# 8. Thematic scenario 'Climate change'

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## 8.1 Scenario base: climate change

### 8.1.1 Present situation and trends

#### *8.1.1.1 Current state of affairs*

Climate change is supposed to be the biggest environmental threat in future, with rather unpredictable consequences. Dealing with climate change means dealing with long-term processes (decades to centuries), with a large degree of uncertainty. In this text, magnitude, time span, uncertainties and impacts of climate change are put into perspective, as well as current and possible policy reactions.

The causes and consequences of climate change can be simplified by a chain of causalities and consequences. Emissions from transport, industry and other sectors lead to increasing atmospheric greenhouse gas (GHG) concentration. This concentration, in turn, leads to many climatologic changes: temperature rise, difference in annual precipitation, and occurrence of extreme weather events. As a consequence, ecosystems change or move geographically, hydrological regimes of rivers change, and ice and snow cover are retreating. Both climatologic and other natural consequences of climate change affect society in a number of ways, varying from increased natural hazards to persistent water scarcity.

#### *8.1.1.2 Trends and territorialization*

Many figures have been published on climate change. Emission rates have started to increase since the 1850s at the beginning of the industrialization age. Atmospheric concentrations of greenhouse gases started to rise from 280 ppm to 375 ppm from 1900 to 2000, with a sharp increase in the last decades. Concentrations in 2000 are the highest of the last 400,000 years (IPCC, 2001).
The most evident climate response is the rise of average world temperature by 0.7 C; in Europe average temperature rose by 0.95 C (EEA, 2004). Precipitation patterns have changed, too, with a 10 to 40% increase in Northern Europe, and up to a 20% decrease in the south. The occurrence of extreme weather events has not convincingly changed, although some indicators point in this direction.
Some natural consequences are very clearly related to climate change. Sea level has risen by 15 cm on average due to melting of arctic ice. Mountain glaciers in the Alps are retreating, and growing season in Central Europe has increased by 10 days since 1960.
Other events are harder to relate to climate change, both because of other factors interfering, the incidental nature of certain extreme events, and increasing vulnerability of societies. Floods might for example be caused by increased built up areas, and the damages might have increased due to recent urbanization in flood-prone areas.
Nevertheless, indicators exist that different parts of Europe are experiencing some consequences already. In the past 20 years, the number of large floods has been exceptionally high in Central Europe, whereas drought has seriously affected agricultural production systems in the south.

#### *8.1.1.3 Projections and expert visions*

To estimate future climate change, the IPCC has identified six scenarios of greenhouse gas emission, according to different socio-economic and technological developments. For each emission scenario, climate change has been quantified by applying a range of models. The difficulty with these models, though, is the uncertainty about the exact mechanism of climate change. The influence of CO2 emission on climate change is (almost) without dispute, but the interactions between emission, concentration and climate change are not fully understood. As a result, each scenario presents a range from a possible minimum to a possible maximum climate change impact.
Between the scenarios and the uncertainties altogether, the minimum expected temperature rise is expected to vary between 1.4 and 5.8 C worldwide in the year 2100, as compared to 1990 levels. For Europe, figures are slightly higher: 2.0 and 6.3 C. All European regions will be affected, although to a lesser extent in the north. In all scenarios, rainfall will be less in the South, whereas Northern Europe is expected to receive more rainfall. Extreme weather events are expected to increase, although very little has been unraveled by science so far.
For the year 2030, the difference between scenarios is very small. This is illustrated by the small variation of temperature rise predicted by 2030, all less than 1° C. The small differences are due to the large time lag existing between changing emission rates, and the consecutive climate change and its impacts. A reduction of CO2 emissions within 10 to 50 years leads to a stabilization of atmospheric CO2 concentrations in 100 years, a temperature stabilization in a few centuries, while sea level rise continues even up to millennia.

Impacts on natural systems and society will be large, but only be felt seriously after the year 2030. Most important impacts are water shortage, desertification, forest fires, decreasing tourism and agriculture in Southern Europe. In the north, floods are expected to be more intense and frequent. Agriculture will expand northwards. Mountainous areas are affected by shrinking winter seasons, negatively affecting tourism. Biodiversity is at threat in most areas. And with frequent heat waves, human casualties will increase. Coastal areas will be affected on a very long term by sea level rises of almost 1 meter by 2100 and possibly up till 5 or 10 meters in the century thereafter.
A more precise estimation of climate change impacts on a regional level has not been published, yet. This is due to the difficulties to regionalize climate change itself, particularly the extreme weather events leading to floods, draughts and storm surges. Several projects are under way to fill this gap (PRUDENCE, ENSEMBLES), but scientists state that they are not yet at the promised level where regional climate models can really influence policy-making.

#### *8.1.1.4 Coping mechanisms*

There are two coping mechanisms to deal with climate change: mitigation and adaptation. Mitigation measures try to reduce greenhouse gas emission and therefore temper the magnitude of climate change. Results can only be expected at the very long run. Mitigation can be in the form of emission reduction (reducing transport or cleaner technology) or capture of CO2 (forest, agriculture).
Adaptation measures are interventions to deal with the impacts of climate change. Adaptation can be pro-active, or preventive, which means that investments take place to prepare for events that might eventually happen. Reserving more space for river beds is a preventive measure; transformation to a less water consuming agriculture in drought areas is another example. Measures can also be re-active. Actions of this kind only deal with the consequences of events as they happen. Reparation of farmers´income after misharvest or flooding is an example.

In producing scenarios for climate change impacts, mitigation and adaptation measures must be taken into account. If mitigation proves successful, emission rates are lower. If adaptation measures are put in place, climate change impacts will not be as serious as they will be without. The other side of the coin is that both measures require visionary and often costly measures. These measures in themselves might have large spatial impacts, too, like the promotion of sustainable energy by wind and bio energy, by water pricing in drought areas, by maintaining landscapes against desertification, or by capturing CO2 through large scale reforestation programs. Politicians might be reluctant because the results of their efforts might never be proved, given the enormous uncertainties and large time span of climate change processes.

### 8.1.2 Existing relevant EU policies

#### *8.1.2.1 Existing policies*

Until now, explicit EU climate change policies are exclusively focused on mitigation efforts to reduce emission of greenhouse gases. They are geared along two lines: first by defining targeted climate change policies, and second by integrating climate change in sector policies. Examples of specific climate change policy are the implementation of a greenhouse gas emission monitoring system and the Directive on Greenhouse Gas Emission Trading (2003) which allows for flexible application of trade schemes. Best example of integrated sector policies is the European Program on Climate Change (EPCC, 2001). Most involved sector policies were energy (energy efficiency, promotion of renewable energy, CO2-energy tax, energy networks) and transport (energy efficient transport, focus on rail and water transport, road pricing).
Aside from the Kyoto targets, the EU has put a long term goal to limit global mean temperature increase to 2° C above pre-industrial levels. This requires in the long term a stabilization of GHG atmospheric concentration of well below 550 ppm. The EU stated that this requires a serious limitation of emission rates to 60% below the 1990 level by 2050. How this should be achieved is still to be negotiated.

An EU framework for adaptation measures to climate change impacts is missing so far. The Sixth Environmental Action Program says the EU should prepare for measures aimed at adaptation to the consequences of climate change, by 1) reviewing Community policies, in particular those relevant to climate change, so that adaptation is addressed adequately in investment decision; 2) encouraging regional climate modeling and assessments both to prepare regional adaptation measures, and to support awareness rising among citizens and business. The 6EAP also underscores the need for consistent policy on prevention, preparedness and response to natural man-made and other risks.

#### *8.1.2.2 Policy impacts*

The two main topics in emission reduction are the internalization of climate costs of energy use by taxes, and the way technological innovation should be promoted. On the internalization issue, little progress has been made. Commissions´ initiatives in this direction have been vetoed since 1992. Only in 2003 the first agreement on taxes has been made, with many exemptions, long introduction periods and applicable only to a few sectors. Technological innovation, on the other side, has been successful to some extent. The car industry has voluntarily committed to emission reductions in EU negotiations, and governments have also invested in clean technology implementation, like wind energy.
These and other mitigation measures have to some extent been successful: emission has fallen by 3% since 1990. However, reduction targets are not being met, and emission rates

are increasing again since 2000. Measures currently in place will not allow the EU to achieve its Kyoto target (Commission of the EU, 2003).
The spatial effects of these measures have not been significant so far. The only exception is the promotion of wind energy, which has increased and changed landscapes in some parts (Germany, Spain). Limitations due to taxing high emission use of transport or conventional technology are not being felt.

Impacts of adaptation measures have not been systematized due to the lack of a EU policy framework on climate change adaptation. Programs addressing issues which can be classified as adaptation measures have not been reviewed for the purpose of this text.

#### *8.1.2.3 Current relevant policy debates*

The EU policy debate on climate change focuses on three issues: the extent to which climate change policy is needed, the mechanisms which are most appropriate to reduce emission rates, and the way adaptation measures should be carried out.
Firstly, European countries generally consider climate change as a serious threat which requires immediate action. The latest EEA publications urge for accelerated GHG emission reduction if the 2° C target is to be met. Although the EEA is rather optimistic in possibilities to do so, the additional measures would cost up to 0,6 % of EU GDP. Is Europe prepared to pay that price?
Secondly, there is a large difference of opinions between those advocating enforcement of lower emission rates by pricing the polluters, and those in favour of stimulating measures to shift towards clean technologies. Another debate concerns the way emissions can be traded. Disagreement exists whether emission reduction should be achieved in a nation's own territory, or if excessive emission rates can be compensated by buy-offs from other countries.
Thirdly, the need for EU-funded adaptation measures is discussed. Since damages of any kind are so difficult to relate to specific climate change impacts, adaptation measures are hard to quantify. On the other hand, solidarity in handling climate change impacts between countries which are and are not hit by its consequences appeals to the basic principles of the EU.

### 8.1.3 Most important driving forces

#### *8.1.3.1 Driving forces of climate change*

Evidently, the driving force behind climate change is the emission of greenhouse gases. The rate of greenhouse gas emission depends positively on economic growth and negatively on the introduction of clean technologies. There are, on the other hand, some forces which temper or aggravate this force. These forces are the natural systems of sinks and emissions of CO2. Vegetation captures CO2, therefore an increase of vegetation cover worldwide extracts greenhouse gas from the atmosphere. Water, snow and ice also store CO2. Although these natural forces are to be taken into account, human induced emission rates are potentially much higher in quantities.

#### *8.1.3.2 Driving forces from science, society and policy*

Climate scientists determine to a large extent the agenda for climate change policies. If they would not have published about the issue, society would not be alarmed. As a result, there is a pressure on scientists to produce more consistent predictions on climate change impacts than what is currently available. If scientists fail to minimize the current uncertainties, certain parts of society might lose interest in the issue.

In society, environmental lobby groups have been important in putting climate change on the agenda. On the other hand, business groups are often combating measures which might harm economic growth. Overall, societies attitude is crucial in the way policy changes are acceptable. Road or water pricing in an atmosphere of urgency tends to be more successful than in an adverse climate of uncertainties whether these measures will at all address the problem.
The political arena about climate change is very much determined by worldwide developments, particularly on mitigation measures. Any emission reduction in Europe is worthless if the US, Asia and other rapidly developing countries are rapidly increasing their emission due to economic growth and limited convincement to reduce emission rates.
It is important to stress that European regions contribute differently to climate change by varying emission rates, and that the consequences of climate change are unequally spread over Europe, too. Regions which hardly produce greenhouse gases, but receive many impacts might have a different standpoint to climate change policies than other regions.

#### *8.1.3.3 Relation with other themes*

Causes and consequences of climate change, together with the coping mechanisms proposed by society and policy make the issue of climate change extremely interdisciplinary. The most relevant issues are mentioned, without intention to prioritize or to be exhaustive.

- Economy: high growth means more emission and more climate change
- Technology: clean technology means less emission.
- Agriculture: potentials for agriculture change according to changing climate zones and water availability.
- Energy: alternative energy means less emission, but potentially large spatial impacts (generation of wind energy, production areas for biofuel, other mechanisms of transport of energy).
- Transport: as alternative sources of energy do not become available, reduction of transport might be enforced.
- Hazards in general: these might increase due to climate change (floods, droughts).
- Tourism: areas which become less or more attractive.
- Nature: ecological zones shift geographically, stressing the survival of many vulnerable species.

### 8.1.4 Identification of scenario hypotheses

It could be argued that the magnitude of climate change and its impacts should be put at the core of scenario building. However, differences between climate change projections are only becoming significant after a 30 to 50 years time period. Any extreme climate fluctuations before 2030 would be rather unrealistic.
Since ESPON scenarios look forward to 2030, only one storyline for climate conditions has been put forward. Global warming has continued, northern Europe has received more intensive rainfalls, and southern Europe has faced serious droughts and heat waves. However, the magnitude of these developments has not been dramatic until 2030.

What might considerably differ in the next 25 years is societies and politicians´ attitude towards climate change. Two different scenario hypotheses are built around two extreme policy standpoints on climate change: *face consequences as they come* or *prepare for the worst*. These two opposing standpoints are the base for the story lines of both sketches. In the first scenario, only weak measures are taken, whereas in the second sketch, all will be done to reduce emissions, and to prevent disastrous damages by taking adaptation measures.

The reason for identifying coping mechanism as a base for the two climate change scenarios is the developments of the past three years, which point to an increasingly difficult situation to achieve international commitments to reduction of greenhouse gases. This alarming situation, also stressed by the G8 presidency, justifies the standpoint that the world, and Europe in particular might be at a breakpoint between the two scenarios.
The emphasis of the scenarios is on the impacts of climate change and adaptation measures to deal with those impacts. Impacts might have very different consequences across the European territory. At the same time, no scenarios have been made before on impacts and the effect of adaptation measures. Scientific knowledge about the effectiveness of adaptation is still immature. Therefore, the scenarios provide for a thinking exercise on how adaptation could help alleviate the worst consequences of climate change.
Greenhouse gas emissions and mitigation measures to reduce them, are briefly included in the scenarios. For this purpose, the EEA scenarios, published in 2005, are copied. Scenario 1 coincides with the baseline GHG emission scenario; scenario 2 is based on the low GHG emission scenario. The pathway how to get to these emission reductions are taken from EEA scenarios as well.

### 8.1.5 Sources of information (annex)

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## 8.2 Scenarios

### 8.2.1 Scenario 1: 'Repairing instead of preventing'

#### *8.2.1.1 Scenario hypothesis*

The potential magnitude of climate change over a long time period has been recognized, but the main players in the policy arena are reluctant to take preventive, sometimes drastic measures. As a result, emission rates are slightly higher in 2030 than they were in 1990, and climate change impacts hit as they come along. Only reparation measures are taken after events happened.

#### *8.2.1.2 Driving forces*

Driving forces related to possible attitudes and policy responses regarding climate change are among others:

- The existence of other important priorities in the public debate which overshadow the issue of climate change, such as security and terrorism, immigration and integration, population ageing, boosting economic development;
- Uncertainty about magnitude and impacts of climate change;
- Difficulties to identify cost-effectiveness of long term adaptation measures.
- Insufficient awareness about the potential impacts of prevention measures;
- Resistance of society and stakeholders towards changing attitudes and practices.

#### *8.2.1.3 Context*

Although growing evidence and public concern about climate change took place between 1990 and 2005, this issue could not improve its position in the political agenda. Alternative proposals based on a trust in market-driven development of clean technologies by US and Asian countries gained positions as compared to the Kyoto emission regulation approach advocated by the EU.
Moreover, no clear ideas about adaptation strategies had been developed by 2005, more than general statements about the high vulnerability of developing countries. Extreme weather events in 2002 and 2003 led to the initiation of the most relevant prevention measures, such as an EU flood regulation plan, and some local initiatives on the prevention of deaths in case of heat waves. In spite of initiatives in some countries (UK, Finland, Spain) to think of long term adaptation planning, this way of thinking was still at a very early stage.

#### *8.2.1.4 Scenario process*

The implementation of the Kyoto Protocol in the EU followed a problematic pathway. Although the Protocol came into force in 2005, and despite the introduction of an emission rights market, few additional measures were taken. No tax was put on conventional energy, because this was hampering economic growth. Public spending on R&D efforts for the development of clean technology was not increased. Optimism reigned that market forces would promote this technology, pushed by high oil prices.
In 2008, it was clear that the EU emission rate was 10% higher as the Kyoto targets proscribed (1% above 1990 level), and emission levels worldwide increased even more. Although a new climate protocol was drafted, its targets were considerably less ambitious as foreseen by the original EU position in 2005.

Meanwhile, climate change took its toll in different ways across several regions in Europe. In southern Europe, 2004/2005 drought was followed by more and longer drought periods in the years after. Northern Europe was hit by floods of different magnitude, whereas some years with heat waves of the magnitude of the 2003 summer repeated. Average climate values like temperature and growing season increased on general.

As a result, many problems unfolded. *Energy supply* was threatened in several occasions. In some regions, such as Corsica, it had been necessary to urgently import oil-fuelled machinery to produce electricity, because hydro-electric plants had no more water reserves. Over all Europe, power plants temporarily decreased their capacity in times of low river discharge, causing some alarming shortages of electricity in times of heat waves, when consumption of air-conditioning was at its highest.

*Water scarcity* was an important issue in many southern European countries. Serious shortages only occurred for agriculture, however, it had its effect on the price of industrial and drinking water.

*Agriculture* was affected mostly negatively in southern Europe. Existing production systems with a high demand for irrigation water were facing heavy losses due to years with water shortages. Changing climate affected all regions in Europe, where ideal growing conditions for a certain crop shifted northwards. This process put particularly dryland agriculture in southern Europe at stake, whereas regions like southern Scandinavia saw there agricultural potential increase. Numerous rural areas in the central and northern parts of Europe had to compensate for the decline of agricultural production in southern Europe. Production of dairy products, vegetables and fruits intensified and the production of energy crops strongly developed. Rural areas were therefore put under high production pressure while they were more and more abandoned by farmers in southern Europe.

Heavy rainfall caused more *floods*, particularly in northern Europe. Damages were significant, because a lot of factors were working against the development of prevention measures. New settlements were developed along rivers due to land speculation and existing building rights.

*Sustainable landscape management* in southern rural areas became extremely difficult. Extreme rainfall events caused numerous damages to soil structures, but were not very beneficial to the re-constitution of underground water reserves, because their duration was too short and their occurrence too irregular. Every year, in particular in summer time, numerous forest fires destroyed large forest areas in southern regions, causing damages also to settlements. The more forests were destroyed, the more the water and humidity retention capacity was reduced. This vicious circle led to more severe constraints in terms of water management and occasioned the washing of soil through periodic heavy rainfalls.

*Biodiversity* decreased or altered in most areas due to changing climatic conditions. Some species could migrate, but many couldn't because of the isolated location of their living environment. As a result, many species became extinct.

*Tourism* was affected, too. In southern coastal regions, mass tourism was confronted to a significant shortage of water supply. The construction of de-salinisation plants of sea water became generalized and this absorbed important amounts of resources and increased the price of holidays. The attractiveness of these regions was also reduced by the fact that numerous highly water consuming facilities such as golf terrains, large swimming pools, artificial parks and green areas etc. had to be restricted. Winter tourism in mountain regions also lost importance, because the occurrence of snow falls became more and more irregular. Seasons for skiing started later and ended sooner. On the other hand, new tourism opportunities grew in central Europe, particularly in coastal areas, where a more stable weather conditions attracted new tourists. All together, the economic importance of tourism in southern Europe declined, whereas it increased in Northern Europe. A significant revival of tourism could be observed in central and northern Europe, but benefiting also to a number of mountainous areas. Winter sport in Nordic countries became very popular.

All material damages caused by the different hazards summed to ever growing losses in terms of money. Insurance companies were forced to change their business models, because costs became far to high to maintain full coverage of all risks.

*Human losses* were becoming important in times of heat waves and floods, notwithstanding some measures like better attention to elderly people. The spread of lyme disease had accelerated because of favorable conditions for its transmitter; teak.

By 2015, these developments delivered a picture of increased vulnerability to climate change, in an environment which was adverse to taking costly measures for both mitigation and adaptation measures. Therefore, politics reacted in a defensive way to these developments.

On mitigation, ongoing energy intensity measures were successful. However, the role of hydro-electricity in energy supply, which had been the most important renewable energy source in southern mountainous regions, decreased significantly. Political pressure for building new nuclear and coal power plants developed.

The intensity of damages generated by climate change had reached such levels that national governments could not cope with the numerous requests for subsidies to finance repair works and to compensate for the loss of farmers' revenue. After difficult negotiations, a specific fund was created in the EU budget, on the model of the budget line for natural hazards created at the end of the 1990s, but with a significantly higher amount of resources. This amount had to be regularly increased. However, no large investments were made for adaptation measures in the long run. The lack of cost-effectiveness calculations refrained the EU from doing larger investments.

By 2030, mitigation measures proved to be too small to make a difference. While new technologies made it possible to reduce nominally the amounts of greenhouse gas emissions, the increase of traffic flows, the development of new coal-fired power plants aiming at counteracting the high price levels of oil and gas, generated large volumes of greenhouse gas emissions. EU greenhouse gas emission was still 8% above the 1990 levels. Climate scientists agreed that a temperature rise of 4° C by 2100 was unavoidable, even if drastic measures would be put in place before 2050.

Damages caused by natural hazards had further increased, and the production basis of the most affected regions (like rural and coastal areas in the south) was seriously deteriorated. EU hazard funds could not cope anymore with the magnitude of the damages.

#### *8.2.1.5 Impacts*

*Macro-economic impacts*

Macro-economic impacts of mitigation measures were negligible, since only cost-effective measures were put in place. However, the costs of new measures towards 2050, needed to prevent a catastrophic climate change towards 2100, are huge.

The macro-economic impacts of natural hazards caused by climate change have been significant. On the one hand, sudden events, such as forest fires of flooding caused important damages to settlements and landscapes which made expensive measures for repair and maintenance necessary. On the other hand, the economic capacity declined structurally in a number of regions, in particular in southern Europe, and more particularly in rural regions and in tourist areas (coasts and mountains). The loss of revenue of the economic stakeholders concerned had to be compensated for by the distribution of resources from public budgets.

*Regional impacts*

At macro-scale, a clear difference existed between northern and southern Europe. Mediterranean, South-West and Southeast Europe were most severely hit by climate change impacts through highest temperature rises, combined with prolonged drought periods. The attractiveness of southern Europe decreased, causing a slowdown of the southward migration flow. Economic development was hampered in the south, causing the economic gravity point to move northward. Central and Northern Europe experienced a boost on agricultural development, whereas Southern Europe saw this sector decline.

At meso-scale, several territorial divisions can be made. In *rural areas* in southern Europe, emigration processes that already took place in 2005 have become more widespread, due to a worsening situation in the agricultural sector, and a lack of alternatives. Abandoned, desertificated regions could be found in large parts of all Mediterranean countries. Rural areas in northern Europe were undergoing increasing pressure to expand agricultural production, due to the decrease of production in Southern Europe. This could affect negatively on natural and environmental conditions.

*Mountainous areas* proved particularly vulnerable to climate change. The loss of biodiversity was high in these regions, making natural management by corridor development extremely difficult. Decreasing snow cover led to declining winter tourism; by 2030, there were no more ski resorts below 1500 meters in the Alps. Water retention in mountainous areas became more difficult, particularly in the south, which led to the loss of another production basis for these areas: hydropower and irrigation water.

*Coastal areas* throughout Europe experienced large changes. Large scale tourism in the Mediterranean had suffered losses due to adverse climate conditions in summer time. These could not be compensated by increased attractiveness in spring and autumn. On the other hand, coastal areas in Central Europe were more and more invaded by mass tourism due to stable weather conditions in summer. All coastal areas throughout Europe experienced serious decline of biodiversity, because of fragmentation of ecosystems and the lack of migration possibilities. Coastal plains on or below sea level experienced an increased threat of floods, although no calamities occurred so far.

At the level of *river basins*, problems with water management increased. While mountains are generally considered as water providers, valleys and plains are the beneficiaries. If mountains become dryer, valleys and plains will be negatively affected.

At micro-scale, *flood prone areas* were indeed more severely hit by floods. This caused numerous deaths as well as a large economic loss. The losses were so high because the construction of housing in flood prone areas had continued.

#### *8.2.1.6 Final image*

By 2030, climate change, accompanied by a lack of prevention policies, has led to important modifications of the European territory.

In southern Europe, large stretches of hilly and mountainous areas which were in 2000 covered by oak and pine forests, have burnt and drought had not made possible the reconstitution of forests. They have become arid and desert areas with only little vegetation. A number of rural areas have been abandoned by farmers. Rural landscapes have no more been maintained and cared for, so that they are invaded by wild vegetation drying in summertime and particularly prone to fires. Life in villages and small towns has been shrinking, with less services and jobs and more ageing population. A number of holiday resorts in coastal areas and in southern mountains have become derelict sites.

In central and northern Europe, the situation is strongly different. Rural areas are more intensely used, both for food and energy production. Tourism is flourishing again, in particular in hilly landscapes and medium-sized mountains. Nordic areas also benefit more from tourism.

Damages to the environment are significant. In southern Europe, valuable Mediterranean landscapes have been destroyed. Numerous areas have become more sensitive to external pressure (sensitiveness of soil to heavy rainfalls, higher risk of fires, fragilisation of ecosystems etc.). Water resources are largely exhausted and do not enable any more the development of large-scale projects. The abandonment of rural areas by farmers has severely affected the cultural landscapes. Derelict sites have emerged in tourist areas.

In central and northern Europe, damages to settlements, infrastructure and landscapes have been caused by flooding in numerous valleys. Stronger environmental pressure can be observed in a number of rural areas due to more intensive agriculture.

#### *8.2.1.7 Main issues resulting from the scenario*

Climate change seems unavoidable and brings with it long-term effects and impacts on the territory. If public policies limit themselves to the Kyoto Agreement and its successor, hoping that the reduction of greenhouse gas emissions will solve the problem, then two types of problems may appear. First, the implementation of the Kyoto Agreement (and the elaboration of a successor) may prove more difficult than expected and second, even if successful, its impacts will be noticeable only in the very long-term. In between, numerous negative aspects of climate change will cause serious damages to the European territory.

### 8.2.2 Scenario 2: 'Anticipation of climate change by prevention measures'

#### *8.2.2.1 Scenario hypothesis*

Politicians and society are thoroughly tackling the climate change issue as a result of a common sense of urgency. Mitigation measures result in drastic cuts in emission rates by 2030, at the expense of some economic growth. Adaptation measures are taken, not only in reaction to extreme weather-related events as they happen, but also envisioning impacts in the long run. As a result, the negative territorial impacts of climate change are at least alleviated by 2030.

#### *8.2.2.2 Driving forces*

Driving forces behind this scenario are all related to a growing sense of urgency amongst politicians and other stakeholders to deal with climate change impacts:

- The awareness of damages already caused by climate change in European regions and the need to urgently take measures in order to avoid the amplification of such damages in future;
- The awareness that the deterioration of the European territory by natural hazards has extremely negative economic and social impacts and endangers the mobilization of the territorial potential of European regions;
- The political willingness to tackle the issues related to climate change at European and world level with strategies additional to the Kyoto agreement.
- Growing scientific input on regional climate change impacts and instruments to plan for long term adaptation measures.

#### *8.2.2.3 Context*

During the decade 1995-2005, Europe has been affected by a series of natural hazards related to climate change (flooding, hurricanes, drought, forest fires etc.) which had a strong psychological impact on the European population and on elected people. The drought in southern Europe during the winter 2004/2005 showed the amplitude and extent of territorial damages and acted as a kind of catalyst for awareness rising. It became clear at European level that more resources should be invested in prevention measures instead of distributing EU money case by case to repair the damages already caused by natural hazards. The first calls for an adaptation framework at EU level were made in 2004.
In 2005, the Kyoto Protocol came into force, thereby facilitating mechanisms like the exchange of emission rights. Although emission levels were rising in the years 2003-2005, the EEA showed that the Kyoto targets could be achieved with additional measures at national and EU level.

#### *8.2.2.4 Scenario process*

The Kyoto Protocol had been taken seriously by the EU. Signs that pointed to an increasing emission in the 2003-2005 period were responded by more severe actions on emission reductions. The emission rights market was successfully implemented. The carbon permit price was steadily increased to EUR 65/t CO2 by 2030. Public spending on R&D increased, and potentially environmentally harmful subsidies were removed.

The development of renewable energy sources was considered as important because the increase of average temperature has significant impacts on energy demand, in particular in summer time. The objective was to reduce electricity demand from hydro-electric, conventional oil or gas fired power plants as well as from nuclear power plants. To this end, solar and wind energy were significantly promoted and generalized. This made possible the saving of water in mountain and river barrages and to limit the emission of greenhouse gas. An additional advantage was that imports of electricity from northern and central European regions could be restricted.

Transport policies had to be re-considered from the point of view of greenhouse gas emissions. New technologies were promoted in order to limit the consumption of fossil energy, especially oil. New types of engines were developed, using less energy as well as other types of fuels. Hydrogen powered engines were experimented, developed and promoted. The problem remained that of the production of hydrogen which is energy intensive. Electricity from renewable energy sources was used to produce a part of the hydrogen needed. It proved to be more difficult to influence the use of trucks and motor cars. Modal shift policies were not so successful as expected. Nevertheless, more and more people were inclined to use public transportation, the quality of which had been significantly improved and the transport of goods was partly shifted onto railways and maritime routes.

By 2008, the emission target of 8% below 1990 levels was reached. Other nations outside the EU also achieved some emission reductions, and believed in the regulatory principles of the Kyoto Protocol. By 2010, a new Agreement comes into force which establishes new emission targets at 40% below 1990 level by 2030.

These drastic measures were not only driven by worrying signs of long term climate change, but also by immediate impacts experienced throughout Europe. Impacts took place as described in the other scenario: droughts, heat waves, floods, water scarcity, declining or increasing tourists, worsening conditions for agriculture, etc.

The response was different, however. In response to the discussions about the need for a EU climate change adaptation policy, a framework had been adopted by 2007. Part of the framework was already addressed in the reform of EU structural policies in 2005/2006. The eligibility of EU-supported actions to measures related to the prevention of natural hazards was enlarged, in particular in relation to climate change. Main building blocks were the protection of water resources, the management of rural landscapes and forests, the relationships between territorial development and renewable energy sources, the prevention of flood damages and the promotion of corridors for migration of species. Although cost-

effectiveness was an important issue, it was not a condition for adaptation measures, since the effectiveness could not be measured according to the scientific knowledge at that time.

The integrated protection of water resources was a particularly important and ambitious priority, especially for the countries and regions of southern Europe. It called for numerous innovative techniques and practices and interfered strongly with a large number of fields of activity. The future of agriculture was one of the most central activities concerned. Crops requiring intensive irrigation were re-considered and adapted. The cultivation of various crops such as maize, requiring large quantities of water, was strongly restricted. Water-saving techniques and technologies were generalized and supported by public resources. Area-specific strategies were elaborated in order to optimize the cultivation of soil in relation with the characteristics of the area (hydrology, local climate, natural vegetation etc.). New types of cultures were introduced which took account of the increase of average temperature and of the scarcity of water. Awareness raising campaigns for farmers were systematically organized. Innovative experiments carried out outside Europe, in particularly arid regions, such as in Egypt, were used as sources of inspiration to match successfully agricultural development with the scarcity of water resources.

Action was also taken in the sector of tourism. Large-scale tourist projects in coastal areas dedicated to mass tourism were abandoned. Solutions were looked for in the case of existing resorts threatened by water scarcity. Reconversion programs were elaborated to promote the quality and diversification of supply in order to avoid the concentration of tourist frequentation in summer time when water scarcity is highest. Specific facilities and utilities were developed, combining hinterland tours, pedestrian and cycling activities, heritage-related and other cultural activities etc. In mountain areas, the relative decline of winter tourism was compensated by new forms of summer tourism; more diffuse and less damaging for the environment.

Agriculture and forestry were not re-considered only from the perspective of their relation to water resources, but also in relation to the maintenance of landscapes and vegetation. The search for new forms of cultivation followed also the objective, in addition to water saving, of maintaining and safeguarding agricultural activities in the southern European regions, in order to protect landscapes from wild vegetation drying in summer time and prone to fires. The management of forests was significantly improved with the implementation of important prevention measures against fires. This included also the promotion of specific tree species, less sensitive to drought. Despite the intensification of such measures, forest fires occurred. In such cases, new forestation measures were undertaken in order to avoid soil erosion and to favor the capture and retention of humidity.

The prevention of flood damages was another important priority, both in northern, southern and central European regions. The experience gained during the period 1995-2005 was used to generalize solutions. A number of measures were developed such as the extension of retention areas for water along rivers, the construction of new dikes to protect settlements, the removal of settlements unlikely to be efficiently protected against floods, the enforcement of measures prohibiting constructions and economic activities other than agriculture in areas threatened. In addition to these measures, specific radar-based weather forecast facilities were developed in Mediterranean regions to inform the population in due time about the occurrence of heavy rainfalls, so that necessary actions can be taken to protect human and animal lives.

The Natura 2000 plan was augmented with the construction of corridors between existing natural areas. The aim of the corridors was to enable species (fauna and flora) to migrate northwards or to higher altitudes in response to climate change. These corridors would not necessarily be protected areas; large tracks constituted of farmlands were assigned to be 'naturally managed'. A monitoring unit was established to verify the effectiveness of the corridors in nature's response to climate change.

By 2015, the strategy was considered as rather successful. The number of natural hazards related to climate change had increased, but their impacts had been relatively contained.

These encouraging results led to a generalization in the implementation of the strategy. The reform of structural policies in 2013/2014 was again used to increase the volume of resources devoted to the prevention of risks and damages related to climate change, considering that this was a precondition to maintain a minimal production basis in the most vulnerable regions.

By 2030, the reduction of GHG emissions was so successful, that stabilization of climate change at a temperature rise of 2° C by 2010 was still a realistic target. Damages related to climate change had increased again, but its magnitude could well be handled due to the adaptation measures put in place.

#### *8.2.2.5 Impacts*

*Macro-economic impacts*

The costs of all mitigation measures mounted to 0.4% of the EU GDP by 2030. The other side is that the development of more indigenous forms of energy production and the reduction of external energy dependency contributed to lower energy costs and a technological advantage over the rest of the world. Adaptation measures also absorbed significant amounts of resources, in particular during the first decade of its implementation. Benefits were difficult to establish. Adapted forms of agriculture and tourism in the southern European regions could for example not avoid economic stagnation. However, things would be much worse if no adaptation would have taken place.

*Regional impacts*

At macro-scale, the contrast of impacts of climate change between southern and northern Europe remained limited. Migration flows of people from northern Europe towards Mediterranean regions (mainly retired people) were reduced, but did not stop, while emigration from southern regions towards more northern regions was contained. Economic development took place along the traditional patterns of hexagon versus periphery.

At meso-level, changes were also much less significant than under Scenario 1, although some changes were unavoidable. The changing water regimes of rivers in valleys and plains, conditioned by changes in the hydrologic systems of mountain areas, could unfortunately not be improved, but water-saving techniques in agriculture and energy production reduced the negative impacts of changing water regimes of rivers. Rural-urban relationships remained rather balanced, due to the fact that rural areas did not lose their vitality in southern Europe. In central and northern Europe, pressure on rural areas was less intense. Peripheral areas without fast train and maritime transport connection faced stagnating economic development, since the use of motorcars increased sharply in price.

At regional/local scale, damages caused by floods in the whole of Europe could be significantly contained, although the occurrence of floods increased. In southern European regions, landscapes could be safeguarded and the impacts of forest fires remained limited. Success in the management of water resources and in renewable energy production opened new development perspectives. The containment of road traffic especially the reduction of greenhouse gas emissions which it generates acted positively along the objectives of the Kyoto Agreement.

#### *8.2.2.6 Final image*

By 2030, natural hazards related to climate change had significantly increased, if compared with the situation prevailing in the early 2000s. The impacts of such hazards were however contained and the European territory had become significantly more resistant against floods, drought, forest fires etc.

A number of changes had taken place, when compared with the situation in 2005, in particular with regard to vegetation and ecosystems. Mediterranean vegetation had progressed towards the north. Ecosystems had significantly changed in nature, but disruptions remained limited.

Intensive agricultural production moved north- and eastwards into Southern Scandinavia and the Baltic States. Southern European regions became famous for the techniques they had developed to cope with climate warming, in particular in the fields of integrated approaches in water management, renewable energy production, maintenance of rural landscapes, development of new forms of tourism in coastal, rural and mountain areas.

#### *8.2.2.7 Main issues resulting from the scenario*

Even if climate change is a fatality, a number of prevention and mitigation policies can enable the containment of negative impacts and the limitation of impacts of generated natural hazards. Through various well conceived and integrated policies, the European territory can be made more resistant to the impacts of climate change. A number of opportunities generated by climate change can also be exploited.

#### *8.2.2.8 Possible indicators for the climate change scenarios*

Some indicators are readily available from IPCC, EEA and ESPON. However, the most interesting indicators which show costs and effects of adaptation measures are very difficult to operationalize.

| **Indicator** | **Scale** | **Source** |
|---|---|---|
| *Climate change and GHG emission* | | |
| Temperature rise | 500x500 km | IPCC |
| Change of precipitation | 500x500 km | IPCC |
| Emission rate | Country level | EEA |
| Cost of mitigation measures | Europe | EEA |
| *Impacts* | | |
| Loss of biodiversity | Country level | EEA |
| Floods | NUTS3 | ESPON .. / EEA |
| Growing season | Country level | EEA |
| *Impacts, unknown sources* | | |
| Cost of adaptation measures | | |
| Changing tourism | | ? |
| Deaths due to heat waves | | ? |
| Desertification | | ? |
| Changing GDP due to change of production system | NUTS2/3 | ? |
| Changing agricultural production | | ? |

**Table 13 Possible indicators**