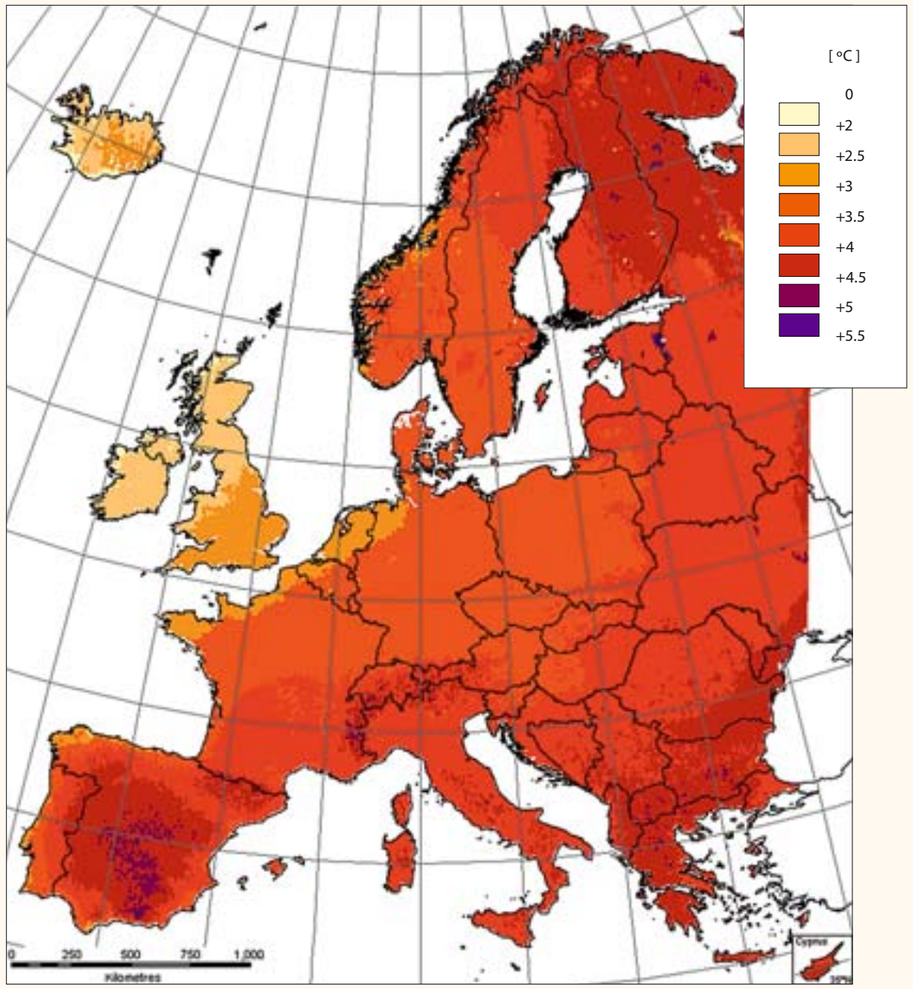



**Figure VIII. Projected change in mean annual temperature by the end of the 21st Century[23]**

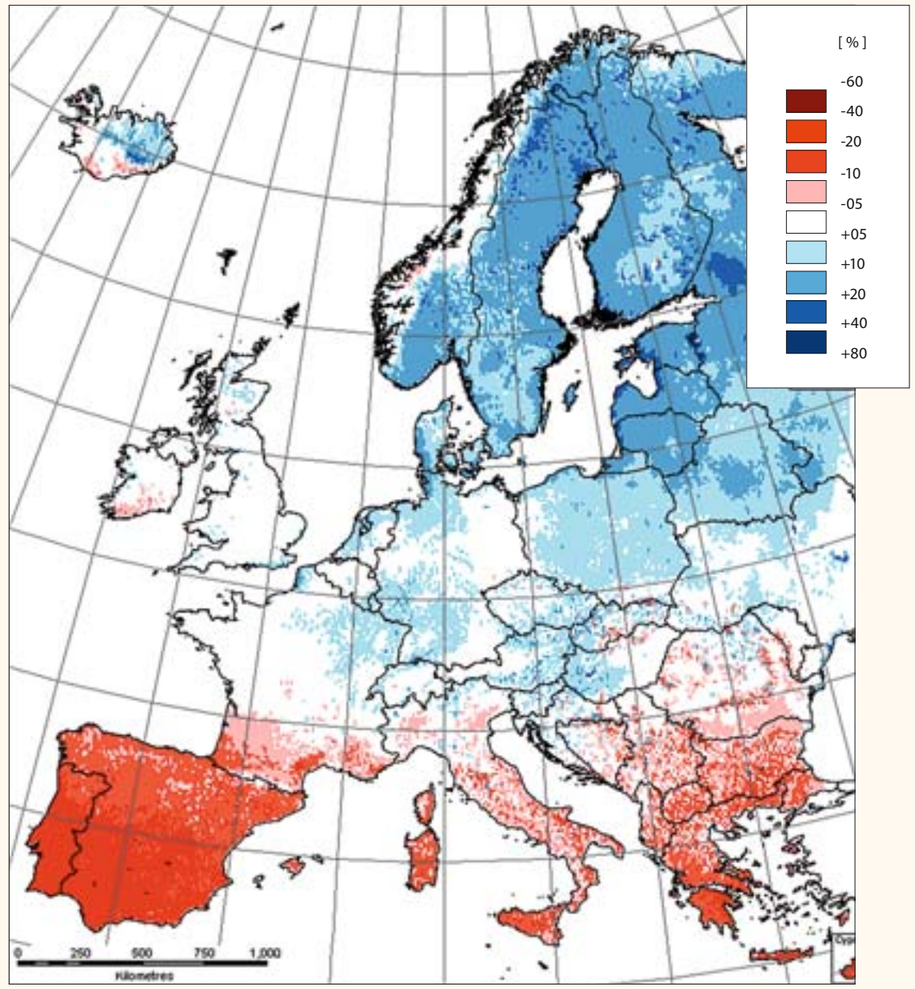



Temperature: change in mean annual temperature [ °C ]

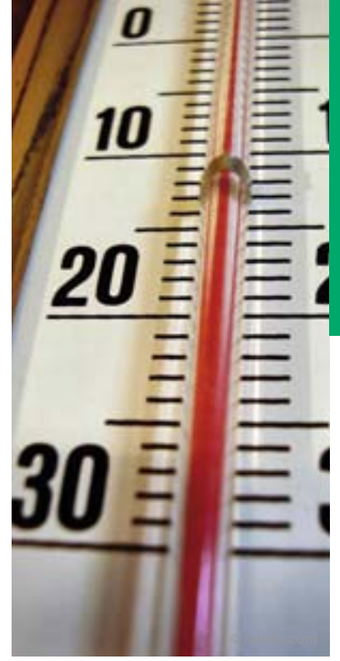
[23] Projections are based on scenario A2 which assumes a future high emissions trend and temperature increase. Projected climate impacts are estimated for 2071–2100 relative to 1961–1990. Maps are based on DMI/PRUDENCE data (http://prudence.dmi.dk), and processed by the EU's Joint Research Centre (JRC) within the JRC funded PESETA study (http://peseta.jrc.es)




**Figure IX. Projected change in mean annual precipitation by the end of the 21st Century**




Precipitation: change in annual amount [ % ]




**Specific risks faced by agriculture:**
**Water shortages**

Most of the impacts of climate change on agriculture will come through water. Climate change is likely to result in a decrease in annual water availability in many parts of Europe due to an expected reduction in summer rainfall – mainly in southern areas and parts of central Europe. In western and Atlantic areas, summers are likely to be dryer and hotter and reduced water resources during this season may lead to conflicting demands between agriculture and other users. The increased risk of water shortages will have a major impact on agricultural production and European landscapes. Many EU areas, notably in southern Member States have practised irrigation for hundreds of years – this is part of the farming tradition – but the sector will need to review irrigation techniques in the light of climate change. Several regions may need to increase the irrigated area to ensure continuous production. But there is no doubt that agriculture has to make further efforts to improve its water use efficiency and reduce water losses, and irrigation plans will need to be based on careful planning and thorough assessments of their impacts.

**Weather hazards**

Impacts from increasing frequency of extreme weather events such as hail, intense winter precipitation, heat waves and droughts will be felt everywhere in Europe. A succession of floods, droughts and storms in recent years has shown Europe's vulnerability to extreme conditions, and their frequency could increase in the short to medium term (up to 2020). In particular, the risk of drought in the southern EU and the possibility of floods in central and northern EU areas are expected to rise.

**Increased pest problems**

Adverse impacts can also be expected from the likely rise in the spatial distribution and intensity of existing pests, diseases, and weeds, due to higher temperatures and humidity. The magnitude of the overall effect is difficult to assess but it is likely to be highly regionalised. Farmers will face the challenge of dealing with increased pest problems, or new pest challenges, within the constraints of what science can provide and within the EU's pesticide authorisation regulatory framework.

**Impact on crop yields and crop distribution**

Projected climatic changes will affect the level and variability of crop yields, livestock management, and the location of production as agro-climatic zones are likely to shift to more northern latitudes. These impacts may even put domestic food supply at risk in certain parts of Europe; they can also lead to increased price instability; and they will mean greater risks for farmers' incomes. This may be exacerbated by the impact climate change will have on important non-EU agricultural producer countries, from which the EU imports significant volumes of agricultural and food commodities.



However, there is still considerable uncertainty attached to forecasts of climate trajectories as well as to the expected impacts on agriculture, in particular at detailed spatial level. The existing variations between forecasts generated by different climate change models and socio-economic scenarios, and according to different time horizons, is an important factor when considering impacts.

**Impacts on consumers**

The probability of reduced production in some EU regions, variability of output, alterations in seasonal patterns, possibly increased farmer costs etc, as a result of climate change, will have knock-on effects for consumers. This may come in the form of supply dislocation and/or price variation. In some Member States, however, the yields and the range of farm produce could improve as the climate changes.

**Climate effects in forests**

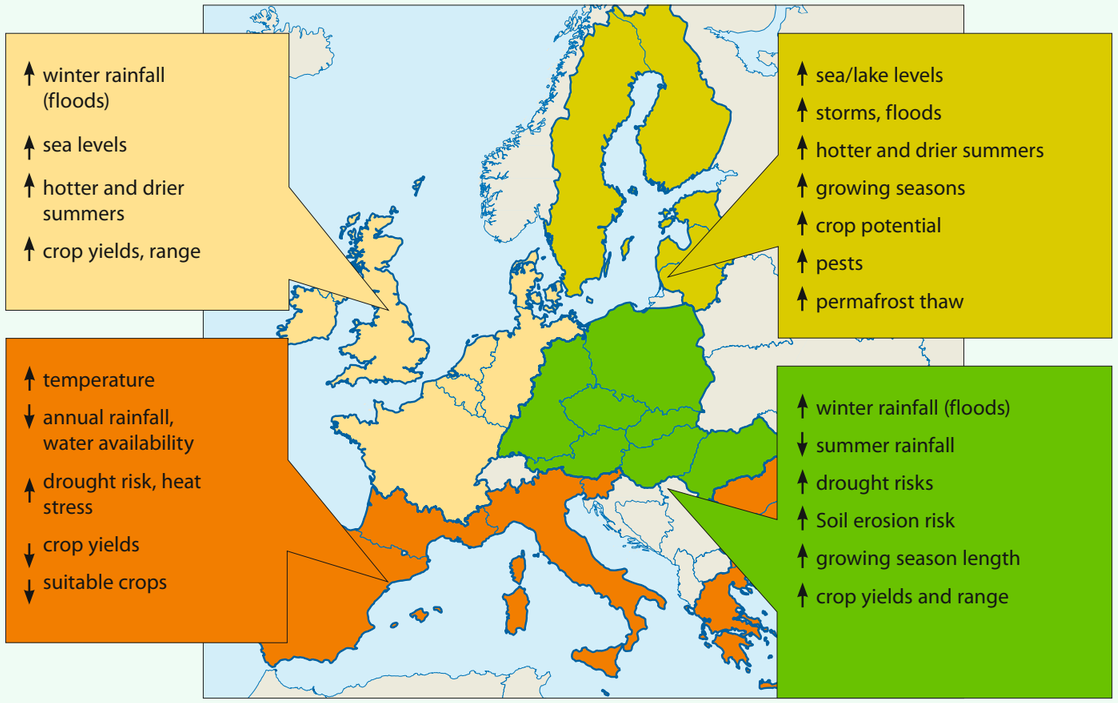
EU forest areas will also be widely affected by changing climatic conditions. Warming is likely to intensify the risk of forests fires and pests; in the longer term it will also affect tree species composition and timber production capacity, although the incidence of these impacts will be geographically different. Extreme weather events, such as heavy winds, storms, and prolonged heat waves and droughts will also have significant impacts on forests. In the long term, climate change might jeopardize the capacity of our forests to provide economic, social and ecological services.

**Different climate change effects in EU regions**

All parts of the EU are increasingly feeling the adverse effects of climate change, but some areas will be more affected. For example, southern Europe and the Mediterranean Basin are among the most vulnerable due to a high risk of water shortages. Also particularly vulnerable are mountain areas, in particular the Alps, where rapid temperature increases lead to the widespread melting of snow and ice, and alterations to river flows. Densely populated floodplains will be under greater threat due to the increased risk of storms, intense rainfall and flash floods leading to widespread damage to farmland, built-up areas and infrastructure.

The wide range of anticipated climate impacts for agriculture is summarized in figure X.


**Figure X. Projected impacts from climate change in different EU regions**




Source: Commission DG Agriculture elaboration based on literature

**Climatic zones**

- Central Europe
- Northern Areas
- South and South-East regions
- West and Atlantic Areas

**Southern and south-eastern EU countries**

Southern and south-eastern areas (Portugal, Spain, south of France, Italy, Slovenia, Greece, Malta, Cyprus, Bulgaria, and southern Romania) will experience the combined effect of large temperature increases and reduced precipitation in areas already having to cope with water scarcity and where there is a heavy dependency on irrigation. In the Iberian Peninsulas annual rainfall may drop by up to 40 % compared to current levels by the end of the century. If no effective adaptation takes place, yield drops could range from 10 % to 30 % (in the long term) possibly creating domestic food supply risks. By 2050, there may be shifts in the planting of crops (e. g. spring crops) from southern areas to higher latitudes as a result of climatic changes. Adaptation measures, such as more balanced crop rotations by introduction of less water demanding crops, will be necessary to avoid the most dramatic effects.

**Central EU regions**

In central European countries (the south and east of Germany, Austria, Poland, Czech Republic, Slovakia, Hungary, northern Romania) climate models predict increases in precipitation during the winter and the possibility of large reductions in summer precipitation in several areas, such as Hungary and northern Romania. Agricultural activities are likely to be affected by high temperatures and summer droughts, increased risk of soil erosion and the migration of pests and diseases. However, some regions, such as Poland, Czech Republic, eastern Germany, may benefit from longer growing seasons that will increase yields and the range of crops.

**Western and Atlantic areas**

In western and northern France, Belgium, Luxembourg, Netherlands, Germany, the United Kingdom, Ireland and Denmark, the predicted mean temperature increases are more moderate than in other regions. Extreme events such as violent storms and floods are projected to become more frequent due to warmer temperatures and higher volumes and intensities of precipitation, in particular in winter. But, summers are likely to be dryer and hotter and reduced water resources during this season may lead to conflicting demands between agriculture and other users for this vital resource. One of the greatest problems to be faced by agriculture in this zone may be rising sea levels, affecting low-lying land in eastern England and the North Sea coasts of Belgium, the Netherlands and Germany, some of the most productive agricultural areas in those countries.

**Northern zones**

In the northern areas (Sweden, Finland, the Baltic States), violent storms and flash floods, with higher and more intense precipitation, are expected particularly in winter and especially in the northernmost regions (e. g. Sweden and Finland). More positively, it may be possible to cultivate new areas and crops, due to longer growing seasons, and yields could substantially increase under limited warming of 1 °C to 3 °C, but production could suffer from new pests and diseases. The warmer climate could also aggravate water quality problems in the Baltic Sea. Permafrost melting due to warming will also be of particular concern for soil structure.

## 7. Agriculture can contribute further to the effort against climate change

The EU agriculture sector is fully aware of climate change challenges and is responding. There are already a number of farm management practices that can potentially reduce emissions below current levels. These vary in cost-effectiveness and practicality, but include: optimisation of fertiliser application rates and spreading; reduced use (or restoration) of organic soils, such as peat soils, which contain high levels of carbon; and better control of manure management systems to reduce methane emissions – through for instance using solid covers for manure lagoons, composting, and anaerobic digestion systems (e.g. for capturing methane and converting it into biogas). Further development of renewable energies from agricultural biomass could contribute to reducing $CO_2$ emissions from energy and transport, while benefiting the agricultural sector.

However, there are also limits to what can currently be achieved in cutting farm emissions, for example the number of technological solutions that are available and affordable for farmers, and the necessity to maintain food production in the EU. In the future, new technologies may emerge to reduce, for example, methane emissions from the digestion process of ruminants.

It is also important to note that, while reducing EU agricultural production, extensifying or meeting onerous conditions in agriculture may address climate change problems, there is a risk of 'exporting' the emissions to other countries that continue to produce without addressing climate change problems and that could fill the food supply gap. For instance, as world demand for animal products is growing, stringent mitigation measures taken in the EU will not result in a net global reduction of emissions if there is a relocation of livestock activities to other countries. In addition, if increased production occurs in countries where animal productivity is lower than in the EU, there may even be a net increase in global GHG emissions, including $CO_2$ losses from the potential changes in land use (conversion of forest land to pastures). This underlines the fact that climate change, including in agriculture, is a global problem requiring global solutions. Some specific ways in which agriculture is already making a contribution are as follows:

**Conversion of animal waste into biogas**

The installation of anaerobic digestion plants[24] for the production of biogas from animal manure is one of the most promising measures to reduce methane, despite the high investment costs involved. This is particularly effective for those regions with high animal densities and volumes of slurry and manure and also has benefits for water protection. EU rural development funds are being used to support biogas facilities. However, for the successful development of biogas, additional measures such as remunerative feed-in tariffs[25] for electricity are required.

**Organic farming methods**

Organic farming, as it does not generally use mineral fertilisers and also applies less organic fertilisers than conventional agriculture, contributes less to emissions. Organic agriculture also generally uses less energy (both per hectare and per unit of product) than conventional farming. The EU has encouraged organic farming for many years. The European Action Plan on Organic Food and Farming of June 2004[26] underlined the dual societal role of organic production in responding to consumer demand and providing public benefits. The plan aims at further supporting the development of organic agriculture.

**Enhancing the carbon sink function of agricultural soils**

The storage of organic carbon in agricultural soils (carbon sinks) offers a considerable potential to remove $CO_2$ from the atmosphere. Chlorophyllic plants absorb $CO_2$ through photosynthesis and use the contained carbon to build organic matter. The role of agricultural ecosystems as carbon sinks is recognized by the Kyoto Protocol, which permits inclusion of sequestration (or release) of carbon from farmland management in the calculation of net national $CO_2$ emissions[27].

Significant amounts of carbon can be stored in soils through a range of farming practices and changes in land use, such as: organic farming; zero or reduced tillage systems that avoid or reduce soil disturbance; use of catch crops[28]; protein crops; planting of hedgerows; maintenance of permanent pastures and conversion of arable land to grassland. Significant amounts of carbon can also be built up through afforestation of farmland, and agri-forestry systems, because woody species (e.g. short rotation willow) can hold considerably more carbon than most agricultural crops, on a more permanent basis.

Scientific knowledge is progressing in this area, although there are still a number of difficulties associated with the

[24] Anaerobic digestion is the natural process of biological degradation of organic material in the absence of air. An anaerobic digester is a man-made system that uses this process to treat different types of organic waste and produce biogas. The biogas can then be converted into heat and electricity. The process reduces gaseous emissions from the input material, while at the same time delivering valuable renewable energy

[25] Legal obligations (and minimum prices) on utilities to purchase electricity from renewable energy installations, such as biogas plants

[26] See: http://ec.europa.eu/agriculture/qual/organic/plan/comm_en.pdf

[27] Article 3.4 of Kyoto Protocol on agriculture and forestry land use

[28] A catch crop is a fast-growing crop that is grown simultaneously with, or between, successive plantings of main crops to provide a vegetal cover the year

implementation of carbon-sequestering measures and uncertainties about their outcomes related to regional and soil type variation and to the stability of carbon content. Despite the uncertainty surrounding the potential for storing carbon via soil management measures, these are very important to the sustainable use of soil. In its latest assessment, the IPPC found that carbon soil sequestration in farmland soils holds the greatest potential for mitigation of global emissions[29].

**Renewable resources for bio-energies and bioproducts**

Renewable energy produced from agricultural biomass[30] can replace emission-intensive energies in transport, heating or electricity. The development of renewable energies is a key measure to ensure that the EU's commitment on GHG emission reductions is met.

In March 2007 EU heads of government endorsed objectives to be achieved by 2020: overall share of 20% of renewables in energy consumption, and a minimum share of 10% of biofuels in fossil fuels use for road transport. In its policy to develop biofuels, the EU is planning measures to ensure that their overall impact on $CO_2$ emissions is positive, including a requirement for a minimum level of reduction of GHG emissions compared to fossil fuels. Legislation will also promote 'second generation' biofuels, which involve advanced conversion technologies and which can use a wider range of biomass resources – by-products, and forest materials – and achieve significant GHG emission reductions.

Potential for further emission reductions is also offered by the gradually increasing use of renewable agricultural resources, such as agro-materials, bioplastics and biochemicals, in industrial production. Numerous studies show that many products from vegetable origin provide advantages for the environment and human health. Local use of biomass also favours a more balanced distribution of agricultural activities across the EU's territory.

**Providing environmental services**

Taking into account the projected severe impacts of climate change on habitats and biodiversity, the role of agriculture as a provider of environmental and ecosystem services will increase in importance under a changing climate. Agricultural management has a major role to play regarding, inter alia, efficient water use in dry regions, protection of water courses against excessive nutrient inflow, flood management, and the maintenance and restoration of multifunctional landscapes such as high nature value farmland that provide habitats and assist migration for numerous species. Promotion of soil measures related to maintenance of organic carbon and protection of permanent grasslands are measures that can enhance carbon sinks while at the same time helping adaptation to climate change risks.

[29] Smith, P., D. Martino, Z. Cai, D. Gwary, H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, B. Scholes, O. Sirotenko, 2007: Agriculture. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change

[30] Biomass refers to arable crops, trees and other plants, agricultural effluents (e.g. manure) and forest residues, which are used as feedstock materials for renewable energy generation (electricity, heating and cooling) or for transport fuels, and for manufacturing bioproducts such as fibres, bioplastics or chemicals. Biomass may also include industrial by-products and the organic fraction of municipal solid waste



**Climate change, agriculture and the consumer**

Farmers are not making efforts to address climate change problems, by adapting their agricultural practices, in a vacuum. They are responding to demand in their market places, sometimes linked to climate change, as well as to EU initiatives. Many food producers and consumers are increasingly trying to reduce their carbon footprint via their production and consumption choices (e.g. improving carbon footprint[31] information; buying locally to reduce food miles). Some farmers are opting for more environmentally sustainable farming techniques (e.g. organic, integrated crop management[32]). But, there are practical problems to be faced. For example, there are no standard methods for carbon foot printing yet. Some form of labelling may be developed but work on this is still in its infancy. This means that neither producers nor consumers are yet sure what the market can deliver.

[31] A carbon footprint is the total amount of carbon dioxide and other greenhouse gases emitted over the full life cycle of a product or service. The carbon footprint is calculated using Life Cycle Assessment methods

[32] Integrating crop production strategies to provide benefits such as pest control, maintain soil fertility etc., while also taking advantage of modern technology

## 8. Agriculture must find further ways to adapt

Climate change is a real concern for the sustainable development of the EU. Finding adaptation solutions is critical for the years to come, particularly in agriculture. Adaptation measures must work towards reducing the vulnerability of the agricultural sector and increasing the resilience of rural areas from an environmental and an economic perspective.

**A wide range of adaptation options at different levels**

Adaptation refers to policies, practices, and projects with the effect of moderating damage and/or realising opportunities associated with climate change, including climate variability and extremes[33]. There is a wide range of adaptive measures ranging from technological options to managerial (e.g. farming practices) and political (e.g. adaptation action plans).

To cope with projected changes in climate conditions, farmers can, inter alia: change their crop rotation to make the best use of available water, adjust sowing dates according to temperature and rainfall patterns, use crop varieties which are better suited to new weather conditions (e.g. more resilient to heat and drought), and plant hedgerows or small wooded areas on arable land that reduce water run-off and act as wind-breaks. Provision of better information on climate risk and adaptation options to the farming community, and support to advisory services and training, are key adaptive measures at sectoral level.

Some Member States are already taken action on adaptation. Immediate attention has focused on research (assessments of climate impacts) and raising awareness. Adaptation strategies covering the agriculture sector have been prepared or are being developed in a number of countries (e.g. Finland, Spain, France, UK). The focus of much of the effort to date has been on prevention of weather-related extremes that are perceived as the most imminent risk (such as floods).

[33] EEA Technical report n° 7/2005 and glossary of the IPCC Third Assessment Report (http://www.ipcc.ch/pub/syrgloss.pdf)
[34] The seasonal timing of life cycle events (changes in plants and animals)



**Farm practices are already changing in response to new climatic conditions**

Some changes in phenology[34] due to changes in mean weather conditions are already observable in Europe, although trends in increasing productivity make it difficult to identify climate change impacts yet. For example, in southern France, an advance of one to three weeks in apricot and peach tree flowering periods has been observed. In Alsace (eastern France) the warming and lengthening of the vine growing season has led to increases in the average alcohol content of wines. In Germany sowing dates for maize and sugar beet have been advanced (by around 10 days). In southern France maize sowing is on average 20 days earlier than usual. Such changes in the farming calendar suggest that farmers are already adapting autonomously to new climate conditions.

As changes in weather patterns intensify, farmers may need to use other varieties and new crops, with specific and new husbandry. Some adaptation methods necessitated by climate change will be costly, due to the need for investment in new equipment and infrastructure, for instance installing and improving irrigation to offset rainfall reduction during the growing season, or adapting ventilation in buildings housing livestock.

**How the CAP supports farmers' adaptation efforts**

Farmers cannot shoulder the burden of climate change alone. Public policy has to give the right support to enable farmers to adapt their farm structures and production methods, and to continue providing services to the rural environment. The CAP already has some building blocks in place which should make it easier to adapt to climate change.

One of these is the 'decoupling' of agricultural support from production (introduced within the CAP reform of 2003 and later extended to the sugar, and fruit and vegetables sectors) under which aid payments to farmers are no longer linked to what farmers' produce. One of the aims of decoupling is to allow farmers to be responsive to various external forces. Responsiveness to the market is often emphasised, which is essential. But, decoupling also helps farmers to respond to their physical environment, by for instance cultivating the most appropriate crops. The recent reforms of the CAP have contributed towards a framework for the sustainable development of EU agriculture, and a better management of environmental resources will be an essential part of the adaptation strategy for agriculture.

Facilitating farmers' access to risk management tools, such as insurance schemes, may also help them to cope with the economic consequences of extreme events driven by climate change. Possible policy tools for managing risks and crises are being examined as, in future, these could be crucial to securing farm incomes and to alleviating significant income fluctuations. The EU has already included specific provisions for risk management tools in the recent reform of the fruit and vegetable sector[35]. For example, producer organisations can use their 'financial envelopes' (amounts of aid), part

[35] See http://ec.europa.eu/agriculture/capreform/fruitveg/index_en.htm (the reform of the common market organisation in fruit and vegetables)

financed by the EU budget, to support producers taking up harvest insurance against natural disasters and the administrative costs of setting up mutual funds.

The second pillar of the CAP – rural development policy – provides opportunities to offset adverse effects that climate change may have for farmers and rural economies. The regulation on EU rural development for the period 2007–2013[36] contains explicit references to EU objectives for climate change mitigation, as well as the need to anticipate the likely effects of climate change on agriculture. Rural development funds have already been used in several ways to help address water scarcity, such as providing support for water saving actions and investment in more efficient irrigation equipment. Agri-environmental schemes targeted to the management of soil, water, and landscape are also important actions from an adaptation perspective. Providing information on climate risks and workable adaptation solutions to farmers, to help them plan their activities better, can be supported by advisory services and training. The vulnerability of farmers is linked to their socio-economic situation and encouraging a culture of change is essential in sustaining their adaptive capacity. Rural development also has a role to play in the conservation and sustainable use of genetic resources. Maintaining a broad genetic resource base is essential to developing varieties more tolerant to heat and water stress. Some forest measures can also be used to address climate effects, such as preventative actions against pest outbreaks and improving the resilience of forests by adapting tree species composition.

[36] http://ec.europa.eu/agriculture/rurdev/leg/index_en.htm




## 9. Improving our knowledge and long-term thinking

The extremely diverse regional agro-climatic conditions and projected impacts of climate change, ranging from positive to very negative, make it difficult to foresee general measures for adaptation at EU level. Adaptive solutions will also have to be found at regional and local level. Successful adaptation will require the collaboration of multiple levels of government; from EU to national, regional and local. Adaptation planning in agriculture cannot be done on the basis of global knowledge about changes in climate patterns, but needs detailed information on regional impacts and meaningful assessment of the adaptive options and their feasibility at local and farm level.

To prepare for adaptation, the EU is promoting research. Knowledge on climate change risks and adaptation options then needs to be translated into practical solutions for farmers and rural planners in their areas of work. The use of training and advisory services is crucial to drive adaptive decisions and actions.

**EU research projects on climate change**

Scientific results provide a basis for understanding the drivers and subsequent impacts of climate change, and for work on identifying cost-effective mitigation and adaptation options. Several projects funded by EU Research Framework Programmes have contributed to improve knowledge in this area.

The PRUDENCE[37] project, for example, has predicted impacts of future climate in different regions of Europe. The ongoing ENSEMBLES project[38] is developing a prediction system for climate change based on high resolution global and regional 'Earth System' models developed in Europe. Both projects have made a substantial contribution to the recent IPCC Fourth Assessment Report. Another large on-going project, ADAM[39] ('Adaptation and Mitigation Strategies: supporting European climate policy'), assesses the costs and effectiveness of mitigation and adaptation policies, and will provide a portfolio of longer term strategy options. The CIRCE ('Climate Change and Impact Research, the Mediterranean Environment') project[40] works in cooperation with North African and Middle East countries to evaluate the consequences of climate change for the society and economy of the Mediterranean area and to identify adaptation actions.

The EU is not only funding research but is also promoting the sharing of knowledge and experiences to enable the partners involved to develop new solutions to climate change challenges. For instance, ClimChAlp[41] (Climate change, impacts and adaptation strategies in the Alpine Space) is an Interreg[42] project grouping all European Alpine regions. The Alps are particularly sensitive to climate change. The project has the objective of improving the assessment of climate impacts and developing a common sustainable development strategy that anticipates climate effects.

The PESETA[43] project ('Projection of Economic impacts of climate change in Sectors of the European Union based on bottom-up Analysis') has developed a methodology for assessing the possible economic impacts of climate change in different economic sectors, including agriculture. The project produced maps which attempt to represent the projected changes in agricultural yields, on the basis of modelled changes in climate variables.

[37] See: http://prudence.dmi.dk
[38] See: http://ensembles-eu.metoffice.com/
[39] See: http://www.adamproject.eu/

[40] See: http://www.circeproject.eu/
[41] See: http://www.climchalp.org/
[42] INTERREG is an EU-funded programme that helps Europe's regions form partnerships to work together on common projects.
[43] See: http://peseta.jrc.es/index.htm

On-going policy support projects in the agricultural field are PICCMAT ('Policy Incentives for Climate Change Mitigation Agricultural Techniques')[44] and ADAGIO ('Adaptation on Agriculture in European Regions at environmental risk under climate change')[45], in the fields of reduction of emissions and adaptation respectively. The PICCMAT project aims at identifying farming practices that reduce GHG emissions, and suggesting measures and policy tools to stakeholders and policy makers. Involving researchers, local agricultural research centres, farm advisory services and farmers, ADAGIO will assess the potential adaptation measures in agriculture for a range of European regions.

The EU is also involved in agronomic and technology research, and in the development of the second generation of biofuels. The application of biotechnology[46] is another area the EU has an interest in. Biotechnology offers possibilities for example for the development of crops that are more tolerant to heat and drought. EU-funded research in biotechnology, related to climate change, is focused on the development of the 'Knowledge-based bio-economy[47] aimed at the replacement of fossil with renewable biological materials. This can lead to applications and products in a wide range of fields, such as novel foods, green chemicals (e.g. bioplastics), as well as sustainable, environmentally friendly biofuels.


[44] See: http://www.climatechangeintelligence.baastel.be/piccmat/
[45] See: http://www.adagio-eu.org/
[46] Biotechnology is a technology mainly based on biology and genetics,especially used in agriculture, food science, and medicine
[47] See: http://ec.europa.eu/research/biosociety/kbbe/kbbe_en.htm



## 10. Concluding remarks

Farmers face many challenges from climate change, but can provide some of the solutions to global warming. Agriculture has additional opportunities to contribute to climate change mitigation by reducing its emissions of methane and nitrous oxide, by enhancing carbon sequestration in agricultural soils, and by providing materials for renewable energies and industrial applications.

Farmers have long proved their capacity to adapt to new challenges. Constant evolution regarding the choice of crops and varieties, and management practices (e.g. timing of farm operations, irrigation) can be observed across the EU. These are mainly autonomous actions at regional and, in particular, at farm level triggered by short-term circumstances (e.g. as a result of weather forecasts). However, the challenges imposed by climate change in the future exceed the limits of autonomous adaptive capacity on farm level, and policies will be required to enable farmers to cope with changes needed in farming systems. Rural development policy can play an important role in providing support to farmers and rural communities facing climate risks.

More research into the impact of climate change on agriculture (and vice versa) is needed. In the meantime, the EU is working on adaptation using the reliable findings it has regarding, for instance, predicted changes in average temperature. The EU has already adopted the safe strategy of coping with the likely short term impacts from extreme weather conditions. Future adjustments to the CAP should involve working towards a policy which will take into account adaptation needs and promote farming practices which are compatible with new climate conditions and that contribute to preserving environmental resources. The biggest challenge is to guarantee the sustainability of European agriculture and rural areas, bringing economic and social viability and resilience to climate change.

Within the 'Health Check' of the CAP, the European Commission is addressing some of the new, interrelated challenges that EU agriculture is called to respond to: climate change, bio-energies, and management of water resources. The Commission will examine whether additional incentives for farmers and rural areas, within rural development measures addressing climate change, are needed. Ways of encouraging more efficient water use and bio-energy, including second generation biofuels, and protecting biodiversity will also be explored. These and other issues are for debate.

## 11. Useful sources of information

European Commission Directorate-General for Agriculture and rural development
See: http://ec.europa.eu/agriculture

European Commission Directorate-General for Environment
See: http://ec.europa.eu/environment/climat/eccp.htm
http://ec.europa.eu/environment/climat/adaptation

European Environment Agency
See: http://www.eea.europa.eu/themes/climate

IPCC
See: http://www.ipcc.ch

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# European Commission
# Directorate-General for Agriculture and Rural Development

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