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Living in a changing climate

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Contents

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Editorial

Hans Bruyninckx
EEA Executive Director

Living in a changing climate

Our climate is changing. Scientific evidence shows that the global average temperature is rising, and rainfall patterns are shifting. It also shows that glaciers, Arctic sea ice and the Greenland ice sheet are melting. The Intergovernmental Panel on Climate Change's Fifth Assessment Report shows that the warming since the mid-20th century is predominantly due to an increase in greenhouse-gas concentrations as a result of emissions from human activities. Combustion of fossil fuels and changes in land use are largely responsible for this increase.

It is clear that we need to reduce global greenhouse-gas emissions substantially in order to avoid the most adverse impacts of climate change. It is also clear that we need to adapt to our changing climate. Even with substantial reductions in our greenhouse-gas emissions, our climate is expected to change to some degree and the impacts of this will be felt across the world, including in Europe. Floods and droughts are expected to become more frequent and intense. Warmer temperatures, changes in precipitation levels and patterns, or extreme weather events are already impacting our health, natural environment, and economy.

Climate change affects us

We might not be aware of it but climate change affects us all: farmers, fishermen, asthma patients, the elderly, infants, urban residents, skiers, beachgoers... Extreme weather events, such as floods and storm surges, can devastate small communities — and even regions and countries. Heatwaves can exacerbate air pollution, aggravating cardiovascular and respiratory diseases, and in some cases resulting in loss of life.

Warmer oceans risk unbalancing the entire food chain, and hence marine life, adding extra pressures to already overexploited fish stocks. Higher temperatures can also change the carbon storage capacity of the soil — the second largest carbon sink after the oceans. Droughts and warmer temperatures can impact agricultural production, driving up the competition between economic sectors for precious resources like water and land.

These impacts result in real losses. Recent research estimates that without adaptation actions heat-related deaths could reach about 200 000 per year in Europe by 2100. The cost of river flood damages could be more than EUR 10 billion a year. Other climate-change impacts include the damage from forest fires, reduced crop yields, or lost workdays due to respiratory diseases.

Faced with such current and future impacts, Europeans have no choice but to adapt to climate change. A European Union-level adaptation strategy is already in place to help countries plan their adaptation activities, and more than 20 European countries have adopted national adaptation strategies.

Some ongoing adaptation projects involve large projects to build new infrastructure (e.g. dykes and flood drains), whereas others propose restoring ecosystems to allow

nature to tackle climate change impacts such as excess water or heat. Different initiatives and funding opportunities exist to help countries, cities, and regions prepare for climate change impacts and reduce their greenhouse-gas emissions.

Reducing emissions

The severity of climate change will depend on how much and how quickly we can cut greenhouse-gas emissions released into the atmosphere. Climate change is one of the biggest challenges of our times. It is a global problem and concerns us all. The scientific community strongly recommends limiting the rise in global average temperatures and reducing greenhouse-gas emissions to avoid adverse impacts of climate change. Within the United Nations Framework Convention on Climate Change, the international community has agreed to limit the global average temperature increase to 2°C above pre-industrial times.

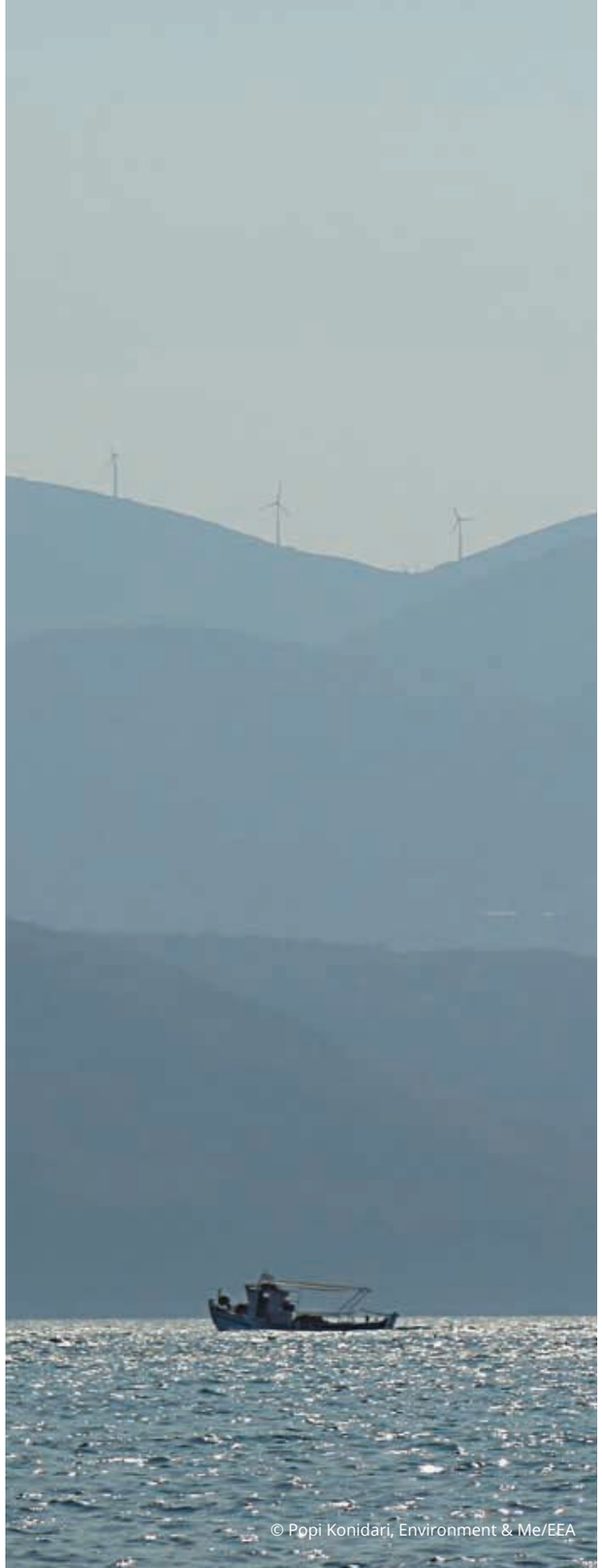
If the global average temperature increases above 2°C, climate change will have much more severe impacts on our health, natural environment, and economy. An average 2°C increase means that temperatures will actually rise more than 2°C in certain parts of the world, especially in the Arctic, where greater impacts will threaten unique natural systems.

The European Union has set ambitious long-term goals on climate-change mitigation. In 2013, the EU had already reduced its domestic greenhouse-gas emissions by 19% compared to 1990 levels. The target of a 20% reduction by 2020 is within reach.

Achieving a reduction of at least 40% in domestic emissions (i.e. emitted in the EU) by 2030 and an 80–95% reduction by 2050 will partly depend on the EU's ability to channel sufficient amounts of public and private funds towards sustainable and innovative technologies. Effective carbon prices and regulations are instrumental in steering investments towards climate-friendly innovations, in renewable energy and energy efficiency in particular. In some cases, funding decisions might also entail divesting away from some sectors and restructuring others.

Emission reductions by EU Member States would address the problem only partly, because the EU currently emits only around 10% of global greenhouse-gas emissions. It is clear that achieving the 2°C target requires a global effort with substantial cuts to global greenhouse-gas emissions. The scientific community estimates that to achieve the 2°C target only a limited amount of carbon can be released into the atmosphere before the end of the century. The world has already released the large majority of this 'carbon budget'. At current rates, the entire carbon budget will be exhausted well before 2100.

To increase our chances of limiting the average temperature increase to 2°C, scientific studies show that global emissions have to peak in 2020, and then start declining. In this context, the upcoming climate talks (COP21) in Paris need to become a turning point for a global agreement on cutting greenhouse-gas emissions and providing support to developing countries.



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A low-carbon future by 2050 is possible

At the heart of the problem lie unsustainable consumption and production patterns. Building on recent trends observed in Europe's environment and on global megatrends, our recent report 'The European environment — state and outlook 2015' calls for a transition to a green economy. The green economy is a sustainable way of life that allows us to live well, and within the limits of our planet. This transition involves structural changes to key systems, such as energy and transport, which require long-term investments in our infrastructure.

Europeans are already investing in these key systems. The challenge is to make sure that all current and future investments put us one step closer to greening our economy, and do not lock us into an unsustainable path of development. Making the right investments today will not only minimise the overall costs of climate change, but it can strengthen Europe's expertise in the thriving eco-industries — the economy of the future. At the end of the day, we all have a stake in defining what life with climate change will look like.

The challenge we are facing might seem daunting. But no matter how big the challenge may be, the 2°C target is still within our reach. We now need to be courageous and ambitious enough to grasp it.

Hans Bruyninckx
EEA Executive Director

Are we ready for climate change?

Climate change is causing a variety of impacts to our health, ecosystems and economy. These impacts are likely to become more serious in the coming decades. If not addressed, these impacts could prove very costly, in terms of ill health, adverse effects on ecosystems, and damaged property and infrastructure. Many adaptation projects are already underway across Europe to prepare for a changing climate.

2014 will be remembered across Europe for its extreme weather events. In May 2014, a low-pressure cyclone hit south-eastern Europe, causing widespread flooding and 2 000 landslides across the Balkans. Then in early June 2014, a series of heavy rainstorms hit northern Europe. By July 2014, Europe was suffering from another problem: heat. Eastern Europe and the United Kingdom experienced a heatwave.

Extreme weather events as well as gradual changes in the climate — such as rising sea levels and warming oceans — will continue. In fact, these events are expected to become more frequent and more intense in the future ([1]). Even if all countries were to radically cut their emissions of greenhouse gases today, the greenhouse gases that have already been released into the atmosphere would continue to have a warming effect on the climate. In addition to substantially reducing greenhouse-gas emissions, countries in Europe and across the world need to put in place policies and measures to adapt to climate change.

Europe's climate is changing

A changing climate will affect almost every aspect of our lives. Increased intensity and frequency of rainfall in many parts of Europe will mean frequent and serious flooding events, destroying homes and affecting other infrastructure (e.g. transport and energy) in risk areas. Elsewhere in Europe, including in southern Europe, higher temperatures and reduced rainfall will mean that many areas might face droughts. This could create competition between agriculture, industry, and households for scarce water resources. It could also create more heat-related health problems.

Climate change will also affect ecosystems across Europe. Many economic sectors depend on healthy and stable ecosystems to provide a variety of products and services to humans. For example, bees pollinate our crops, while forests help to absorb greenhouse gases. Changes to the balance of species and habitats in ecosystems could have wide-reaching effects. A reduction in rainfall in southern Europe could make it impossible to grow certain crops, while higher temperatures might allow alien invasive species and species that carry diseases to migrate northwards.

Warmer oceans are already forcing various fish species to move northward, which in turn puts further pressure on the fisheries sector. For example, the northward shift in mackerel stocks has exacerbated the already existing problem of overfishing of herring and mackerel in the Northeast Atlantic.

Climate change has a cost

Extreme weather events can result in loss of life, and bring economic and social activity in the affected area to a halt. Substantial funds are often required for rebuilding damaged property and infrastructure. However, most of the damage from extreme weather events in recent decades cannot be attributed to climate change alone. Socio-economic developments, and decisions such as expanding cities towards floodplains, are the main causes of the increased damage. But without adaptation actions, damage costs and other adverse effects are projected to increase as our climate continues to change.

The costs of future climate change are potentially very large. Recent research estimates that without adaptation actions, heat-related deaths could reach about 200 000 per year in Europe by 2100, and the cost of river flood damages could be more than EUR 10 billion a year([2]). In the case of extensive climate change and no adaptation actions, forest fires could affect an area of roughly 800 000 hectares every year. The number of people affected by droughts could also increase by a factor of seven to about 150 million per year, and economic losses due to sea-level rise would more than triple to EUR 42 billion a year.

Although climate change is mostly expected to create costs for society, it may also create a limited number of new opportunities, which often come with new risks. Warmer winters in northern Europe might mean a reduced need for winter heating. On the other hand, warmer summers might increase the energy consumed for cooling. With sea ice melting, Arctic sea lanes might be opened to shipping and thus cut transport costs. But increased shipping might expose the Arctic to pollution and should be regulated to ensure that it is safe and clean.

Whatever the projected impacts are, be it more rain, higher temperatures, or less freshwater, European countries need to adapt their rural landscape, cities, and economy to a changing climate and reduce our vulnerability to climate change.

What is 'climate change adaptation'?

'Adaptation' covers a wide range of activities and policies that seek to prepare societies for a changing climate. When adaptation policies are implemented they can reduce the impacts and damage costs of climate change, and prepare societies to thrive and develop in a changed climate. Some of these actions have a relatively low cost, such as information campaigns on how to stay cool in warm weather or an early-warning system for heatwaves. Other adaptation actions can be very expensive, such as building dykes and coastal defences (such construction measures are often referred as 'grey adaptation'), relocating houses out of flood-plains, or expanding retention basins to respond to droughts.

Some adaptation measures involve using natural methods to increase an area's resilience to climate change. Such 'green adaptation' actions include restoring sand-dunes to prevent erosion or planting trees on river banks to reduce flooding. The city of Nijmegen in the Netherlands has implemented green adaptation measures of this sort. The Waal River bends and narrows around Nijmegen, causing floods in this coastal city. To prevent the damage from these floods, the city is building a canal, giving the river more room to flow. This also creates new spaces for recreation and for nature.

The Dutch Building with Nature programme is another good example of the combination of grey and green adaptation. It has promoted the restoration of coastal wetlands such as swamps, reedbeds, marshes, and mudflats. These wetland areas help to prevent soil subsidence thanks to the root structures of wetland plants. By preventing soil subsidence at coastal areas, this protects the surrounding area from flooding.

Other adaptation measures consist of using laws, taxes, financial incentives and information campaigns to enhance resilience to climate change (measures knowns as 'soft adaptation'). An information campaign in Zaragoza, Spain, made the city's 700 000 inhabitants more aware of the need to use water sparingly to survive the lengthier droughts expected for this semi-arid region. Coupled with control of leakage from the water supply distribution network, the project has almost halved daily water use per person compared with 1980, and the city's total water consumption has fallen by 30% since 1995.

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Adaptation in the European Union

The European Union and its Member States are already working on climate change adaptation. In 2013, the European Commission adopted the communication 'An EU Strategy on adaptation to climate change', which helps countries plan their adaptation activities. The Strategy also promotes the creation and sharing of knowledge, and aims to enhance resilience in key sectors by using EU funds. More than 20 European countries have already adopted adaptation strategies, outlining initial actions they will take (e.g. vulnerability assessments and research) and how they intend to adapt to a changing climate. However, in terms of concrete action on-the-ground, many countries are still at a very early stage.

An EEA survey of adaptation measures showed that water management is the sector that most countries are prioritising. However, countries also direct resources to providing information to their citizens. For example, as part of its efforts to reduce the spread of insect-borne diseases, the region of Emilia Romagna runs an awareness campaign on the dangers of Lyme disease, dengue, and West Nile disease.

Many countries have created online adaptation-knowledge platforms to facilitate the sharing of transnational, national, and local experiences and good practice ([3]). The Climate-ADAPT ([4]) portal, managed by the European Environment Agency and the European Commission, provides a European platform for sharing such experiences.

Not adapting is not a viable option

Extreme weather events and EU policies have placed adaptation policies and measures higher on the political agenda in European countries in recent decades. However, according to a recent survey, many countries are prevented from taking action by a lack of resources such as time, money, or technology. 'Uncertainties about the extent of future climate change' and 'unclear responsibilities' were also seen as barriers by a large number of countries ([5]).

The effects of climate change vary from region to region. Policymakers also face the difficulty of incorporating future changes in wealth, infrastructure, and population into their climate-change adaptation plans. What will an increasingly older and urbanised population need in terms of transport, housing, energy, health services, or simply food production, in a changing climate?

Rather than treating adaptation as a separate policy sphere, adaptation can best be implemented through better integration into every other area of public policy. Within their adaptation strategies, EU countries and the European Union are exploring how they can integrate adaptation concerns into different policy spheres such as agriculture, health, energy, or transport.

Extreme weather events in particular show that not adapting is a very costly decision and is not a viable option in the medium and long term. For example, transport infrastructure is often severely damaged in floods. When movement of people, goods, or services is hindered, the indirect costs to the economy can be many times higher than the direct cost of damaged transport infrastructure.

It is clear that, like many other infrastructure projects, adapting transport infrastructure is costly. It may also be difficult because the transport system involves different groups, from vehicle manufacturers to infrastructure managers to passengers. One cost-efficient solution is to consider adaptation measures when infrastructure is built or renewed, and the EU budget offers different funding opportunities to support infrastructure projects.

An effective solution requires a longer-term and wider perspective with the integration of climate change into different public policies around sustainability. In the case of climate change adaptation, this raises questions about how to build our cities, how to transport people and products, how to supply energy to our homes and factories, how to produce our food, and how to manage our natural environment.

It is also clear that an effective combination of adaptation and mitigation measures can help to ensure that future impacts of climate change are limited, and that when they do come, Europe is better prepared and more resilient.

Europe's climate is changing

A changing climate will affect almost every aspect of our lives. Increased intensity and frequency of rainfall in many parts of Europe will mean frequent and serious flooding events. Elsewhere in Europe, including in southern Europe, higher temperatures and reduced rainfall will mean that many areas might face droughts.

Many economic sectors depend on healthy and stable ecosystems to provide a variety of products and services to humans. Changes to the balance of species and habitats in ecosystems could have wide-reaching effects. A reduction in rainfall in southern Europe could make it impossible to grow certain crops, while higher temperatures might allow alien invasive species and species that carry diseases to migrate northwards.

Arctic

Temperature rise much larger than global average
Decrease in Arctic sea-ice coverage
Decrease in Greenland ice sheet
Decrease in permafrost areas
Increasing risk of biodiversity loss
Intensified shipping and exploitation of oil and gas resources

Northern Europe

Temperature rise much larger than global average
Decrease in snow, lake and river ice cover
Increase in river flows
Northward movement of species
Increase in crop yields
Decrease in energy demand for heating
Increase in hydropower potential
Increasing damage risk from winter storms
Increase in summer tourism

North-western Europe

Increase in winter precipitation
Increase in river flow
Northward movement of species
Decrease in energy demand for heating
Increasing risk of river and coastal flooding

Central and eastern Europe

Increase in warm temperature extremes
Decrease in summer precipitation
Increase in water temperature
Increasing risk of forest fire
Decrease in economic value of forests

Coastal zones and regional seas

Sea-level rise
Increase in sea surface temperatures
Increase in ocean acidity
Northward expansion of fish and plankton species
Changes in phytoplankton communities
Increasing risk for fish stocks

Mountain areas

Temperature rise larger than European average
Decrease in glacier extent and volume
Decrease in mountain permafrost areas
Upward shift of plant and animal species
High risk of species extinction in Alpine regions
Increasing risk of soil erosion
Decrease in ski tourism

Mediterranean region

Temperature rise larger than European average
Decrease in annual precipitation
Decrease in annual river flow
Increasing risk of biodiversity loss
Increasing risk of desertification
Increasing water demand for agriculture
Decrease in crop yields
Increasing risk of forest fire
Increase in mortality from heatwaves
Expansion of habitats for disease-carrying insects
Decrease in hydropower potential
Decrease in summer tourism and potential increase in other seasons

Source: EEA Report No 12/2012. Climate change, impacts and vulnerability in Europe 2012.

Bettina Menne
Programme Manager at WHO Europe

Climate change and human health

Climate change in Europe is already affecting public health, and will continue to do so in the future. How does it affect Europeans today? What does the future look like? We asked these questions to Bettina Menne from WHO Europe.

Does climate change affect human health?

Climate change affects public health in many different ways. There are direct and indirect impacts, as well as those that occur immediately and those that occur over a longer period of time. We estimate that 150 000 deaths worldwide were caused by climate change in 2000. According to a new WHO study, this is projected to increase to 250 000 deaths per year worldwide by 2040. This estimate would have actually been higher if we had not factored in the reduction of child mortality expected in future years.

Extreme weather events are already among the top climate-change impacts that affect public health. In addition, mortality related to heatwaves and flooding is expected to increase, in particular in Europe. And changes in the distribution of vector-borne diseases will also affect human health.

How do extreme weather events affect public health?

Different types of extreme weather events affect different regions. Heatwaves are mostly a problem in southern Europe and the Mediterranean, but they are also a problem in other regions. According to estimates, the heatwave of 2003 caused 70 000 excess deaths in 12 European countries, mostly among older people. As people get older, the thermal regulation of the body is impaired, which makes older people more vulnerable to high temperatures.

By 2050, heatwaves are projected to cause 120 000 excess deaths per year in the European Union, and to have an economic cost of EUR 150 billion if no further measures are taken. This higher estimate is not only due to more frequent and higher temperatures but also due to Europe's changing demographics. Currently, around 20% of EU citizens are over 65 years of age, and their share in the population is expected to increase to around 30% in 2050.

High temperatures are also often associated with air pollution, and ground-level ozone pollution in particular. Air pollution can cause respiratory and cardiovascular problems, especially among children and older people, and can result in premature deaths.

Other extreme weather events — such as high precipitation events that might cause floods — also affect public health.

How do floods affect our health?

To give a concrete example, the devastating floods in 2014 in Bosnia and Herzegovina, Croatia, and Serbia caused 60 deaths and affected more than 2.5 million people. In addition to the immediate health impacts, rescue operations and public health services were also affected. Many hospitals, especially lower floors where heavy medical equipment is often kept, were flooded. This reduced the capacity of health services to cope with the disaster and to care for existing patients.

In the aftermath of such a disaster, displaced people who lost their homes are also likely to suffer from other long-term health problems, including stress.

There are also indirect health risks, largely due to deterioration or contamination of the environment. For example, floods can carry pollutants and chemicals from industrial facilities, waste water, and sewage water. This can lead to the contamination of drinking water and agricultural land. When there is no secure faecal and chemical disposal, floodwaters or greater run-off can carry contaminants to lakes and the sea, and some might enter our food chain.

What other kinds of health risks are associated with climate change?

The health risks come from a variety of sources. Higher temperatures facilitate forest fires. Around 70 000 forest fires occur every year on the European continent. Although the large majority are man-made, high temperatures and droughts often worsen the overall damage. While some fires might result in loss of lives and property, they all cause air pollution, especially from particulate matter. This in turns triggers illness and premature death.

Higher temperatures, milder winters, and wetter summers are expanding the area where certain disease-carrying insects (such as ticks and mosquitoes) can survive and thrive. These insects can then carry diseases — such as Lyme disease, dengue, and malaria — to new areas where the climate was not suitable to the disease previously.

Climate change could also mean that some diseases might no longer be able to thrive in the areas they currently affect. For example, future warming could mean that ticks — and consequently tick-borne diseases — will be found at higher altitudes and further north, closely linked to the changing distribution of their natural hosts, such as deer.

Seasonal variations — some seasons starting earlier and lasting longer — might also have adverse impacts on human health. This could have a particular effect on people with allergies. We might also experience peaks in asthma cases, triggered by combined exposure to different allergens at the same time.

There are also other long-term health risks associated with climate change. Changes in temperature and precipitation are expected to affect food-production capacity in the wider pan-European region, with significant reductions expected in Central Asia.
A further reduction of production capacity in the region could not only exacerbate the malnutrition problem, but also could have widespread impacts by raising food prices worldwide. Climate change is therefore a factor we have to take into account when we look at food security and access to affordable food. It can aggravate existing social and economic problems.

How can public authorities prepare for the health impacts of climate change?

Compared with many other regions, European health services are relatively better equipped to deal with the health impacts of climate change. Malaria, for example, is not likely to re-establish itself in the European Union. Nevertheless, single events such as floods or long-lasting heatwaves will continue to exert increasing pressure on the health services in affected areas. European countries will need to strengthen and adapt their health services to cope with the potential impacts of climate change in their area. Some measures could involve relocating and refitting hospitals to prepare against possible floods. Other measures could include better tools for sharing information with vulnerable groups to prevent their exposure to pollution.

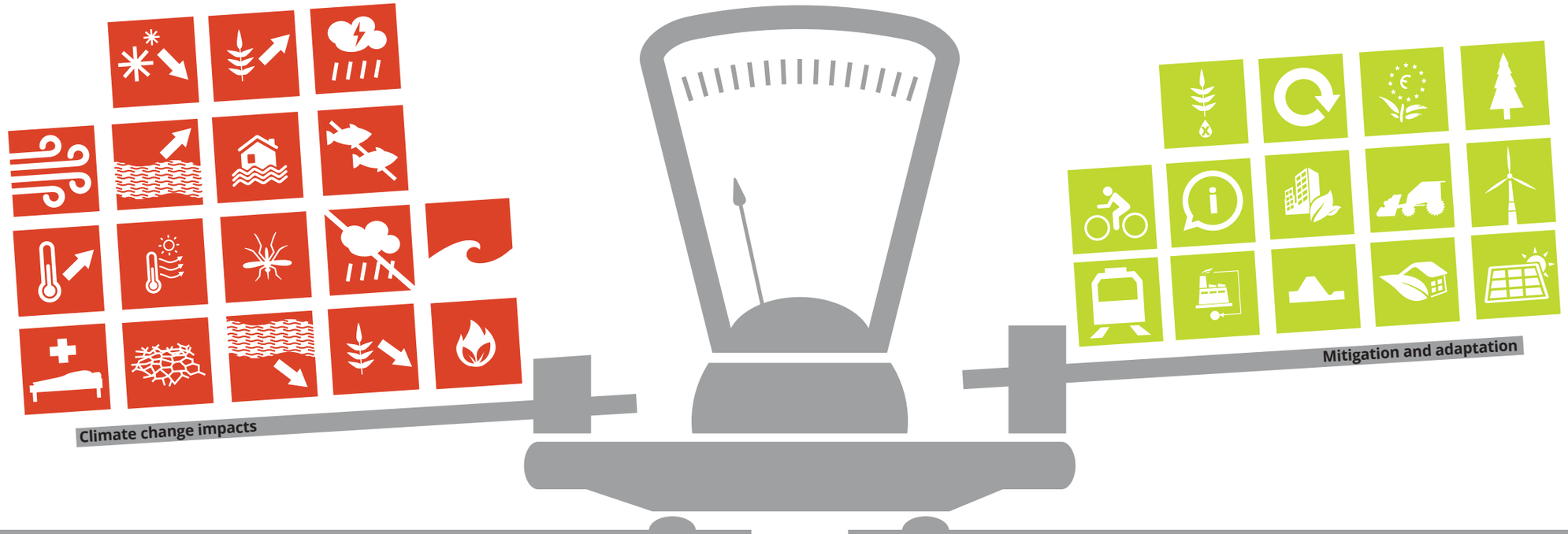
WHO Europe has been working on the health effects of climate change for more than 20 years. We develop methods and tools, carry out impact assessments, and provide assistance to Member States to adapt to climate change ([6]). In our recent report ([7]), we recommend adaptation measures, but we stress that adaptation measures will not be enough on their own.

It is quite clear that countries also need to undertake measures to mitigate climate change to protect public health. Some of these measures can have significant health co-benefits. For example, the promotion of so-called 'active transport' (such as cycling and walking) can contribute to reducing obesity and non-communicable diseases. And renewable energy such as solar energy can help to provide continuous energy to health services in remote areas.

Are we ready for climate change?

Climate change is causing a variety of impacts to our health, ecosystems and economy. These impacts are likely to become more serious in the coming decades. If not addressed, these impacts could prove very costly, in terms of ill health, adverse effects on ecosystems, and damaged property and infrastructure.

Adaptation covers a wide range of activities and policies that seek to prepare societies for a changing climate. An effective combination of adaptation and mitigation measures can help to ensure that future impacts of climate change are limited, and that when they do come, Europe is better prepared and more resilient.



2100?

Without adaptation and mitigation measures, in Europe, by 2100:

Forest fires could affect an area of roughly 800 000 hectares every year.

River flood damages could cost more than EUR 10 billion a year.

The number of people affected by droughts could increase to about 150 million per year.

Economic loss due to sea-level rise would more than triple to EUR 42 billion a year.

Heat-related deaths could reach about 200 000 per year.

CO_2 GDP

EU greenhouse-gas emissions have decreased by 19% since 1990, despite a 45 % increase in GDP.

The EU's total resource use has declined by 19% since 2007 and recycling rates have improved.

Major EU engineering companies already earn up to 40% of revenues from their environment portfolios

Domestic material consumption in the EU declined by 10% from 2000 to 2012, despite a 16% increase in economic output.

Employment in the eco-industries increased by 47% from 2000 to 2012, adding 1.4 million new jobs.

From 1990 to 2012, the share of renewables in energy production more than doubled in the EU.

Sources: EEA, 2015. European environment — state and outlook 2015: Climate change impacts and adaptation, Energy, Green economy, Resource efficiency, Waste.

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Climate change and the seas

Climate change is warming the oceans, causing acidification of marine environments, and changing rainfall patterns. This combination of factors often exacerbates the impacts of other human pressures on the seas, leading to loss of marine biodiversity. Many human livelihoods depend on marine biodiversity and ecosystems, so action to limit ocean warming must be taken quickly.

Changes in the marine food web

The oceans absorb heat from the atmosphere. Measurements now show that the warming of the oceans has affected areas far below the ocean surface in recent decades. The effect on marine life of warming oceans is strong, and biodiversity is at ever greater risk. Nowhere is this more clearly highlighted than in the case of warmer-water plankton in the Northeast Atlantic. Some copepod are moving northwards at a rate of 200–250 km per decade. These small copepods are near the bottom of the food chain. Fish and other animals of the Northeast Atlantic feed on these copepods and their distribution pattern in the oceans may change as a result of the copepods' northward movement ([8]).

Animals living outside their optimal temperature range expend more energy on respiration to the detriment of their other functions. This weakens them, making them more vulnerable to disease, and allowing other species that are better suited to the new temperature regime to get a competitive advantage. In addition, the spores, eggs, or offspring of these animals will struggle to develop in suboptimal temperatures. As some species suffer in the new conditions, this can have spillover effects on the other organisms that depend on or interact with them. This chain of events ultimately influences the overall functioning of the ecosystem, which can lead to loss of biodiversity. This is exactly what is happening with copepods: because they are eaten by so many other organisms their suffering influences the entire food web.

Higher up in the food chain, animals that cannot find food are forced to move in order to survive. In Europe, where sea surface temperature is increasing more rapidly than in the global oceans ([9]), they move predominantly northwards ([10]). This phenomenon can affect fish stocks, as illustrated by the way mackerel have started to spend more time in more northern waters. This can have a knock-on effect on local fishermen and communities further afield. One of the knock-on effects was the infamous 'mackerel war' between the EU and the Faroe Islands. The 'mackerel war' arose partly because of overfishing of blue whiting and partly as a direct result of fish species, including herring and mackerel, moving further north in response to rising sea temperatures. The extra time spent by the fish stocks in Faroese waters resulted in a disagreement on fishing rights. From a Faroese perspective, they had a right to

the fish in their waters, but from an EU perspective, agreements on sustainable fishing quotas were being breached, potentially leading to the risk of overfishing with the loss of EU income and jobs as a consequence ([11]). The dispute came to an end in 2014, when the EU lifted import bans on the fish caught in Faroese waters in return for an end to fishing carried out by the islanders.

Acidification

In addition to absorbing heat, the oceans are also a carbon-dioxide sink. The more CO_2 enters the atmosphere, the more is absorbed into the oceans, where it reacts with water to produce carbonic acid, resulting in acidification. The oceans have absorbed more than a quarter of the carbon dioxide released into the atmosphere since 1750 through human activities ([12]).

Ocean acidification has historically been associated with each of the five major extinction events that have occurred on Earth. Today acidification is happening 100 times faster than any other period in the last 55 million years ([13]) and species may not be able to adapt quickly enough.

Acidification affects marine life in different ways. For example, corals, mussels, oysters and other marine organisms that build shells of calcium carbonate have a more difficult time constructing their shells or skeletal material as sea water pH decreases. Thus, anthropogenic reductions in sea water pH could affect entire marine ecosystems.

Dead zones

A rise in ocean temperature also speeds up the metabolism of organisms and their oxygen intake, which in turn reduces oxygen concentrations in water. This can ultimately make parts of the ocean uninhabitable for sea life.

Oxygen in the sea can also be depleted as a result of nutrients entering the water. For example, rainfall brings nutrients from agricultural fertilisers to the sea. This enrichment with nutrients such as nitrates and phosphates may occur naturally, but about 80% of all nutrients in the sea come from land-based activities, including sewage, industrial waste, municipal waste, and agricultural run-off. The rest mainly comes from nitrous gases emitted when burning fossil fuels from traffic, industry, power generation, and heating ([14]). In the parts of Europe where increased rainfall and temperature are brought about by climate change, the effects of nutrient enrichment are exacerbated.

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Enrichment of water with nutrients drives a process known as 'eutrophication', which leads to excessive plant growth. When this happens in the sea, it creates what is known as an algal bloom. Through excess respiration and the eventual death and decay of these aquatic plants, oxygen is removed from the water. This results in an oxygen deficit and ultimately leads to hypoxic areas or 'dead zones' where aerobic life can no longer survive.

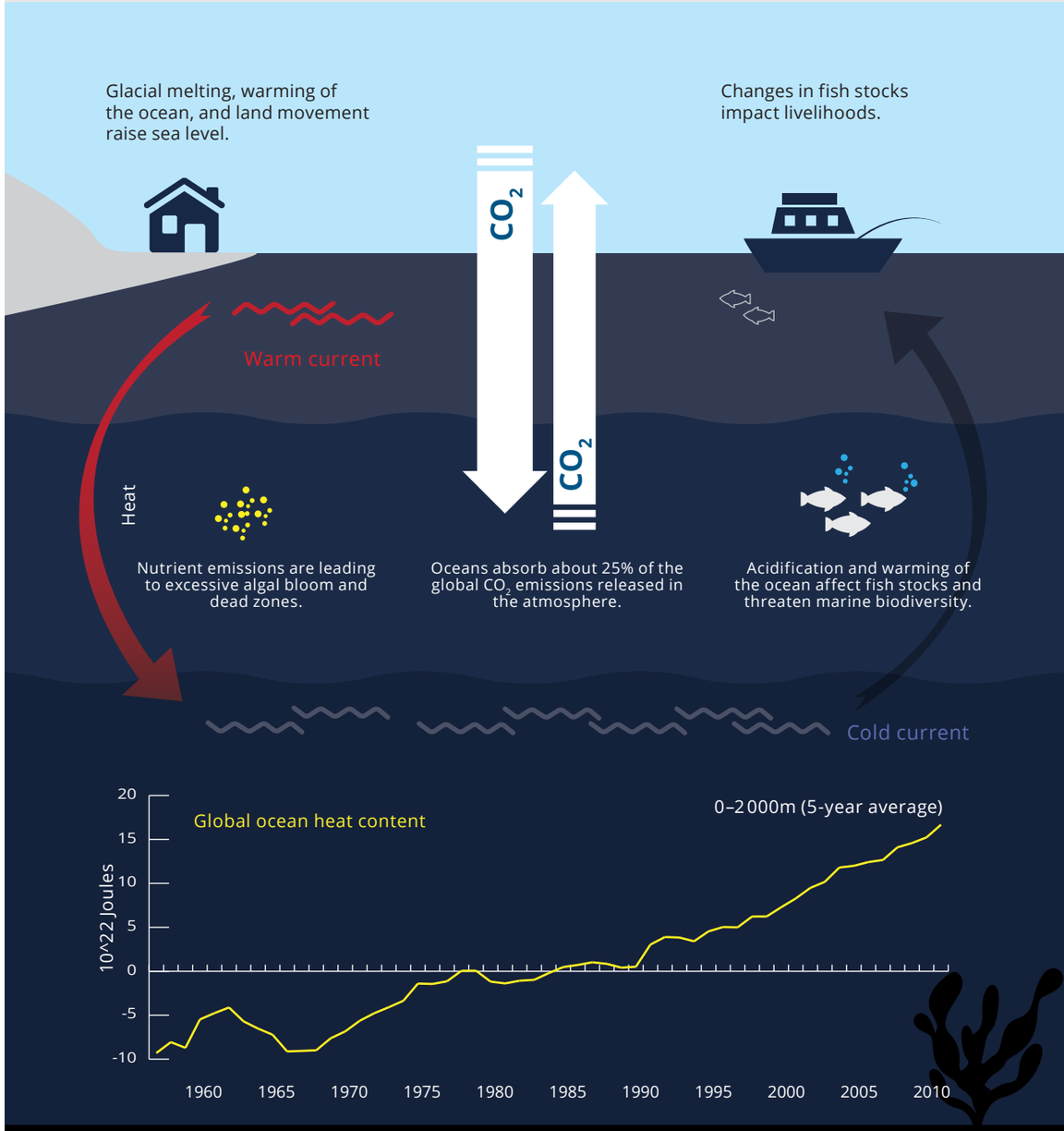
Such dead zones can be observed in Europe's partially enclosed seas, such as the Baltic Sea and the Black Sea. Water temperature in the Baltic Sea has increased by about 2°C over the last century, which has contributed to the increase in the extent of dead zones. Moreover, the global occurrence of dead zones has doubled in frequency every decade since the mid-1900s ([15]). And unfortunately, even if the nutrient emissions to European seas were to be halted today, the legacy of past nutrient emissions would continue to cause dead zones for decades to come before the seas were returned to their former state.

Uncertain future

Although certain models look at possible climate change scenarios, it is difficult to predict how marine species will behave as the stresses on the oceans are magnified. But we do know that we must take action to mitigate climate change now in order to limit further ocean warming and ocean acidification, and the effects that both of these have on the environment and our well-being.

Climate change and the seas

Climate change is warming the oceans, causing acidification of marine environments, and changing rainfall patterns. This combination of factors often exacerbates the impacts of other human pressures on the seas, leading to biodiversity loss in the oceans.



Sources: Sabine et al. 2004. (http://www.pmel.noaa.gov/pubs/outstand/sabi2683/sabi2683.shtml).
EEA indicator on ocean heat content. Data from National Oceanic and Atmospheric Administration (NOAA).

Agriculture and climate change

Agriculture both contributes to climate change and is affected by climate change. The EU needs to reduce its greenhouse-gas emissions from agriculture and adapt its food-production system to cope with climate change. But climate change is only one of many pressures on agriculture. Faced with growing global demand and competition for resources, the EU's food production and consumption need to be seen in a broader context, linking agriculture, energy, and food security.

Food is a basic human need, and a healthy diet is a key component of our health and wellbeing. A complex and increasingly globalised system of production and delivery has developed over time to meet our need for food and for different flavours. In today's world, a fish caught in the Atlantic might be served within days in a restaurant in Prague alongside rice imported from India. Similarly, European food products are sold and consumed in the rest of the world.

Agriculture contributes to climate change

Before reaching our plates, our food is produced, stored, processed, packaged, transported, prepared, and served. At every stage, food provisioning releases greenhouse gases into the atmosphere. Farming in particular releases significant amounts of methane and nitrous oxide, two powerful greenhouse gases. Methane is produced by livestock during digestion due to enteric fermentation and is released via belches. It can also escape from stored manure and organic waste in landfills. Nitrous oxide emissions are an indirect product of organic and mineral nitrogen fertilisers.

Agriculture accounted for 10% of the EU's total greenhouse-gas emissions in 2012. A significant decline in livestock numbers, more efficient application of fertilisers, and better manure management reduced the EU's emissions from agriculture by 24% between 1990 and 2012.

However, agriculture in the rest of the world is moving in the opposite direction. Between 2001 and 2011, global emissions from crop and livestock production grew by 14%. The increase occurred mainly in developing countries, due to a rise in total agricultural output. This was driven by increased global food demand and changes in food-consumption patterns due to rising incomes in some developing countries. Emissions from enteric fermentation increased 11% in this period and accounted for 39% of the sector's total greenhouse-gas outputs in 2011.

Given the central importance of food in our lives, a further reduction of greenhouse-gas emissions from agriculture remains quite challenging. Nevertheless, there is still potential to further reduce the greenhouse-gas emissions linked to food production in the EU. A better integration of innovative techniques into production methods, such as capturing methane from manure, more efficient use of fertilisers, and greater efficiency in meat and dairy production (i.e. reducing emissions per unit of food produced) can help.

In addition to such efficiency gains, changes on the consumption side can help to further lower greenhouse-gas emissions linked to food. In general, meat and dairy products have the highest global footprint of carbon, raw materials, and water per kilogramme of any food. In terms of greenhouse-gas emissions, livestock and fodder production each generate more than 3 billion tonnes of CO_2 equivalent. Post-farm transport and processing account for only a tiny fraction of the emissions linked to food. By reducing food waste and our consumption of emission-intensive food products, we can contribute to cutting the greenhouse-gas emissions of agriculture.

Climate change affects agriculture

Crops need suitable soil, water, sunlight, and heat to grow. Warmer air temperatures have already affected the length of the growing season over large parts of Europe. Flowering and harvest dates for cereal crops are now happening several days earlier in the season. These changes are expected to continue in many regions.

In general, in northern Europe agricultural productivity might increase due to a longer growing season and an extension of the frost-free period. Warmer temperatures and longer growing seasons might also allow new crops to be cultivated. In southern Europe, however, extreme heat events and reductions in precipitation and water availability are expected to hamper crop productivity. Crop yields are also expected to vary increasingly from year to year due to extreme weather events and other factors such as pests and diseases.

In parts of the Mediterranean area, due to extreme heat and water stress in summer months, some summer crops might be cultivated in winter instead. Other areas, such as western France and south-eastern Europe, are expected to face yield reductions due to hot and dry summers without the possibility of shifting crop production into winter.

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Changes in temperatures and growing seasons might also affect the proliferation and the spreading of some species, such as insects, invasive weeds, or diseases, all of which might in turn affect crop yields. A part of the potential yield losses can be offset by farming practices, such as rotating crops to match water availability, adjusting sowing dates to temperature and rainfall patterns, and using crop varieties better suited to new conditions (e.g. heat- and drought-resilient crops).

Land-based food sources are not the only food sources affected by climate change. The distribution of some fish stocks has already changed in the Northeast Atlantic, affecting the communities relying on these stocks throughout the supply chain. Along with increased maritime shipping, warmer water temperatures can also help facilitate the establishment of invasive marine species, causing local fish stocks to collapse.

Some EU funds, including the European Agricultural Fund for Rural Development, Common Agricultural Policy (CAP), and loans from the European Investment Bank, are available to help farmers and fishing communities to adapt to climate change. There are also other funds under the CAP aimed at helping to reduce greenhouse-gas emissions from agricultural activities.

Global market, global demand, global warming...

In line with projected population growth and changes in dietary habits in favour of higher meat consumption, the global demand for food is expected to grow by up to 70% in the coming decades. Agriculture is already one of the economic sectors with the largest environmental impact. This substantial increase in demand will unsurprisingly create additional pressures. How can we meet this increasing global demand while at the same time reducing the impacts of European food production and consumption on the environment?

Reducing the amount of food produced is not a viable solution. The EU is one of the world's largest food producers, producing around one eighth of the global cereal output, two thirds of the world's wine, half of its sugar beet, and three quarters of its olive oil ([16]). Any reduction in key staples is likely to jeopardise food security in the EU and in the world, and increase global food prices. This would make it harder for many groups around the world to access affordable and nutritious food.

Producing more food out of the land that is already used for agriculture often requires heavier use of nitrogen-based fertilisers, which in turn release nitrous oxide emissions and contribute to climate change. Intensive agriculture and fertiliser use also release nitrates to the soil and to water bodies.

Although not directly linked to climate change, high concentrations of nutrients (especially phosphates and nitrates) in water bodies cause eutrophication. Eutrophication promotes algae growth and depletes oxygen in the water, which in turn has severe impacts on aquatic life and water quality.

Whether in Europe or the rest of the world, meeting the growing demand for food by using more land would have serious impacts on the environment and the climate. The areas most suitable to agriculture in Europe are already cultivated to a large extent. Land, especially fertile agricultural land, is a limited resource in Europe and across the world.

Converting forest areas into agricultural land is also not a solution as this process is a source of greenhouse-gas emissions. Similar to many other land-use changes, deforestation (currently occurring mainly outside the European Union) also puts biodiversity at risk, further undermining nature's ability to cope with climate change impacts (such as absorbing heavy rainfall).

Competing demands

It is clear that the world will need to produce more food and that key resources are limited. Agriculture has high impacts on the environment and the climate. Moreover, climate change affects — and will continue to affect — how much food can be produced and where.

Who gets to produce what and where is a socio-political question and is likely to become more controversial in the future. The global competition for these essential resources, especially with the pending impacts of climate change, is driving developed countries to purchase large patches of agricultural land in less-developed countries. Such land purchases and climate change impacts raise questions about food security in developing countries in particular. Food security is not only a matter of producing sufficient quantities of food, but also of having access to food of sufficient nutritional value.

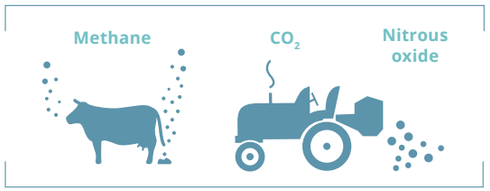
This complex problem requires a coherent and integrated policy approach to climate change, energy, and food security. Faced with climate change and competition for scarce resources, the entire food system will need to transform itself and be much more resource efficient while continuously reducing its environmental impacts, including its greenhouse-gas emissions. We need to increase yields while reducing our dependence on agrochemicals, to reduce food waste, and to reduce our consumption of resource-intensive and greenhouse gas-intensive foods such as meat.

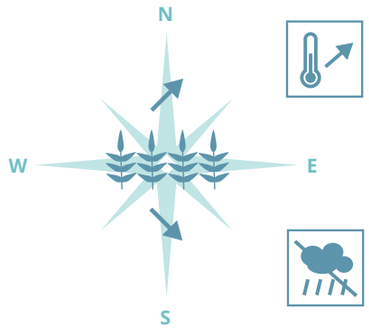
In doing this, we must also remember that farmers can play a key role in maintaining and managing Europe's biodiversity. They are also a critical component of the rural economy. Therefore, policy measures to tackle this highly complex problem of food and the environment should take into consideration agriculture's impacts on the environment and its socio-economic importance for many communities.

Climate change and agriculture

Agriculture both contributes to climate change and is affected by climate change. The EU needs to reduce its greenhouse-gas emissions from agriculture and adapt its food-production system to cope with climate change. Faced with growing global demand and competition for resources, the EU's food production and consumption need to be seen in a broader context, linking agriculture, energy, and food security.

Agriculture accounts for 10% of the EU's greenhouse-gas emissions.





-24% From 1990 to 2012, greenhouse-gas emissions from agriculture in the EU decreased by 24%.

In southern Europe extreme heat events and reduced precipitation and water availability are expected to reduce crop yields, while the suitability for growing crops may improve in northern Europe.

Greenhouse-gas emissions from agriculture can be reduced further by:

- Better integration of innovative techniques
- Capturing methane from manure
- More efficient use of fertilisers
- Greater efficiency in meat and dairy production
- Reducing food waste
- Consuming less meat and other products with high carbon footprint

Globally

+14% Between 2001 and 2011, greenhouse-gas emissions from crop and livestock production grew by 14%.

+70% The demand for food is expected to grow by up to 70% in coming decades.

Did you know?

Meat and dairy products have the highest global footprint of carbon, raw materials and water per kilogramme of any food.

Post-farm transport and processing account for only a tiny fraction of the emissions linked to food.

Sources: EEA, 2015. European Environment — state and outlook 2015: Agriculture. Eurostat, 2014. Statistics explained: Agricultural production — crops (ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_production_-_crops).

Soil and climate change

Soil is an important — and often neglected — element of the climate system. It is the second largest carbon store, or 'sink', after the oceans. Depending on the region, climate change might result in more carbon being stored in plants and soil due to vegetation growth, or more carbon being released into the atmosphere. Restoring key ecosystems on land, and a sustainable use of the land in urban and rural areas, can help us mitigate and adapt to climate change.

Climate change is often seen as something that occurs in the atmosphere. After all, when plants photosynthesise, they draw carbon out of the atmosphere. But atmospheric carbon also affects the soil, because carbon that is not used for above-ground plant growth is distributed through the roots of a plant, which deposit carbon in the soil. If undisturbed, this carbon can become stable, and remain locked away for thousands of years ([17]). Healthy soils can thus mitigate climate change.

When it comes to carbon storage, not all soils are equal. The most carbon-rich soils are peatlands, mostly found in northern Europe, the United Kingdom and Ireland. Grassland soils also store a lot of carbon per hectare. In contrast, the soil in warm and dry areas in southern Europe contains less carbon ([18]).

Climate change puts soil under pressure

In some parts of Europe, higher temperatures may lead to more vegetation growth and more carbon stored in the soil. However, higher temperatures could also increase decomposition and mineralisation of the organic matter in the soil, reducing organic carbon content ([19]).

In other areas, the carbon-containing organic matter in stable peatlands is prevented from decomposing due to the low levels of oxygen in the water. If such areas dry out, the organic matter can quickly break down, releasing carbon dioxide (CO_2) into the atmosphere ([20]).

There are already signs that soil moisture content is being affected by rising temperatures and changes in precipitation patterns. And future projections show this may continue, with a general change in summer soil moisture over most of Europe over the period 2021 to 2050, including significant decreases in the Mediterranean region and some increases in the north-eastern part of Europe ([21]).

The increasing concentration of carbon dioxide in our atmosphere may cause the microbes in the soil to work faster to break down organic matter, potentially releasing even more carbon dioxide ([22]). The release of greenhouse gases from the soil is expected to be particularly substantial in the far north of Europe and Russia, where melting permafrost may release large quantities of methane, a greenhouse gas much more potent than carbon dioxide.

It is not yet clear what the overall effect will be, as different regions absorb and emit different levels of greenhouse gases. But there is a clear risk that a warming climate can lead the soil to release more greenhouse gases, which can further heat the climate in a self-reinforcing spiral.

Agriculture and forestry to keep the carbon underground

Climate change is not the only thing that risks turning soil from a carbon sink to a source of emissions. The way we use land can also have a clear influence on the amount of carbon that the soil can hold.

Currently, the carbon stock of European forests is growing, due to changes in forest management and environmental changes. About half of that carbon stock is stored in forest soils. However, when forests are degraded or cleared, their stored carbon is released back to the atmosphere. In this case, forests may become net contributors of carbon to the atmosphere ([23]).

On farmland, ploughing the soil is known to accelerate decomposition and mineralisation of organic matter. In order to keep carbon and nutrients in the soil, researchers suggest reducing tillage, farming with complex crop rotations, using so-called 'cover crops' and leaving crop residues on the surface of the soil ([24]). Leaving crop residue on the surface before and during planting operations can help to protect against the risk of soil erosion. Such protection is essential given that it can take thousands of years to form just a few centimetres of soil ([25]). Reduced

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tillage involves less breaking and turning of the soil. However, reduced or no-till methods are often associated with higher use of chemical fertilisers, which can have other negative effects on the environment.

Similarly, because organic agriculture uses manure inputs, it can rebuild the soil's organic carbon deep below the soil surface. Organic agriculture has the added benefit of cutting greenhouse gases because it does not use chemical fertilisers ([26]). The UN Food and Agriculture Organization calculates that CO_2 emissions per hectare of organic agriculture systems are 48% to 66% lower than in conventional systems ([27]).

Interestingly, some forms of biofuel production may actually reduce the carbon stored in the soil. A recent study found that biofuels made from corn residue may actually increase greenhouse-gas emissions overall, because the organic matter is burnt as fuel rather than returned to the soil ([28]).

Overall, the adoption of appropriate farming and forestry practices offers enormous potential for restoring the soil and removing CO_2 from the atmosphere.

Protecting cities with soil

After homes in the Belgian village of Velm near Sint-Truiden were flooded with muddy water five times in 2002, the residents put pressure on the local municipality to do something ([29]). Floods of muddy water had become a recurring problem in the area as water ran off bare fields, carrying sediment with it. To solve this problem, authorities looked to the soil to protect homes. They adopted a number of measures such as planting cover crops in the winter when the soil was bare and thus at risk of flooding. They also left crop residues on the field to reduce erosion. Such measures to restore natural systems have successfully prevented muddy floods between 2002 and the present day, despite several heavy rainfall events.

Flood regulation and prevention is just one of the vital 'services' that healthy soil delivers. We may come to increasingly rely on this service as extreme weather events such as floods become more frequent and severe.

There are many other ways that the quality of soil will dictate how climate change affects us. Permeable soil can also protect from heatwaves, by storing large amounts of water and keeping temperatures down. This latter point is particularly important in cities, where hard surfaces (soil sealing) can create the 'heat island effect'.

Several European cities are trying to make use of these soil functions. For example, Gomeznarro Park ([30]) in Madrid was restored to include new permeable surfaces, vegetation and underground water storage. This solution has been replicated elsewhere in Madrid and across Spain.

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Restoring ecosystems

The latest evidence is clear: restoring some ecosystems can actually help capture carbon from the atmosphere. For example, actively restoring peatlands has proved to be a successful response to the loss of organic carbon that results from peat exploitation for energy use ([31]). The fastest way to increase organic carbon in farmed soil is to convert arable land to grassland, according to a study from the European Commission's Joint Research Centre ([32]).

Unfortunately, some recent trends seem to be going in the opposite direction. Between 1990 and 2012, the area of arable land, permanent crops, pastures, and semi-natural vegetation decreased in Europe ([33]). More concretely, 'land take' in Europe resulted in a loss of 0.81% in arable-land productive capacity as fields were converted to towns, roads, and other infrastructure between 1990 and 2006 ([34]). Such urban development projects often involve sealing the soil with an impervious layer. Food security concerns aside, this also means Europe has a reduced capacity to store organic carbon, prevent floods, and keep temperatures down ([35]).

If managed correctly, soil can help us to reduce greenhouse gases and adapt to the worst effects of climate change. But if we fail to care for the soil, we may quickly exacerbate the problems connected to climate change.

Soil and climate change

Soil is an important and often neglected element of the climate system. It is the second largest carbon store, or 'sink', after the oceans. Restoring key ecosystems on land, and a sustainable use of the land in urban and rural areas, can help us mitigate and adapt to climate change.

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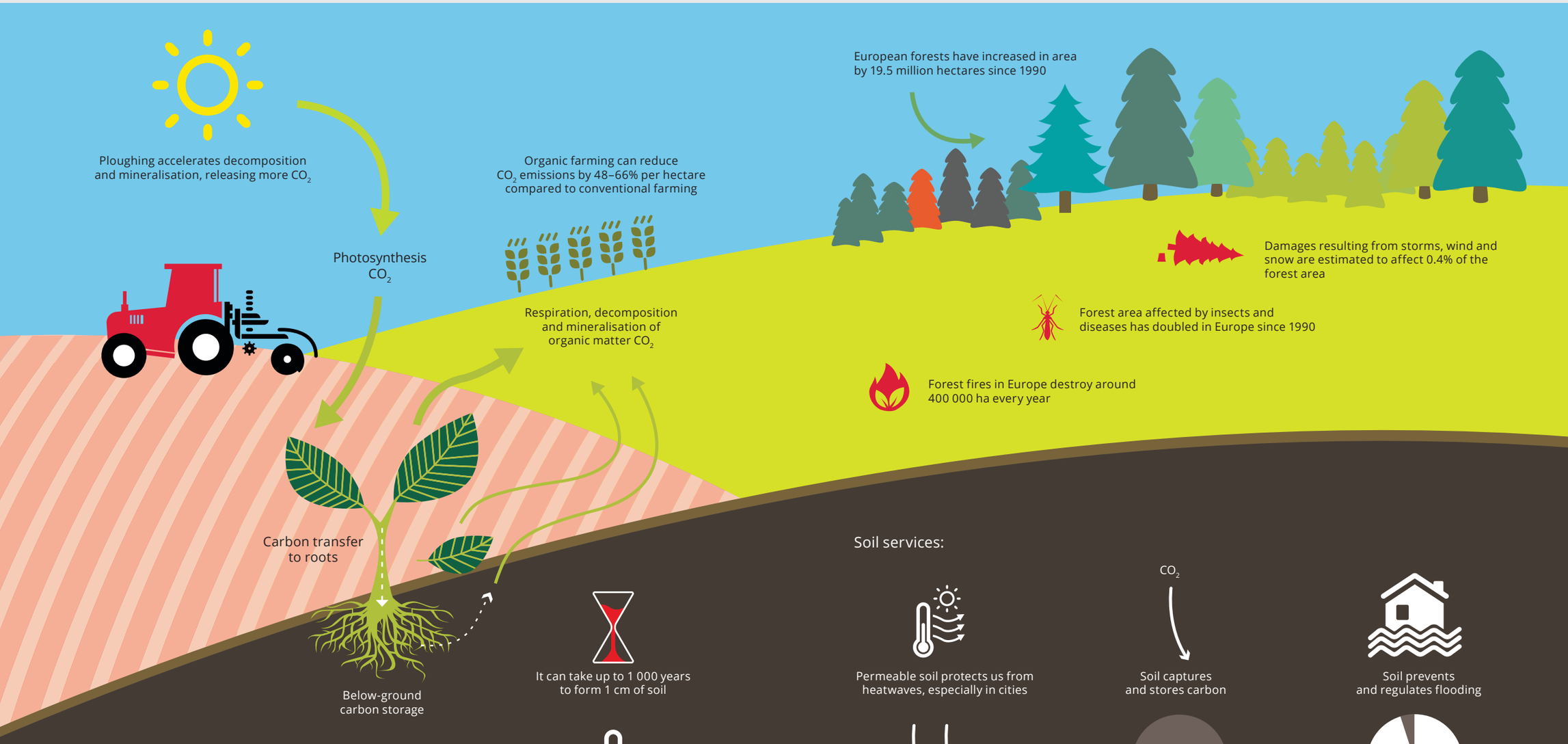


Sources: EEA, 2015. European Environment — state and outlook 2015: Forests, Soil; UNECE, 2015: Forests in the ECE region — trends and challenges in achieving the global objectives on Forests. ECE/TIM/SP/37 FAO, 2002. Organic agriculture, environment and food security (www.fao.org/docrep/005/y4137e/y4137e02b.htm); FAO, 2015. Soil facts (www.fao.org/soils-2015).

Holger Robrecht
Deputy Regional Director of ICLEI

Climate change and cities

Most Europeans now live in cities, so the choices we make about urban infrastructure will have a large influence on how well we cope with climate change. More frequent rainfall, flooding, and heatwaves are likely to be among the challenges that Europe's cities will face from climate change. We asked Holger Robrecht, Deputy Regional Director of ICLEI, what cities are doing to adapt to climate change.

What effects will climate change have on cities?

Climate change will have a variety of effects on cities. The most likely effects in Europe are an increase in extreme weather events like flooding, storms, and heatwaves.
This could have a serious effect on urban infrastructure such as transport systems, sewage systems, and even food-delivery systems. In heavy rainfalls and floods, the danger is that our drainage and sewage systems cannot cope. We have seen an example of this during the rain storm in 2011 in Copenhagen, which showed the disruption that can happen in heavy rainfalls. This storm led to flooding in houses, and it also damaged railways, roads, and the metro system. Heavy rainfalls can also cause landslides in mountains and hills outside cities. These landslides can cut off roads, making it difficult to deliver food and other goods. We have already seen this happen in the Philippines and in Italy, in the Liguria region around Genoa.

Climate change places pressure on our 'hard' infrastructure such as roads, houses, and sewage systems. But it also places pressure on our 'soft' infrastructure such as our health systems. This is very evident in events such as heatwaves, which are another problem for urban areas. Cities create 'heat islands' that are far warmer than rural areas. Old people are especially at risk of mortality in urban areas. This creates a new type of challenge for our health systems.

How are cities adapting to the challenge of climate change?

Many cities in Europe have very forward-thinking adaptation plans, including London, Copenhagen, Bratislava, and Almada in Portugal. If I could highlight just three, they would be Rotterdam, Ghent, and Bologna. In the case of Rotterdam and Ghent, these cities partnered with research organisations to assess the places in the cities that would be the hottest during heatwaves. They decided to place thermometers in a variety of locations, and even placed mobile thermometers on trams. In this way, they could detect the places in the cities where the heat-island effect was greatest. As a result, they were able to take remedial actions, such as planting trees, to reduce the effects of some of these heat islands.

Bologna adopted a very different approach. Bologna is an old medieval city at risk of flooding by the Po river. However, it is also affected by heavy rainfall and by heatwaves, so they face a triple challenge. The city government of Bologna developed a mobile phone app, through which citizens detect and report any kind of damage in the city that came from any event such as heavy rainfall or heatwave. The app also allows citizens to make suggestions to the city government on how to prepare for any future event that might happen. The app was part of Bologna's Blue AP adaptation plan and received funding from the EU.

Is adapting to climate change on the political agenda in Europe?

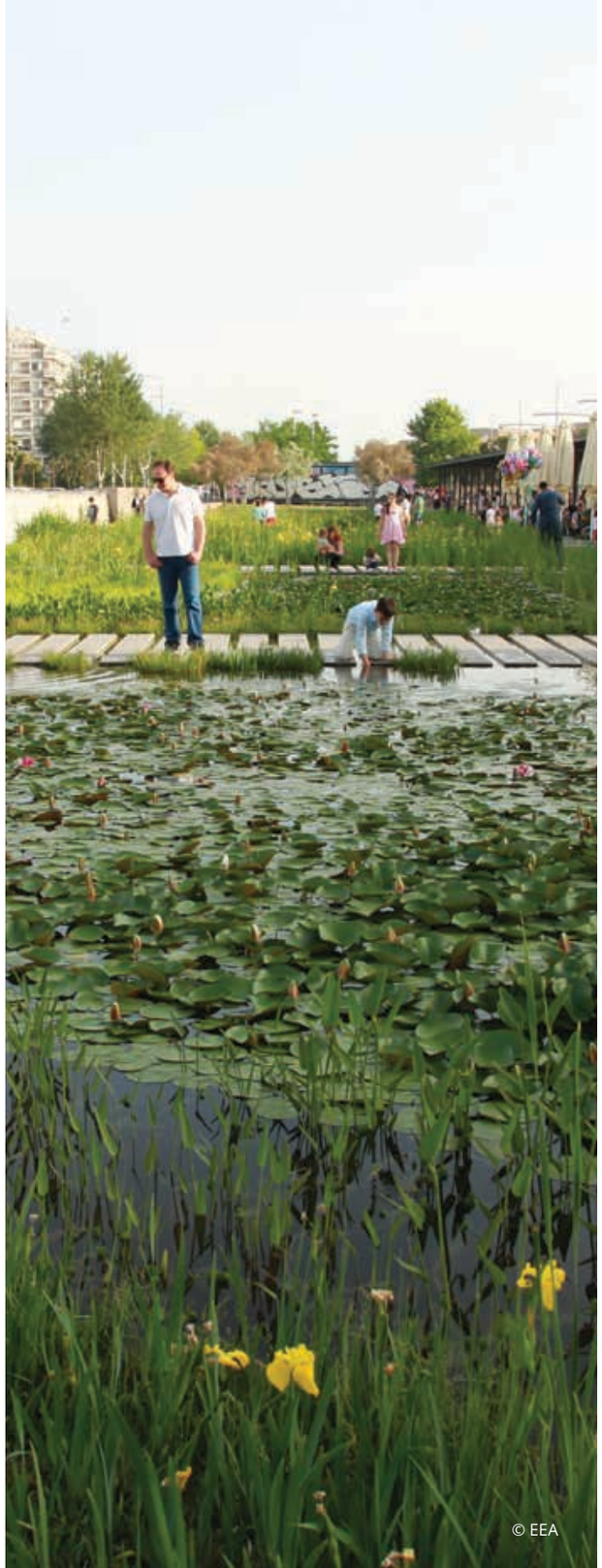
Yes. In recent years, climate change adaption has grown greatly in importance. This is because so many areas in Europe have been affected by extreme events from climate change in the past decade. And the effects of these extreme weather events have often been far worse than anybody would have predicted ten years ago. For example, in 2010 Cyclone Xynthia flooded many areas in coastal France and left almost million people without electricity. Last year, Croatia and Serbia suffered heavy flooding from rainfalls. And in early June last year, a prolonged heatwave was followed by heavy rains that hit Belgium, the Netherlands, and Luxembourg. The storm then moved into the Ruhr, leading to damages and floods between in the area Dusseldorf and Dortmund. Heatwaves have been another great challenge in Europe, with particularly warm summers in 2013 and 2014. These events have made governments and cities aware of the necessity to adapt to climate change.

What are the biggest challenges that cities face in dealing with climate-change problems?

Cities face a variety of challenges in adapting to climate change. Lack of knowledge may be the greatest challenge. Many city governments do not know how their city will be affected by climate change. Those cities that wish to take action to prepare for climate change often don't know what actions to take or how to organise their response. And many cities are unaware that there is funding and advice available across Europe.

These challenges are now being addressed. Some national governments have programmes in place to help their cities create adaptation plans. The UK government has a programme called UKCIP and the German government has a programme called KomPass. At the EU-level, there is now an EU Strategy on Adaptation to Climate Change. And the EU has created a website called Climate-ADAPT, run by the European Environment Agency. Climate-ADAPT helps cities, regions, and national governments learn about climate change adaptation. And there is a European-level organisation specifically established to help cities: Mayors Adapt.

At ICLEI, we organise conferences like the Bonn Resilient Cities conference and — together with the European Environment Agency — the Open European Day for supporting exchange between city practitioners. We also offer direct climate-related services to cities.



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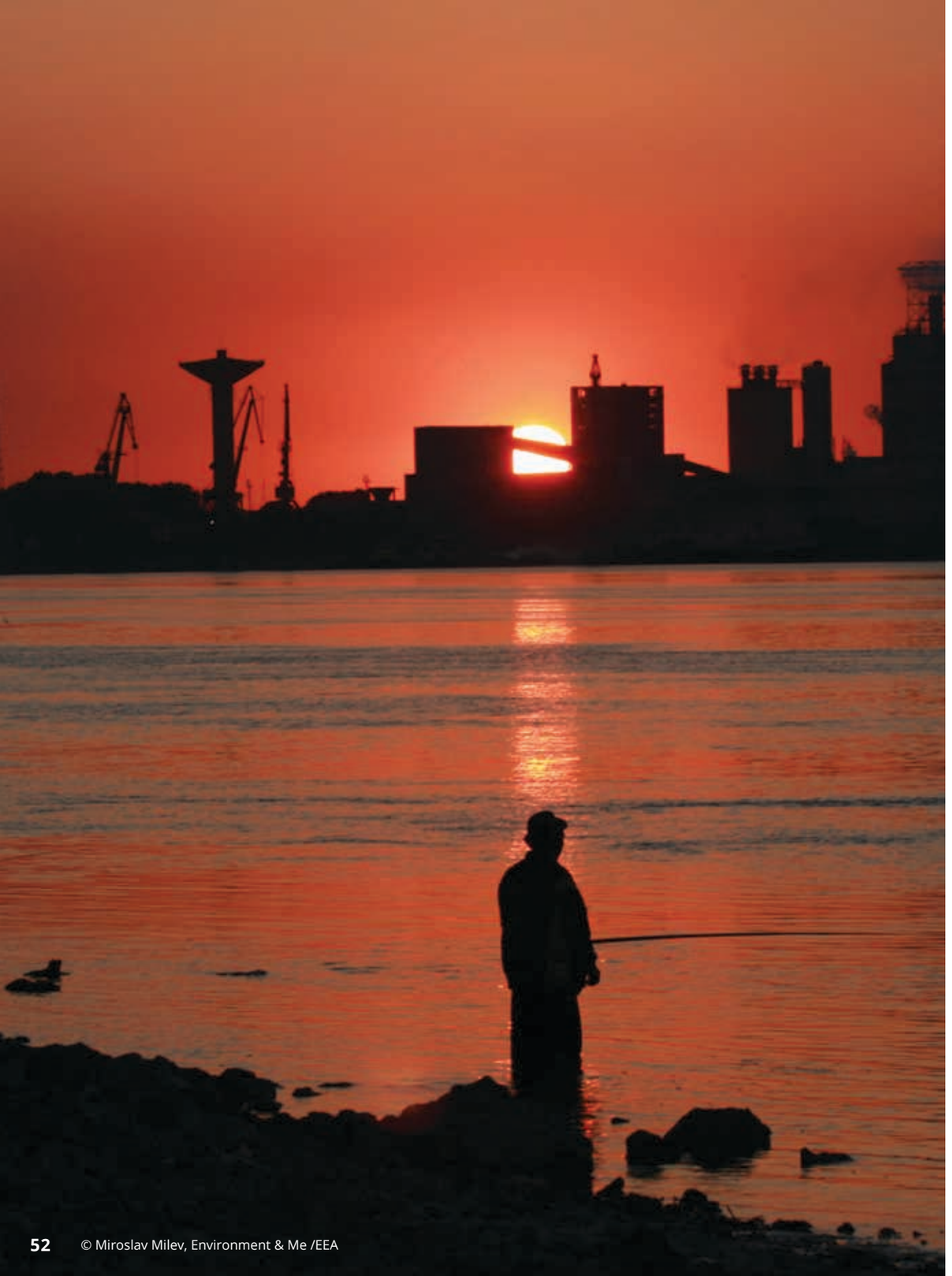
Finally, there are also funds available: the EU has set aside 20% of its budget to help cities and countries prevent — and adapt to — climate change. However, many cities are unaware of this funding.

One of the more practical challenges that cities face is in organising their response across administrative levels. Climate change adaptation means making connections across administrative boundaries. For example, if you look at rivers that cross different cities, the responsibility for water management in the urban part of a river might not even lie with the city in question. Things can get even more complicated for rivers like the Rhine and the Danube that cross several countries. Therefore, flood protection related to these rivers means cities need to experiment with new types of governance between cities and countries. In the case of the river Rhine, Switzerland, France, Germany, and the Netherlands all came together in order to plan retention areas for flood water. Cities and countries will need to plan much more in this way in the future in order to adapt to climate change.



Mitigating climate change

2014 was the hottest year on record. It was also one more year in series of increasingly warm decades. To limit global warming to 2°C above pre-industrial levels and minimise the impacts of climate change, greenhouse gases released into the atmosphere need to be reduced substantially. Governments can set targets, but it is ultimately up to industry, businesses, local authorities, and households to take action. This action must aim to ensure that emissions are reduced, atmospheric greenhouse-gas concentrations stabilised, temperature rises halted, and climate change limited.

In 2014, global temperatures were 0.69°C above the 20th century global average ([36]). Scientists agree that the warming is due to atmospheric greenhouse gases emitted mainly as a result of anthropogenic combustion of fossil fuels. This warming in turn causes climate change. Since the industrial revolution, the amount of greenhouse gases present in the atmosphere has steadily been increasing.

Greenhouse gases such as carbon dioxide (CO_2) and methane are released both naturally and as a result of human activity. Combustion of fossil fuels adds to naturally occurring CO_2 in the atmosphere. Worldwide deforestation amplifies this phenomenon by reducing trees, which remove CO_2 from the atmosphere. Meanwhile, agriculture and poorly managed landfill play a large role in the release of methane. Furthermore, combustion of fossil fuels also leads to the release to the atmosphere of air pollutants such as nitrogen oxides, sulphur dioxide, and particulate matter. Some of these pollutants can also play a role in warming (or, in the case of aerosols, cooling) our climate.

Due to their persistence in the atmosphere and the non-localised effect of concentrations, the impacts these gases have on the earth's climate are global issues. This means that a global deal to mitigate emissions is paramount in preventing the continued acceleration of climate change.

A global deal on climate change

This year, the Conference of Parties (COP) ([37]) to the 1992 United Nations Framework Convention on Climate Change (UNFCCC) will meet in Paris to coordinate the latest step in the international political response to climate change. Building on two decades of negotiations, COP21 aims to achieve an ambitious, legally binding and global agreement on climate change that will set targets on greenhouse-gas emissions to which all countries should adhere. The agreement is also expected to include objectives and actions on climate change adaptation, focusing on vulnerable developing countries in particular.

The European Union's efforts to reduce greenhouse-gas emissions are working. In fact, the EU is expected to meet its unilateral 20% reduction target (compared to 1990) ahead of the agreed 2020 deadline. Moreover, the EU intends to reduce domestic emissions by at least 40% by 2030 and further decarbonise its economy by 2050. But despite the EU's decreasing emissions and its shrinking share of worldwide emissions, global emissions continue to rise.

Government policies and target setting

At COP15, held in Copenhagen in 2009, an aspirational goal of limiting global warming to 2°C above pre-industrial levels was agreed. COP21 intends to adopt a 'new instrument' that translates this limit into actions to be implemented from 2020. Alongside adaptation to existing climate change, efforts to reduce greenhouse-gas emissions and promote the transition towards resilient, low-carbon societies and economies should play a major role in this international agreement.

Prior to COP21, national governments are invited to publicly declare the actions they intend to commit to under the new global agreement — their Intended Nationally Determined Contributions (INDCs) ([38]). The European Union and its Member States have already submitted their INDCs, committing to reducing domestic greenhouse-gas emissions by at least 40% by 2030 compared to 1990. This binding target will be achieved by the EU as a whole. This target is also in line with the EU objective to reduce its own greenhouse-gas emissions by 80–95% by 2050 compared to 1990. The UNFCCC intends to publish a synthesis report of these pledges before COP21.

To fulfil these commitments, governments will need to develop and implement effective policies. For example, the European Union's Emissions Trading Scheme (ETS) ([39]) is central to its mitigation efforts. It limits emissions from some 12 000 power stations and industrial plants across 31 countries by setting a cap on the total amount of greenhouse gases they can emit, and this cap is reduced over time. The European Commission proposes that in 2030 ETS emissions will be 43% lower than they were in 2005. Companies buy and sell emissions allowances, and after a year they must give back enough allowances to the authorities to cover all their emissions or else be subject to heavy fines. The scheme puts a monetary value on carbon, benefitting those that reduce their emissions. It also seeks to encourage investment in clean, low-carbon technologies.

The signals conveyed by governments to polluters are clear: reducing emissions doesn't just demonstrate environmental good will, it also makes good business sense.

Energy and materials use

The environmental impact of industrial activity comes mainly from energy consumption, chemical production processes, and the use of resources in industrial production. Until recently, it was assumed that greater economic prosperity and growth were intrinsically linked with greater negative environmental impacts. However, in the last two decades, some developed countries have started breaking this link between economic growth and the use of energy and materials. These countries have been using less material and energy to produce the same value of output, while also reducing the amount of carbon released per unit of energy. These phenomena of dematerialisation and decarbonisation have led to reductions in greenhouse-gas emissions. The technological and behavioural drivers behind this decoupling can help developing countries to mitigate their emissions as their economies grow.

The energy supply industry traditionally relied on the combustion of high-carbon fossil fuels to generate electricity. However, the ongoing switch in the short term to more efficient natural gas burning technology, combined with the growth of renewable energy sources, points to a future where this sector's emissions continue to decline beyond current targets.

In the manufacturing sector, lessons may be learnt from nature. Industrial ecology is a field of study that considers the parallels between industrial and natural systems, and suggests features that industry could adopt. For example, in nature no material is wasted. Anything not needed in a certain process is recycled and transformed for use elsewhere. Waste products resulting from one process become the building blocks of a new one, and the whole system runs on energy from the sun.

Lifecycle assessment (LCA) is increasingly used to understand how such reuse and recycling of energy and materials can contribute to emission reductions. LCA considers total energy use and emissions to air, water, and land as indicators of potential environmental harm. Incorporating LCA into decision-making can bring about environmental benefits and cost savings, while encouraging more economic, and less-polluting alternatives.

Other sectors must also play a role in future emissions reductions. The European Council has agreed to further reduce emissions from sectors not covered by the ETS by 30% compared to 2005. The EU's Effort Sharing Decision (ESD) ([40]) establishes binding annual targets for individual Member States until 2020 for all the emissions of these sectors, such as transport, buildings, agriculture and waste. Transport is the main source of emissions that is not covered by the EU-ETS. Emission reductions in the transport sector remain limited ([41]), while projected emissions reductions under current policies in the agricultural sector are also limited ([42]).

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Cities and households must also play their part

Climate-change mitigation is not just about industry meeting or going beyond targets. At national, local, and individual levels we all have a role to play. Cities and households in particular need to act to reduce emissions.

Cities are on the frontline of the fight against climate change. In March 2015, leaders of 30 European cities agreed to use their EUR 10 billion per year collective purchasing power to buy eco-friendly goods and services in emissions-heavy sectors such as transport, domestic heating, and energy supply ([43]). This initiative complements the Covenant of Mayors ([44]), a European movement within which local and regional authorities voluntarily commit to increase energy efficiency and the use of renewable energy resources on their territories. Currently numbering 6 279 signatories, its aim is to meet and exceed the EU's 20% emissions reduction objective by 2020.

Households are also vital. Consumption patterns can affect emissions both directly and indirectly. Between 2000 and 2007, households increasingly purchased goods and services with reduced environmental pressures per Euro spent ([45]). In particular, more environmentally-friendly housing, water, transport, food, non-alcoholic beverages, electricity, and other fuels were purchased in this period. However, the increase in total expenditure in many of these consumption categories may have offset the gains.

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Such changes in consumption, along with improvements in production processes and services, have resulted in reductions in greenhouse-gas emissions across all consumption categories measured. However, further efficiency gains and a shift towards less environmentally-intensive consumption are needed if global consumption overall continues to increase. Moreover, the impact of European consumption of goods manufactured outside the EU cannot be underestimated.

From global targets to action on the ground

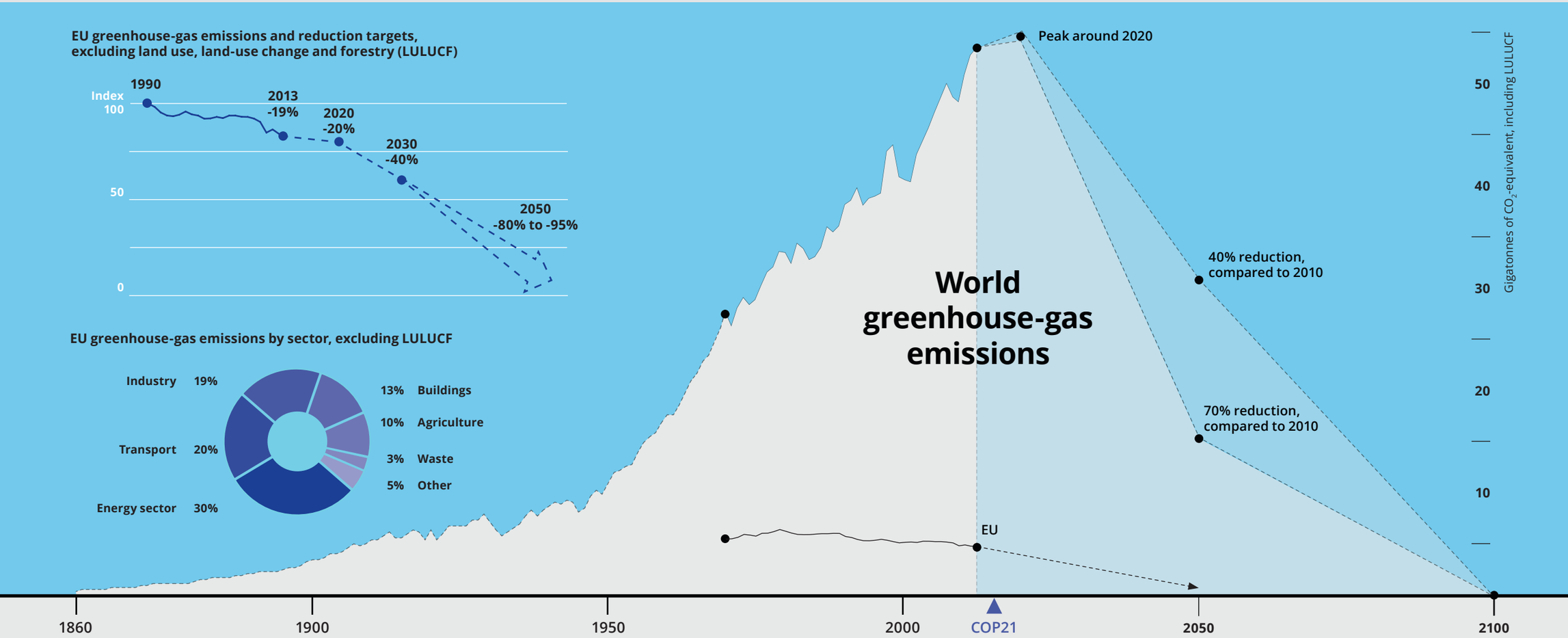
Overall, the message is clear. A climate deal at COP21 is essential. It will go a long way to set targets for emissions reductions and to give clear indications about what needs to be done on both climate-change mitigation and adaptation. Agreeing on emission-reduction targets alone cannot halt climate change. To achieve such targets, well-designed, ambitious, and binding policies leading to emissions reductions are necessary. These policies should provide the catalyst for industry and households to reduce emissions throughout the production and consumption process.

It is clear that emissions from economic activities are closely linked to our consumption patterns. Local authorities, households, and individuals can all exert pressure on existing production systems. Reducing our consumption, and consuming products and services that have less severe impacts on the environment will cause a shift in the way these products and services are produced and sold. Ultimately, climate action starts at home.

Mitigating climate change

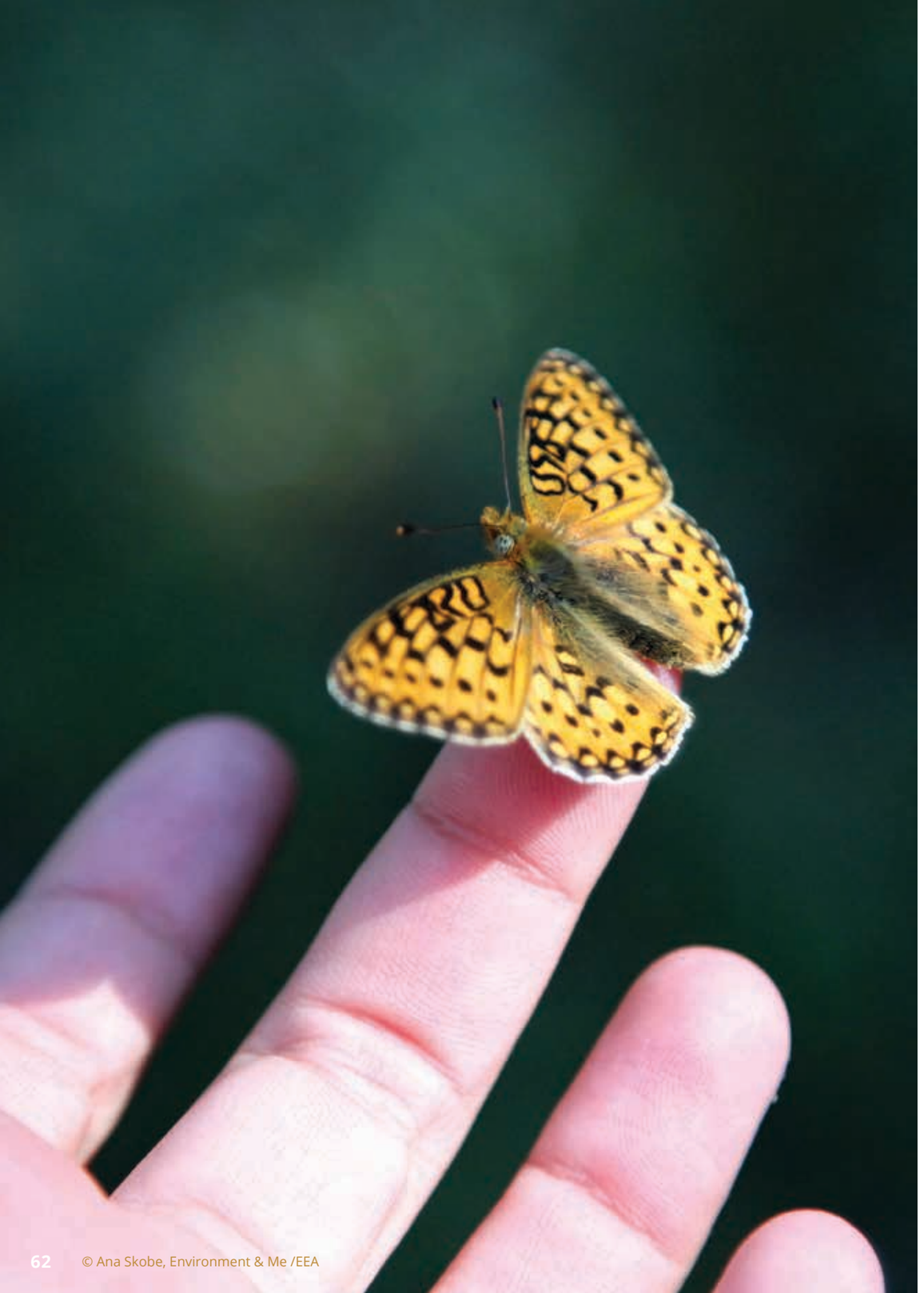
The European Union's efforts to reduce greenhouse-gas emissions are working. In fact, the EU is expected to meet its unilateral 20% reduction target (compared to 1990) ahead of the agreed 2020 deadline. Moreover, the EU intends to reduce domestic emissions by at least 40% by 2030 and further decarbonise its economy by 2050. The EU currently emits around 10% of global greenhouse-gas emissions.

The international community has agreed to limit the global average temperature increase to 2°C above pre-industrial times. Scientific studies show that, to increase our chances of limiting the average temperature increase to 2°C, global emissions have to peak in 2020, and then start declining. Global emissions in 2050 have to be 40 to 70% lower than in 2010 and they have to fall to near zero — or below — by 2100.



Notes: (1) World GHG emissions 1860–1970 are estimated based on EDGAR data and "Global CO_2 emissions, 1860–2006" figure in climate change mitigation chapter of SOER 2010. (2) The EU long-term pathway on the right (in black) is only indicative as the EU target for 2050 excludes the net impact of LULUCF.

Sources: EEA, 2014. Annual EU greenhouse gas inventory 1990–2012 and inventory report 2014; EEA, 2010. Mitigating climate change - SOER 2010 thematic assessment; European Commission-Joint Research Centre, 2014. Global Emissions EDGAR v4.2 FT2012 (November 2014); IPCC, 2014. Mitigation of Climate Change. Contribution of Working Group III to the 5th Assessment Report of the IPCC. Read more: EEA Report 'Trends and projections in Europe'.



Climate change and investments

Measures to mitigate and adapt to climate change are often considered to be expensive, and are seen as an additional burden on the economy. But European countries are already spending public and private funds on research, infrastructure, agriculture, energy, transport, urban development, social protection, health, and nature conservation. We can ensure that our existing expenditure on these areas favours climate-friendly and sustainable options that will help to create new jobs.

Climate change will affect us in a variety of ways, whether through increased air pollution, acidification of oceans, or flooded homes and fields. Some damage costs, such as economic loss due to damaged property from floods, are relatively easy to quantify in monetary terms. But other costs are more difficult to estimate. Can we put an accurate price tag on potential ill health or future reductions in crop productivity due to climate change?

Despite such difficulties and the uncertainties linked to climate change, the Intergovernmental Panel on Climate Change (IPCC) estimates the likely economic loss caused by just 2°C of global warming to be between 0.2–2% of global gross domestic product (GDP), even if strong adaptation measures are taken. Once warming proceeds beyond this, the costs would rise further ([46]).

Although we may not know the exact amount, costs from climate change are real and we are already paying for them in many ways, such as damaged property, medical expenses, and reduced crop yields.

In order to prevent or minimise some of the future costs to our society, economy, and environment, we need to take action. This raises the following questions: how much do we need to invest and in what areas?

Investing in infrastructure

Worldwide, we are consuming increasingly more resources. We need more food, land, and water to feed a growing global population, and we need more energy to heat homes and to fuel our cars. Our increasing levels of consumption are being met by unsustainable production patterns, which deplete non-renewable resources. This also results in more pollutants being released to the atmosphere, water bodies, and land.

The efforts to tackle climate change should be seen in the context of a broader transition to a 'green economy' — a sustainable way of life that allows us to live well, while keeping our resource use within the sustainable limits of our planet. The European Union's 7th Environment Action Programme identifies 'investments' as one of the key pillars enabling this transition.

Investments are critical in tackling climate change because the investment choices made today have long-term implications — both positive and negative — for how basic societal needs are met in the future. One of the key ways that investments can help to tackle climate change is through infrastructure. Our societies build infrastructure to meet basic societal needs such as water, energy and mobility. This infrastructure is often very costly and is used for decades. It is therefore crucial in shaping the way we live. Some investment decisions might provide real opportunities to transform the way we meet these needs, while others risk locking us into unsustainable practices for decades.

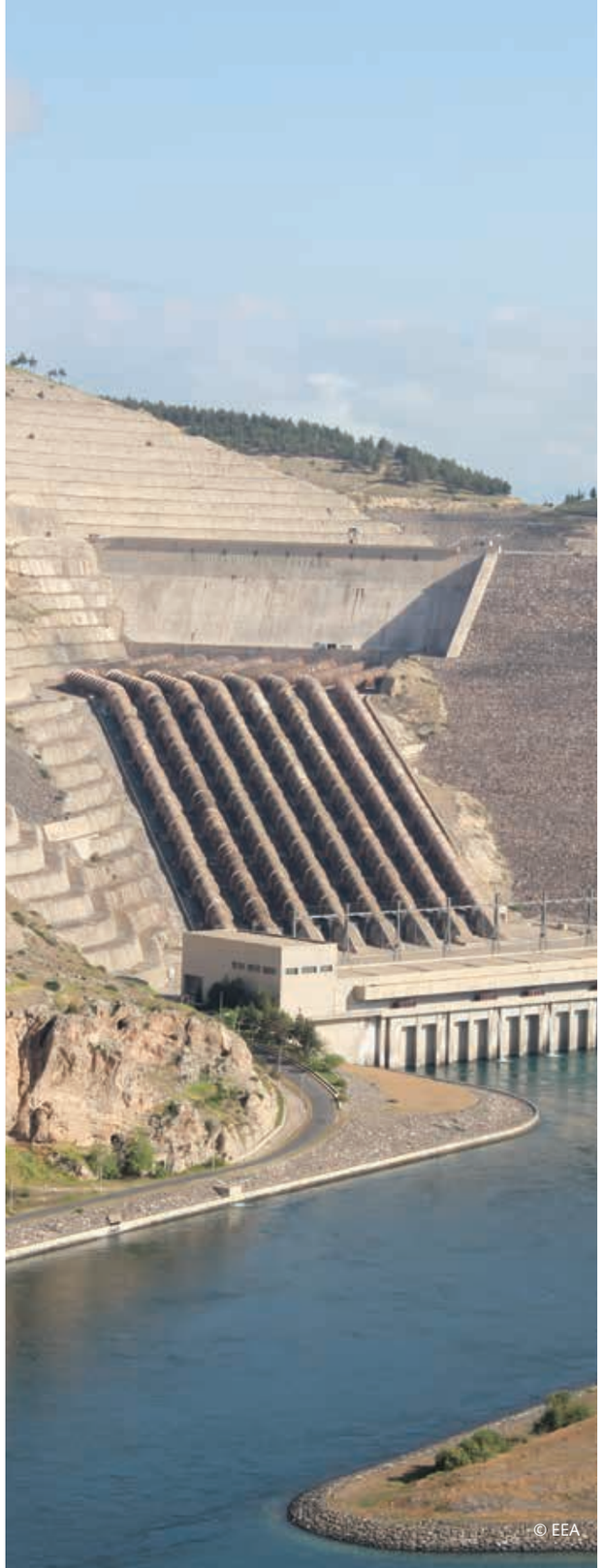
The International Monetary Fund (IMF) has estimated that the world spends approximately EUR 4.8 trillion (USD 5.3 trillion) a year on energy subsidies, mainly on fossil fuels ([47]). The IMF's definition of 'subsidies' in the context of its recent report covers the unpaid costs of all the environmental damage caused by fossil fuels. In the same report, the IMF estimates direct subsidies (i.e. government policies underwriting oil, gas, and coal production or consumption) to amount to approximately EUR 460 billion globally (USD 500 billion). Such subsidies might result in unintended outcomes, where long-term investment decisions concerning our energy infrastructure continue to favour fossil fuels.

Decarbonising the energy and transport systems?

Combustion of fossil fuels is one of the key contributors to greenhouse-gas emissions released into the atmosphere. Fossil fuels are also one of the key components of the global energy system, meeting our need for energy in our homes, offices, factories, and cars.

A total shift from fossil fuels to sustainable renewable alternatives is not easy. It requires changes in the entire energy system from production and storage to distribution and final consumption. For example, the electricity produced by solar panels should be made available for use at a later date in another location, and possibly another country. This can only be achieved if well-connected smart grids are in place. Other systems such as the transport system will also need radical change. This will involve replacing the current fleet with electric vehicles, and creating new public transport networks that can address the demand for mobility by offering alternatives to driving in private cars. When taken altogether, the investment needs to bring about these changes could be massive.

According to European Commission ([48]) estimates, making the EU's energy and transport systems 'low carbon' will require around EUR 270 billion of additional public and private investment per year for the next 40 years. This additional amount corresponds to around 1.5% of EU GDP — similar to the IPCC's climate change economic loss estimate of 0.2–2% of global GDP by 2050. So will investors act now to minimise future impacts?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Re-directing existing expenditure

Governments, businesses, and citizens are already spending money on building transport networks, power generation, housing, and consumption goods and services in the EU. Although it varies among the Member States, government spending in the EU is close to around 50% of GDP ([49]). A part of this consists of investment expenditure (technically 'gross capital formation') on areas such as large infrastructure projects, research, health services, etc. The same is true for household or business expenditure.

So what kind of energy and mobility system we are going to build for the future? Are we going to lock our money into unsustainable solutions or are we going to create the space in which sustainable alternatives can grow and transform the way we meet our needs? Public funding can play an instrumental role here by providing incentives and sending 'green' signals to the market. For example, the decision to shift public funds from fossil fuels towards renewable energy generation would send a clear signal not only to energy producers, but also to researchers and energy users.

In line with its Europe 2020 Strategy, the EU allocates nearly EUR 1 trillion for sustainable growth, jobs, and competitiveness in its multiannual budget for 2014–2020. At least 20% of this multiannual budget will be spent on transforming Europe into a low-carbon and climate-resilient economy. To achieve this goal, climate objectives have been included in relevant EU policies and

programmes such as structural funds, research, agriculture, maritime policy, fisheries, and the LIFE programme on nature conservation and climate action ([50]).

These funds are complemented by public expenditure at national, regional, and local levels in the EU Member States, as well as by private sector investments (e.g. businesses, pension schemes, households). There are also global funding channels, such as the Green Climate Fund set up under the UNFCCC (United Nations Framework Convention on Climate Change), aimed at helping developing countries to adapt to climate change impacts and to adopt mitigation measures.

The opportunity ahead

We know that we need to invest to meet growing demand in some areas. According to the New Climate Economy report ([51]), global energy use is projected to grow by between 20% and 35% in the next 15 years. To meet this demand, more than EUR 41 trillion will be required between 2015 and 2030 for key categories of energy infrastructure. Given that energy production and use already account for two-thirds of global greenhouse-gas emissions, the type of energy sources we invest today will largely determine whether we will succeed in limiting global warming to 2°C or not.

Some sectors and communities will undoubtedly be affected by this shift and re-channelling of funds towards sustainable alternatives. Governments will need to use social policies to support those affected by this transition. Governments and public authorities will also need to adjust to changing realities. For example, a total divestment from fossil fuels would also imply reduced tax revenues and royalties from these sectors. It would also imply downsizing in the affected sectors and likely job losses.

In some ways, change is already underway. Despite the economic crisis that affected the European economy from 2008 onwards, eco-industries (e.g. renewable energy, wastewater treatment, and recycling) in the European Union continue to grow. Between 2000 and 2012, eco-industries grew by more than 50% in terms of value added and by almost 1.4 million additional jobs to reach a workforce of 4.3 million, while the rest of the economy showed otherwise relatively flat growth and stagnant employment rates in this period. This boom in eco-industry jobs could equally be seen as part of an evolving and competitive workforce, with fewer people working in unsustainable sectors (e.g. coal extraction).

With higher awareness levels, some communities and businesses are also deliberately divesting or opting out of unsustainable solutions in favour of supporting niche innovations. Investing in environmental innovation and research would not only help the EU to adopt cleaner technologies and build a sustainable future, it would also boost the EU's economy and competitiveness. Europe can reap the benefits of being a global leader in eco-industries by exporting its technology and know-how to help meet the anticipated growth in global demand in energy, mobility, and housing.

It is true that a transition to a green economy will take time. But the earlier we act, the lower will be the costs and the greater will be the benefits.

Further reading

EEA sources

EEA report 'Europe's environment — state and outlook 2015' (SOER 2015)
The **Synthesis** report; **European briefings**: in particular 'Climate change impacts and adaptation', 'Mitigating climate change', 'Soil' and 'Agriculture'; **Global megatrends**: in particular 'Diverging population trends', 'Intensified global competition for resources', and 'Increasingly severe consequences of climate change'; **Cross-country comparisons**: in particular 'Mitigating climate change'.

- EEA report on 'National adaptation policy processes in European countries' (2014)
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- European Climate Adaptation Platform Climate-ADAPT

External sources

- European Commission Directorate-General for Climate Action
- United Nations Framework Convention on Climate Change
- Mayors Adapt, an initiative of the European Commission to encourage adaptation in cities
- ICLEI, a global cities network that promotes sustainability in cities
- World Health Organization Europe
- Food and Agriculture Organization of the United Nations

Environment & Me

The European Environment Agency invited European citizens to share their thoughts, concerns and views in a photography competition 'Environment & Me'. The EEA received more than 800 photographs, depicting a personal or a generic story, focusing on a wide range of environmental topics. A selection of the entries are used in Signals 2015, Europe's Environment — state and outlook 2015 (SOER 2015) as well as in other EEA outputs.

More information on Environment & Me is available at www.eea.europa.eu/competition.

To view the finalists, please visit our Flick'r account at www.flickr.com/photos/europeanenvironmentagency.

Endnotes

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EEA Signals 2015

The European Environment Agency (EEA) publishes Signals annually, providing a snapshot of issues of interest to the environmental debate and the wider public. Signals 2015 focuses on climate change.

Our climate is changing. Global average temperatures are increasing, sea levels are rising, precipitation patterns are changing, and extreme weather events are becoming more frequent and severe. In a series of short articles and interviews, Signals 2015 presents an overview of what causes climate change and what climate change means for human health, the environment, and the economy.

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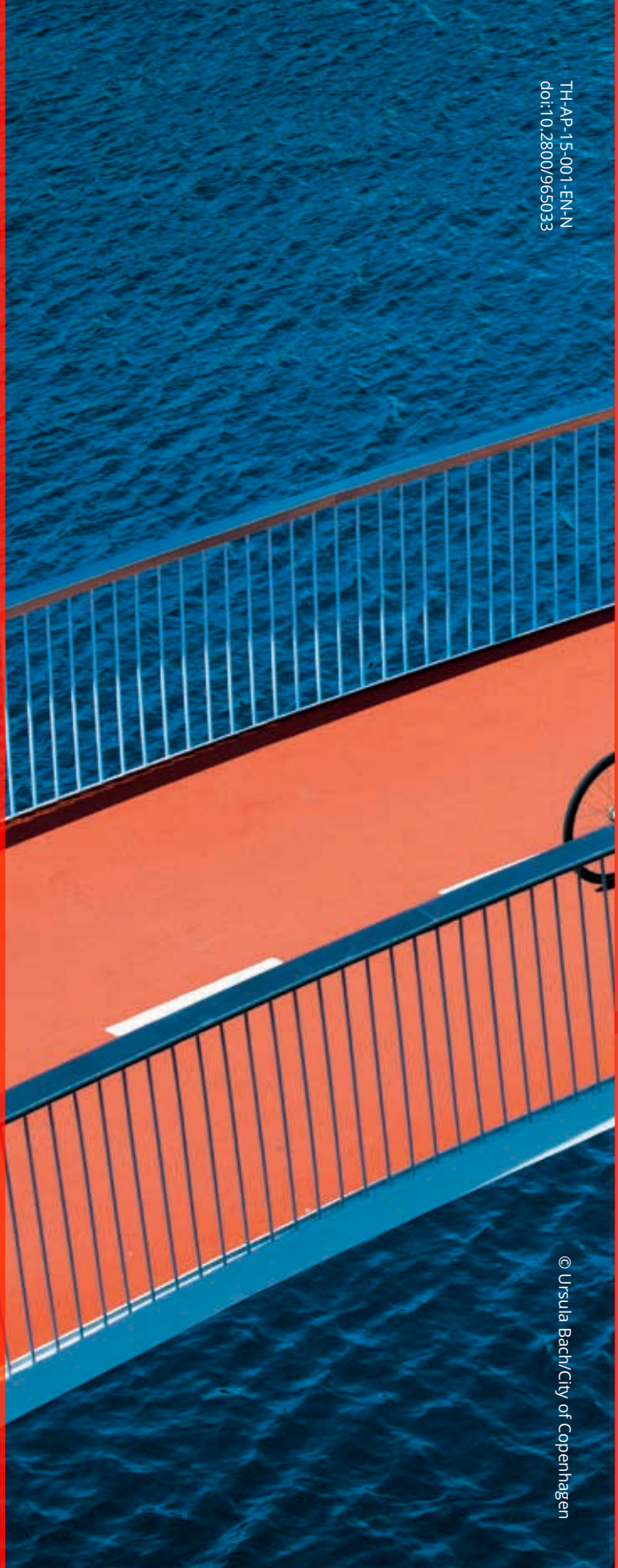

EEA Signals 2015

Living in a changing climate