THE EUROPEAN ENVIRONMENT STATE AND OUTLOOK 2015

SYNTHESIS REPORT

European Environment Agency

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Foreword

The European Union has provided global environmental leadership for some 40 years. This report synthesises the information resulting from four decades of implementation of a well-defined and ambitious EU policy agenda. It represents the tip of the knowledge available to EEA and its network, Eionet.

The overall findings point to successes in reducing environmental pressures. These achievements are especially remarkable when seen in the context of vastly changed European and global settings over the past decades. Without a strong policy agenda, the large growth of the economy over this period would have resulted in much stronger impacts on ecosystems and human health. The EU has demonstrated that well designed, binding policies work and deliver huge benefits.

In the 7th Environment Action Programme, 'Living well, within the limits of our planet', the EU formulates an engaging vision of the future to 2050: a low carbon society, a green, circular economy and resilient ecosystems, as the basis for citizens' well-being. Yet, looking ahead, this report, like its 2010 predecessor, highlights major challenges linked to unsustainable systems of production and consumption and their long-term, often complex, and cumulative impacts on ecosystems and people's health. In addition, globalisation links Europeans to the rest of the world through a number of systems that enable the two-way flow of people, finance, materials and ideas.

This has brought us many benefits alongside concerns around the environmental impacts of our linear buy-use-dispose economy, our untenable dependency on many natural resources, an ecological footprint that exceeds the planet's capacity, external environmental impacts on poorer countries, and unequal distribution of the socio-ecological benefits from economic globalisation. Achieving the EU 2050 vision remains far from self-evident. Indeed the very idea of what it means to live within planetary limits is something that we have a hard time grasping.

What is clear, however, is that transforming key systems such as the transport, energy, housing and food systems lies at the heart of long-term remedies. We will need to find ways to make them fundamentally sustainable, by decarbonising them, making them much more resource efficient and making them compatible with ecosystem resilience. Also relevant is the redesign of the systems that have steered these provisioning systems and have created unsustainable lock-ins: finance, fiscal, health, legal and education.

The EU is leading the way through policies such as the 7th Environment Action Programme, the 2030 Climate and Energy package, the Europe 2020 Strategy and the Horizon 2020 research and innovation programme. These and other policies share similar goals and in different ways seek to balance social, economic and environmental considerations. Implementing and strengthening them smartly can help to push science and technological frontiers in Europe, create jobs and enhance competitiveness, while common approaches to solving shared problems make full economic sense.

As a knowledge actor, the EEA and its partners are responding to these challenges by designing a new knowledge agenda that links supporting policy implementation to an increased understanding of how to achieve more systemic long-term objectives. This is guided by innovations that break out of silo-thinking, facilitate information sharing and integration and provide new indicators to enable policymakers to compare economic, social and environmental performance. Last but not least, foresight and other methods will be increasingly used to inform the pathways towards 2050.

The opportunities and challenges are equally huge. They require common purpose, commitments, efforts, ethics and investments from all of us. Starting in 2015, we have 35 years to ensure that the children born today will live on a sustainable planet by 2050. This may seem like a distant future, but many of the decisions we make today will decide whether and how we are going to deliver on this societal project. I hope that the content of the SOER 2015 will support everyone who is looking for evidence, understanding and motivation.

Hans Bruyninckx,
Executive Director

Executive summary

The European environment — state and outlook report 2015 (SOER 2015)

In 2015, Europe stands roughly halfway between the initiation of EU environmental policy in the early 1970s and the EU's 2050 vision of 'living well within the limits of the planet' ([1]). Underlying this vision is a recognition that Europe's economic prosperity and well-being is intrinsically linked to its natural environment — from fertile soils to clean air and water.

Looking back on the last 40 years, implementation of environment and climate policies has delivered substantial benefits for the functioning of Europe's ecosystems and for the health and living standards of its citizens. In many parts of Europe, the local environment is arguably in as good a state today as it has been since the start of industrialisation. Reduced pollution, nature protection and better waste management have all contributed.

Environmental policies are also creating economic opportunities and thereby contributing to the Europe 2020 Strategy, aimed at making the EU into a smart, sustainable and inclusive economy by 2020. For example, the environment industry sector, which produces goods and services that reduce environmental degradation and maintain natural resources, grew by more than 50% in size between 2000 and 2011. It has been one of the few economic sectors to have flourished in terms of revenues, trade and jobs since the 2008 financial crisis.

Despite the environmental improvements of recent decades, the challenges that Europe faces today are considerable. European natural capital is being degraded by socio-economic activities such as agriculture, fisheries, transport, industry, tourism and urban sprawl. And global pressures on the

([1]) The 2050 vision is set out in the EU's 7th Environment Action Programme (EU, 2013).

environment have grown at an unprecedented rate since the 1990s, driven not least by economic and population growth, and changing consumption patterns.

At the same time, growing understanding of the characteristics of Europe's environmental challenges and their interdependence with economic and social systems in a globalised world has brought with it increasing recognition that existing knowledge and governance approaches are inadequate to deal with them.

It is against this backdrop that the SOER 2015 has been written. Based on data and information from numerous published sources, this synthesis report evaluates the European environment's state, trends and prospects in a global context, and analyses opportunities to recalibrate policies and knowledge in line with the 2050 vision.

Europe's environment today

Achieving the 2050 vision focuses actions in three key areas:

- protecting the natural capital that supports economic prosperity and human well-being;
- stimulating resource-efficient, low-carbon economic and social development;
- safeguarding people from environmental health risks.

The analysis summarised in Table ES.1 indicates that while environmental policy has delivered many improvements, substantial challenges remain in each of these areas.

Europe's **natural capital** is not yet being protected, conserved and enhanced in line with the ambitions of the 7th Environment Action Programme. Reduced pollution has significantly improved the quality

Table ES.1 An indicative summary of environmental trends

	5–10 year trends	20+ years outlook	Progress to policy targets	Read more in Section ...
Protecting, conserving and enhancing natural capital				
Terrestrial and freshwater biodiversity			☐	3.3
Land use and soil functions			No target	3.4
Ecological status of freshwater bodies			☒	3.5
Water quality and nutrient loading			☐	3.6
Air pollution and its ecosystem impacts			☐	3.7
Marine and coastal biodiversity			☒	3.8
Climate change impacts on ecosystems			No target	3.9
Resource efficiency and the low-carbon economy				
Material resource efficiency and material use			No target	4.3
Waste management			☐	4.4
Greenhouse gas emissions and climate change mitigation			☑/☒	4.5
Energy consumption and fossil fuel use			☑	4.6
Transport demand and related environmental impacts			☐	4.7
Industrial pollution to air, soil and water			☐	4.8
Water use and water quantity stress			☒	4.9
Safeguarding from environmental risks to health				
Water pollution and related environmental health risks			☑/☐	5.4
Air pollution and related environmental health risks			☐	5.5
Noise pollution (especially in urban areas)		N.A.	☐	5.6
Urban systems and grey infrastructure			No target	5.7
Climate change and related environmental health risks			No target	5.8
Chemicals and related environmental health risks			☐/☒	5.9

Indicative assessment of trends and outlook		Indicative assessment of progress to policy targets	
	Deteriorating trends dominate	☒	Largely not on track to achieving key policy targets
	Trends show mixed picture	☐	Partially on track to achieving key policy targets
	Improving trends dominate	☑	Largely on track to achieving key policy targets

Note: The indicative assessments presented here are based on key indicators (as available and used in SOER thematic briefings), as well as expert judgement. The corresponding 'Trends and outlook' boxes in the respective sections provide additional explanations.

of Europe's air and water. But loss of soil functions, land degradation and climate change remain major concerns, threatening the flows of environmental goods and services that underpin Europe's economic output and well-being.

A high proportion of protected species (60%) and habitat types (77%) are considered to be in unfavourable conservation status, and Europe is not on track to meet its overall target of halting biodiversity loss by 2020, even though some more specific targets are being met. Looking ahead, climate change impacts are projected to intensify and the underlying drivers of biodiversity loss are expected to persist.

Turning to **resource efficiency** and the low-carbon society, the short-term trends are more encouraging. European greenhouse gas emissions have decreased by 19% since 1990 despite a 45% increase in economic output. Other environmental pressures have also decoupled in absolute terms from economic growth. Fossil fuel use has declined, as have emissions of some pollutants from transport and industry. More recently, the EU's total resource use has declined by 19% since 2007, less waste is being generated and recycling rates have improved in nearly every country.

While policies are working, the 2008 financial crisis and subsequent economic recessions also contributed to the reduction of some pressures, and it remains to be seen whether all improvements will be sustained. Moreover, the level of ambition of existing environmental policy may be inadequate to achieve Europe's long-term environmental goals. For example, projected greenhouse gas emissions reductions are currently insufficient to bring the EU onto a pathway towards its 2050 target of reducing emissions by 80–95%.

Regarding **environmental risks to health**, there have been marked improvements in the quality of drinking water and bathing water in recent decades and some hazardous pollutants have been reduced. However, despite some improvements in air quality, air and noise pollution continue to cause serious health impacts, particularly in urban areas. In 2011, about 430 000 premature deaths in the EU were attributed to fine particulate matter ($PM_{2.5}$). Exposure to environmental noise is estimated to contribute to at least 10 000 premature deaths due to coronary heart disease and strokes each year. And growing use of chemicals, particularly in consumer products, has been associated with an observed increase of endocrine diseases and disorders in humans.

The outlook for environmental health risks in coming decades is uncertain but raises concern in some areas. Projected improvements in air quality, for example, are not expected to be sufficient to prevent continuing harm to health and the environment, while health impacts resulting from climate change are expected to worsen.

Understanding systemic challenges

Looking across these three priority areas of the 7th Environment Action Programme, Europe has made progress in reducing some key environmental pressures, but often these improvements have not yet translated into improved ecosystem resilience or reduced risks to health and well-being. Furthermore, the long-term outlook is often less positive than recent trends might suggest.

A variety of factors contribute to these disparities. The dynamics of environmental systems can mean that there is a substantial **time lag** before declining pressures translate into improvements in the state of the environment. In addition, many **pressures remain considerable** in absolute terms despite recent reductions. For example, fossil fuels still account for three-quarters of the EU energy supply, imposing a heavy burden on ecosystems through climate change, acidification and eutrophication impacts.

Feedbacks, interdependencies and lock-ins in environmental and socio-economic systems also undermine efforts to mitigate environmental pressures and related impacts. For example, improved efficiency in production processes can lower the costs of goods and services, incentivising increased consumption (the 'rebound effect'). Changing exposure patterns and human vulnerabilities, for example linked to urbanisation, can offset reductions in pressures. And the unsustainable systems of production and consumption that are responsible for many environmental pressures also provide diverse benefits, including jobs and earnings. This can create strong incentives for sectors or communities to resist change.

Perhaps the most difficult challenges for European environmental governance arise from the fact that **environmental drivers, trends and impacts are increasingly globalised**. A variety of long-term megatrends today affect Europe's environment, consumption patterns and living standards. For example, the escalating resource use and emissions that have accompanied global economic growth in recent decades have offset the benefits of Europe's success in cutting greenhouse gas emissions and pollution, as well as creating new risks. Globalisation of supply chains also means that many impacts of Europe's production and consumption occur in other parts of the world, where European businesses, consumers and policymakers have relatively limited knowledge, incentives and scope to influence them.

Recalibrating policy and knowledge for transition to a green economy

The EEA's report *The European environment — state and outlook 2010* (SOER 2010) drew attention to the urgent need for Europe to shift towards a much more integrated approach to addressing persistent, systemic environmental challenges. It identified the transition towards a green economy as one of the changes needed to secure the long-term sustainability of Europe and its neighbourhood. The analysis summarised in Table ES.1, provides limited evidence of progress in effecting this fundamental shift.

Taken together, the analysis suggests that neither environmental policies alone nor economic and technology-driven efficiency gains are likely to be sufficient to achieve the 2050 vision. Instead, living well within ecological limits will require fundamental transitions in the systems of production and consumption that are the root cause of environmental and climate pressures. Such transitions will, by their character, entail profound changes in dominant institutions, practices, technologies, policies, lifestyles and thinking.

Recalibrating existing policy approaches can make an essential contribution to such transitions. In the environment and climate policy domain, four established and complementary approaches could enhance progress to long-term transitions if considered together and implemented coherently. These are: **mitigating** known ecosystem and human health impacts while creating socio-economic opportunities through resource-efficient technological innovations; **adapting** to expected climate and other environmental changes by increasing resilience, for example in cities; **avoiding** potentially serious environmental harm to people's health and well-being and ecosystems by taking precautionary and preventive action, based on early warnings from science; and **restoring** resilience in ecosystems and society by enhancing natural resources, contributing to economic development and addressing social inequities.

Europe's success in moving towards a green economy will depend in part on striking the right balance between these four approaches. Policy packages that include objectives and targets explicitly recognising the relationships between resource efficiency, ecosystem resilience and human well-being would accelerate the reconfiguration of Europe's systems of production and consumption. Governance approaches that engage citizens, non-governmental organisations, businesses and cities would offer additional levers in this context.

A variety of other opportunities are available for steering the needed transitions in unsustainable systems of production and consumption:

- **Implementation, integration and coherence of environment and climate policy**. The foundation for short- and long-term improvements in Europe's environment, people's health and economic prosperity rests on full implementation of policies, and better integration of the environment into the sectoral policies that contribute most to environmental pressures and impacts. Such areas include energy, agriculture, transport, industry, tourism, fisheries and regional development.

- **Investing for the future**. The production-consumption systems that meet basic social needs such as food, energy, housing and mobility rely on costly and long-lasting infrastructure, meaning that investment choices can have long-term implications. This makes it essential to avoid investments that lock society into existing technologies, and thereby limit innovation options or hinder investments in substitutes.

- **Supporting and upscaling niche innovations**. The pace of innovation and diffusion of ideas plays a central role in driving systemic transitions. In addition to new technologies, innovation can take diverse forms, including financial tools such as green bonds and payments for ecosystem services; integrated resource management approaches; and social innovations such as 'prosumerism', which merge the role of consumers and producers in developing and providing, for example, energy, food and mobility services.

- **Improving the knowledge base**. There is a gap between available, established monitoring, data and indicators and the knowledge required to support transitions. Addressing this gap requires investment in better understanding of systems science, forward-looking information, systemic risks and the relationships between environmental change and human well-being.

The common timeframe that applies to the EU's 7th Environment Action Programme, the EU's Multiannual Financial Framework 2014–2020, the Europe 2020 Strategy and the Framework Programme for Research and Innovation (Horizon 2020) offers a unique opportunity to harness synergies across policy, investment and research activities in support of the transition to a green economy.

The financial crisis has not reduced the focus of European citizens on environmental issues. Indeed, European citizens strongly believe that more needs to be done at all levels to protect the environment, and that national progress should be measured using environmental, social and economic criteria.

In its 7th Environment Action Programme, the EU envisions that young children today will live around half their lives in a low-carbon society, based on a circular economy and resilient ecosystems. Achieving this commitment can put Europe at the frontier of science and technology but calls for a greater sense of urgency and more courageous actions. This report offers a knowledge-based contribution towards meeting those visions and goals.

The changing context of European environmental policy

> 'In 2050, we live well, within the planet's ecological limits. Our prosperity and healthy environment stem from an innovative, circular economy where nothing is wasted and where natural resources are managed sustainably, and biodiversity is protected, valued and restored in ways that enhance our society's resilience. Our low-carbon growth has long been decoupled from resource use, setting the pace for a safe and sustainable global society.'
>
> **Source:** 7th Environment Action Programme (EU, 2013).

1.1 European environmental policy is aimed at living well, within the limits of the planet

The above vision is at the heart of European environmental policy in the 7th Environment Action Programme which was adopted by the European Union (EU) in 2013 (EU, 2013). But the inherent ambition is by no means limited to this programme, and a host of recent policy documents have complementary or similar ambitions at their core ([2]).

This vision is no longer, if indeed it ever was, just an environmental one. It is inseparable from its broader economic and societal context. Unsustainable use of natural resources not only undermines the resilience of ecosystems, it also has both direct and indirect implications for health and living standards. Current consumption and production patterns enhance our quality of life — and paradoxically put it at risk at the same time.

Environmental pressures associated with these patterns have a real and growing impact on our economy and our well-being. For example, it has been estimated that the costs of damage to health and environment caused by air pollutants from European industrial facilities exceed EUR 100 billion

([2]) See, for example, the European Union's Roadmap to a Resource Efficient Europe (2011), Energy Roadmap 2050 (2011), A Roadmap for moving to a competitive low-carbon economy in 2050 (2011), Roadmap to a single European transport area (documented as a White Paper in 2011), Biodiversity Strategy (2012), and several other European or national-level documents.

annually (EEA, 2014t). These costs are not only economic; they also take the form of reduced life expectancy for European citizens.

Beyond this, there are indications that our economies are approaching the ecological limits within which they are embedded, and that we are already experiencing some of the effects of physical and environmental resource constraints. The increasingly severe consequences of extreme weather events and climate change illustrate this, as do water scarcity and droughts, habitat destruction, biodiversity loss, and degradation of land and soil.

Looking ahead, demographic and economic baseline projections point towards continuing population growth and an unprecedented increase in the number of middle-class consumers worldwide. Today, less than 2 billion of the global population of 7 billion are regarded as middle class consumers. By 2050, the number of people on the planet is expected to reach 9 billion, with more than 5 billion belonging to the middle class (Kharas, 2010). This growth will likely be accompanied by an intensification of global competition for resources and by growing demands on ecosystems.

These developments raise the question of whether the planet's ecological limits can sustain the economic growth upon which our consumption and production patterns rely. Already, growing competition raises concerns about access to key resources, and prices of major resource categories have been very volatile in recent years, reversing long-term downward trends.

These trends highlight the importance of the link between economic sustainability and the state of the environment. We must ensure that the environment can be used to meet material needs and at the same provide a healthy living space. It is clear that tomorrow's economic performance will depend on making environmental concerns a fundamental part of our economic and social policies ([3]), rather than merely regarding nature protection as an 'add-on'.

Furthering such integration between environmental, economic and social policies is at the core of the Treaty on European Union, which aims to 'work for the sustainable development of Europe based on balanced economic

([3]) Expressed, for example, in a speech on 'New environmentalism' by the former European Commissioner Janez Potočnik on 20 June 2013 (EC, 2013e).

growth and price stability, a highly competitive social market economy, aiming at full employment and social progress, and a high level of protection and improvement of the quality of the environment' (Article 3, Treaty on European Union).

This report *The European environment — state and outlook 2015* sets out to inform progress towards this integration. It provides a comprehensive overview of the state of, trends in, and prospects for the environment in Europe at what might be described as a halfway point: we can now look back at some 40 years of EU environmental policy, while 2050 (the year by which we aspire to live well, within the limits of the planet) is a little less than 40 years away.

1.2 Over the past 40 years, environmental policies in Europe have had notable success

Since the 1970s, a broad range of environment legislation has been put in place. This now amounts to the most comprehensive modern set of standards in the world. The body of EU environmental law — also known as the *environmental acquis* — amounts to some 500 directives, regulations and decisions.

Over the same period, the level of environmental protection in most parts of Europe has improved measurably. Emissions of specific pollutants to the air, water and soil have generally been reduced significantly. These improvements are to a substantial degree a result of the comprehensive environment legislation established across Europe, and they are delivering a range of direct environmental, economic and societal benefits, as well as more indirect ones.

Environmental policies have contributed to some progress towards a sustainable green economy — i.e. an economy, in which policies and innovations enable society to use resources efficiently, thereby enhancing human well-being in an inclusive manner, while maintaining the natural systems that sustain us. The EU's policies have stimulated innovation and investments in environmental goods and services, generating jobs and export opportunities (EU, 2013). In addition, integration of environmental goals into sectoral policies — such as those governing agriculture, transport or energy — has provided financial incentives for environmental protection.

European Union air policies and legislation have delivered real benefits both for human health and the environment. At the same time, they have offered economic opportunities, for example, for the clean technology sector. Estimates presented in the European Commission's proposal for a Clean Air Policy Package show that major engineering companies in the EU already earn up to 40% of their revenues from their environment portfolios, and this is set to increase (EC, 2013a).

This overall progress in environmental quality has been documented by the four previous reports on *The European environment — state and outlook* (SOER) published in 1995, 1999, 2005 and 2010, respectively. All of these reports have concluded that, by and large, 'environmental policy has delivered substantial improvements [...] however, major environmental challenges remain'.

For large parts of Europe and across many areas of the environment, the immediate situation has improved. For many of us, our local environment is today arguably in as good a state as it has been since the industrialisation of our societies. However, in several cases, local environmental trends continue to be a cause for concern, often due to insufficient implementation of agreed policies.

At the same time, the depletion of natural capital continues to jeopardise good ecological status and ecosystem resilience (understood here as the ability of the environment to adapt to or tolerate disturbance without collapsing into a qualitatively different state). Biodiversity loss, climate change, or chemical burdens create additional risks and uncertainty. In other words, reductions in certain environmental pressures have not necessarily resulted in a positive outlook for the environment more broadly.

Recent assessments of the main trends and progress over the past 10 years repeatedly confirm these mixed trends (EEA, 2012b). Chapters 3, 4, and 5 of this report provide updated thematic assessments of these and similar environmental challenges — and again confirm this overall picture.

1.3 Our understanding of the systemic nature of many environmental challenges has evolved

In recent years, environment and climate policies have evolved in response to a deepening understanding of environmental concerns. This understanding, as captured in both this report and previous ones in *The European environment — state and outlook* (SOER) series, recognises that the environmental challenges we face today do not much differ from those of a decade ago.

Recently adopted environmental policy initiatives continue to address climate change, loss of biodiversity, unsustainable use of natural resources, and environmental pressures on health. Although these issues remain important, there is an enhanced appreciation of the links between them, as well as their interplay with a wide range of societal trends. These interlinkages make it more complex both to define problems and to respond to them (Table 1.1).

Table 1.1 Evolution of environmental challenges

Characterisation of the type of challenge	Specific	Diffuse	Systemic
Key features	Linear cause-effect; large (point) sources; often local	Cumulative causes; multiple sources; often regional	Systemic causes; interlinked sources; often global
In the spotlight in	1970s/1980s (and continuing today)	1980s/1990s (and continuing today)	1990s/2000s (and continuing today)
Includes issues such as	Forest damage due to acid rain; urban wastewater	Transport emissions; eutrophication	Climate change; biodiversity loss
Dominant policy response	Targeted policies and single-issue instruments	Policy integration and raising public awareness	Coherent policy packages and other systemic approaches

Source: EEA, 2010d.

Generally speaking, specific environmental issues, often with local effects, have in the past been dealt with through targeted policies and single-issue instruments. This has been the case for issues such as waste disposal and species protection. However, since the 1990s, the recognition of diffuse pressures from various sources has led to an increased focus on the integration of environmental concerns within sectoral policies, such as in transport or agriculture, with mixed results.

As noted above — and illustrated throughout this report — such policies have contributed to reducing some of the pressures on the environment. However, they have arguably been less successful in halting biodiversity loss due to habitat destruction and overexploitation; in eliminating risks to human health resulting from the combination of chemicals introduced into our environment; or in halting climate change. In other words, we struggle with addressing long-term, systemic environmental challenges.

Several factors and complex interactions underlie this contrasting performance. In the case of environmental problems with relatively specific cause-effect relationships, more straightforward policy design can reduce environmental pressures and the immediate harm they cause. For more complex environmental problems, multiple causes can contribute to environmental degradation, making policy responses more difficult to formulate. Modern environmental policy needs to address both types of problem.

To some degree this evolving understanding of environmental challenges is already reflected in the emerging approach to develop coherent 'policy packages' that build on a three-tier response:

(1) setting general quality standards related to the state of environment that guide the overall development of coherent policy approaches internationally;

(2) setting corresponding overall targets related to environmental pressures (often including a breakdown either by country or economic sector, or both);

(3) formulating specific policies that address pressure points, drivers, sectors, or standards.

EU climate change policies illustrate this approach: the overall policy ambitions are largely guided by the internationally agreed goal of keeping global warming to below 2 °C compared to pre-industrial levels. Within the European Union this translates into overall greenhouse gas emission reduction targets (e.g. cutting emissions at EU level by 20% by 2020, and by 40% by 2030, relative to 1990 levels). This in turn links to a series of more specific policies, including directives on emissions trading, renewable energy, energy efficiency, and others.

The Thematic Strategy on air pollution guides current EU air quality policy. Here, EU legislation follows a twin-track approach of implementing both local air quality standards and source-based mitigation controls. These source-based mitigation controls include binding national limits for emissions of the most important pollutants. In addition, there is source-specific legislation addressing industrial emissions, vehicle emissions, fuel quality standards, and other sources of air pollution.

A third example is the recent Circular Economy Package proposed by the European Commission (EC, 2014d). The package breaks down the overarching aim of achieving a zero-waste society into a set of more specific interim targets. Achieving these targets will require their full consideration and integration within more specific policies (which are often sector specific).

1.4 Environmental policy ambitions address the short, medium and long term

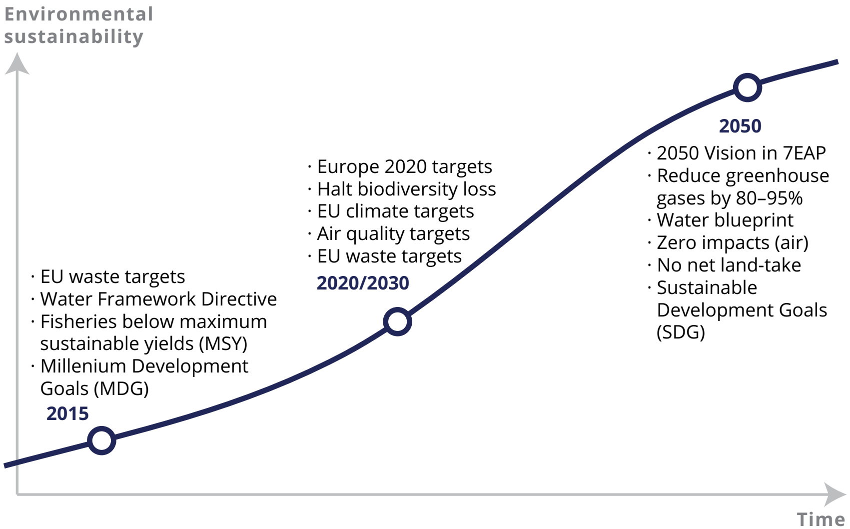
Restoring ecosystem resilience and improving human well-being often take substantially longer than achieving reductions in environmental pressures or achieving gains in resource efficiency. While the latter is often a matter of two decades or less, the former usually require several decades of sustained effort (EEA, 2012b). These different time scales pose a challenge for policymaking.

Nevertheless, the different time-scales can be integrated into a successful comprehensive strategy, as achieving long-term visions depends on reaching short-term targets. Consequently, the European Union and many

European countries are increasingly formulating environmental and climate policies that address these different time-scales (Figure 1.1). These include:

- specific environmental policies, with their own timelines and deadlines for implementation, reporting and revision, often including more short-term targets;
- thematic environmental and sectoral policies, formulated in the perspective of more comprehensive policies, including specific medium-term 2020 or 2030 targets;
- longer-term visions and targets, mostly with a 2050 societal transition perspective.

Figure 1.1 Long-term transition/intermediate targets related to environmental policy



2015	Thematic policies, timelines and deadlines
2020/2030	Comprehensive policies (Europe 2020, 7th Environment Action Programme), or specific target
2050	Long-term visions and targets with a societal transition perspective

Source: EEA, 2014m.

Within this setting, the 7th Environment Action Programme plays a particular role and offers a coherent framework for environmental policies, uniting the short, medium and long terms. These policies are broadly based on the principle of preventive action; the principle of rectification of pollution at source; the polluter-pays principle; and the precautionary principle. As mentioned above, the programme further specifies an ambitious vision for 2050, and sets out nine priority objectives to move towards this vision (Box 1.1).

Box 1.1 The European Union's 7th Environment Action Programme

Three interrelated thematic objectives should be pursued in parallel, as action taken under one objective will often help to contribute to the achievement of the others:

1. to protect, conserve and enhance the Union's natural capital,
2. to turn the Union into a resource-efficient, green and competitive low-carbon economy,
3. to safeguard the Union's citizens from environment-related pressures and risks to health and well-being.

Achieving the above mentioned thematic objectives requires an enabling framework that supports effective action — they are thus complemented by four related priority objectives:

4. to maximise the benefits of Union environment legislation by improving implementation,
5. to improve the knowledge and evidence base for Union environment policy,
6. to secure investment for environment and climate policy and address environmental externalities,
7. to improve environmental integration and policy coherence.

Two additional priority objectives focus on meeting local, regional and global challenges:

8. to enhance the sustainability of the Union's cities
9. to increase the Union's effectiveness in addressing international environmental and climate-related challenges.

Source: 7th Environment Action Programme (EU, 2013).

The EU's Europe 2020 Strategy is an example of a medium-term strategy. It addresses the interdependence between environmental, economic and social policy. It sets the combined goal of becoming a smart, sustainable and inclusive economy. One of the five explicit headline targets to be achieved by the end of the decade focuses on climate change and energy sustainability (Box 1.2).

The Roadmap to a Resource Efficient Europe is a sub-initiative of the Europe 2020 Strategy. It explicitly addresses our use of resources and proposes ways to decouple economic growth from resource use and its environmental impact. However, its focus to date is on boosting resource productivity, not on achieving an absolute decoupling of resource use or ensuring ecological resilience.

Box 1.2 Five headline targets of the Europe 2020 Strategy

Europe 2020 is the European Union's current growth strategy. It stresses the triple goal of becoming a smart, sustainable and inclusive economy — including five more specific headline targets for the whole EU.

1. Employment: 75% of 20–64 year-olds to be employed.
2. Research and development (R&D): 3% of the EU's GDP to be invested in R&D.
3. Climate change and energy sustainability: greenhouse gas emissions 20% lower than 1990 (or 30%, if the conditions are right); 20% of energy from renewables; 20% increase in energy efficiency.
4. Education: reducing the rates of early school leaving below 10%, and at least 40% of 30–34 year-olds completing third level education.
5. Fighting poverty and social exclusion: at least 20 million fewer people in — or at risk of — poverty and social exclusion.

Source: Europe 2020 website at http://ec.europa.eu/europe2020/index_en.htm.

1.5 SOER 2015 provides an assessment of the state and outlook for the environment in Europe

This report sets out to provide policymakers and the public with a comprehensive assessment of our progress towards achieving environmental sustainability in general, and specific policy targets in particular. This assessment is based on objective, reliable and comparable environmental information, and draws upon the evidence and knowledge base available to the European Environment Agency (EEA) and the European Environment Information and Observation Network (Eionet).

With this in mind, this report informs European environmental policy in general and its implementation in the period to 2020 in particular. It includes both a reflection on the European environment in a global context, as well as dedicated chapters summarising the state of, trends in, and prospects for the state of the environment in Europe.

The analysis presented here draws on — and is complemented by — a series of briefings on key issues. This includes 11 briefings on global 'megatrends' and their relevance for the European environment, 25 European-level thematic briefings focusing on specific environmental themes, and 9 briefings that offer a comparison of progress across European countries based on common indicators. Thirty-nine country briefings summarise the state of the environment in those European countries, and three regional briefings provide a similar overview for the Arctic region, the Mediterranean Sea and the Black Sea — regions where Europe shares the responsibility to safeguard vulnerable ecosystems with its neighbours (Figure 1.2).

The chapters of this synthesis report focus on three particular dimensions.

The focus of Part 1 of this report (i.e. Chapters 1 and 2) is to further improve our understanding of the unprecedented changes, interconnected risks, global 'megatrends' and ecological limits that both directly and indirectly affect the European environment. There are many links between environment and climate challenges and their underlying driving forces, making them more complex to understand.

Figure 1.2 Structure of SOER 2015

SOER**2015**

Global megatrends	European briefings	Cross-country comparisons	Countries and regions
A set of 11 briefings, which address: • Diverging global population trends • Towards a more urban world • Changing disease burdens and risks of pandemics • Accelerating technological change • Continued economic growth? • An increasingly multipolar world • Intensified global competition for resources • Growing pressures on ecosystems • Increasingly severe consequences of climate change • Increasing environmental pollution • Diversifying approaches to governance. In addition there will be a global megatrends report.	A set of 25 briefings, which address: • Agriculture • Air pollution • Biodiversity • Climate change impacts and adaptation • Consumption • Energy • Forests • Freshwater quality • Green economy • Health and environment • Hydrological systems and sustainable water management • Industry • Land systems • Marine environment • Maritime activities • Mitigating climate change • Natural capital and ecosystem services • Noise • Resource efficiency • Soil • The air and climate system • Tourism • Transport • Urban systems • Waste.	A set of 9 briefings, which address: • Agriculture — organic farming • Air pollution — emissions of selected pollutants • Biodiversity — protected areas • Energy — energy consumption and share of renewable energy • Freshwater quality — nutrients in rivers • Mitigating climate change — greenhouse gas emissions • Resource efficiency — material resource efficiency and productivity • Transport — passenger transport demand and modal split • Waste — municipal solid waste generation and management. These comparisons are based on environmental indicators common for most European countries.	A set of 39 briefings, which summarise reports on the state and outlook of the environment in each of 39 European countries: • 33 EEA member countries • 6 cooperating countries in the Western Balkans. In addition, 3 briefings give an overview of the main environmental challenges in selected regions that extend beyond Europe: • Arctic region • Black Sea region • Mediterranean Sea region.

All of the above is available at: **www.eea.europa.eu/soer**.

The focus of Part 2 (i.e. Chapters 3, 4 and 5) is to inform the implementation and improvement of existing policy approaches, in particular those embodied in the three thematic objectives outlined in the 7th Environment Action Programme: (1) to protect, conserve and enhance Europe's natural capital; (2) to turn Europe into a resource-efficient, green and competitive low-carbon economy; and (3) to safeguard Europe's citizens from environment related pressures and risks to health and well-being.

Spread across these three chapters in Part 2 are summary assessments of the trends and outlook for 20 environmental issues. Based on expert judgement, and informed by key environmental indicators, these assessments highlight selected trends as observed over the past 5–10 years, and offer an outlook for 20 years or more based on existing policies and measures. Furthermore, the chapters indicate the general progress towards policy goals for the respective issues (see Table 1.2 for the related assessment criteria used).

Part 3 (i.e. Chapters 6 and 7) reflects on the emerging overall picture of the state and outlook of the European environment. Based on this better understanding of where we stand today, these chapters aims to signal opportunities for recalibrating environmental policy to facilitate transition towards a more sustainable society.

Table 1.2 Legend used in the 'trends and outlook' summary assessment in each section

Indicative assessment of trends and outlook		Indicative assessment of progress to policy targets	
	Deteriorating trends dominate	☒	Largely not on track to achieving key policy targets
	Trends show mixed picture	☐	Partially on track to achieving key policy targets
	Improving trends dominate	☑	Largely on track to achieving key policy targets

The European environment in a wider perspective

2.1 Many of today's environmental challenges have a systemic character

European environmental policy measures have proven to be particularly effective when it comes to tackling local, regional and continental environmental pressures. However, some of the environmental and climate challenges we are facing today differ from those we have successfully addressed over the past 40 years: they are both systemic and cumulative in their nature and depend not only on our actions in Europe, but also on their global context.

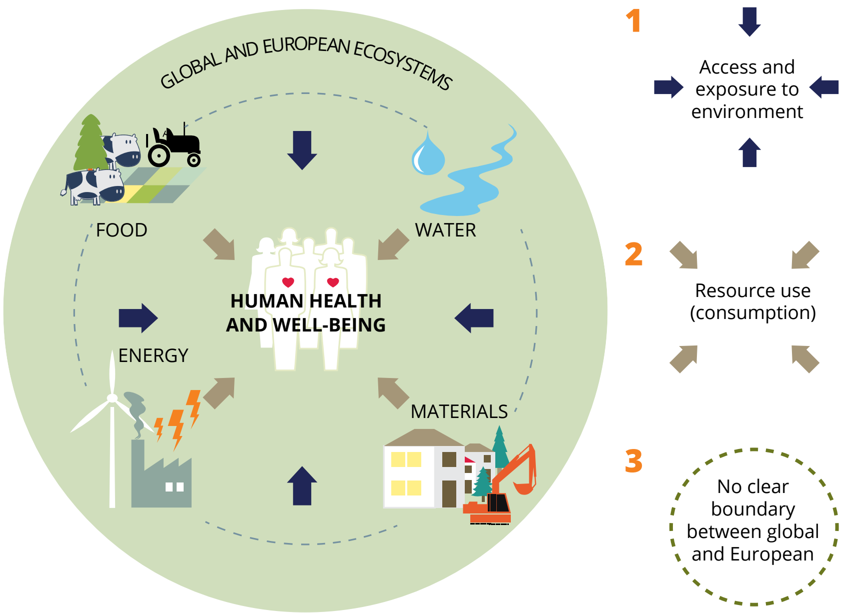
Many of today's environmental challenges are characterised by their complexity (i.e. they have multiple causes and feature many interdependencies between their underlying drivers and associated impacts). They are difficult to delineate or define clearly as they pervade different parts of the environment and society in various ways. Thus, they are often perceived differently by different groups in society and at different geographical scales.

Three systemic characteristics that are common to many of today's environmental challenges are of particular importance here (Figure 2.1).

First, they directly and indirectly **affect exposure to environmental factors** that affect human health and well-being, as well as our prosperity and standard of living. Such factors include harmful substances in our environment; severe weather events such as floods and droughts; and (in extreme cases) the potential for entire ecosystems to become uninhabitable. All of these factors may limit our future access to basic environmental goods, such as clean air, clean water and fertile soils.

Second, they are intrinsically **linked to our consumption and resource use patterns**. Major resource use categories can be distinguished in this regard: food, water, energy and materials (the latter of which also include construction materials, metals and minerals, fibre, wood, chemicals and

Figure 2.1 **Three systemic characteristics of environmental challenges**



Source: EEA.

plastics), as well as land. Using these resources is essential for human well-being. At the same time, extracting and using resources — especially when unchecked — adversely alters the ecosystems that provide them.

The resources within these categories are also heavily interlinked. For example, substituting fossil fuel use with bioenergy crops may help address energy concerns, but it has been linked to deforestation and land conversions at the expense of natural areas (UNEP, 2012a). This has implications for the area available for food crops. Because global food markets are linked, it also has implications for food prices. As a result, environmental degradation has severe implications for the current and long-term security of access to key resources.

Third, their evolution **depends on European trends and global megatrends**, including those related to demographics, economic growth, trade patterns, technological progress, and international cooperation. These long-term patterns of change that unfold at a global scale over decades are increasingly difficult to disentangle (Box 2.1). This interconnected global context makes it more difficult for countries to resolve environmental problems unilaterally. Even large groups of countries acting together (such as the EU) cannot resolve these problems on their own.

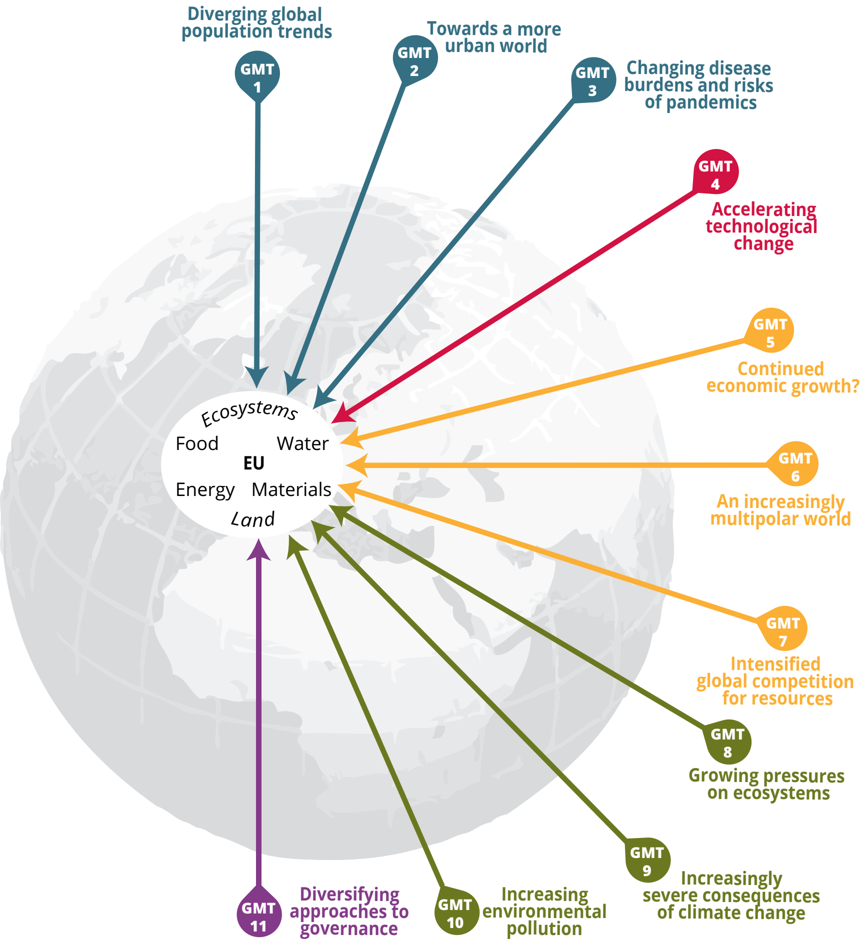
The case of climate change illustrates this well: emissions contribute to global atmospheric concentrations, producing impacts far from the source — and potentially far into the future. Similarly, although emissions of ozone precursor gases in Europe have decreased significantly in recent decades, measured ground-level ozone concentrations have reduced only marginally or have even increased due to long-range transport of pollutants from outside Europe (EEA, 2014r).

2.2 Global megatrends affect the prospects for the European environment

Globalisation and the unfolding of global trends imply that environmental conditions and policies in Europe cannot be fully understood — or properly managed — in isolation from global dynamics. Global megatrends will alter future European consumption patterns and influence the European environment and climate. By anticipating these developments Europe can harvest the opportunities they create to reach environmental targets and move towards the objectives stated in the 7th Environment Action Programme.

Such megatrends relate to demographics, economic growth, patterns of production and trade, technological progress, the degradation of ecosystems, and climate change (Figure 2.2 and Box 2.1).

Figure 2.2 Global megatrends analysed in SOER 2015



Source: EEA.

Box 2.1 A selection of global megatrends, as analysed in SOER 2010 and SOER 2015

Diverging global population trends: The world population has doubled to 7 billion since the 1960s and is projected to continue growing, although in advanced economies populations are ageing and in some cases reducing in size. Conversely, populations in the least developed countries are expanding rapidly.

Towards a more urban world: Today, about half of the global population lives in urban areas, and this share is projected to increase to two thirds by 2050. With adequate investment this continued urbanisation can boost innovative solutions to environmental problems, but may also increase resource use and pollution.

Changing disease burdens and risks of pandemics: The risk of exposure to new, emerging and re-emerging diseases, and new pandemics is linked to poverty and grows with climate change and the increasing mobility of people and goods.

Accelerating technological change: New technologies are radically transforming the world, particularly in the fields of nano-, bio-, information and communication technologies. This provides opportunities to reduce humanity's environmental impacts and increase resource security but also brings risks and uncertainties.

Continued economic growth?: While the continuing impact of the recent economic recession still dampens economic optimism in Europe, most outlook studies foresee continued economic expansion globally in the coming decades — with accelerating consumption and resource use, particularly in Asia and Latin America.

An increasingly multipolar world: In the past, a relatively small number of countries have dominated global production and consumption. Today, a significant rebalancing of economic power is under way, as Asian countries in particular are coming to the fore, with impacts on global interdependence and trade.

Intensified global competition for resources: As they grow, economies tend to use more resources, both renewable biological resources and non-renewable stocks of minerals, metals and fossil fuels. Industrial developments and changing consumption patterns all contribute to this increase in demand.

Growing pressures on ecosystems: Driven by global population growth and associated food and energy needs, as well as by evolving consumption patterns, the loss of global biodiversity and the degradation of natural ecosystems is set to continue — affecting most severely poor people in developing countries.

Increasingly severe consequences of climate change: Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. As climate change unfolds, severe impacts are anticipated for both ecosystems and human societies (including food security, drought frequency and extreme weather).

Increasing environmental pollution: Across the world, ecosystems are today exposed to critical levels of pollution in increasingly complex mixtures. Human activities, global population growth and changing consumption patterns are the key drivers behind this growing environmental burden.

Diversifying approaches to governance: A mismatch between the increasingly long-term global challenges facing society and the more limited powers of governments is creating demand for additional governance approaches, with a greater role for business and civil society. These changes are necessary but raise concerns about coordination, effectiveness and accountability.

By 2050, the global population is expected to exceed 9 billion, according to projections by the United Nations (UN, 2013). Today, the global population is 7 billion, and in 1950 it stood at less than 3 billion. Since 1900, materials use has increased tenfold (Krausmann et al., 2009), and may double again by 2030 (SERI, 2013). World demand for energy and water are both projected to rise by between 30% and 40% over the next 20 years (see, for example, IEA, 2013, or The 2030 Water Resource Group, 2009).

Similarly, total demand for food, feed, and fibre is projected to grow by about 60% between now and 2050 (FAO, 2012), while the area of arable land per person may decrease by 1.5% per year if no major policy changes are initiated (FAO, 2009).

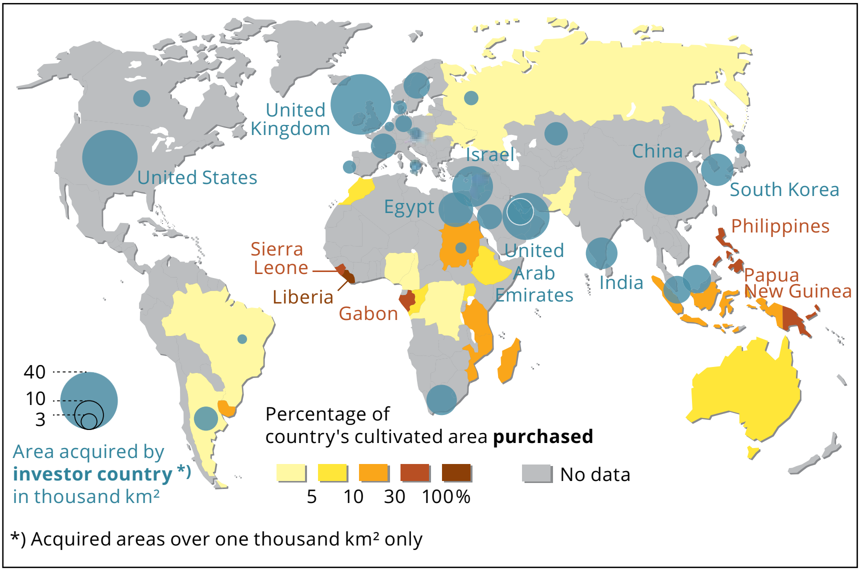
Human appropriation of net primary production (i.e. the share of vegetation growth that is directly or indirectly used by humans) has steadily increased with population growth. Human-induced land-use changes, such as the conversion of forest to cropland or infrastructure (including mining), account for a major part of the annual appropriation of biomass in Africa, the Middle East, eastern Europe, central Asia and Russia. In contrast, crops or timber account for most of the appropriation in western industrial countries and Asia.

Seen individually, each of the above global trends is striking in its own right. Taken together they look set to have a profound impact on the state of the environment and the availability of key resources globally.

Growing concerns about food, water and energy security have fuelled transnational land acquisitions in the last 5–10 years, primarily in developing countries. Between 2005 and 2009 alone, global foreign land acquisitions totalled some 470 000 km^2, which is comparable to the size of Spain. In some countries (particularly in Africa) large parts of the agricultural area have been sold to foreign investors, mostly from Europe, North America, China and the Middle East (Map 2.1).

Combined with population growth and climate change, increasing demand for food is also expected to create significant threats to the availability of freshwater (Murray et al., 2012). Even if we continue to use water more

Map 2.1 **Transnational land acquisitions, 2005–2009**



Source: Adapted from Rulli et al., 2013.

efficiently, the absolute agricultural intensification needed to meet the world's growing food and feed demand — due to population growth and changing diets — could lead to severe water stress in many world regions (Pfister et al., 2011).

The escalating resource scarcities in other parts of the world that could result from these trends have far-reaching implications for Europe. Most obviously, increased competition raises concerns about security of access to supplies of key resources. Prices of major resource categories have risen in recent years after several decades when they seemed to be in long-term decline. Higher prices reduce the spending power of all consumers but the effects are often felt most keenly by the poorest ([4]).

([4]) The World Bank, 2008, suggests that the food crisis in 2008 increased the number of poor globally by 100 million, with long-term consequences for health and education. Oil price rises compounded this effect. Food prices subsequently spiked to similar levels in 2011 and 2012 (World Bank, 2013).

These developments have both direct and indirect implications for the outlook on resource security. Europe's long-term supply of — and access to — food, energy, water and material resources depends not only on improving resource efficiency and ensuring resilient ecosystems in Europe but also on global dynamics beyond Europe's control. European efforts to reduce environmental pressures are increasingly offset by accelerating trends in other parts of the world.

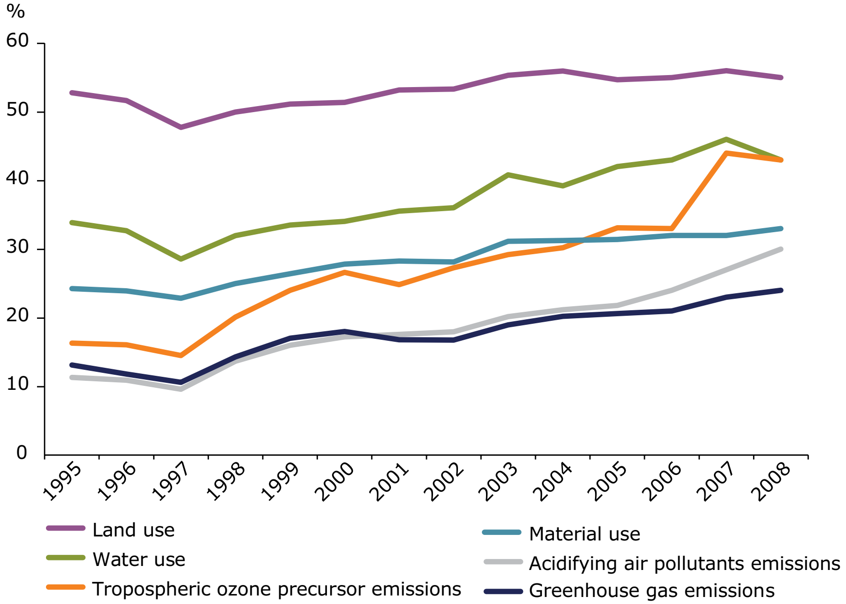
2.3 European consumption and production patterns impact both the European and global environment

Globalisation not only means that global trends have implications for society, the economy, and the environment in Europe. It also means that consumption and production patterns in a country or region contribute to environmental pressures in other parts of the world.

The environmental consequences of European consumption and production can be understood from two different perspectives. Firstly, a 'production' perspective broadly looks at pressures exerted by resource use, emissions and ecosystem degradation within the European territory. Secondly, a 'consumption' perspective focuses on environmental pressures of the resources used or emissions embedded in products and services consumed in Europe — both those produced in Europe and those imported.

A considerable share of the environmental pressures associated with consumption in the EU is felt outside the EU's territory. Depending on the type of pressure, between 24% and 56% of the associated total footprint occurs outside Europe (EEA, 2014f). To illustrate this: of the land footprint associated with products consumed within the EU, on average 56% is estimated to lie outside the EU territory. The share of the environmental footprint of EU demand that is exerted outside EU borders has increased during the past decade for land, water, and material use, as well as for air emissions (Figure 2.3).

Figure 2.3 Share of the total environmental footprint exerted outside EU borders associated with the EU-27's final demand



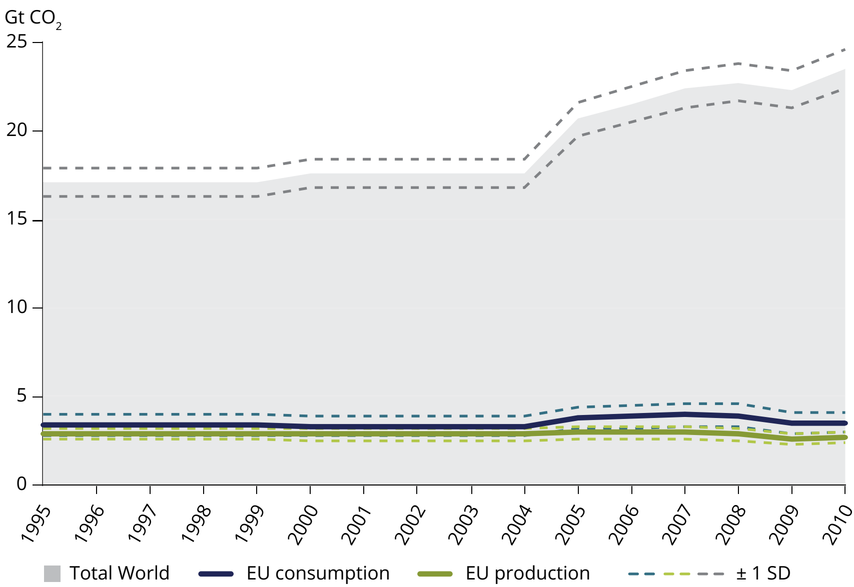
Note: The footprint relates to total final demand, comprising household consumption, government consumption and capital investment.

Source: EEA, 2014f; based on JRC/IPTS analysis of World Input-Output Database (WIOD), EC, 2012e.

Estimates show that the total material requirement and emissions caused by the three European consumption areas with the highest associated environmental pressures — i.e. food, mobility, and housing (built environment) — showed no significant reductions between 2000 and 2007 (EEA, 2014r). However, when looking from a production perspective, in many economic sectors there has been a reduction in material demand and emissions, or a decoupling between growth and emissions. This divergence between production perspective trends and consumption perspective trends is common.

In the case of carbon dioxide, EU consumption emissions due to goods consumed in Europe are higher than production emissions of goods produced in Europe, with the largest difference occurring in 2008 where consumption emissions were about a third higher than production emissions (Figure 2.4). Over the period 1995–2010, EU production emissions show a decreasing emission trend whereas consumption emissions after an initial increase were slightly higher in 2010 than in 1995 (Gandy et al., 2014). Global emissions have risen over the same time period and European consumption and production emissions have decreased as a fraction of the global CO_2 emissions embedded in goods from 20% to 17% and from 15% to 12%, respectively. However, it should be borne in mind that consumption-based estimates are subject to greater data uncertainty and shorter time series, as well as difficulties in defining system boundaries (EEA, 2013g).

Figure 2.4 Estimated global level, production and consumption carbon dioxide (CO_2) emissions embedded in goods



Note: Emissions embedded in goods (products and services) excludes residential emissions as well as emissions by private road transport. Private road transport is estimated to contribute 50% of total road emissions.

Source: Gandy et al., 2014.

The lack of standardisation makes it more difficult to use consumption based estimates in policymaking. International environmental conventions (such as the United Nations Framework Convention on Climate Change, UNFCCC) are based on the 'territorial' perspective when accounting for a country's emissions and mitigation efforts, referring only to areas that are under a country's sovereignty and where a country can implement and enforce legislation and policies. The territorial perspective includes all emissions taking place on the country's territory, regardless of the economic actors responsible for them.

Although a consumption perspective on emissions is not addressed in international conventions, it is embedded in the EU's policy framework on sustainable production and consumption, for example via product standards and life-cycle approaches. When it comes to climate change in particular, carbon emissions need to be considered globally as they affect the planet's climate system no matter where they are released. Thus, major efforts at combatting climate change continue to focus on reaching a global agreement on emission reductions, covering all sources of emissions, and where all countries contribute their fair share.

There is a similar divergence between production pressures and consumption pressures when it comes to the use of water resources. Here the divergence can be seen by comparing water use within European territory with 'virtual water' trade (embedded in water-intensive products, such as agricultural commodities). The 'virtual water' concept captures the volume of freshwater used to produce goods that are traded internationally. It is estimated that the number of trade connections and the volume of water associated with global food trade more than doubled in the period from 1986 to 2007 (Dalin et al., 2012).

The 'virtual water' concept has its limitations for use in policymaking (EEA, 2012h). Still, for most European countries and regions such consumption based estimates of water use exceed territory based estimates (Lenzen et al., 2013). However, it is worth noting that some parts of Europe are net exporters of virtual water. For example, the Spanish region of Andalusia uses large amounts of water in its exports of potatoes, vegetables and citrus fruits, while importing cereals and arable crops with lower water requirements (EEA, 2012h).

At a more aggregate level, the difference between production pressures and consumption pressures can be illustrated using the concept of 'footprints' (e.g. Tukker et al., 2014; WWF, 2014). The 'ecological footprint', for example, provides an indication of the combined use of land, renewable material resources and fossil fuels. It shows that for most European countries this currently exceeds their available biologically productive area or 'biocapacity'. Available estimates suggest that total global consumption exceeds the planet's regenerative capacity by more than 50% (WWF, 2014).

These different ways of looking at the difference between production related pressures and consumption related pressures all show that European consumption habits are affecting the global environment. This raises questions as to whether European consumption patterns would be sustainable if globally adopted — especially given the global environmental changes already occurring.

2.4 Human activities affect vital ecosystem dynamics at multiple scales

Human activities across the globe are already significantly changing major bio-geochemical cycles on Earth. The changes are sufficiently large to alter the normal functioning of these cycles. Such bio-geochemical cycles involve the planetary scale pathways for the transport and transformation of matter within the earth's biosphere, hydrosphere, lithosphere, and atmosphere. They regulate the transport of carbon, nitrogen, phosphorus, sulphur, and water, all of which are of fundamental importance for the planet's ecosystems (Bolin and Cook, 1983).

Simply put, these dynamics can be summarised by two types of human-induced global environmental changes, which both directly and indirectly impact the state of the environment in Europe (Turner II et al., 1990; Rockström et al., 2009a):

- **systemic changes** (systemic processes at a global scale), i.e. changes that manifest at continental or global scale with direct impact on environmental systems (such as climate change or ocean acidification),

- **cumulative changes** (aggregated processes from local or regional scale), i.e. changes that primarily occur on a local scale but are so widespread that they amount to a global phenomenon (such as soil degradation, or water scarcity).

The resulting human influence on global cycles has now reached unprecedented levels in the history of the planet, and researchers argue that we have recently entered a new geological epoch: the Anthropocene (Crutzen, 2002). During the past three centuries, as human population increased more than tenfold, an estimated 30–50% of the global land surface has been transformed by human action.

The corresponding numbers — often cited to illustrate the impact on bio-geochemical cycles — are staggering. For example:

- use of **carbon** based fossil fuels has increased by a factor of 12 over the 20th century, and concentrations of several greenhouse gases have substantially increased in the atmosphere, i.e. carbon dioxide (CO_2) by more than 30% and methane (CH_4) by more than 100%;

- more **nitrogen** is now fixed synthetically and applied as fertilisers in agriculture than fixed naturally in all terrestrial ecosystems, and nitrous oxide emissions from fossil-fuel and biomass combustion is larger than the inputs from natural sources;

- global **phosphorus** flows to the biosphere have tripled compared to pre-industrial levels, due to the growth in fertiliser use and livestock production (MacDonald et al., 2011);

- today, **sulphur** dioxide (SO_2) emissions from the burning of coal and oil around the world are at least double the amount of all natural emissions (which occur mainly as marine dimethyl-sulphide from the oceans);

- more than half of all accessible **freshwater** is used by mankind globally (mostly for agricultural production), and underground water resources are being depleted rapidly in many areas.

Thus, at a global scale we are generating more pollution and waste, causing increasing pressure on the planet's ecosystems. The scientific community is in agreement that we are contributing to global warming, and it highlights the increasing risk of water stress and water scarcity. Despite some positive developments, global habitat loss, biodiversity loss and environmental degradation have risen to unprecedented levels. Nearly two thirds of the world's ecosystems have been assessed as being in decline (MA, 2005).

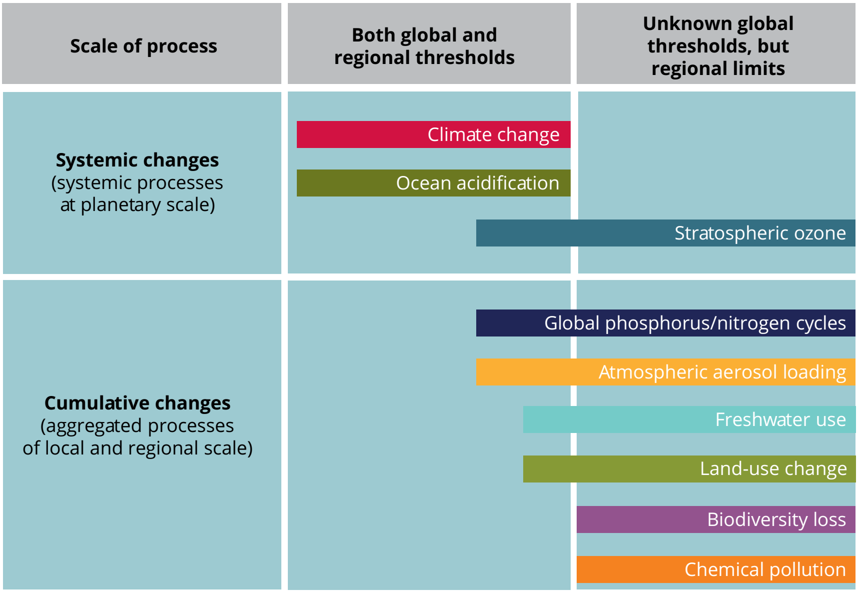
Human exposure to these pressures and the resulting impacts are unevenly distributed, with poorer areas and societal groups often being much more affected than others. In its most recent assessment, the Intergovernmental Panel on Climate Change (IPCC, 2014b) suggests that climate change will exacerbate poverty in developing countries and amplify risks. This is a particular concern for those living in poor-quality housing and lacking basic infrastructure, as low-income groups rely disproportionately on the sustainability of local ecosystem services. Global environmental change is thus likely to enhance social inequities, with possible knock-on effects for migration and security.

The associated risks also extend to high-income countries. The Organisation for Economic Cooperation and Development has warned that the continued degradation and erosion of natural capital could endanger two centuries of rising living standards (OECD, 2012).

2.5 Excessive use of natural resources jeopardises humanity's safe operating space

It has been argued that enough is now known about the functioning of the earth's systems to justify the delineation of boundaries at planetary scale (Rockström et al., 2009a). Such planetary boundaries are human-determined levels that are a 'safe' distance from dangerous thresholds beyond which adverse environmental changes become irreversible, putting at risk ecosystem resilience and threatening human livelihoods (Figure 2.5).

Figure 2.5 Categories of planetary boundaries



Source: Adapted from Rockström et al., 2009b.

One planetary boundary of this sort has already been outlined by researchers who warn of the risks involved in climate change. In policy terms, these warnings have been translated into the 2 °C threshold: global mean temperatures must not increase by more than 2 °C above pre-industrial levels in order to avoid irreversible changes to the global climate.

Similarly, for ocean acidification, a bio-physical threshold might be defined in relation to the level of aragonite saturation in surface waters (which needs to be maintained at 80% or higher of the average global pre-industrial surface seawater) to ensure that coral reefs and associated ecosystems are not seriously impacted.

The International Resource Panel established by UNEP has argued that the overall conversion of forest or other types of land to cropland should not exceed 1 640 million hectares at the global level (UNEP, 2014a). Cropland currently already comprises about 1 500 million hectares, equal to around 10% of the world land area. It is worth noting, that under business-as-usual conditions, a further expansion of between 120 to 500 million hectares by 2050 is projected by the same assessment (UNEP, 2014a).

However, for other global change processes a 'safe operating space' may be more difficult to define, as thresholds may not exist or the thresholds may differ between different regional or even local ecosystems. In some cases, this may be because of scientific uncertainty about what the bio-physical thresholds or tipping points for different processes are and how they relate to each other. In other cases, the consequences of passing thresholds is unclear or we may not even be aware that we are approaching them.

Despite uncertainty, there is evidence that both planetary and regional boundaries for some areas have already been transgressed, including for biodiversity loss, climate change and the nitrogen cycle (Rockström et al., 2009a). In parts of the world, ecological limits for water stress, soil erosion or deforestation have been transgressed at local or regional scale.

This has both global and regional implications. For example, many regional seas across the globe suffer from oxygen depletion (hypoxia) due to excess nutrient discharges, which leads to a collapse of fish stocks. Europe is already suffering from this problem. The Baltic Sea — as a semi-enclosed regional sea with low salinity — is now considered the largest human-induced hypoxic area in the world (Carstensen et al., 2014).

When reflecting on whether and how ecological limits might be reflected in environmental policy objectives at European and national level, it is also important to consider the regional specifics. An understanding of concepts such as planetary boundaries can provide a meaningful starting point for discussing the role of ecological limits and policy options at levels lower than the global scale. However, defining these is not straightforward and will depend greatly on regional and local specifics (Box 2.2).

Box 2.2 How can we define a safe operating space?

There is an on-going academic debate about how best to define terms such as 'planetary boundaries' or the related concept of a 'safe operating space' (Rockström et al., 2009a). Complementary concepts and discussions can be found in earlier research on 'carrying capacity' (Daily and Ehrlich, 1992); 'limits to growth' (Meadows et al., 1972); 'critical loads' and 'critical levels' (UNECE, 1979); and 'safe minimum standards' (Ciriacy-Wantrup, 1952). As far back as the 18th century there were reflections on how to ensure sustainable forestry (von Carlowitz, 1713).

The increased understanding of ecological limits developed during recent decades opens up questions about how a safe operating space can be translated into a policy context. The primary aim of such research has not necessarily been to support policymaking directly. However, this research may lend itself to reflections on how best to develop environmental targets and indicators to achieve the goal of 'living well, within the limits of our planet'. When designing policies and indicators for this purpose, three problems must be overcome:

- Knowledge gaps: There remain both 'known unknowns' and 'unknown unknowns', as regards environmental thresholds at both the European and global level — and the consequences of exceeding these. In addition, thresholds for non-linear processes are difficult to define at all.
- Policy gaps: Even where we do have knowledge about global systems, policies might fall short of what is currently known to be needed to stay within environmental constraints.
- Implementation gaps: This is the gap between the plans made and the results delivered. For example, plans may be frustrated by incompatibilities between policies in different sectors.

Source: Based on Hoff et al., 2014.

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Protecting, conserving and enhancing natural capital

3.1 Natural capital underpins the economy, society and human well-being

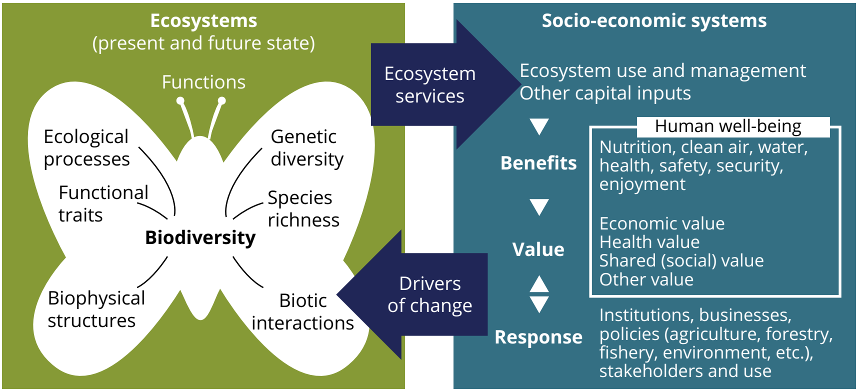
The term **'capital'** is generally used by economists to describe a stock of anything that has the capacity to generate a flow (normally of goods and services) that benefits — and is valued by — people. The emergence of the concept of natural capital in recent decades reflects the recognition that environmental systems play a fundamental role in determining economic output and human well-being — providing resources and services, and absorbing emissions and wastes.

Natural capital is the most fundamental of the core forms of capital (i.e. manufactured, human, social and natural) since it provides the basic conditions for human existence. These conditions include fertile soil, multifunctional forests, productive land and seas, good quality freshwater and clean air. They also include services such as pollination, climate regulation and protection from natural disasters (EU, 2013). Natural capital sets the ecological limits for our socio-economic systems; it is both limited and vulnerable.

The 'flow' provided by natural capital comes in the form of ecosystem services. Ecosystem services are the contributions that ecosystems make to human well-being (Figure 3.1). The main categories are provisioning services (e.g. biomass, water, fibre); regulating and maintenance services (e.g. soil formation, pest and disease control); and cultural services (e.g. the physical, intellectual, spiritual and symbolic interactions with ecosystems, landscapes and seascapes) (CICES, 2013). These three types of services are underpinned by supporting services (e.g. nutrient cycling) and are provided at a range of scales from the global (e.g. climate regulation) to the local (e.g. flood protection).

The complexity of natural systems and irreversibility of some environmental change mean that replacing natural capital with other forms of capital is often impossible (a phenomenon known as non-substitutability) or

Figure 3.1 Conceptual framework for EU-wide ecosystem assessments



Source: Maes et al., 2013.

carries significant risks. The risks and costs from continued degradation of ecosystems and their services have not yet been properly integrated in our economic systems, social systems, and decision-making.

The state and prospects of natural capital provide an indication of the environmental sustainability of our economy and society. While Europe has undoubtedly made progress in preserving and enhancing its semi-natural systems in certain areas, continued overall loss of natural capital is jeopardising efforts to attain biodiversity and climate objectives (EU, 2013). Most of the pressures on Europe's natural capital are fundamentally based in the socio-economic systems of production and consumption that provide for our material well-being. Economic and demographic projections suggest that these pressures are likely to grow.

Applying the concept of capital to nature raises some difficulties. These include concerns about the growing commodification of the world and a lack of recognition of the intrinsic importance of biodiversity and of a clean, healthy environment. In this context it is important to emphasise that natural capital is not the same as nature; natural capital is the basis of production in the human economy and the provider of ecosystem services.

Therefore any socio-economic valuation of Europe's natural capital, while an important tool to integrate monetary values into economic systems and related policies, should go hand-in-hand with recognition that economic valuation will not fully include the intrinsic value of nature or the cultural and spiritual services that it provides.

Box 3.1 Structure of Chapter 3

Assessing trends in natural capital is a comprehensive undertaking, and SOER 2010 highlighted the need for dedicated management of natural capital as a means of integrating environmental priorities and the many sectoral interests that depend upon them. This chapter focuses on ecosystems, and complements the focus on the resources component of natural capital in Chapter 4. The sections within this chapter attempt to assess ecosystem capital by addressing three dimensions:

- trends in the state of — and prospects for — biodiversity, ecosystems, and their services, with a focus on biodiversity, land, soils, freshwater and marine ecosystems (Sections 3.3 to 3.5, 3.8);
- trends in the impacts of pressures on ecosystems and their services, with a focus on climate change as well as on the emission of nutrients and pollutants to the air and water (Sections 3.6 to 3.9);
- reflections on the scope for long-term, interconnected ecosystem-based management approaches (Section 3.10).

3.2 European policy aims to protect, conserve and enhance natural capital

The European Union and its Member States — as well as many neighbouring countries in Europe — have introduced a substantial amount of legislation to protect, conserve and enhance ecosystems and their services (Table 3.1). A wide range of European policies affect and benefit from natural capital. These include the Common Agricultural Policy, Common Fisheries Policy, cohesion policy, and rural development policies. The ultimate objective of these policies may not be protection of natural capital. Nevertheless, legislation to tackle climate change, chemicals, industrial emissions and waste helps to ease the pressures on soil, ecosystems, species, and habitats as well as reducing nutrient releases (EU, 2013).

More recently, EU policies such as the 7th Environment Action Programme and the Biodiversity Strategy to 2020 (EC, 2011b; EU, 2013) have shifted towards a more systemic perspective on the issue, explicitly addressing natural capital. A priority objective of the 7th Environment Action Programme is 'to protect, conserve and enhance the Union's natural capital', and this objective is set in the context of a longer-term vision that 'by 2050 we live well, within the planet's ecological limits... natural resources are managed sustainably, and biodiversity is protected, valued and restored in ways that enhance society's resilience'.

Resilience refers to the ability to adapt to or tolerate disturbance without collapsing into a qualitatively different state. Enhancing society's resilience will only be possible by maintaining and enhancing ecosystem resilience because social, economic and ecological sustainability are interdependent. When we undermine ecosystem resilience, we reduce nature's capacity to provide essential services, putting growing pressure on individuals and society. Conversely ecological sustainability depends on social factors and decisions to protect the environment.

The complex nature of ecosystem degradation (multiple causes, pathways and effects that are difficult to disentangle) leads to challenges in translating the concept of ecological resilience into policy. Policy initiatives have sought to overcome these challenges by using concepts such as 'good ecological status' and 'good environmental status' for water bodies, or 'favourable conservation status' for habitats and species. However, the relationship between ecosystem resilience, decreasing environmental pressures, and improvements in resource efficiency is often ill-defined. There are weaker links between resilience and policy measures and targets than between resource efficiency and policy measures and targets.

Table 3.1 Examples of EU policies relating to Objective 1 of the 7th Environment Action Programme

Topic	Overarching strategies	Related directives
Biodiversity	Biodiversity Strategy to 2020	Birds Directive Habitats Directive Invasive Alien Species Regulation
Land and soil	Thematic Strategy on Soil Roadmap to a Resource Efficient Europe	
Water	Blueprint to Safeguard Europe's Water Resources	Water Framework Directive Flood Risk Directive Urban Waste Water Treatment Directive Priority Substances Directive Drinking Water Directive Groundwater Directive Nitrates Directive
Marine	Integrated Maritime Policy including the Common Fisheries Policy and Blue Growth Strategy	Marine Strategy Framework Directive Maritime Spatial Planning Directive
Air	Thematic Strategy on air pollution	Ambient Air Quality Directive National Emission Ceilings Directive
Climate	EU Strategy on adaption to climate change 2020 Climate and energy package	Renewable Energy Directive Biomass Directive Energy Efficiency Directive
In addition, several EU policies affect several of the above topics — examples include: • Strategic Environmental Assessment Directive • Environmental Impact Assessment Directive		

Note: For more detailed information on specific policies, see the respective SOER 2015 thematic briefings.

3.3 Biodiversity decline and ecosystem degradation reduce resilience

Trends and outlook: Terrestrial and freshwater biodiversity	
	5–10 year trends: High proportion of protected species and habitats in unfavourable conditions.
	20+ year outlook: Underlying drivers of biodiversity loss are not changing favourably. Full implementation of policy is needed to deliver improvements.
□	*Progress to policy targets:* Not on track to halting overall biodiversity loss (Biodiversity Strategy), but some more specific targets are being met.
!	*See also:* SOER 2015 thematic briefings on biodiversity; agriculture; and forests.

Biodiversity is the variety of life and includes all living organisms found in the atmosphere, on land and in water. It encompasses diversity within and among species, habitats and ecosystems. Biodiversity underpins ecosystem functioning and the provision of ecosystem services. Despite these benefits and despite biodiversity's importance for humans, biodiversity continues to be lost, mainly due to pressures caused by human activities.

Changes in natural and semi-natural habitats — including loss, fragmentation and degradation — impose considerable negative impacts through urban sprawl, agricultural intensification, land abandonment, and intensively managed forests. Overexploitation of natural resources — in particular fisheries — remains a large problem. The accelerated establishment and spread of invasive alien species is not only an important driver of biodiversity loss, it also causes considerable economic damage (EEA, 2012g, 2012d). The increasing impacts from climate change are already affecting species and habitats, exacerbating other threats. These impacts are projected to become progressively more significant in the coming decades (EEA, 2012a). Encouragingly, some pollution pressures such as emissions of sulphur dioxide (SO_2) have decreased; but others, such as atmospheric nitrogen deposition, remain a problem (EEA, 2014a).

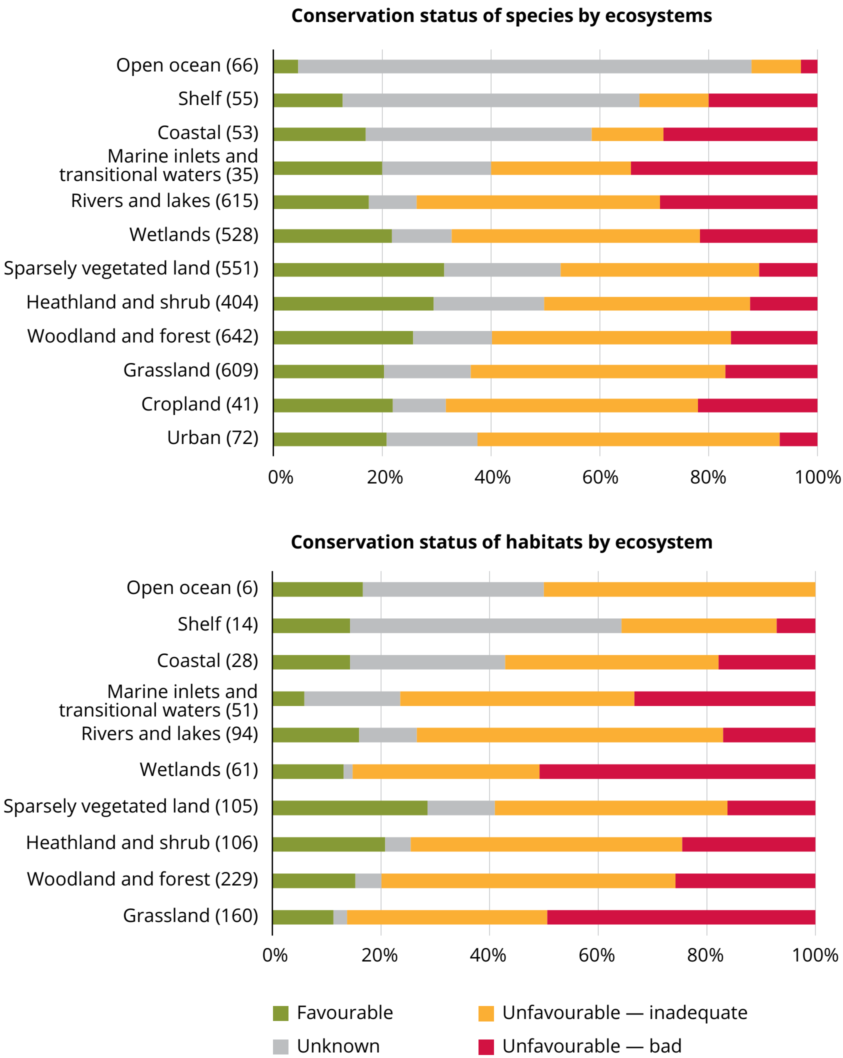
In 2010, it was clear that neither the global nor the European target of halting biodiversity loss had been met, despite important progress in nature conservation measures in Europe. This progress included the expansion of the Natura 2000 network of protected areas and the recovery of some wildlife species e.g. large carnivores. In 2011, the European Commission adopted the Biodiversity Strategy to 2020 with the headline target of 'halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restoring them in so far as is feasible, while stepping up the EU contribution to averting global biodiversity loss'. This goal is complemented by six targets aimed at conserving and restoring nature, maintaining and enhancing ecosystems and their services, addressing specific drivers of biodiversity loss (agriculture, forestry, fisheries, invasive alien species), and averting global biodiversity loss.

Much is still unknown about the complete status and trends of European biodiversity and how these relate to the functioning of ecosystems and the long-term delivery of ecosystem services. Nonetheless, available information on protected species and habitats gives rise to concern. The Habitats Directive Article 17 assessment for 2007–2012, shows that only 23% of animal and plant species and only 16% of habitat types were considered to be in a favourable conservation status (Figure 3.2). The breakdown by ecosystem type shows that for both species and habitats the overall percentage in favourable condition is higher in terrestrial ecosystems than in freshwater and marine ecosystems.

The main change from the 2001–2006 assessment is a reduction in the proportion of assessments where conservation status is unknown, from 31% to 17% for species and from 18% to 7% for habitats, illustrating improvements in the knowledge and evidence base. A high proportion of species (60%) and habitats (77%) assessed in the 2007–2012 assessment remain in unfavourable condition. For species, this represents an increase from 52% in the 2001–2006 assessment and for habitats, an increase from 65%. As there have been methodological changes from the previous reporting period, it is not possible to say whether this represents a deterioration in condition or reflects the improvements in the knowledge base. In addition, even with greater societal responses to biodiversity loss, positive actions can take time to have an impact on the status of biodiversity.

A significant achievement has been the expansion of the Natura 2000 network of protected areas to 18% of EU land area and to 4% of EU marine waters. Conserving and managing these and other nationally-designated

Figure 3.2 Conservation status of species (top) and habitats (bottom) by ecosystem type (number of assessments in brackets) from Habitats Directive Article 17 reporting 2007–2012



Source: EEA.

areas (and enhancing their coherence through developing green infrastructure, such as wildlife corridors) is a critical step to protect Europe's biodiversity.

Achieving a significant and measurable improvement in the status of species and habitats will require the full and effective implementation of the Biodiversity Strategy to 2020 and of EU nature legislation. It will also require policy coherence between relevant sectoral and regional policies (e.g. agriculture, fisheries, regional development and cohesion, forestry, energy, tourism, transport, and industry). Consequently, the fate of European biodiversity and the ecosystem services it underpins is closely intertwined with policy developments in these areas.

In addressing biodiversity, Europe must also look beyond its own borders. High per-capita consumption is ultimately an underlying cause for many of the drivers causing biodiversity loss; and in today's increasingly globalised economy, international trade chains accelerate habitat degradation far away from the place of consumption. Consequently, European efforts to halt biodiversity loss should ensure that pressures are not transferred to other parts of the world thereby exacerbating global biodiversity loss.

3.4 Land-use change and intensification threaten soil ecosystem services and drive biodiversity loss

Trends and outlook: Land use and soil functions	
	5–10 year trends: Loss of soil functions due to (urban) land take and land degradation (e.g. as a consequence of soil erosion or land intensification) is continuing; nearly a third of Europe's landscape is highly fragmented.
	20+ year outlook: Land use and management, and their associated environmental and socio-economic drivers, are not expected to change favourably.
No target	*Progress to policy targets:* The only non-binding explicit objective is to arrive at 'no net land take by 2050', and to restore at least 15% of degraded ecosystems by 2020.
!	*See also:* SOER 2015 thematic briefings on land systems; agriculture; and soil.

Land use is a major factor influencing the distribution and functioning of ecosystems and thus the delivery of ecosystem services. The degradation, fragmentation and unsustainable use of land is jeopardising the provision of several key ecosystem services, threatening biodiversity, and increasing

Europe's vulnerability to climate change and natural disasters. It is also exacerbating soil degradation and desertification. More than 25% of the EU's territory is affected by soil erosion by water, which compromises soil functions and freshwater quality. Soil contamination and soil sealing are also persistent problems (EU, 2013).

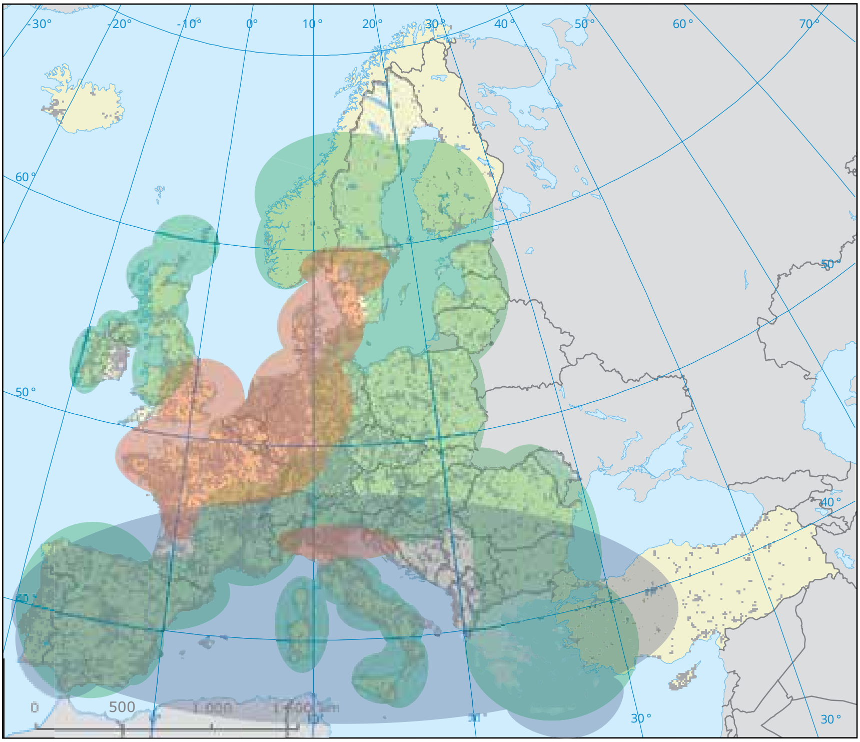
Urbanisation is the dominant trend in European land-use change, and in combination with land abandonment and intensification of agricultural production this is leading to a decline in the area of natural and semi-natural habitats. In place of these natural and semi-natural habitats come commercial, industrial, mining, or construction sites, a change referred to as land take. Urbanisation also means that those natural and semi-natural habitats that remain are increasingly fragmented by built-up areas and transport infrastructure. 30% of the EU's territory is highly fragmented, affecting the connectivity and health of ecosystems. This also affects the ability of ecosystems to provide services, and to provide viable habitats for species (EU, 2013) (see also Section 4.10).

Available data show that close to half of land take has come at the expense of arable farmland and permanent crops, nearly a third at the expense of pastures and mosaic farmland, and over 10% at the expense of forests and transitional woodland shrubs (EEA, 2013j). As these land-cover types are substituted to varying degrees by impervious cover, this affects the provision of important services provided by soils, such as the storing, filtering, and transforming of substances such as nutrients, contaminants, and water.

Land take is a long-term change, which is difficult or costly to reverse. It is now becoming evident that there are complex trade-offs between land-use patterns, the environmental pressures generated by that land use, and social and economic needs (Map 3.1).

There has been a variety of commitments on land use at both international and national level. The Rio+20 outcomes (UN, 2012a) call for a land degradation neutral world, while the EU has an objective of 'no net land take' by 2050. EU policy also calls for targets to be set for sustainable use of land and soil (EU, 2013). Limiting land take is also already an important

Map 3.1 **Synthesis map of urban land take and agricultural challenges**



Indicative map of combined environmental challenges related to land use

Marginal agricultural areas

Challenges: maintain on-field biodiversity, stimulate favourable practices, increase profitability without intensifying

Prime agricultural areas

Challenges: reduce pressures on air, soil and natural habitats, nature reserve approach to remaining high nature value agri patches

Main irrigated areas

Challenges: reduce water stress

Urbanising areas

Urban land take 2000–2006
Challenges: minimising and mitigating habitat loss and fragmentation

Outside coverage

Source: EEA, 2013f.

land policy target at national and sub-national level (ETC SIA, 2013). The European Commission is currently preparing a communication on land as a resource. It has indicated that its aim is to unify these commitments on land use and spatial planning into a coherent policy that takes into account the respective competencies of the European Union and its Member States.

In order to avoid increases in land take, incentives for land recycling and compact urban development may be worth pursuing. Adopting a landscape perspective and green infrastructure approaches (which embrace an area's physical characteristics and the ecosystem services it provides) is a useful way to foster integration between different policy areas. This can also help address fragmentation and manage trade-offs. The policy areas of agriculture and spatial planning are especially suited to integration of this sort, as there are strong interactions between agricultural land-use and European and global environmental processes.

3.5 Europe is far from meeting water policy objectives and having healthy aquatic ecosystems

Trends and outlook: Ecological status of freshwater bodies	
	5–10 year trends: Mixed progress; more than half of rivers and lakes are in less than good ecological status.
	20+ year outlook: Continuous progress is expected as implementation of the Water Framework Directive continues.
☒	*Progress to policy targets:* Only half of surface water bodies meet the 2015 target to achieve good status.
!	*See also:* SOER 2015 thematic briefings on freshwater quality; and hydrological systems and sustainable water management.

The main aim of European and national water policy is to ensure that throughout Europe, a sufficient quantity of good-quality water is available for people's needs and for the environment. In 2000, the Water Framework Directive established a framework for the management, protection and improvement of the quality of water resources across the EU. Its main objective is that all surface water and groundwater should hold good status by 2015 (unless there are grounds for exemption). Achieving good status means meeting certain standards for the ecology, chemistry, morphology and quantity of waters.

Water quantity and quality are closely linked. In 2012, the 'Blueprint to Safeguard Europe's Water Resources' stressed that a key element of meeting the standard of good status is ensuring that there is no over-exploitation of water resources (EC, 2012b). In 2010, EU Member States released 160 River Basin Management Plans aimed at protecting and improving the water environment. The plans covered the period 2009–2015, with the second set of River Basin Management Plans covering the period 2016–2021 due for finalisation in 2015. Over the last few years, European countries that are not EU Member States have developed similar river basin activities to those introduced by the Water Framework Directive (Box 3.2).

Box 3.2 River basin management activities in EEA member and cooperating countries outside the EU

Norway and Iceland have activities for implementing the EU Water Framework Directive (Vannportalen, 2012; Guðmundsdóttir, 2010), and in Switzerland and Turkey, there are water policies comparable to the Water Framework Directive regarding water protection and management (EEA, 2010c; Cicek, 2012).

In these countries outside the EU, a large proportion of waters are affected by similar pressures as those identified by the EU River Basin Management Plans. Many of the West Balkan river basins are heavily affected by hydromorphological alterations and pollution from municipal, industrial, and agrochemical sources. This pollution is a major threat to freshwater ecosystems (Skoulikidis, 2009). In Switzerland there are significant deficits in the ecological status of surface waters, particularly in the intensively used lowland areas (Swiss Plateau) with recent assessments showing that 38% of medium and large river sites have insufficient macroinvertebrate quality and that roughly half of the total river length (below 1 200 m above sea level) is in a modified, non-natural, artificial or covered state.

Countries are also involved in transboundary activities. The Sava is the third-longest tributary of the Danube, and runs through Slovenia, Croatia, Bosnia and Herzegovina, and Serbia, with part of its catchment in Montenegro and Albania. The International Sava River Commission is working together with these countries on the development of the Sava River Basin Management Plan, in line with the Water Framework Directive. Similarly, Switzerland cooperates with neighbouring states to achieve water protection goals, and thus indirectly adopts certain principles of the Water Framework Directive.

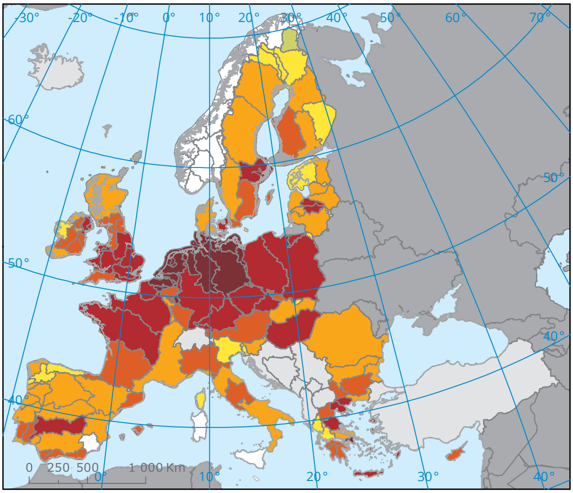
In 2009, 43% of surface water bodies were in good or high ecological status, and the Water Framework Directive objective of reaching good ecological status by 2015 is only likely to be met by 53% of surface water bodies (Map 3.2). This constitutes a modest improvement and is far from meeting policy objectives. Rivers and transitional waters are on average in a worse condition than lakes and coastal waters. Concerns about the ecological status of surface water bodies are most pronounced for central and north-western Europe in areas with intensive agricultural practices and high population densities. The status of coastal and transitional waters, in the Black Sea and greater North Sea regions is also of concern.

Pollution from diffuse sources affects most surface water bodies. Agriculture is a particularly large source of diffuse pollution, causing nutrient enrichment from fertiliser run-off. Agricultural pesticides have also been widely detected in surface and groundwater bodies. Hydromorphological pressures (changes to the physical shape of water bodies) also affect many surface water bodies. Hydromorphological pressures alter habitats and are mainly the result of hydropower, navigation, agriculture, flood protection, and urban development. The second set of River Basin Management Plans must include measures to reduce hydromorphological pressures if they cause less than good ecological status.

Chemical status is another cause for concern. Around 10% of rivers and lakes are in poor chemical status, with polycyclic aromatic hydrocarbons a widespread cause of poor status in rivers, and heavy metals a significant contributor to poor status in rivers and lakes. Around 25% of groundwater has poor status, with nitrate being the primary cause. Notably, the chemical status of 40% of Europe's surface waters remains unknown.

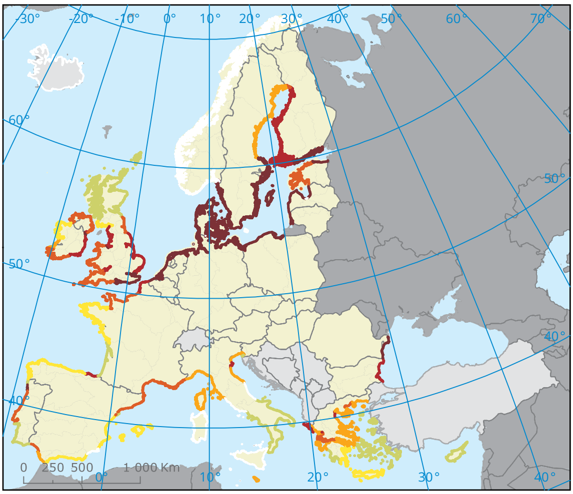
While there is relative clarity about the types of pressures encountered in river basins, there is less clarity on how these will be addressed and how measures will contribute to achieving environmental objectives. The next cycle of River Basin Management Plans (2016–2021) will need to improve this situation. In addition, improving efficiency of water use and adapting to climate change are major challenges for water management. Restoring freshwater ecosystems and floodplain rehabilitation as part of green infrastructure will help address these challenges. These actions will also deliver multiple benefits by using natural water retention methods to improve ecosystem quality, reduce floods and reduce water scarcity.

Map 3.2 Percentage of good ecological status or potential of classified rivers and lakes (top) and coastal and transitional waters (bottom) in Water Framework Directive river basin districts



Percentage of classified water bodies in less than good ecological status or potential in rivers and lakes

- < 10%
- 10–30%
- 30–50%
- 50–70%
- 70–90%
- ≥ 90%
- EEA member countries not reporting under Water Framework Directive
- No data
- Outside coverage



Percentage of classified water bodies in less than good ecological status or potential in coastal and transitional waters

- < 10%
- 10–30%
- 30–50%
- 50–70%
- 70–90%
- ≥ 90%
- EEA member countries not reporting under Water Framework Directive
- No data
- Outside coverage

Note: Switzerland data sets on river and lake water quality reported in the framework of EEA priority data flows are not compatible with the EU Water Framework Directive assessments and are not included above (see Box 3.2 for details).

Source: EEA, 2012c.

Achieving healthy aquatic ecosystems requires taking a systemic view, as the state of aquatic ecosystems is closely connected to how we manage land and water resources, and to pressures from sectors such as agriculture, energy and transport. There are ample opportunities to improve water management to achieve policy objectives. These include stringent implementation of existing water policy, and integration of water policy objectives into other areas such as the Common Agricultural Policy, EU Cohesion and Structural Funds, and sectoral policies.

3.6 Water quality has improved but the nutrient load of water bodies remains a problem

Trends and outlook: Water quality and nutrient loading	
	5–10 year trends: Water quality has improved, although concentrations of nutrients in many places are still high and affect the status of waters.
	20+ year outlook: In regions with intensive agriculture production, diffuse nitrogen pollution will still be high, resulting in continued eutrophication problems.
□	*Progress to policy targets:* Although the Urban Waste Water Treatment Directive and the Nitrates Directive continue to deliver pollution control, diffuse nitrogen pollution remains problematic.
!	*See also:* SOER 2015 thematic briefings on freshwater quality; and hydrological systems and sustainable water management.

Excessive nutrient (nitrogen and phosphorus) inputs in aquatic environments cause eutrophication, resulting in changes in species abundance and diversity, as well as algal blooms, deoxygenated dead zones, and leaching of nitrate to groundwater. All of these changes threaten the long-term quality of aquatic environments. This has implications for the provision of ecosystem services such as drinking water, fisheries, and recreation opportunities.

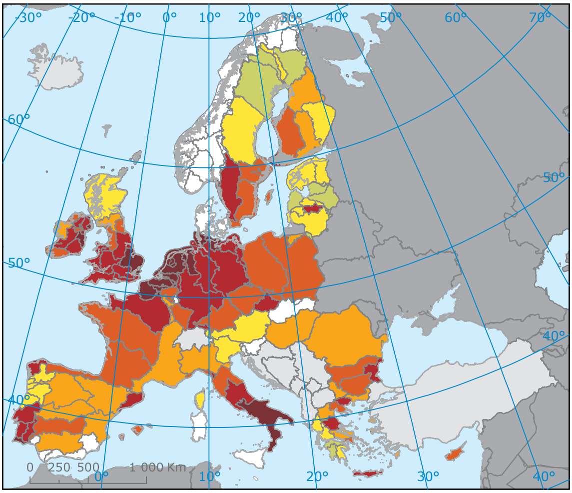
Europe's waters are much cleaner than they were 25 years ago, due to investment in sewage systems to reduce pollution from urban wastewater treatment. Nevertheless, challenges remain. More than 40% of rivers and coastal water bodies are affected by diffuse pollution from agriculture, while between 20% and 25% are subject to point source pollution, for example, from industrial facilities, sewage systems and wastewater treatment plants (Map 3.3).

Nutrient levels in freshwater bodies are decreasing. Average levels of phosphate and nitrate in European rivers declined by 57% and 20% respectively between 1992 and 2011 (EEA, 2014q). This mostly reflects improvements in wastewater treatment and reductions in the levels of phosphorus in detergents, rather than the effect of measures to reduce agricultural inputs of nitrate at European and national levels.

Although agricultural nitrogen balances are declining, they are still high in some countries, particularly in lowland western Europe. Measures to tackle agricultural pollution include improving the efficiency of nitrogen use in crop and animal production; conserving nitrogen in animal manure during storage and application; and full compliance with the Nitrates Directive. Improving cross-compliance (the mechanism that ties financial support for farmers to compliance with European laws) and tackling inadequate wastewater treatment and ammonia release from inefficient fertiliser management are particularly important for achieving further significant reductions in nutrient releases (EU, 2013).

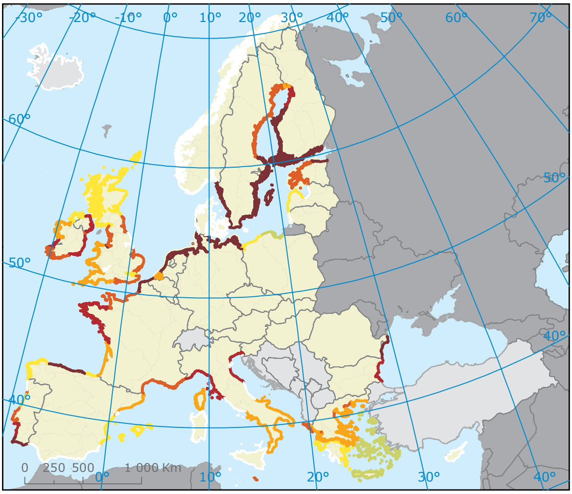
Reducing overall nutrient inputs to watersheds at the European scale also requires an approach that encompasses hydrological systems as a whole, because nutrient loading in rivers and surface waters has a downstream impact on transitional and coastal waters. Any measure to reduce nutrient inputs must also take into account time lags, as measures focused on rivers take a while to reduce pressures on coastal and marine environments.

Map 3.3 **Percentage of classified rivers and lakes (top) and coastal and transitional waters (bottom) in Water Framework Directive river basin districts affected by pollution pressures**



Percentage of classified water bodies affected by point and/or diffuse pressures in rivers and lakes

- < 10%
- 10–30%
- 30–50%
- 50–70%
- 70–90%
- ≥ 90%
- EEA member countries not reporting under Water Framework Directive
- No data
- Outside coverage



Percentage of classified water bodies affected by point and/or diffuse pressures in coastal and transitional waters

- < 10%
- 10–30%
- 30–50%
- 50–70%
- 70–90%
- ≥ 90%
- EEA member countries not reporting under Water Framework Directive
- No data
- Outside coverage

Note: Switzerland data sets are not compatible with the EU Water Framework Directive assessments and so are not included above. Switzerland has high levels of point and/or diffuse pollution pressures, particularly in lowland areas.

Source: EEA, 2012c.

3.7 Despite cuts in air emissions, ecosystems still suffer from eutrophication, acidification and ozone

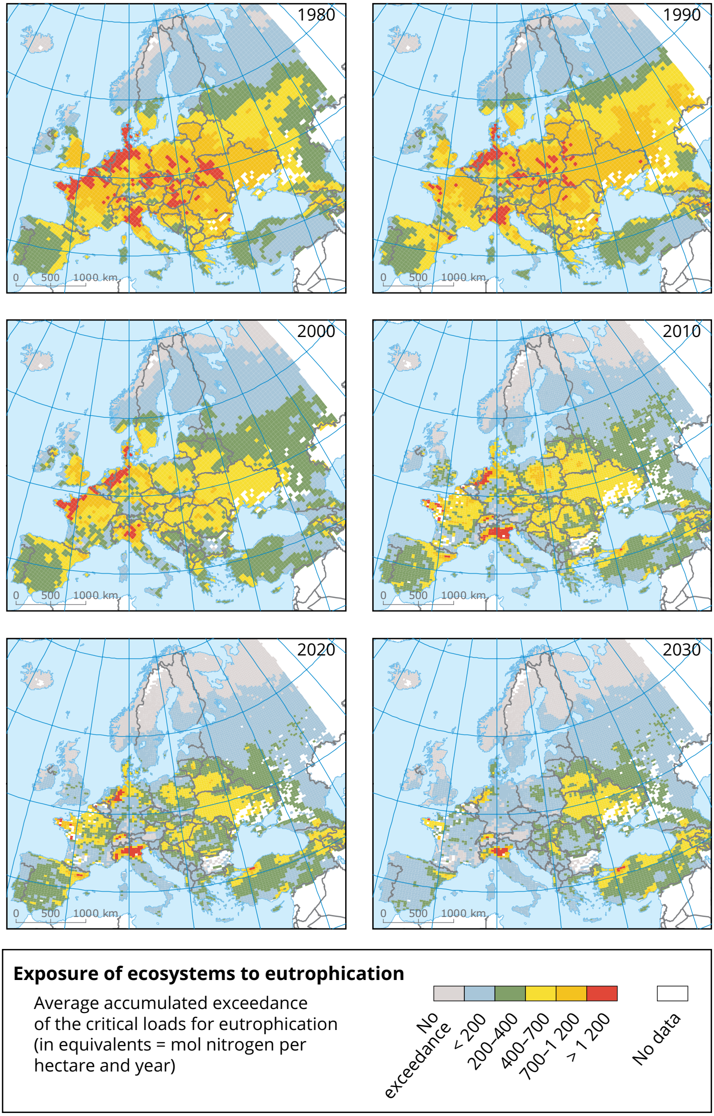
Trends and outlook: Air pollution and its ecosystem impacts	
	5–10 year trends: Lower emissions of air pollutants have contributed to fewer exceedances of acidification and eutrophication limits.
	20+ year outlook: Long-term problems from eutrophication are forecast to persist in some areas, although adverse impacts caused by acidification will be greatly improved.
□	*Progress to policy targets:* There has been mixed progress in meeting the EU's 2010 interim environmental objectives for eutrophication and acidification.
!	*See also:* SOER 2015 thematic briefing on air pollution.

Air pollution harms both human and ecosystem health. It contributes to eutrophication, atmospheric ozone, and the acidification of water and soil. It also impacts agricultural production and forests, causing yield losses.

Air pollution's most important effects result from emissions from transport, power generation and agriculture. Although there has been a reduction in emissions of air pollutants over the last two decades, the complex links between emissions and air quality mean that this does not always result in a corresponding improvement in the exposure of ecosystems to these pollutants.

In recent decades there have been significant improvements in reducing ecosystem exposure to excess levels of acidification, and the situation is predicted to improve further over the coming 20 years (EEA, 2013h). However, there has not been the same degree of improvement regarding eutrophication. Most of continental Europe experiences exceedances of critical loads (the upper limit that an ecosystem such as a lake or forest can tolerate without damaging its structure or function) for eutrophication. It is estimated that around 63% of European ecosystem areas and 73% of the area covered by the Natura 2000 network of protected areas were exposed to air pollution levels that exceeded eutrophication limits in 2010. The projections for 2020 indicate exposure to eutrophication will still be widespread (Map 3.4).

Map 3.4 **Areas where critical loads for eutrophication for freshwater and terrestrial habitats are exceeded (CSI 005) by nitrogen depositions caused by emissions between 1980 (top left) and 2030 (bottom right)**



Source: EEA, 2014d.

The divergence between levels of acidification and levels of eutrophication largely occurs because emissions of pollutants containing nitrogen (which can lead to eutrophication) have not fallen as much as emissions of sulphur (which causes acidification). Ammonia (NH_3) emitted from agricultural activities and nitrogen oxides (NO_x) emitted from combustion processes are the predominant air pollutants causing eutrophication (EEA, 2014d).

The EU Air Quality Directive has an objective to protect vegetation from high ozone concentrations. Most vegetation and agricultural crops are exposed to levels above the target. In 2011, this comprised 88% of Europe's agricultural area, with the highest values observed in southern and central Europe (EEA, 2013h).

European air policy has undergone substantial review, and proposals for the Clean Air Policy Package were adopted by the European Commission in late 2013. The package, which contains a range of measures and targets, is anticipated — if agreed and implemented as foreseen — to deliver a range of benefits. These benefits include protecting 123 000 km^2 of ecosystems from excess eutrophication (including 56 000 km^2 of protected Natura 2000 areas), and protecting 19 000 km^2 of forest ecosystems from acidification by 2030 compared to a business-as-usual scenario (EC, 2013a).

Beyond 2030, the time-frame of 2050 has been suggested as the time by which Europe should meet its long-term objectives of achieving levels of air pollution that do not lead to unacceptable harm to human health and the environment. Achieving these longer-term objectives and the necessary reductions in emissions will require integration of air, climate and biodiversity policies. In addition, the transboundary effects of air pollution remain challenging and emission reductions in Europe may not be enough on their own to achieve the long-term objectives.

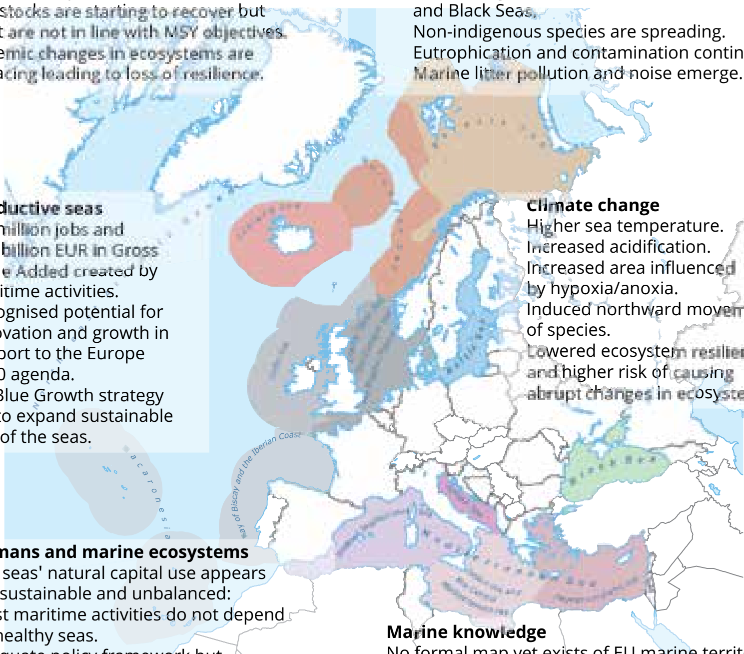
3.8 Marine and coastal biodiversity is declining, jeopardising increasingly needed ecosystem services

Trends and outlook: Marine and coastal biodiversity	
	5–10 year trends: A low number of species are in favourable conservation status or good environmental status.
	20+ year outlook: Pressures and effects of climate change on marine ecosystems are set to continue. Full implementation of policies is needed to deliver improvements.
☒	*Progress to policy targets:* Target to reach good environmental status by 2020 (rf. Marine Strategy Framework Directive) remains a significant challenge.
!	*See also:* SOER 2015 thematic briefings on marine environment; and maritime activities.

Marine and coastal areas provide natural resources as well as access to trade, transport, opportunities for recreation, and many other goods and services. Maritime and coastal activities remain essential to the European economy and society, with high expectations for 'blue growth' i.e. sustainable growth in the maritime sector. The Marine Strategy Framework Directive is the environmental pillar of the Integrated Maritime Policy. Together with EU nature legislation and the Biodiversity Strategy to 2020, the Marine Strategy Framework Directive forms the basis of the EU's policy to achieve healthy, clean and productive seas by 2020. The main objective of the Marine Strategy Framework Directive is achieving 'good environmental status' by 2020, and at its core is the concept of implementing an ecosystem-based approach to the management of human activities in the marine environment.

Europe's seas face a range of sustainability challenges (Map 3.5). Marine and coastal ecosystems and biodiversity are under pressure throughout Europe, and their status is of concern (Section 3.3). The target of achieving good environmental status by 2020 is at risk due to overfishing, sea floor damage, pollution by nutrient enrichment and contaminants (including marine litter and underwater noise), introduction of invasive alien species, and the acidification of Europe's seas.

Map 3.5 Regional seas surrounding Europe and the sustainability challenges they face



Healthy seas?
9% of marine habitat assessments and 7% of marine species assessments considered in favourable conservation status.
Clear signs that many species groups and habitats are not in good health due to loss of biodiversity.
Fish stocks are starting to recover but most are not in line with MSY objectives.
Systemic changes in ecosystems are surfacing leading to loss of resilience.

Clean and undisturbed seas?
Seafloor integrity threatened by physical loss and damage.
Overfishing has been decreasing since 2007 in EU Atlantic and Baltic waters, but 41% assessed stocks remain fished above MSY.
Overfishing is dominant in Mediterranean and Black Seas.
Non-indigenous species are spreading.
Eutrophication and contamination continues.
Marine litter pollution and noise emerge.

Productive seas
6.1 million jobs and 467 billion EUR in Gross Value Added created by maritime activities.
Recognised potential for innovation and growth in support to the Europe 2020 agenda.
EU Blue Growth strategy set to expand sustainable use of the seas.

Climate change
Higher sea temperature.
Increased acidification.
Increased area influenced by hypoxia/anoxia.
Induced northward movement of species.
Lowered ecosystem resilience and higher risk of causing abrupt changes in ecosystems.

Humans and marine ecosystems
The seas' natural capital use appears not sustainable and unbalanced: most maritime activities do not depend on healthy seas.
Adequate policy framework but challenges remain on its implementation.
Policy targets are often not met on time.
Scientific advice is not always heeded when setting targets.
Ecosystem-based management key to secure ecosystem services and their benefits.

Marine knowledge
No formal map yet exists of EU marine territory.
Many commercial fish stocks are not assessed.
Poor overview of spatial extent of human activities.
Insufficient regional coordination for sharing and harmonising marine data.
EU reporting obligations with high numbers of unknowns or not assessed.

Source: Adapted from EEA, 2014k.

Impacts from human activities have inadvertently combined to shift the balance of entire ecosystems, as witnessed in the Black and Baltic Seas, as well as some parts of the Mediterranean Sea. In response, European policies governing the coastal and marine environment now widely use an ecosystem-based approach, which aims to address the combined effects of multiple pressures. Targeted policy actions and committed management efforts towards balancing human activities can protect and restore species and habitats, helping preserve ecosystem integrity. The expansion of the marine Natura 2000 network of protected areas and of recent fisheries management efforts are examples of positive actions.

For commercially exploited fish stocks, fishing pressure has been decreasing since 2007 in EU Atlantic and Baltic waters, with visible improvement in the status of the fished stocks. The number of assessed stocks in these waters fished above their maximum sustainable yield has fallen from 94% in 2007 to 41% in 2014. In contrast, 91% of assessed stocks in the Mediterranean were being overfished in 2014 (EC, 2014e). However, the total number of commercially exploited stocks remains considerably higher than the number assessed. In the Black Sea the status of only seven stocks are known and five of them (71%) are overfished.

The new Common Fisheries Policy still has to overcome implementation challenges for Europe to reach the goal of fishing at maximum sustainable yield rates for all fish stocks by 2020. These challenges include fleet overcapacity, availability of scientific advice, adherence to scientific advice, an adequate uptake of management measures, and reduction of adverse effects on the ecosystem, particularly damage to the sea floor.

Achieving sustainable use of the marine environment is a challenge. The growth of maritime activities such as transport, offshore renewable energy generation, tourism, and extraction of living and non-living resources is taking place without the full understanding of the complex interactions between natural and human-induced changes. It is also taking place in the context of a lack of information on aspects of marine biodiversity and ecosystems. Therefore a key challenge will be to ensure coherence between blue growth on the one hand and the policy objectives of halting the loss of biodiversity and achieving good environmental status by 2020 on the other. This will be necessary for long-term ecosystem resilience and therefore for the social resilience of communities who depend on maritime activities.

3.9 The impacts of climate change on ecosystems and society call for adaptation measures

	Trends and outlook: Climate change impacts on ecosystems
	5–10 year trends: Seasonal cycles and distribution of many species have changed due to temperature increase, warming oceans, and the shrinking of the cryosphere.
	20+ year outlook: Increasingly severe climate change and impacts on species and ecosystems are projected.
No target	*Progress to policy targets:* The EU 2013 Strategy and national strategies on climate change adaptation are being implemented, and mainstreaming of climate change adaptation in policies addressing biodiversity and ecosystems takes place to some extent.
!	*See also:* SOER 2015 thematic briefings on climate change impacts and adaptation; biodiversity; marine environment; and freshwater quality.

Climate change is occurring in Europe and around the world. Climatic changes have established new records in recent years: mean temperature has increased, and precipitation patterns have changed. Glaciers, ice sheets, and Arctic sea ice have also decreased much faster than previously projected (EEA, 2012a; IPCC, 2014a). Climate change is a stress factor for ecosystems, putting their structure and functioning at risk and undermining their resilience to other pressures (EEA, 2012b).

The key observed and projected impacts from climate change for the main biogeographical regions in Europe are shown in Map 3.6. European seas are affected by climate change through ocean acidification and increasing water temperatures. Coastlines are also vulnerable, facing rising sea levels, erosion, and more powerful storms. Freshwater systems are impacted through a decrease in river flows in southern and eastern Europe, and an increase in river flows in other regions. Freshwater ecosystems are also affected by an increase in the frequency and intensity of droughts (particularly in southern Europe), and by an increase in water temperature. Terrestrial ecosystems exhibit shifts in phenology and distribution, and also suffer from invasive alien species. Agriculture is affected by shifts in crop phenology, shifts in suitable cropping area, changes in yields, and by increased water demand for irrigation in southern and south-western Europe. Forests are affected by storm patterns, pests, diseases, droughts and forest fires (EEA, 2012a; IPCC, 2014a).

The provision of ecosystem services is projected to decline across all categories in response to climate change in the Mediterranean region and mountain areas. Both gains and losses in the provision of ecosystem services are projected for the other European regions, and the provision of cultural services such as recreation and tourism are projected to decline in the Continental, Northern and Southern regions (IPCC, 2014a).

Stronger and more numerous climate change impacts are projected for the future. Even if greenhouse gas emissions were to stop today, climate change would continue for many decades as a result of past emissions and the inertia of the climate system (IPCC, 2013). While mitigation of climate change is crucial, it is also necessary to adapt to already experienced changes in climate and to plausible future climate scenarios. Adaptation focuses on ensuring that even under changing conditions we maintain the functionality of the different assets that sustain us, including built infrastructure, the natural environment, and our culture, society and economy (EEA, 2013c).

Overall, Europe's capacity to adapt is high compared to other world regions. But there are important differences between different parts of Europe in terms of both the impacts they are likely to experience and their capacity to adapt (IPCC, 2014a). In 2013, an EU Strategy on adaptation to climate change was agreed. The Strategy supported mainstreaming (the process whereby adaptation concerns are integrated in existing sectoral EU policies) and funded adaptation actions in countries. It also enhanced research and information sharing. As of June 2014, 21 European countries had adopted national adaptation strategies, and 12 had also developed a national action plan (EEA, 2014n).

Map 3.6 Key observed and projected impacts from climate change for the main regions in Europe

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

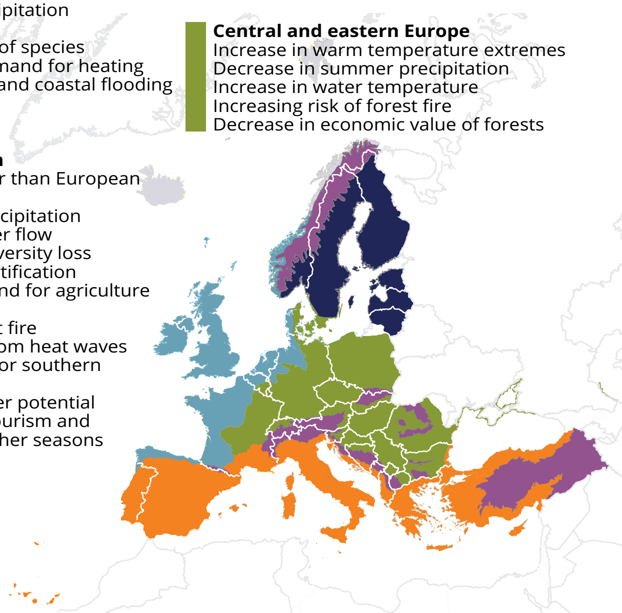
Coastal zones and regional seas
Sea-level rise
Increase in sea surface temperatures
Increase in ocean acidity
Northward expansion of fish and plankton species
Changes in phytoplankton communities
Increasing risk for fish stocks

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

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

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 heat waves
Expansion of habitats for southern disease vectors
Decrease in hydropower potential
Decrease in summer tourism and potential increase in other seasons



Source: EEA, 2012i.

Climate change risk or vulnerability assessments are available for 22 countries, but information is often lacking on the costs and benefits of adaptation. There is also an information gap regarding the effects of adaptation management actions on biodiversity as empirical studies are quite scarce (Bonn et al., 2014). Development of green infrastructure is an important tool in enhancing the role of nature-based adaptation and the European Commission has published guidelines for adaptation planning for the Natura 2000 network of protected sites (EC, 2013c).

Climate change adaptation brings several challenges to the fore. One challenge is the multiple governance levels that must be engaged: Europe needs to respond to the impacts of climate change at local, regional, national and EU levels. Another challenge is integrating the many different sectoral policy areas that are affected: adaptation requires the consideration of multiple synergies and trade-offs between competing objectives. These issues are particularly illustrated by forests. Forests have a multifunctional role, providing a range of services such as the provision of wood and other forest-based products, climate change mitigation and adaptation, recreation, and tourism opportunities. They also have tremendous biodiversity value (Forest Europe, UNECE and FAO, 2011).

3.10 Integrated management of natural capital can increase environmental, economic and social resilience

The need for integrated and adaptive management approaches for natural capital is clear. As illustrated by the case of nitrogen, responses to complex problems can be characterised by fragmented and parallel approaches that lose sight of the bigger picture (Box 3.3).

Within the individual areas presented in this chapter, there has been clear progress on some issues, but in many cases overall trends are heading in the wrong direction. There are critical knowledge gaps relating to the state and trends of ecosystem services. However, progress is being made and work under the Mapping and Assessment of Ecosystems and their Services

(MAES) process will make an important contribution in this regard. There are also gaps in legislation, particularly in relation to soil, and these gaps jeopardise the provision of ecosystem services.

The recent shift in the policy framework to a more systemic perspective on natural capital marks an important step towards the implementation of integrated management approaches. There are many synergies and co-benefits to a more integrated approach. Action to mitigate and adapt to climate change will increase the resilience of the economy and society while stimulating innovation and protecting natural resources. However, there are also trade-offs that need to be made explicit as there are nearly always costs (either to biodiversity and ecosystems or to people) with any particular course of action.

Box 3.3 The need for an integrated approach to manage nitrogen

Over the past century, humans have caused changes to the global nitrogen cycle and current levels already exceed globally sustainable limits (Rockström et al., 2009a). Humans have converted atmospheric nitrogen into many reactive nitrogen forms (which are essential for life but occur in limited amounts in nature). In Europe, the supply of reactive nitrogen into the environment has more than tripled since 1900, impacting on water quality, air quality, the greenhouse gas balance, ecosystems and biodiversity, and soil quality (Sutton et al., 2011).

Reactive nitrogen is extremely mobile, cascading through air, soils, and water, and changing between different forms of nitrogen compounds. This means that nitrogen management requires an integrated approach to avoid shifting pollution across soil, air, and water, or moving it downstream. It also requires international cooperation and bringing together different disciplines and stakeholders.

Existing policies related to nitrogen are fragmented and the European Nitrogen Assessment identified a package of seven key actions for better management of the European nitrogen cycle. These relate to agriculture, transport and industry, wastewater treatment and societal consumption patterns, and they aim to provide an integrated package for the development and application of policy instruments (Sutton et al., 2011). The 7th Environment Action Programme aims to ensure that by 2020 the nitrogen cycle is managed in a more sustainable and resource-efficient way.

Ecosystem-based management is a critical part of this integrated approach. The goal is to maintain ecosystems in a healthy, clean, productive and resilient condition, which also enables them to provide humans with the services and benefits they depend on. Ecosystem-based management is a spatial approach that acknowledges the connections, cumulative impacts, and multiple objectives that exist in a particular area. In this way, ecosystem-based management differs from traditional approaches that address single concerns e.g. species, sectors or activities (McLeod and Leslie, 2009). The implementation of this approach to the management of human activities — already occurring in the aquatic environment and within green infrastructure development — will provide important evidence and learning to inform the wider application of such long-term, interconnected approaches to tackling systemic environmental challenges.

Integrated management approaches also provide an opportunity to correct the prioritisation of manufactured capital over human, social and natural capital. Accounting systems — both physical and monetary — are important to inform policy and investment decisions, because getting the balance right between use, protection and enhancement of natural capital will require information on the current status of stocks. This is a challenge given the enormous scale and diversity of environmental stocks and flows and the need to quantify trends in a variety of different ecosystem elements.

Accounts will need to be complemented by indicators that can inform policy development, policy implementation, and monitor progress. The implementation of the revised UN System of Integrated Environmental and Economic Accounting (SEEA), the European Strategy for Environmental Accounting, and the development of ecosystem accounts are important steps forward. The Biodiversity Strategy target to assess the economic value of ecosystem services (and promote the integration of these values into accounting and reporting systems at EU and national level by 2020) is an important policy driver.

Protecting, conserving and enhancing natural capital requires action to improve ecological resilience and maximise the benefits environmental policy can deliver for the economy and society, while respecting the planet's ecological limits. Maintaining resilient ecosystems requires a strong, coherent policy framework with an emphasis on implementation, integration, and recognition of the relationship between ecosystem resilience, resource efficiency and human well-being. Chapter 4 will show how improving resource efficiency will ease the pressure on natural capital. Chapter 5 will show how enhancing ecosystem resilience will deliver benefits for human health and well-being.

Resource efficiency and the low-carbon economy

4.1 Increased resource efficiency is essential for continued socio-economic progress

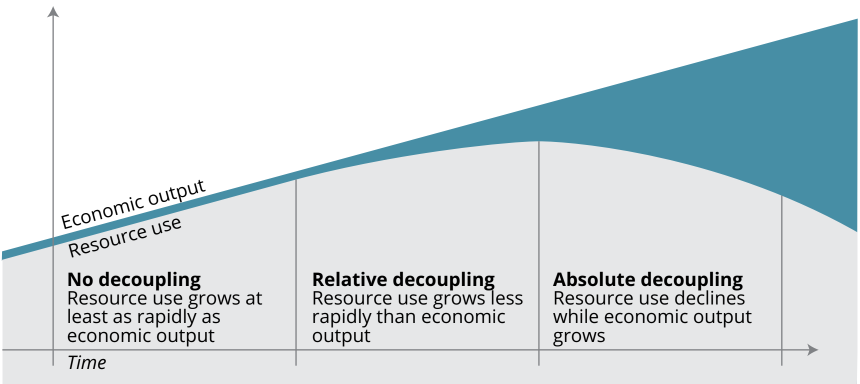
The emergence of resource efficiency and the low-carbon economy as European policy priorities is grounded in a recognition that the prevailing model of economic development — based on steadily growing resource use and harmful emissions — cannot be sustained in the long term. Already today, Europe's systems of production and consumption look vulnerable. The continent's ecological footprint (i.e. the area needed to meet Europe's resource demand) is twice the size of its land area (WWF, 2014), and the EU is heavily and increasingly reliant on imports to meet its resource needs (Eurostat, 2014d).

At the most basic level, resource efficiency captures the notion of 'doing more with less'. It expresses the relationship of society's demands on nature (in terms of resource extraction, pollutant emissions and ecosystem pressures more broadly) to the returns generated (such as economic output or improved living standards). The transition to a low-carbon economy is one particularly important aspect of the broader goal of reducing the environmental burden of society's resource use.

Increasing resource efficiency is essential to sustain socio-economic progress in a world of finite resources and ecosystem capacity, but it is not sufficient. After all, increasing efficiency is only an indication that output is growing more than resource use and emissions. It does not guarantee a reduction in environmental pressures in absolute terms.

In assessing the sustainability of European systems of production and consumption, it is therefore necessary to move beyond measuring whether production is increasing faster than resource use and related pressures ('**relative decoupling**'). Rather, there is a need to assess whether there is evidence of '**absolute decoupling**', with production increasing while resource use declines (Figure 4.1). In addition to assessing the relationship of resource use to economic output, it is also important to evaluate whether the environmental impacts resulting from society's resource use are decreasing ('**impact decoupling').**

Figure 4.1 Relative and absolute decoupling



Source: EEA.

Box 4.1 Structure of Chapter 4

While the notion of 'doing more with less' is conceptually very simple, quantifying resource efficiency is often more complex in practice. First, resources differ greatly. Some are non-renewable, some renewable; some are depletable, some are not; some are hugely abundant, some extremely scarce. As a result, aggregating different resource types is often misleading and sometimes impossible.

Equally, the benefits that society derives from resources also vary greatly. In some instances it makes sense to evaluate resource efficiency by comparing resource inputs to economic outputs (for example GDP). In other cases, assessing whether society is using resources in ways that deliver the most benefits requires a broader approach, encompassing non-market factors such as the cultural values associated with landscapes.

Assessing resource efficiency trends therefore requires a range of different perspectives. Sections 4.3–4.10 of this chapter attempt to do this by addressing three different questions:

- Are we decoupling resource use, and outputs of waste and emissions from aggregate economic growth? This is addressed in Sections 4.3–4.5, which focus on material resources, carbon emissions, and waste prevention and management.
- Are we reducing the environmental pressures associated with particular sectors and consumption categories? This is addressed in Sections 4.6–4.8, which focus on energy, transport and industry. Agricultural trends and related environmental impacts are described in some detail in Chapter 3.
- Are we maximising the benefits that we derive from non-depletable but finite resources such as water and land? This is addressed in Sections 4.9 and 4.10.

4.2 Resource efficiency and greenhouse gas emission reductions are strategic policy priorities

In recent years, resource efficiency and the low-carbon society have emerged as central themes in global discussions on the transition to a green economy (OECD, 2014; UNEP, 2014b). The fundamental importance of these issues to future prosperity is likewise reflected in Europe's medium- and long-term planning. For example, priority objective 2 of the 7th Environment Action Programme (EU, 2013) identifies the need to 'turn the Union into a resource-efficient, green, and competitive low-carbon economy'.

At the strategic level, EU policy sets out a broad framework for resource efficiency and climate change policy, including a variety of long-term (non-binding) objectives. For example, the Roadmap to a Resource Efficient Europe (EC, 2011c) includes a vision for 2050, wherein 'the EU's economy has grown in a way that respects resource constraints and planetary boundaries, thus contributing to global economic transformation … all resources are sustainably managed, from raw materials to energy, water, air, land and soil' ([5]). Similarly, the Roadmap to a low-carbon economy (EC, 2011a) stipulates that, by 2050, the EU should cut its emissions to 80% below 1990 levels through domestic reductions.

These are complemented by policies addressing specific pressures and sectors. The EU's 2020 targets on greenhouse gas emissions and energy consumption (EC, 2010) are prominent examples. Others include the Regulation on Registration, Evaluation, Authorisation and restriction of Chemicals (REACH) (EU, 2006), the Industrial Emissions Directive (EU, 2010a) and the European Commission's White Paper on Transport (EC, 2011e).

([5]) The EU's Thematic Strategy on the use of natural resources (EC, 2005) defines resources broadly, including 'raw materials such as minerals, biomass and biological resources; environmental media such as air, water and soil; flow resources such as wind, geothermal, tidal and solar energy; and space (land area)'.

Another important cluster of policies aims to facilitate a shift away from the linear 'take-make-consume-dispose' pattern of growth, towards a circular model that extracts maximum value from resources by keeping them within the economy when a product has reached the end of its life. As noted in the European Commission's communication, Towards a circular economy: a zero-waste programme for Europe (EC, 2014d), the transition to a circular economy requires changes across supply chains, including in product design, business models, consumption choices, and prevention and management of waste.

Table 4.1 Examples of EU policies relating to Objective 2 of the 7th Environment Action Programme

Topic	Overarching strategies	Related directives
General	Resource-efficient Europe flagship initiative under the Europe 2020 Strategy Roadmap to a Resource Efficient Europe Roadmap for moving to a competitive low-carbon Europe	
Waste	Thematic Strategy on the prevention and recycling of waste	Waste Framework Directive Landfill Directive Waste Incineration Directive
Energy	Green Paper on a 2030 framework for climate and energy	Energy Efficiency Directive Renewables Directive
Transport	Roadmap to a single European transport area	Fuel Quality Directive Emissions Standards Directives
Water	Blueprint to Safeguard Europe's Water Resources	Water Framework Directive
Design and innovation	Eco-innovation Action Plan	Ecodesign and Energy Label Directives and the Ecolabel Regulation

Note: For more detailed information on specific policies, see the respective SOER 2015 thematic briefings.

4.3 Despite more efficient material use, European consumption remains very resource intensive

Trends and outlook: Material resource efficiency and use	
	5–10 year trends: There has been some absolute decoupling of resource use from economic output since 2000, although the economic recession contributed to this trend.
	20+ year outlook: European economic systems remain resource intensive, and a return to economic growth could reverse recent improvements.
No target	*Progress to policy targets:* The targets in this area are currently qualitative in character.
!	*See also:* SOER 2015 thematic briefings on resource efficiency; and consumption.

Faced with growing global competition for resources, European policies have put increasing focus on 'dematerialising' economic output, i.e. reducing the quantity of resources used by the economy. For example, the Roadmap to a Resource Efficient Europe (EC, 2011c) emphasises the risks associated with rising resource prices and the burdens on ecosystems that result from escalating demand for resources.

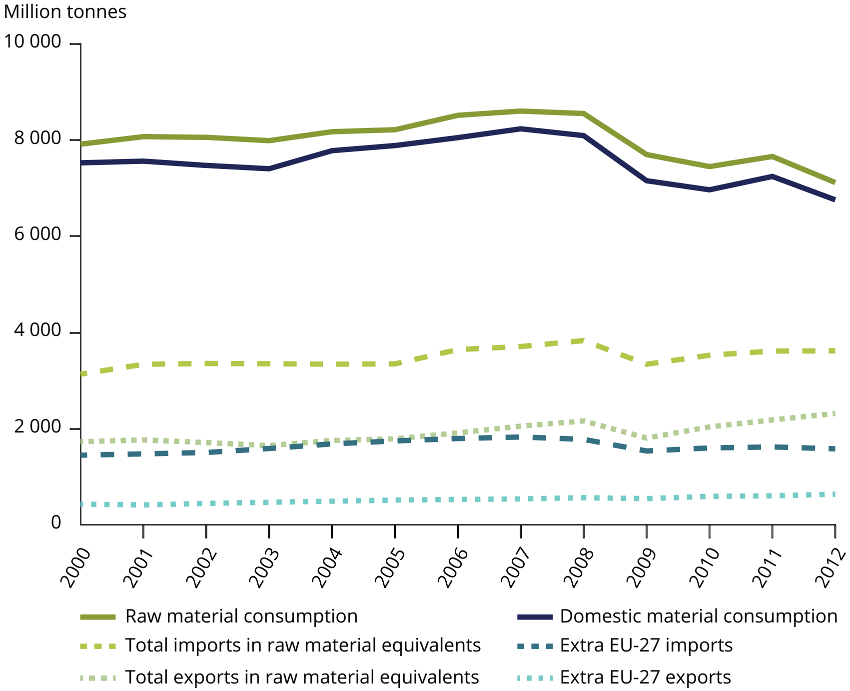
The EU's Resource Efficiency Scoreboard (Eurostat, 2014h), which is being developed pursuant to the Roadmap to a Resource Efficient Europe, presents a mixture of perspectives on resource efficiency trends. It establishes 'resource productivity' — the ratio of economic output (GDP) to domestic material consumption (DMC) — as its lead indicator. Domestic material consumption estimates the amount of raw materials (measured by mass) directly used by an economy, including both materials extracted from domestic territory and net inflows of goods and resources from abroad.

As the European Commission has noted (EC, 2014j), the indicator 'GDP/DMC' has some shortcomings. It clusters diverse resources by weight, obscuring huge differences in scarcity, value and associated environmental impacts. It also provides a distorted picture of resource demands from overseas, because it includes only net imports of resources, rather than encompassing the raw materials consumed in producing imports.

Recognising these limitations, Eurostat has developed EU-27 estimates of raw material consumption (RMC), which is sometimes described as the 'material footprint'. RMC provides a more complete picture of the resource use associated with European consumption by converting imports and exports into 'raw material equivalents', which estimate the raw materials used in producing traded goods. As illustrated in Figure 4.2, this conversion leads to a substantial increase in the resource use associated with EU external trade, although the overall impact on total EU resource consumption is fairly small.

Despite their limitations, DMC and RMC can provide a useful indication of the physical scale of the economy. As illustrated in Figure 4.2, EU resource

Figure 4.2 **EU-27 domestic material consumption and raw material consumption, 2000–2012**



Note: Raw material consumption data are only available for the EU-27. For comparability, the domestic material consumption data cover the same countries.

Source: Eurostat,2014d, 2014e.

consumption declined in the period 2000–2012, although the financial crisis of 2008 and subsequent economic recessions in Europe clearly contributed to this trend.

In contrast to the decline in material consumption, EU-28 GDP grew by 16% between 2000 and 2012. As a result, EU-28 resource productivity (GDP/DMC) increased by 29%, from 1.34 EUR/kg of resources used in 2000 to 1.73 EUR/kg in 2012. Despite recent improvements in resource productivity, European consumption patterns remain resource intensive by global standards.

In addition, other estimates of European resource use present a less optimistic picture of efficiency improvements. For example, Wiedmann et al. (2013) calculate that the EU-27 material footprint increased in line with GDP in the period 2000–2008. This raises questions about the resource intensity of European lifestyles. Apparent efficiency improvements may partially be explained by the relocation of material extraction and manufacturing to other areas of the world.

4.4 Waste management is improving but Europe remains far from a circular economy

Trends and outlook: Waste management	
	5–10 year trends: Less waste is being landfilled due to reduced generation of some wastes, increased recycling and greater use of waste for energy recovery.
	20+ year outlook: Total waste generation is still high, although implementation of waste prevention programmes could alleviate this.
□	*Progress to policy targets:* Past successes with some waste streams, but only mixed progress across countries towards meeting recycling and landfill targets.
!	*See also:* SOER 2015 thematic briefings on resource efficiency; and consumption.

The notion of the 'circular economy where nothing is wasted' (EU, 2013) is central to efforts to boost resource efficiency. Waste prevention, reuse and recycling enable society to extract maximum value from resources, and adapt consumption to actual needs. In doing so, they reduce demand for virgin resources, thereby mitigating related energy use and environmental impacts.

Improving waste prevention and management requires action across the full product lifecycle, not merely the end-of-life phase. Factors such as design and choice of material inputs play a major role in determining a product's useful lifespan and the possibilities for repair, reusing parts, or recycling.

The EU has introduced multiple waste policies and targets since the 1990s, ranging from measures targeting specific waste streams and treatment options, towards broader instruments such as the Waste Framework Directive (EU, 2008b). These measures are complemented by product legislation such as the Ecodesign Directive (EU, 2009c) and the Ecolabel Regulation (EU, 2010b), which aim to influence both production and consumption choices.

As set out in the Waste Framework Directive, the overarching logic guiding EU policy on waste is the waste hierarchy, which prioritises waste prevention, followed by preparation for reuse; recycling; recovery; and finally disposal as the least desirable option. Viewed against this framework, European trends in waste generation and management are largely positive. Although data gaps and differences in national methodologies for calculating waste introduce uncertainties into data, there is some evidence that waste generation has declined. EU-28 per capita waste generation (excluding mineral wastes) declined by 7% in the period 2004–2012, from 1 943 kg/person to 1 817 kg/person (Eurostat, 2014c).

Available data indicate some decoupling of waste generation from economic production in the manufacturing and service sectors, and from household spending in the consumption phase. Per capita generation of municipal waste declined by 4% between 2004 and 2012, falling to 481 kg per capita.

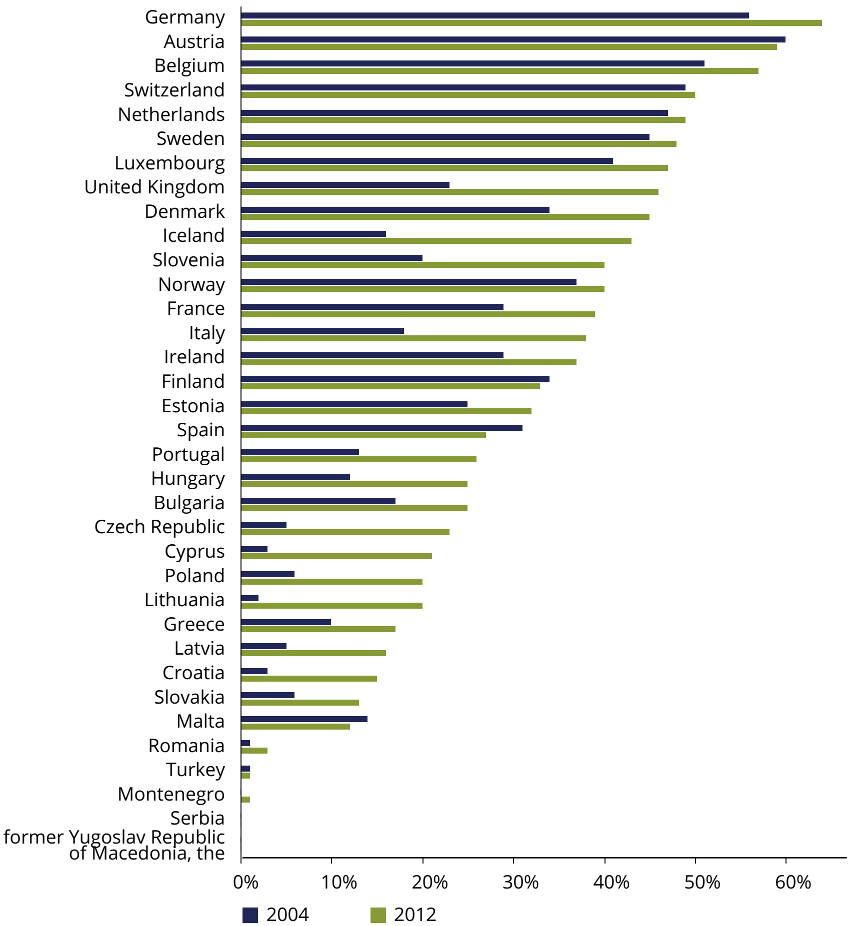
Looking beyond waste generation, there are also signs of improved waste management in Europe. Between 2004 and 2010, the EU-28, Iceland and Norway reduced the amount of waste deposited in landfills substantially, from 31% of total waste generated (excluding mineral, combustion, animal and vegetable wastes) to 22%. This was partly due to an improvement in recycling rates of municipal waste, from 28% in 2004 to 36% in 2012.

Better waste management has reduced pressures associated with waste disposal, such as pollution from incineration or landfilling. But it has also mitigated pressures associated with extracting and processing new resources. The EEA estimates that improved municipal waste management in the EU-27, Switzerland and Norway cut annual net greenhouse gas emissions by 57 million tonnes of CO_2-equivalent in the period 1990–2012, with most of that reduction achieved since 2000. The two main factors responsible for this were reduced methane emissions from landfill and avoided emissions through recycling.

Recycled materials meet a substantial proportion of EU demand for some materials. For example, they accounted for about 56% of EU-27 steel production in recent years (BIR, 2013). However, the large differences in recycling rates across Europe (illustrated for municipal waste in Figure 4.3) indicate that there are significant opportunities for increased recycling in many countries. Better recycling technologies, infrastructure, and collection rates could further reduce environmental pressures and European reliance on resource imports, including some critical materials (EEA, 2011a). On the other hand, overcapacity in incineration plants in some countries presents a competitive challenge for recycling, making it harder to shift waste management up the waste hierarchy (ETC/SCP, 2014).

Despite recent progress in waste prevention and management, EU waste generation remains substantial, and performance relative to policy targets is mixed. The EU appears to be progressing towards its 2020 objective of achieving a decline in waste generated per capita. But waste management will need to change radically in order to phase out completely the landfilling of recyclable or recoverable waste. Similarly, many EU Member States will need to make an extraordinary effort in order to achieve the target of 50% recycling of some municipal waste streams by 2020 (EEA, 2013l, 2013m).

Figure 4.3 Municipal waste recycling rates in European countries, 2004 and 2012



Note: The recycling rate is calculated as the percentage of municipal waste generated that is recycled and composted. Changes in reporting methodology means that 2012 data are not fully comparable with 2004 data for Austria, Cyprus, Malta, Slovakia and Spain. 2005 data used instead of 2004 for Poland due to changes in methodology. Due to data availability instead of 2004 data, 2003 data were used for Iceland; 2007 data used for Croatia; 2006 data used for Serbia. For the former Yugoslav Republic of Macedonia, 2008 data were used for 2004, and 2011 used for 2012.

Source: Eurostat Data Centre on Waste.

4.5 The transition to a low-carbon society requires greater greenhouse gas emission cuts

Trends and outlook: Greenhouse gas emissions and climate change mitigation	
	5–10 year trends: The EU has cut greenhouse gas emissions to 19.2% below 1990 levels while increasing GDP by 45%, halving 'emission intensity'.
	20+ year outlook: The projected reductions of EU greenhouse gas emissions as result of implemented policies are insufficient to bring the EU on a pathway towards the 2050 decarbonisation target.
☑/☒	*Progress to policy targets:* The EU is on track to 'over-deliver' on its international and domestic 2020 targets, but is not on track towards its 2030 and 2050 targets.
!	*See also:* SOER 2015 thematic briefing on mitigating climate change.

In order to avoid 'dangerous interference with the climate system', the international community has agreed to limit the global mean temperature increase since pre-industrial times to less than 2 °C (UNFCCC, 2011). In line with the Intergovernmental Panel on Climate Change assessment of the actions needed by developed countries to achieve the 2 °C target, the EU aims to cut its greenhouse gas emissions by 80–95% below 1990 levels by 2050 (EC, 2011a).

Pursuant to this overarching goal, European countries have adopted a number of policy measures, including international commitments under the Kyoto Protocol. For 2020, the EU has unilaterally committed to cut its emissions by at least 20% compared to 1990 levels (EC, 2010).

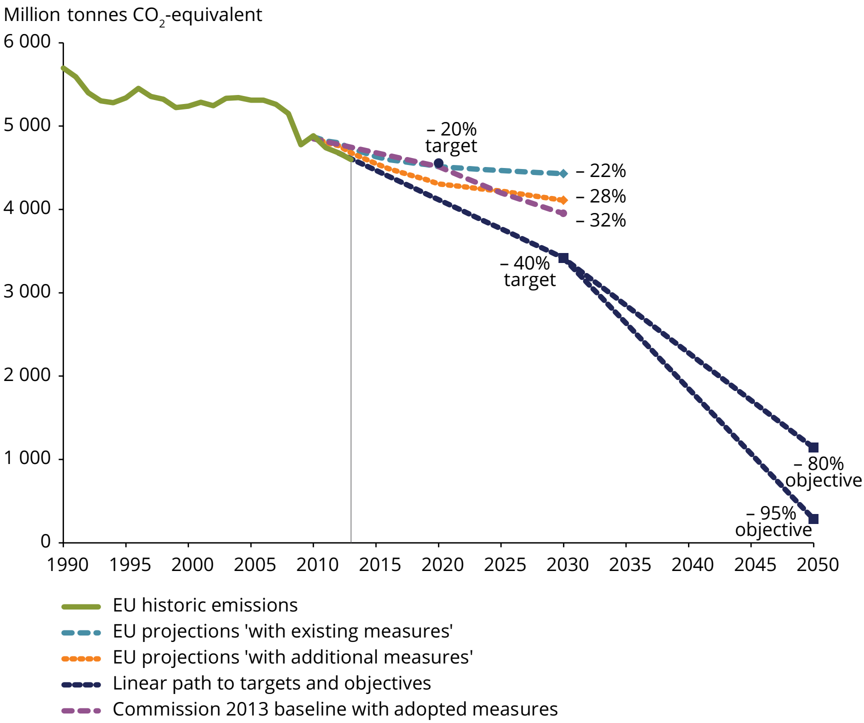
In the last two decades, the EU has made significant advances in decoupling carbon emissions from economic growth. EU-28 greenhouse gas emissions declined by 19% in the period 1990–2012, despite a 6% increase in population and a 45% expansion of economic output. As a result, greenhouse gas emissions per euro of GDP fell by 44% over this period. EU per capita emissions declined from 11.8 tonnes of CO_2-equivalent in 1990 to 9.0 tonnes in 2012 (EEA, 2014h; EC, 2014a; Eurostat, 2014g).

Both macroeconomic trends and policy initiatives have contributed to these emission reductions. Economic restructuring in eastern Europe during the 1990s played a role, particularly via changing agricultural practices and the closure of heavily polluting plants in the energy and industrial sectors.

More recently, the financial crisis and subsequent economic problems in Europe certainly contributed to a sharp decline in emissions (Figure 4.4), although EEA analysis indicates that economic contraction accounted for less than half of the decline in emissions between 2008 and 2012 (EEA, 2014x). In the period 1990–2012, climate and energy policies had a significant impact on greenhouse gas emissions, boosting energy efficiency and the share of renewables in the energy mix of European countries.

The EU's success in mitigating carbon emissions is reflected in robust progress towards its policy targets in this area. EU-15 total average

Figure 4.4 Greenhouse gas emission trends (1990–2012), projections to 2030 and targets to 2050



Source: EEA, 2014w.

emissions in the period 2008–2012 were 12% below base-year levels ([6]), implying that the EU-15 comfortably achieved its 8% reduction target under the Kyoto Protocol's first commitment period. The EU-28 is already very close to meeting its unilateral 20% reduction target for 2020, and looks well set to achieve its commitment to reduce average emissions to 20% below base-year levels in the Kyoto Protocol's second commitment period (2013–2020).

These achievements notwithstanding, the EU remains far from the 80–95% reduction needed by 2050. According to Member State projections, existing policy measures would only reduce EU-28 emissions by one percentage point between 2020 and 2030, to 22% below 1990 levels, and implementing the additional measures currently planned would increase this reduction to 28%. The European Commission estimates that full implementation of the Climate and Energy Package for 2020 would reduce emissions in 2030 to 32% below 1990 levels (Figure 4.4).

These projections imply existing measures will be insufficient to achieve the 40% reduction by 2030, which has been proposed by the European Commission as the minimum needed to remain on course for the 2050 target (EC, 2014c).

Estimates of the emissions associated with European consumption (including greenhouse gas emissions 'embedded' in net trade flows) indicate that European demand also drives emissions in other parts of the world. Estimates based on the World Input-Output Database indicate that in 2009 the CO_2 emissions associated with EU-27 consumption equalled 4 407 million tonnes, which was 2% higher than in 1995 (EEA, 2013g). In comparison, the UNFCCC production-based estimate of 4 139 million tonnes in 2009, was 9% lower than in 1995. For more information on Europe's contribution to global emissions see Section 2.3.

These data indicate that, in order to meet its 2050 objectives and contribute fully to meeting the global 2 °C target, the EU will need to accelerate its implementation of new policies, while restructuring the ways that Europe meets its demand for energy, food, transport and housing.

([6]) Under the Kyoto Protocol, the greenhouse gas emission level in the 'base year' is the relevant starting point for tracking progress towards national Kyoto targets. Base-year levels are calculated primarily based on greenhouse gas emissions in 1990.

4.6 Reducing fossil fuel dependence would cut harmful emissions and boost energy security

Trends and outlook: Energy consumption and fossil fuel use	
	5–10 year trends: Renewable energy has increased substantially in the EU and energy efficiency has also improved.
	20+ year outlook: Fossil fuels continue to dominate EU energy production. Transforming the energy system into an environmentally compatible one requires substantial investments.
☑	*Progress to policy:* The EU is on track to meet its 20% renewable energy target in 2020 and its 20% energy efficiency target in 2020.
!	*See also:* SOER 2015 thematic briefings on energy; and mitigating climate change.

Although fundamental to modern lifestyles and living standards, energy production is also responsible for considerable harm to the environment and human well-being. As in other world regions, fossil fuels dominate the European energy system, accounting for more than three-quarters of EEA-33 energy consumption in 2011 and almost 80% of greenhouse gas emissions (EEA, 2013i).

Cutting Europe's reliance on fossil fuels — by reducing energy consumption and switching to alternative energy sources — is essential to achieve the EU's 2050 climate policy goals. It would also deliver substantial additional economic, environmental and social benefits. Fossil fuels are responsible for most emissions of pollutants such as sulphur oxides (SO_X), nitrogen oxides (NO_X) and particulate matter. In addition, Europe's growing reliance on fossil fuel imports makes it vulnerable to supply constraints and price volatility, particularly in view of the escalating energy demand of fast-growing economies in south and east Asia. In 2011, 56% of all fossil fuels consumed in the EU were imported, compared to 45% in 1990.

Responding to these concerns, the EU has committed that by 2020 it will reduce energy consumption by 20% relative to business-as-usual projections. In absolute terms, that translates into a 12% reduction relative to energy consumption in 2010 (EU, 2012). The EU also intends that renewable energies will contribute 20% of final energy consumption by 2020, with a minimum 10% share in transport (EU, 2009a).

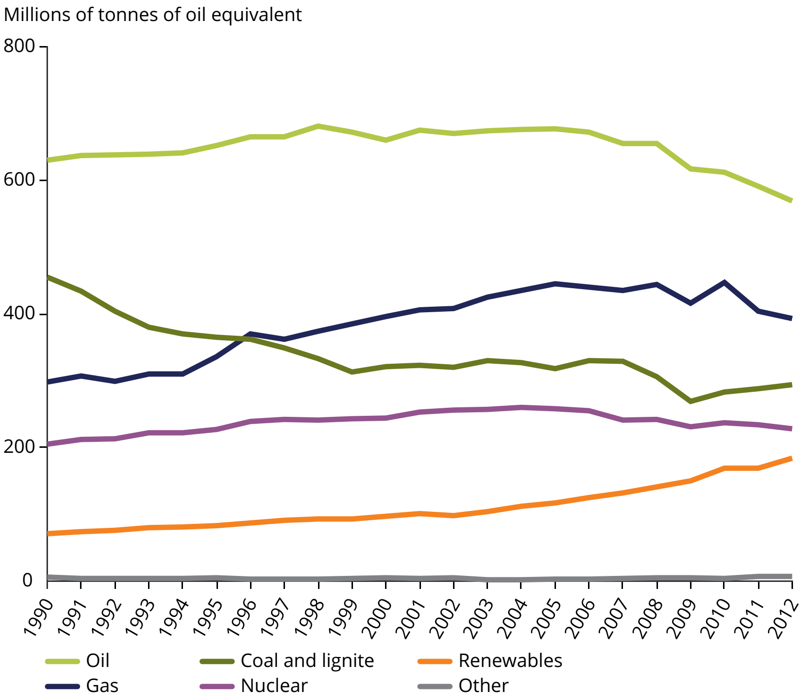
European heads of state and government have agreed new headline targets for 2030, reducing greenhouse gases emissions by at least 40% from 1990 levels, increasing renewable energy to make up at least 27% of final energy consumption, and cutting energy consumption by at least 27% compared to business-as-usual (European Council, 2014).

The EU has already achieved some success in decoupling energy use from economic output. In 2012, gross inland energy consumption in the EU was 1% higher than in 1990, despite a 45% increase in economic output during that period. Although the economic turmoil of recent years has constrained energy demand, policies and measures have also played a key role. Looking ahead, analysis of national energy efficiency action plans indicates that full implementation and enforcement of national energy efficiency policies would enable the EU to achieve its 2020 target (EEA, 2014w).

Turning to the energy mix, the EU remains heavily dependent on fossil fuels, although their contribution to gross inland energy consumption declined from 83% in 1990 to 75% in 2012. This decline was largely offset by increased use of renewable energy, which accounted for 11% of EU primary energy consumption in 2012, up from 4% in 1990 (Figure 4.5). As a result, the EU is on track to achieve its 2020 target for renewables, which requires that they should account for 20% of the EU's gross final energy consumption (EEA, 2013n).

Ensuring a cost-efficient transformation of the European energy system necessitates a diverse mixture of actions addressing both supply and demand at the continental scale. On the supply side, breaking the continuing dominance of fossil fuels will require a strong commitment to improving energy efficiency, deploying renewable energy, and continuous climate and environment proofing of energy projects. Substantial investments and regulatory change will be needed to integrate networks and facilitate the growth of renewables. On the demand side, there is a need for fundamental changes in society's energy use. Smart meters, appropriate market incentives, access to finance for households, energy saving appliances, and high performance standards for buildings can all contribute.

Figure 4.5 **Gross inland energy consumption by fuel (EU-28, Iceland, Norway and Turkey), 1990–2012**



Note: The following percentage figures quantify the proportion of total gross inland energy consumption that each fuel contributed in 2012: oil 34%, gas 23%, coal and lignite 18%, nuclear 14%, renewables 11%, other 0%.

Source: EEA, 2014v.

4.7 Increasing transport demand affects the environment and human health

Trends and outlook: Transport demand and related environmental impacts	
	5–10 year trends: The economic crisis lowered transport demand and reduced pollutant and greenhouse gas emissions, but transport continued to cause harmful impacts.
	20+ year outlook: Certain transport-related impacts are decreasing, but creating a sustainable mobility system will require faster introduction of measures to control impacts.
☐	*Progress to policy targets:* Good progress to efficiency and short-term greenhouse gas targets but a significant distance remains toward longer-term policy objectives.
!	*See also:* SOER 2015 thematic briefing on transport.

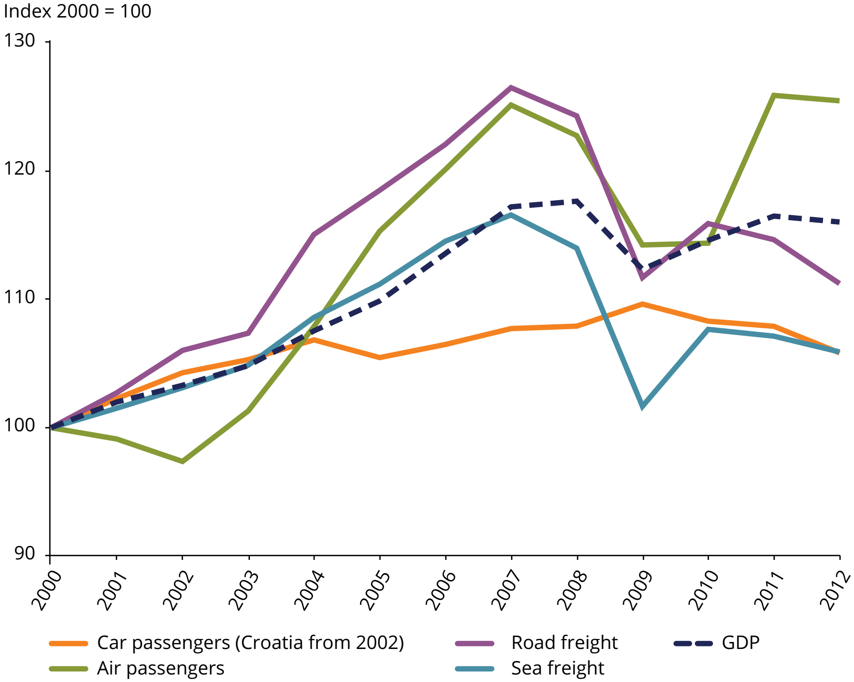
European demand for transport has increased in line with GDP in recent years, reflecting the close interdependence of transport and economic development. Although use of several transport modes has declined slightly since 2007 relative to their pre-recession peaks, air travel reached an all-time high in 2011 (Figure 4.6).

Transport systems can also impose numerous costs on society, particularly in terms of air and noise pollution (see also Sections 5.4 and 5.5), greenhouse gas emissions (Section 4.5) and landscape fragmentation (Sections 3.4 and 4.10). Harmful health and environmental impacts from transport can be reduced in three ways: **avoiding** unnecessary transport; **shifting** necessary transport from environmentally harmful to more environmentally friendly modes; and **improving** the environmental performance of all modes of transport, including the efficient use of infrastructure.

European measures to reduce transport emissions have tended to focus on the last of these approaches: improving efficiency. These measures have included fuel-quality standards; exhaust-emission limits for air pollutants and carbon dioxide (CO_2); and inclusion of the transport sector within national emission limits for air pollutants (EU, 2001b), and under the EU Effort Sharing Decision for greenhouse gases (EU, 2009b).

These measures have achieved some success. The introduction of technologies such as catalytic converters, for example, has greatly reduced road transport pollution. Member States are also making progress towards the goal of providing 10% of transport energy in each country from renewable sources by 2020. And carbon dioxide (CO_2) emissions per km are declining in accordance with the targets set out in EU legislation for new vehicles (EU, 2009d).

Figure 4.6 Growth in modal transport demand (km) and GDP in EU-28



Source: Based on EC (2014a) and Eurostat (2014b).

Nevertheless, efficiency improvements alone will not address all environmental concerns, partly because efficiency gains are often offset by growing demand (Box 4.2). Transport, including emissions from international transport, is the only EU sector to have increased its greenhouse gas emissions since 1990, accounting for 24% of total emissions in 2012. Road traffic is also the dominant source of noise in terms of the numbers of people exposed to harmful levels, with rail and aircraft also contributing to population exposure.

Alongside increasing traffic volumes, the promotion of diesel vehicles is contributing to air quality problems. This is because diesel cars generally emit more particulate matter and nitrogen oxides than petrol cars but less carbon dioxide, although recent data indicate that the carbon dioxide difference is decreasing (EEA, 2014l). In addition, NO_X emissions from diesel vehicles under real-world driving conditions often exceed the test-cycle limits specified in the Euro emission standards, a problem that also affects official fuel consumption and CO_2-emission values.

Developing alternative fuel vehicles could certainly reduce the burden placed on the environment by the transport system. However, it will require very large investments in infrastructure (in both the transport and energy sectors) and the displacement of entrenched fossil fuel-based systems. Moreover, it will not solve other problems such as congestion, road safety, noise levels, and land use.

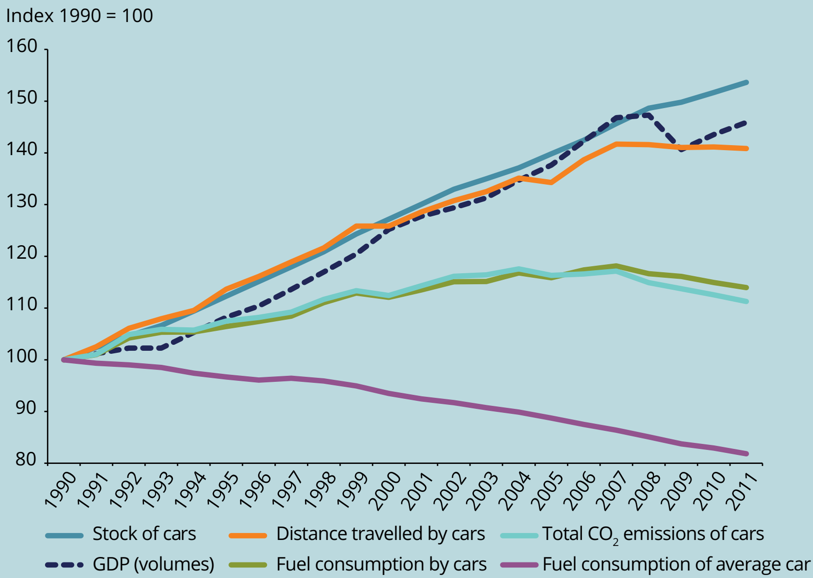
For these reasons, more fundamental changes in the way Europe transports passengers and goods will be needed. Encouragingly, there is some evidence of a cultural shift away from car use in developed regions, particularly among younger generations (Goodwin, 2012). At the same time, cycling, using a car pool, or opting for public transport are becoming more popular.

Box 4.2 Limited gains from efficiency improvements in the car transport sector

Efficiency improvements are often insufficient to guarantee a decline in environmental pressures. Technology-driven gains may be undermined by lifestyle changes or increased consumption, partly because efficiency improvements tend to make a product or service cheaper. This phenomenon is known as the 'rebound effect'. This trend is apparent in the transport sector. Although fuel efficiency and emission characteristics of cars improved steadily in the period 1990 to 2009, rapid growth in car ownership and in kilometres driven offset the potential improvements. The subsequent decline in distance travelled and fuel consumption was clearly linked to the economic problems since 2008.

The European Commission's White Paper on Transport (EC, 2011e) calls for carbon dioxide (CO_2) emissions from transport to be reduced by at least 60% by 2050, compared to 1990 levels. The use of new technologies has been identified as the most important means to achieve this reduction. However, as the trends in Figure 4.7 illustrate, technical solutions may not always deliver expected reductions in environmental pressures. Creating a transport system that maximises social and economic benefits, while minimising environmental and human harm, requires an integrated approach, addressing both production and consumption.

Figure 4.7 Fuel efficiency and fuel consumption in private cars, 1990–2011



Source: Odyssee database (Enerdata, 2014) and EC, 2014a.

4.8 Industrial pollutant emissions have declined but still cause considerable damage each year

Trends and outlook: Industrial pollution to air, soil and water	
	5–10 year trends: Industrial emissions are decoupling from industrial output in absolute terms.
	20+ year outlook: Industrial emissions are expected to decrease further, but harm to the environment and human health remains considerable.
□	*Progress to policy targets:* Good progress in implementation of Best Available Techniques. Policy has been strengthened through the Industrial Emissions Directive, which remains to be fully implemented.
!	*See also:* SOER 2015 thematic briefings on industry; air pollution; soil; and freshwater quality.

Like the energy and transport sectors, European industry delivers a complex mixture of benefits and costs to society. In addition to producing goods and services, the sector generates substantial employment, earnings and tax revenues. Yet industry also contributes significantly to the emissions of many important air pollutants and greenhouse gases, causing widespread harm to the environment and human health.

EU policies such as the Integrated Pollution Prevention and Control (IPPC) Directive (EU, 2008a) and related directives have played an important role in limiting the adverse environmental effects of industrial production in recent decades. More recently, the obligations on industry have been brought together in the Industrial Emissions Directive (EU, 2010a), which sets out requirements for some 50 000 large industrial installations to avoid or minimise emissions and waste.

In terms of climate change policy, the most important measure addressing industry is the EU Emissions Trading System (EU, 2003, 2009b) (Box 4.3). The EU Emissions Trading System addresses the greenhouse gas emissions from more than 12 000 installations in power generation, manufacturing, and industry in 31 countries. It also addresses the greenhouse gas emissions from about 1 300 aircraft operators, covering around 45% of EU greenhouse gas emissions in total. Greenhouse gas emissions covered by the EU Emissions Trading System decreased by 19% between 2005 and 2013.

Box 4.3 The EU Emissions Trading System

The EU Emissions Trading System is a tool for improving efficiency, offering a means to enhance economic returns within ecosystem boundaries. It operates by establishing a limit for the greenhouse gas emissions in various sectors and enabling participants to trade their individual emissions entitlements, thereby creating incentives for emission reductions to occur where they are cheapest.

Although the EU Emissions Trading System has been successful in delivering emission reductions, it has been criticised in recent years for failing to incentivise sufficient low-carbon investment. This has primarily occurred because Europe's unanticipated economic difficulties since 2008 contributed to low demand for allowances. A large surplus of emission allowances accumulated, affecting carbon prices.

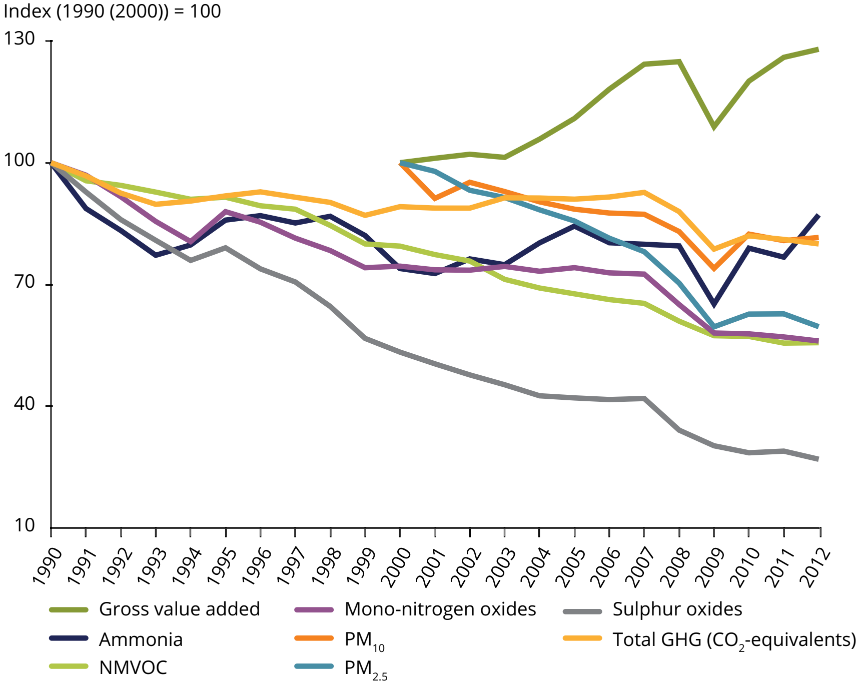
As an initial response, the ETS Directive was amended in December 2013 and the auctioning of 900 million allowances was later postponed from 2014–2016 to 2019–2020. In January 2014, the Commission proposed establishing a Market Stability Reserve to make the EU Emissions Trading System more robust and ensure that it continues to deliver cost-effective emission reductions (EC, 2014h).

Europe's industrial emissions of pollutants and greenhouse gases have decreased since 1990, while sectoral economic output has increased (Figure 4.8). Environmental regulations such as the EU's Large Combustion Plant (LCP) Directive (EU, 2001a), have contributed to these reductions. Other factors contributing to emissions reductions include energy efficiency, changes in the energy mix, end-of-pipe pollutant abatement technologies, a shift in Europe away from certain heavy and more polluting types of manufacture, and company participation in voluntary schemes to reduce environmental impacts.

Despite the improvements presented in Figure 4.8, industry continues to contribute significantly to European air pollutant and greenhouse gas emissions. In 2012, industry accounted for 85% of emissions of sulphur dioxide (SO_2), 40% of emissions of nitrogen oxides (NO_X), 20% of emissions of fine particulate matter ($PM_{2.5}$) and non-methane volatile organic compounds, and 50% of greenhouse gas emissions in EEA-33 countries (EEA, 2014b, 2014h).

The costs associated with Europe's industrial air pollution are considerable. According to recent EEA analysis, the damage costs (relating to harm to human health, crop yield losses and material damage) associated with air pollution released by the 14 000 most polluting facilities in Europe are estimated to be at least EUR 329–1 053 billion in the five year period 2008–2012. It is estimated that half of the costs occurred as a result of the emissions from just 147, or 1%, of the facilities (EEA, 2014t).

Figure 4.8 **Industry emissions (air pollutants and greenhouse gases) and gross value added (EEA-33), 1990–2012**



Source: EEA, 2014o; and Eurostat, 2014f.

Looking ahead, further implementation of the Industrial Emissions Directive will help reduce these impacts. In addition, the European Commission's proposed Clean Air Policy Package (EC) puts forward a new directive on medium-sized combustion plants (EC, 2013f), which would reduce the annual emissions from these plants by an estimated 45% for sulphur dioxide (SO_2), 19% for nitrogen oxides (NO_X), and 85% for particulate matter (EC, 2013d).

Future actions to strengthen pollution controls at source would also benefit from being complemented with measures to steer consumers towards less harmful products and services. As noted in Sections 4.3 and 4.4, consumption-based estimates of resource use and greenhouse gas emissions suggest that the benefits of less harmful production in Europe may be partially offset by increasing environmental pressures in other world regions linked to the production of goods for the European market.

4.9 Reducing water stress requires enhanced efficiency and water demand management

Trends and outlook: Water use and water stress	
	5–10 year trends: Water use is decreasing for most sectors and in most regions but agricultural water use, in particular in southern Europe, remains a problem.
	20+ years outlook: Water stress remains a concern in some regions, and efficiency improvements may not offset all impacts of climate change.
☒	*Progress to policy targets:* Water scarcity and droughts continue to affect some European regions, impacting both economic sectors and freshwater ecosystems.
!	*See also:* SOER 2015 thematic briefings on freshwater quality; hydrological systems and sustainable water management; climate change impacts and adaptation; and agriculture.

Freshwater ecosystems deliver essential services to our societies and economies. Yet in many instances, human demand for water is in direct competition with the water needed to maintain ecological functions. Managing water sustainably means first ensuring that humans and ecosystems alike have the quantity and quality of water to meet their needs, and then allocating and using the remaining resources in ways that most benefit society. The EU's Water Framework Directive and Groundwater Directive define the boundaries for sustainable water use via the 'good status' objective for surface water (rivers and lakes) and groundwater bodies (see Section 3.5).

In Europe, humans abstract on average around 13% of all renewable and accessible freshwater from natural water bodies, including surface waters and groundwater. Although this extraction rate is relatively low by global standards, over-exploitation still poses a threat to Europe's freshwater resources (EEA, 2009b).

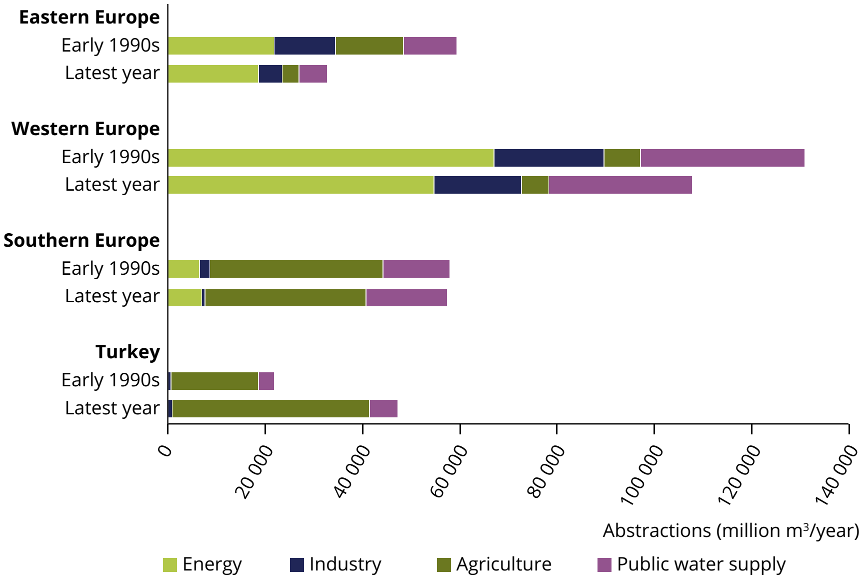
European water abstraction has declined overall since the 1990s (Figure 4.9). However, agriculture, industry, public-water supply and tourism put considerable stress on Europe's water resources. Demand often exceeds local availability, particularly during the summer (EEA, 2009b, 2012j). Eurostat data for the period 1985–2009 indicate that five European countries (Belgium, Cyprus, Italy, Malta and Spain) abstracted more than 20% of their available resources, suggesting that their water resources are under stress. However, aggregated annual national data do not necessarily reflect the extent and severity of over-exploitation of water resources at sub-national levels, or seasonal variation in water availability and use.

The costs associated with mismanagement of water resources can be very substantial. Over-abstraction is causing low river flows, lowered groundwater levels, and the drying-up of wetlands. All of these trends have detrimental impacts on freshwater ecosystems. In 2007, the European Commission (EC, 2007a) estimated that at least 17% of EU territory had been affected by water scarcity and put the cost of droughts in Europe over the previous 30 years at EUR 100 billion — with significant consequences for the associated aquatic ecosystems and dependent users (EEA, 2009b). Climate change is projected to increase water shortages, particularly in the Mediterranean region (EEA, 2012a).

There are many opportunities to enhance water-use efficiency, alleviating environmental pressures but potentially also delivering cost savings and co-benefits such as reduced energy use (for example in treatment of drinking water and wastewater).

Industrial and public water management can be improved through measures such as more efficient production processes, water-saving measures in buildings, and better urban planning. The variance in leakage

Figure 4.9 Changes in the use of freshwater for irrigation, industry, energy cooling and public water supply since the early 1990s



Note: The data show the aggregate water abstraction per country or region. The 'early 1990s' data are based on the earliest available data for each country since 1990 and most relate to 1990–1992. The 'latest year' relates to the most recent available data for each country and most relate to 2009–2011. For an explanation of the countries included in each region see CSI 018.

Source: Eurostat, 2014a.

rates from water pipes across Europe — from less than 10% in some locations to more than 40% in others — also points to opportunities to achieve substantial water savings (EEA, 2012c). In the agricultural sector, water-efficient irrigation techniques such as drip irrigation, altered crop patterns, and wastewater reuse are particularly promising (EEA, 2012h).

Across economic sectors, effective water metering and pricing have an essential role in improving demand management and incentivising the most beneficial allocation of water within society (after sufficient water has been allocated to satisfy the needs of humans and ecosystems). However, a review of European water pricing (EEA, 2013d) found that many Member States fall well short of the Water Framework Directive's requirement that they recover the full costs of providing water services, including resource and environmental costs. Irrigation water tariffs in particular are often highly subsidised, arguably incentivising inefficient water use.

4.10 Spatial planning strongly influences the benefits that Europeans derive from land resources

As with water resources, Europe's land resources are finite and can be used in diverse ways, such as for forestry, pasture, biodiversity conservation or urban development. These choices provide contrasting mixtures of benefits and costs to land owners, local people, and society as a whole. Land-use changes that offer increased economic returns from land (such as agricultural intensification or urban sprawl) can imply the loss of non-market benefits such as carbon sequestration or the cultural value of traditional landscapes. Better land management therefore consists of finding ways to balance such trade-offs.

In practice, this tends to mean constraining the growth of urban areas and limiting intrusions of infrastructure (such as transport networks) into nature, since these processes can lead to biodiversity loss and degradation of related ecosystem services (see Sections 3.3 and 3.4). Diffuse settlement patterns often result in more resource-intensive lifestyles because of increased transport and domestic energy needs. This can further increase the burden on ecosystems.

The importance of urban infrastructure in determining land-use efficiency is reflected in the EU's goal of 'no net land take' by 2050. Europe faces a significant challenge in achieving this goal. The available data since 1990 indicate that residential urban areas expanded at four times the rate of population growth, while industrial areas grew more than seven times as rapidly (EEA, 2013f). Urban areas are therefore becoming less compact.

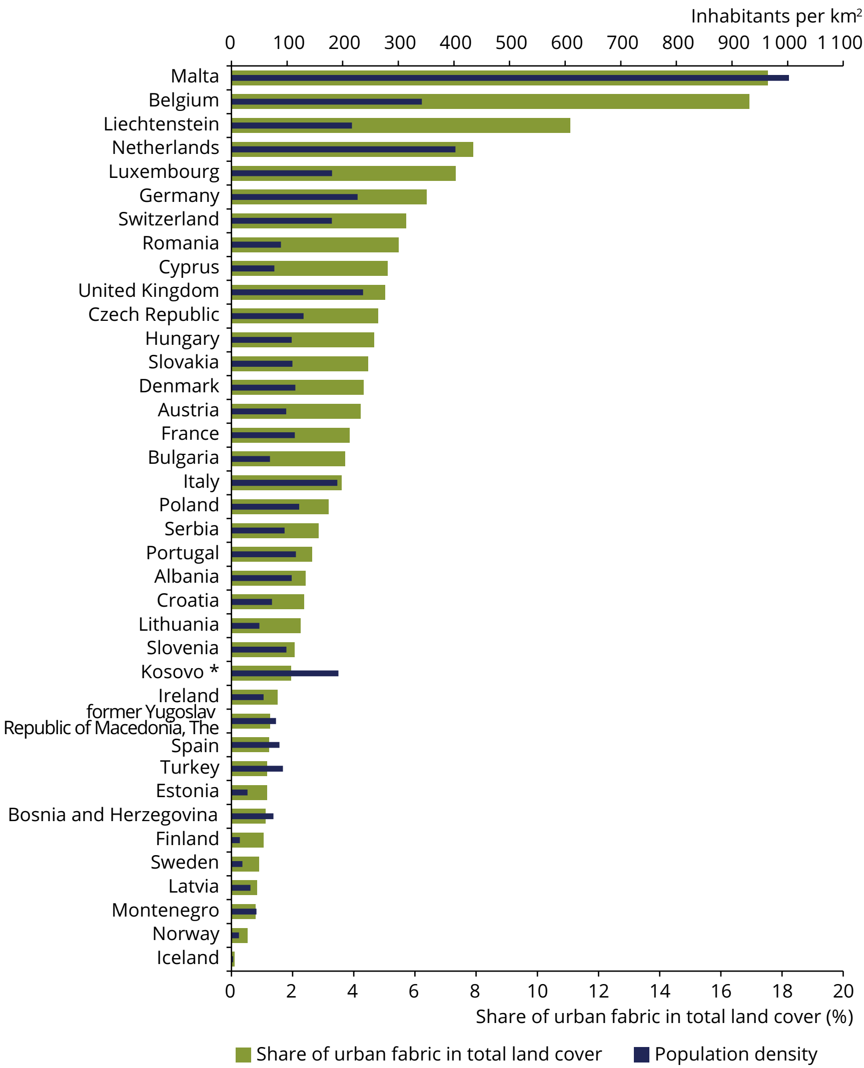
Although European population growth is likely to be minimal in coming decades, other drivers of increased housing demand may persist. Household formation is one such driver, and it can continue to grow — even in the absence of population growth — as households become smaller. The number of households in the EU-28 grew 23% between 1990 and 2010, from 170 million to 209 million. Increasing wealth, ageing of the population, and changing lifestyles are likely to sustain the reduction in average household size.

The striking differences in urbanisation patterns across Europe suggest that there are opportunities to improve land-use efficiency. For example, the share of urban land in Belgium is almost twice as high as in the Netherlands, despite a population density that is one third lower (Figure 4.10). These figures reflect differences in spatial planning. The Netherlands has more planning restrictions, more compact urban settlements, and a lower share of detached houses than Belgium.

Better spatial planning has the potential to incentivise more resource-efficient approaches to the built environment. It can help to reduce energy use for commuting and for space heating, and avoid the intrusion of urban infrastructure into natural areas (EEA, 2013f). An integrated approach to spatial planning should optimise economic development opportunities and ecosystem services, reducing human exposure to environmental pressures, and reducing social inequities. The challenge is to design a future urban environment with broad public appeal, meeting the evolving needs of the population (EEA, 2013f). Part of the solution is likely to involve developing 'green infrastructure' within urban areas, i.e. planned networks of natural or semi-natural areas managed to deliver a range of ecosystem services (EC, 2013b).

Improved spatial planning would involve both increased restrictions on urban sprawl, and the alleviation of restrictions on development within urban areas. This is undoubtedly an area characterised by complex trade-offs. Some people prefer living close to nature, rather than in a compact urban setting. Equally, governments often impose restrictions on the height of new buildings to preserve a city's cultural identity and urban environment. These are undoubtedly characteristics that are valued by inhabitants and contribute to well-being. At the same time, it is important to recognise that such restrictions can also greatly increase the cost of housing in city centres (particularly impacting poorer households) and drive urban sprawl.

Figure 4.10 Urbanisation patterns across Europe



Note: The land cover data derive from the most recent available update of the Corine Land Cover series (2006). The population data are for the same year.

* as defined under United Nations Security Council Resolution 1244/99.

Source: EEA, 2014c; and Eurostat, 2014g.

4.11 An integrated perspective on production-consumption systems is needed

Several consistent themes emerge from the above analysis of resource efficiency trends in Europe. In many areas, efficiency is improving: society is finding ways to increase economic output relative to the associated environmental pressures. Yet in most areas, the changes look unlikely to deliver on the EU's 2050 vision of an economy in which 'all resources are sustainably managed, from raw materials, to energy, water, air, land and soil.'

Part of the challenge appears to lie in the fact that innovations that alleviate pressures in one area can cause feedbacks that increase pressures elsewhere. Efficiency gains can reduce production costs, effectively increasing consumer spending power and thereby enabling increased consumption (the rebound effect). In the transport sector, for example, increasing fuel efficiency has had limited impact on overall fuel use because it has resulted in increased driving (Box 4.1). Similar trends have been seen in many other areas, including household appliances and space heating (EEA, 2012e).

Often these efficiency gains result from technological advances, but they can also arise from behavioural changes, such as throwing away less food. Reducing food waste in this way may reduce a consumer's demand for fresh produce, but it also leaves them with more money to spend on other things (WRAP, 2012). The aggregate environmental impact of this decision will depend on whether the consumer chooses to use those funds to purchase better quality, sustainably produced food, or rather to increase consumption of other goods and services.

These types of feedback effects suggest that there is a need to look beyond isolated efficiency improvements and instead address in an integrated way the production-consumption systems that fulfil societal functions (e.g. food, housing, mobility). Such a perspective implies focusing not just on material flows but also on the social, economic and environmental systems that structure society's resource use.

Viewing consumption and production as aspects of complex systems exposes some of the challenges in shifting to resource use patterns that produce better socio-economic and environmental outcomes. For example, drawing on Meadows (2008), it is apparent that production-consumption systems can serve multiple, potentially contradictory functions. From the perspective of the consumer, the primary function of the food system may be to supply food of the desired type, quantity, quality and price. From the perspective of the farmer or food processor, the food system's main function may be as a source of employment and earnings. For rural communities, the system may play a key role in social cohesion, land use and traditions.

The multifunctional character of production-consumption systems means that different groups are likely to have contrasting incentives for facilitating or resisting change. Alterations to complex systems are likely to generate trade-offs. Even if a measure produces a beneficial outcome for society as a whole, it may face strong opposition if it threatens the livelihoods of a specific group of people. Individuals or groups may have particularly strong interests in maintaining the status quo if they have made investments (for example in skills, knowledge or machinery) that could become redundant as a result of changes.

Globalisation further complicates the governance challenge. As highlighted in Sections 4.3 and 4.4, there is some evidence that Europe's reductions in the material and greenhouse gas emission intensity of production in recent years are partly due to the shift of some industrial output overseas. Although Europe appears to have made considerable progress from a production perspective, the trend looks less positive from a consumption perspective.

Such contrasting trends point to difficulties in reconfiguring the globalised systems that meet European demand for goods and services. European consumers and regulators alike have little information about the resource use and related impacts associated with highly complex and diverse supply chains, and they have limited ability to influence them using traditional, state-bound policy instruments. This reality points to the need for new governance approaches that transcend national boundaries and engage businesses and society more fully.

Safeguarding people from environmental risks to health

5.1 Human well-being critically depends on a healthy environment

Human health and well-being are intimately linked to the state of the environment. Good quality natural environments can provide multiple benefits to physical, mental and social well-being. However, environmental degradation — such as that caused by air and water pollution, noise, radiation, chemicals or biological agents — can have negative effects on health.

Despite substantial improvements in recent decades, environmental health challenges remain considerable. In addition to established problems — such as air pollution, water pollution and noise — new health issues are emerging. These are associated with long-term environmental and socio-economic trends, lifestyle and consumption changes, and the rapid uptake of new chemicals and technologies. Furthermore, the unequal distribution of environmental and socio-economic conditions contribute to pervasive health inequalities (WHO, 2012; EEA/JRC, 2013).

Human-induced environmental phenomena, such as climate change, depletion of natural resources, and biodiversity loss have potentially wide-ranging and long-term effects on human health and well-being. Their complex interplay calls for integrated analysis of the relations between environment, health and our systems of production and consumption (EEA/JRC, 2013; EEA, 2014i).

As an example of systemic analysis, the ecosystem-based perspective links human health and well-being with the preservation of natural capital and related ecosystem services (EEA, 2013f). Although very promising, ecosystem-based approaches are still hampered by knowledge gaps and uncertainties. Information exists on certain specific themes, such as air pollution, noise, water quality, and some hazardous chemicals, but understanding of the interaction of multiple environmental pressures in combination with social and demographic factors is currently limited.

Box 5.1 Structure of Chapter 5

Human health and well-being are intrinsically linked with the quality of the environment. A range of detrimental health effects have been linked to environmental pollution and other forms of environmental degradation, and the health benefits of a high quality natural environment are increasingly recognised. This chapter provides an insight into the impacts on human health of climate change and other environmental factors. It highlights the evolving nature of environmental challenges to health and well-being, and what this means for how we address these challenges.

The sections of this chapter are structured around the following aspects of the relationship between environment, health and well-being:

- reflections on how environmental conditions, demography, lifestyle, and consumption patterns interact to affect health in Europe (Section 5.3);
- impacts of specific environmental issues, such as water pollution, air pollution, and noise on human health (Sections 5.4, 5.5 and 5.6);
- human health and well-being considerations in the context of complex systems, such as urban environment and climate change (Sections 5.7 and 5.8);
- reflections on the need for new approaches to address complex environmental challenges and emerging risks (Section 5.9).

5.2 European policy takes a broader perspective on the environment, human health and well-being

Concerns about human health and well-being are powerful drivers for environmental policy but have primarily been addressed through separate approaches dealing with air quality, water quality, noise and chemicals. Since the finalisation of the EU Environment and Health Action Plan (EC, 2004a) in 2010, there has been no dedicated environment and health policy in the EU.

Implementation of the existing environmental policies is likely to reduce specific health burdens further, but the need for more systemic approaches to reduce health risks is recognised in recent EU policies. The newly amended Environmental Impact Assessment Directive strengthens the provisions for assessing and preventing risks, including to human health (EU, 2014a).

Priority objective 3 of the 7th Environment Action Programme is 'to safeguard citizens from environment-related pressures and risks to health and well-being'. It addresses air quality, water quality, and noise, and announces an EU strategy for a non-toxic environment, to be supported by a knowledge base on chemical exposure and toxicity. Furthermore, it considers the health impacts of mixtures of chemicals, and risk management of new and emerging issues, such as endocrine disrupting substances and nanomaterials (EU, 2013).

Chemicals policy is a particularly important area when it comes to health and the environment. The main 'horizontal' chemical policy, REACH (addressing the registration, evaluation, authorisation and restriction of chemicals) (EU, 2006), includes a range of measures to improve the protection of human health and the environment. However, the regulation does not address the problem of simultaneous exposures to multiple chemicals. Driven by growing evidence and societal concerns, further legislative work is foreseen on this issue (EC, 2012c), as well as on the issue of endocrine disrupters (EC, 2012d).

Promoting good health and reducing inequalities, a central theme in EU health policy (EC, 2007b; EU, 2014b), is also an integral part of Europe's smart and inclusive growth objectives (EC, 2010).

At the international level, the World Health Organization pan-European Environment and Health Process addresses environment and climate-related threats to human health, particularly in children (WHO, 2010a). The new World Health Organization health strategy for Europe considers well-being as a possible focus for reorienting 21st century public policy, including its environmental dimension (WHO, 2013a).

Multilateral environmental agreements, such as those related to chemicals (UNEP, 2012b), are also of direct relevance to human health and well-being. The Rio+20 outcome document defines human health as 'a precondition for and an outcome and indicator of all three dimensions of sustainable development' (UN, 2012a).

Table 5.1 Examples of EU policies relating to Objective 3 of the 7th Environment Action Programme

Topic	Overarching strategies	Directives (examples)
Air	EU Thematic Strategy on air pollution EU Clean Air Policy Package	Ambient Air Quality Directives National Emission Ceilings Directive
Water	The Water Framework Directive A Blueprint to Safeguard Europe's Water Resources	Drinking Water Directives Urban Waste Water Treatment Directive Bathing Water Directive The Directive on Environmental Quality Standards
Noise		The Environmental Noise Directive
Chemicals	Registration, Evaluation, Authorisation and restriction of Chemicals regulation Thematic Strategy on the sustainable use of pesticides	Directive establishing a framework for Community action to achieve the sustainable use of pesticides Classification, Labelling and Packaging Regulation Regulation concerning the making available on the market and use of biocidal products Regulation concerning the placing of plant protection products on the market
Climate	EU Strategy on adaptation to climate change Green Infrastructure — Enhancing Europe's Natural Capital	

Note: For more detailed information on specific policies, see the respective SOER 2015 thematic briefings.

5.3 Environmental, demographic and lifestyle changes contribute to major health challenges

Various demographic and socio-economic trends, combined with persistent inequalities, affect the European population's vulnerability to multiple pressures, including those related to environment and climate.

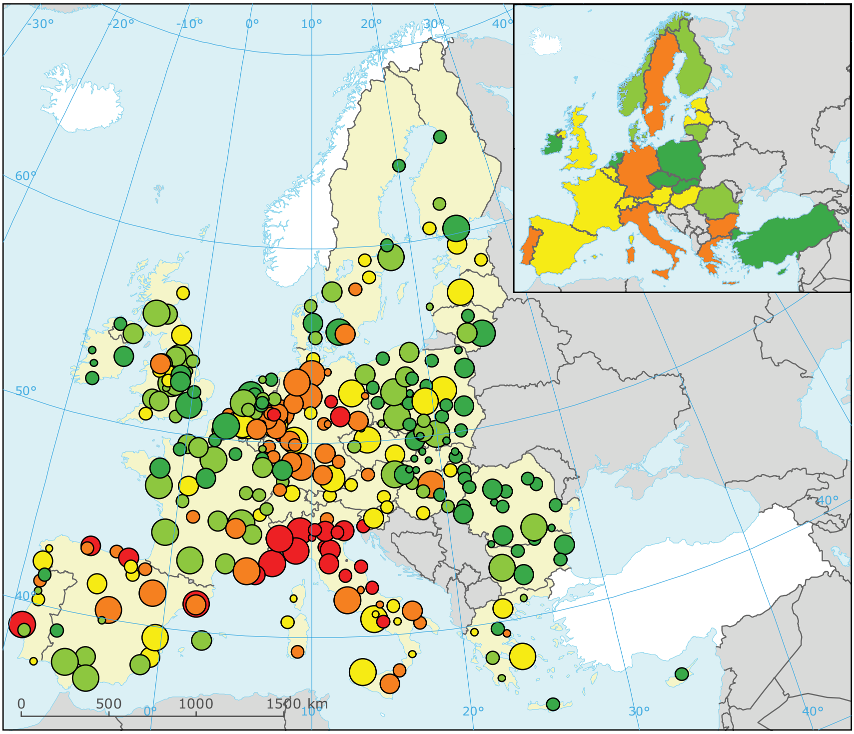
EU citizens live longer than in many other parts of the world. Life expectancy at birth in the EU-28 exceeded 80 years in 2012, and is higher for women. The gap between the lowest life expectancy (68.4 years for men in Lithuania) and the highest (85.5 years for women in Spain) in the EU is considerable. The expected years lived without disability, as measured by healthy life years at birth, does not exceed 62 years in the EU-28 (EC, 2014f).

The share of the older population in the EU-27 has been increasing in recent years. The current proportion of people aged 65 years and over, already exceeds 17.5% and is projected to reach 29.5% by 2060 (Eurostat, 2008, 2010, 2011) (Map 5.1).

The leading causes of poor health in Europe are cardiovascular and respiratory diseases, cancer, diabetes, obesity, and mental disorders (IHME, 2013). Neuro-developmental disorders in children and reproductive problems are of growing concern, along with the emergence of communicable, vector-borne diseases, especially in the context of climate change and globalisation (ECDC, 2012c, 2013). The factors driving these growing public health issues are not sufficiently understood. Exposure to environmental factors certainly plays a role, but the complex causal pathways and interactions with demography or lifestyle factors are poorly understood. More knowledge is needed to effectively tackle these challenges (Balbus et al., 2013; Vineis et al., 2014; EEA/JRC, 2013).

The unequal distribution of environment-related costs and benefits across society is another important factor. Evidence is growing that environment-related inequalities and their potential impacts on health and well-being are strongly related to socio-economic factors, and to coping and adaptation capacities (Marmot et al., 2010; WHO, 2012; EEA/JRC, 2013). Furthermore, poor environmental conditions tend to be associated with social stressors (such as poverty, violence, etc.). However, little is known

Map 5.1 Proportion of urban population aged 65 years and more



Vulnerable people — elderly people are considered to be a group sensitive to different climate change exposures

Proportion of aged population ≥ 65 in cities/countries, 2004

< 14
14–15
15–17
17–20
> 20

No data
Outside data coverage

Total population in cities, 2004 (Swiss cities, 2013)

< 100 000
100 000–250 000
250 000–500 000
500 000–1 000 000
> 1 000 000

Source: EEA, 2012i.

about the combined health effects of stress and pollution (Clougherty and Kubzansky, 2009; Clougherty et al., 2007).

Factors such as housing, food, mobility, and recreation affect both environmental pressures and human exposure to them. Lifestyles and consumption patterns, partly shaped by individual choices, play an important role here. In the long term, maintaining human health may increasingly depend on finding ways to meet societal needs at much lower environmental costs. Further efforts to improve the quality of the environment will therefore need to combine pollution abatement measures with incentives for resource-efficient production systems and sustainable consumption patterns.

5.4 Water availability has generally improved, but pollution and scarcity still cause health problems

Trends and outlook: Water pollution and related environmental health risks	
	5–10 year trends: Drinking and bathing water continuously improving, and some hazardous pollutants have been reduced.
	20+ year outlook: More extreme events (flooding and drought) due to climate change may result in more water and health-related issues. Emerging pollutants, such as from pharmaceuticals and personal care products, may be a future concern, as may be algal blooms and pathogenic microorganisms.
☑/☐	*Progress to policy targets:* High compliance with the Bathing Water Directive and the Drinking Water Directive across Europe. Concern remains on the impact of chemicals (including new emerging pollutants).
!	*See also:* SOER 2015 thematic briefings on freshwater quality; and health and environment.

The quantitative, ecological and chemical status of European waters can significantly affect human health and well-being (see also Section 3.5). These health effects can be felt directly, through lack of access to good quality drinking water, inadequate sanitation, exposure to contaminated bathing water, and consumption of contaminated freshwater and seafood. They can also be felt indirectly, when the ability of ecosystems to provide essential services for human well-being is undermined. The overall burden of water-borne diseases in Europe is probably underestimated (EFSA, 2013), and is likely to be affected by climate change (WHO, 2008; IPCC, 2014a).

Most Europeans receive treated drinking water from municipal supply systems, compliant with the quality standards set by the Drinking Water Directive (EU, 1998). Smaller water supplies, which serve some 22% of the EU population and have lower compliance with the quality standards (KWR, 2011), are more prone to contamination and to impacts of climate change. Special efforts are needed to improve the compliance of these smaller water supplies with Drinking Water Directive standards and to become resilient to climate change (EEA, 2011f; WHO, 2011c, 2010b).

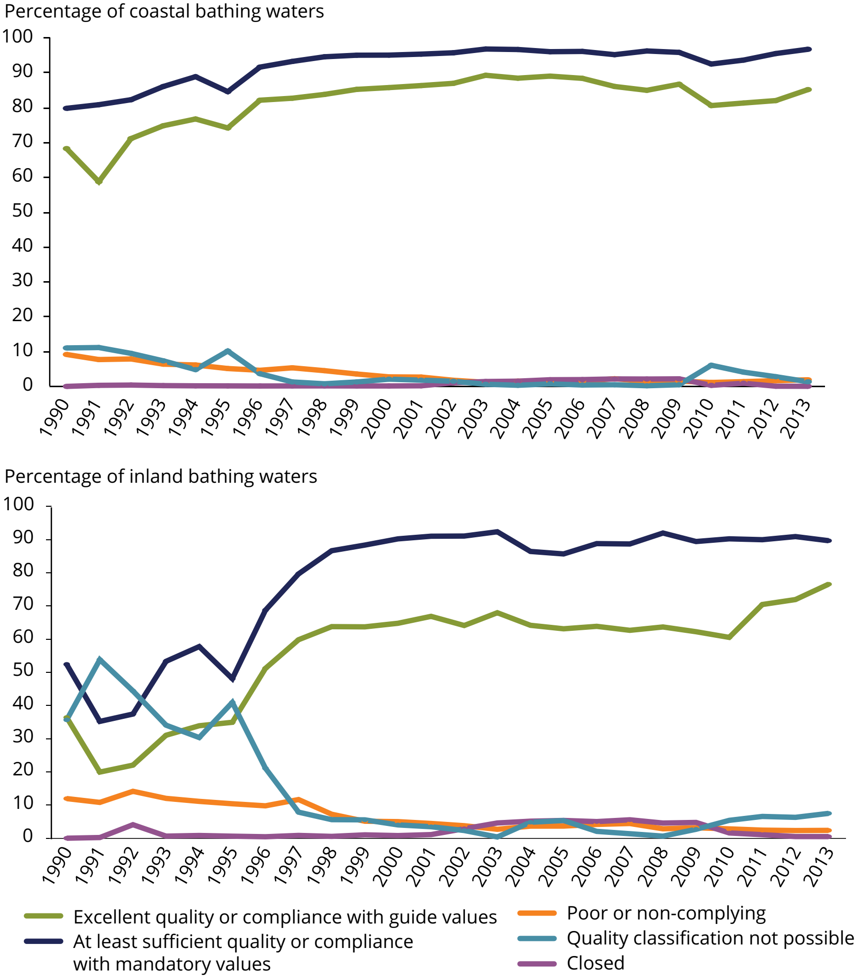
Progress in collecting and treating wastewater in Europe since the 1990s, under the Urban Waste Water Treatment Directive (EU, 1991), together with national legislation, has contributed to a sizeable improvement in bathing water quality, and reduced public health risks in parts of Europe (EEA, 2014g) (Figure 5.1).

Despite considerable progress in reducing the discharge of pollutants into Europe's waters in recent decades, nutrients, pesticides, industrial chemicals, and household chemicals continue to affect the quality of surface, ground and marine waters. This threatens aquatic ecosystems and raises concern about potential human health impacts (EEA, 2011d; ETC/ICM, 2013) (see also Sections 3.5 and 3.6).

Chemicals from pharmaceuticals, personal care products, and other consumer products can have adverse effects on the environment and on human health. Endocrine disruption, which impacts the body's hormonal system, is of particular concern. Unfortunately, the environmental pathways and potential human health impacts of these chemicals are poorly understood, especially when people are exposed to mixtures of chemicals, or when exposure occurs in vulnerable population groups such as pregnant women, small children and people suffering from certain diseases (EEA, 2011d; Larsson et al., 2007; EEA, 2012f; EEA/JRC, 2013). Reducing chemical pollution at source has become an important resource efficiency measure, as advanced wastewater treatment and treatment of drinking water is energy and chemicals intensive.

Algal blooms and the associated proliferation of toxin-producing cyanobacteria are linked to nutrient enrichment of water bodies, especially during hot weather, with possible human health impacts (Jöhnk et al., 2008; Lucentini et al., 2009). Climate change can increase the frequency of harmful

Figure 5.1 **Quality of coastal (top) and inland (bottom) bathing water in Europe, 1990–2013**



Note: The figure shows the bathing water quality in European countries over time: 1990, 7 EU Member States; 1991 to 1994, 12 EU Member States; 1995–1996, 14 EU Member States; 1997 to 2003, 15 EU Member States; 2004, 21 EU Member States; 2005–2006, 25 EU Member States; 2007 to 2011, 27 EU Member States. Five Member States (Austria, the Czech Republic, Hungary, Luxembourg and Slovakia) have no coastal bathing waters. The quality classes under the New Bathing Water Directive (2006/7/EC) are jointed with compliance categories under the Bathing Water Directive (76/160/EEC).

Source: Indicator: Bathing water quality (CSI 022), EEA, 2014g.

algal blooms and the growth of cyanobacteria, as well as the growth of other pathogenic microorganisms (Baker-Austin et al., 2012; IPCC, 2014a).

Meanwhile, water scarcity and drought are issues of increasing concern, with potentially severe consequences for agriculture, energy, tourism, and drinking water provision. Water shortages are projected to increase with climate change, particularly in the Mediterranean region (EEA, 2012h, 2012a). The resulting low flows can increase concentrations of biological and chemical contaminants (EEA, 2013c). Towns and cities can come to rely increasingly on groundwater to provide secure access to freshwater (EEA, 2012j). This raises sustainability concerns because groundwater resources often replenish slowly. Indirect climate change effects on water resources include impacts on animal health, food production, and ecosystem functioning (WHO, 2010b; IPCC, 2014a).

5.5 Ambient air quality has improved, but many citizens are still exposed to dangerous pollutants

	Trends and outlook: Air pollution and related environmental health risks
	5–10 year trends: Europe's air quality is slowly improving, but fine particulate matter ($PM_{2.5}$) and ground-level ozone in particular continue to cause serious impacts on health.
	20+ year outlook: Air quality is expected to further improve in the years to 2030, but harmful levels of air pollution will persist.
□	*Progress to policy:* The number of countries meeting existing EU air quality standards is slowly increasing, but a large number are still not in compliance.
!	*See also:* SOER 2015 thematic briefing on air pollution.

Air pollution can damage human health through direct exposure via inhalation or indirectly through exposure to contaminants transported through the air, deposited on plants and the soil, and accumulated in the food chain. Air pollution continues to contribute to much of the burden of lung cancer, and respiratory and cardiovascular diseases in Europe (WHO, 2006, 2013b; IARC, 2012, 2013). The evidence is growing for other health effects, including reduced foetal growth and pre-term birth in children exposed prenatally, and impacts on health in adult life from perinatal exposure (WHO, 2013b; EEA/JRC, 2013).

The EU has introduced and implemented a range of legal instruments to improve air quality. Measures to combat pollution at source, and further implementation of the proposed Clean Air Package, in line with the latest knowledge, are expected to result in further improvement in air quality and in reduced health impacts by 2030 (EU, 2013).

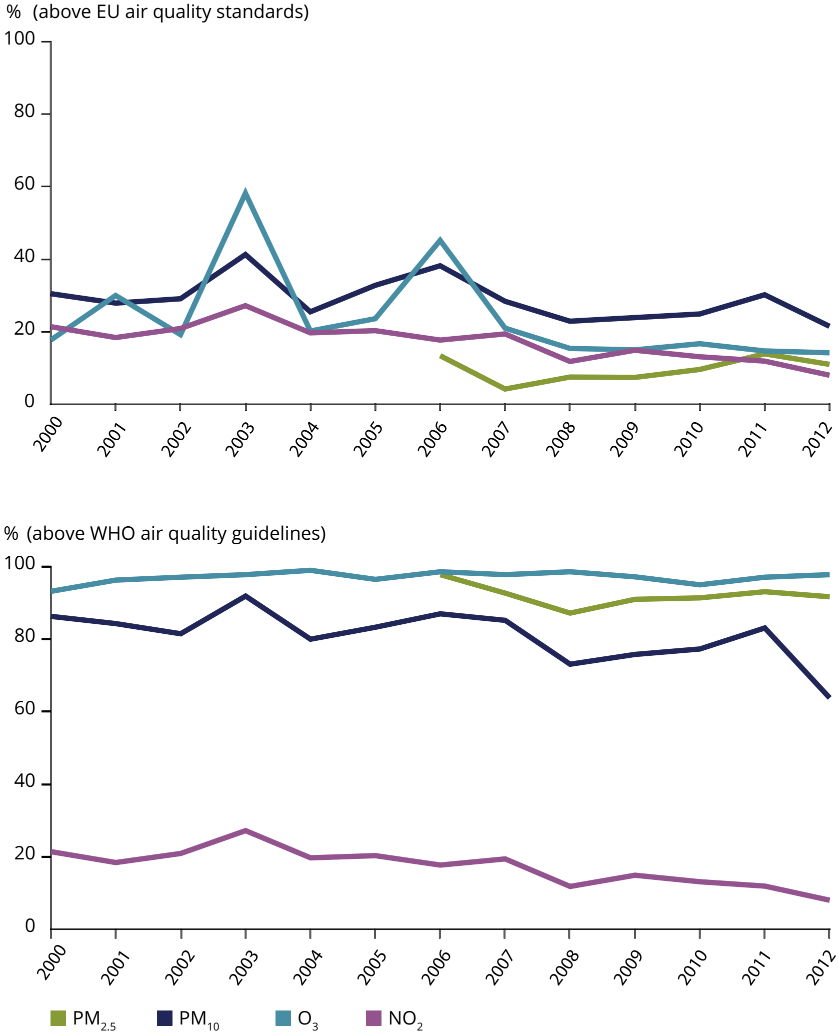
The situation regarding pollutants such as lead, sulphur dioxide and benzene has improved. Other pollutants remain of particular health concern. These include particulate matter (PM), for which no lower threshold for health effects has yet been established, ground-level ozone (O_3), nitrogen dioxide (NO_2), and carcinogenic polycyclic hydrocarbons, such as benzo(a)pyrene (BaP) (WHO, 2006). A significant proportion of Europe's urban population remains exposed to harmful levels of air pollution (Figure 5.2). The exposure of Europe's population becomes even more evident when using the exposure estimates based on World Health Organization air quality guidelines (WHO, 2006), which are more stringent than EU air quality standards for most regulated pollutants (EEA, 2014a).

Vehicles, industry, power plants, agriculture and households contribute to Europe's air pollution. Transport remains a main contributor to poor air quality levels in cities and related health impacts. Increasing traffic volumes, coupled with the promotion of diesel vehicles have played a role in this (EEA, 2013b; Global Road Safety Facility et al., 2014). Fundamental changes in the transport system, including technological solutions and behavioural change are needed to reduce its harmful impacts (see also Section 4.7).

The transboundary nature of particulate matter and ozone pollution requires national as well as international efforts to reduce emissions of precursor pollutants such as nitrogen oxides, ammonia and volatile organic compounds.

Another important source of particulate matter and polycyclic aromatic hydrocarbons is coal and wood burning for heating, in households as well as in commercial and institutional facilities. Low-level household emissions can significantly affect the concentrations close to the ground. Emissions of benzo(a)pyrene increased by 21% between 2003 and 2012, driven by the increase (24%) in emissions from domestic combustion in Europe. Exposure to benzo(a)pyrene is widespread, especially in central and eastern Europe.

Figure 5.2 **Percentage of the EU urban population potentially exposed to air pollution exceeding selected EU air quality standards (top) and WHO air quality guidelines (bottom), 2000–2012**



Note: For further details on the methodological approach, see CSI 004.

Source: CSI 004, EEA, 2014a.

In 2012, some 25% of the EU urban population was exposed to benzo(a)pyrene concentrations above the EU target value. When estimated against the WHO air quality guidelines, as much as 88% of the EU urban population was exposed to benzo(a)pyrene concentrations above the reference level (EEA, 2014a).

Available estimates of health impacts of air pollution may vary due to different assumptions and some methodological issues ([7]). The European Commission estimated that health impacts of exposure to particulate matter could have declined by up to 20% between 2000 and 2010 (EU, 2013). Nevertheless, the toll of air pollution on health remains substantial. The EEA assessed that in 2011, about 430 000 premature deaths in the EU-28 were attributed to fine particulate matter ($PM_{2.5}$), while the estimated impact of exposure to O_3 concentrations exceeded 16 000 premature deaths per year ([8]) (EEA, 2014a).

Robust estimates are lacking for the less severe but more widespread impacts of air pollution, such as hospitalisations or use of medication. The existing assessments are based mainly on single-pollutant approaches, whereas air pollution actually comprises a complex mixture of chemical components that interact to produce impacts on human health (WHO, 2013b). Furthermore, concentrations of pollutants may vary due to meteorology, as dispersion and atmospheric conditions differ from year to year.

The quality of indoor air is also affected by ambient air quality, combustion processes, consumer products, energy efficiency improvements in buildings, and human behaviour. Exposure to indoor chemicals and biological agents has been linked to respiratory symptoms, allergies, asthma, and impacts on the immunological system (WHO, 2009a, 2010c, 2009c). Radon, a gas naturally present in the earth that leaks into buildings, is a well-established

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([7]) Quantification of the health impacts of air pollution follows the environmental burden of disease approach. The differences between different studies are largely determined by approaches to estimate the ambient pollutant concentrations (using either observations or models), as well as other assumptions, such as years of assessment, population groups, inclusion of natural contribution to air pollution, etc. The concentration-response functions used in the calculations are generally the same.

([8]) Ozone titration in cities leads to lower O_3 concentrations at the expense of higher NO_2 concentrations. Since the interdependent excess premature mortality from NO_2 has not been estimated, the results obtained can be regarded as underestimating the actual impact of O_3 on premature mortality.

carcinogen. Exposure to this dangerous indoor air pollutant can occur underground or in poorly ventilated indoor environments. Although European citizens spend more than 85% of their time indoors, there is currently no dedicated policy framework that bridges safety, health, energy efficiency and sustainability (EEA/JRC, 2013).

5.6 Exposure to noise is a major health concern in urban areas

Trends and outlook: Noise pollution (especially in urban areas)	
	5–10 year trends: Exposure to noise in selected urban agglomerations has remained broadly constant between 2006 and 2011 according to two key noise indicators.
N.A.	*20+ years outlook:* No data are yet available that would allow an assessment of long-term trends to be made.
☐	*Progress to policy:* No clear targets, but the 7th Environment Action Programme aims to significantly reduce noise exposure by 2020, moving closer to WHO recommended levels.
!	*See also:* SOER 2015 thematic briefings on transport; noise; and urban systems.

Noise pollution has long been recognised as a quality of life and well-being issue, but is increasingly being recognised as a public health issue. Road traffic is the greatest contributor to noise exposure in Europe. While its potential to contribute to harmful impacts is clear, tackling noise pollution is challenging, as it is a direct consequence of society's demand and need for mobility and productivity.

The Environmental Noise Directive (EU, 2002) requires EU Member States to undertake noise mapping (producing results in terms of common indicators) and to prepare action plans based on the noise maps. These action plans also aim to protect urban quiet areas against an increase in noise.

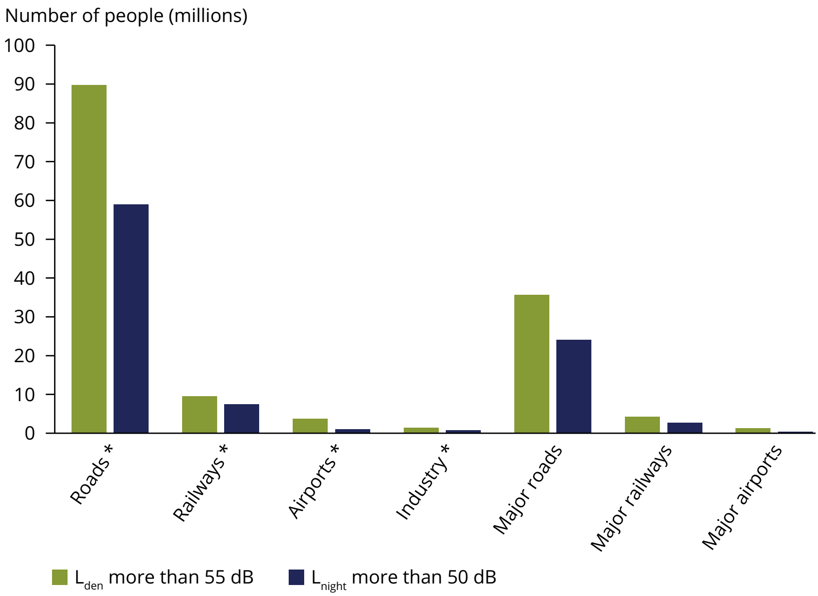
In 2011, at least 125 million people were estimated as being exposed to high levels of road traffic noise above the L_{den} ([9]) noise indicator of 55 dB (EEA, 2014p). In addition, many people were also exposed to rail, aircraft, and industrial noise, particularly in towns and cities (Figure 5.3). The average

([9]) L_{den} — Environmental Noise Directive noise indicator — day, evening and night equivalent level.

exposure to noise (i.e. L_{den} above 55 dB and L_{night} above 50 dB) in selected urban agglomerations remained broadly constant between 2006 and 2011 according to comparable data reported by countries for these two years.

Environmental noise is not only a source of annoyance; it has been linked with increased risk of cardiovascular diseases, including heart attack and stroke (WHO, 2009b; JRC, 2013). The European Environmental Burden of Disease for noise is estimated as being at least 1 million life years lost per year, based upon earlier noise exposure data for 2006 and for road traffic alone (WHO/JRC, 2011). Most recently, exposure to environmental

Figure 5.3 **Exposure to environmental noise in Europe within (*) and outside urban agglomerations in 2011**



Note: Based on data reported by countries by 28 August 2013. Noise mapping and assessment methods may differ by country. Gaps in reported information have been filled with expert estimates where necessary.

Source: EEA, 2014p.

noise has been estimated to contribute around 10 000 cases of premature deaths due to coronary heart disease and stroke each year, with almost 90% of the noise-related health impacts being associated with road traffic noise (EEA, 2014p). However, these numbers are likely to be largely underestimated, as many countries do not report complete data sets, an issue that prevents robust trend and exposure analysis.

Reduction of exposure to noise is an important public health measure that must be addressed by both European and local measures. Examples of local measures include installation of road or rail noise barriers, where appropriate, or managing flight movements around airport locations. However, the most effective actions are those that reduce noise at source, for example by decreasing noise emissions of individual vehicles by introducing quieter tyres.

Green areas can also assist in reducing urban noise levels. There are opportunities to rethink urban design, architecture and transport in order to improve the management of urban noise. A recently issued guide on good practice in quiet areas (EEA, 2014j) is designed to support cities and countries in their efforts. Opportunities to improve public awareness and citizen engagement would also benefit from being further strengthened (e.g. EEA, 2011c, 2011e).

There is also emerging evidence that environmental noise may interact with air pollution, leading to greater impacts on human health (Selander et al., 2009; JRC, 2013). This illustrates the value of considering integrated mitigation approaches that address common sources of both air pollution and noise, such as road transport.

Further efforts to significantly decrease noise pollution in Europe by 2020 will require an updated noise policy aligned with the latest scientific knowledge, as well as improvements in city design and measures to reduce noise at source (EU, 2013).

5.7 Urban systems are relatively resource efficient, but also create multiple exposure patterns

Trends and outlook: Urban systems and quality of life	
	5–10 year trends: Some improvements, especially housing and end-of-pipe emission solutions. Good air quality and accessibility to green areas remain issues in large cities. Extension of urban areas and urban sprawl continue.
	20+ year outlook: Increases in urban population throughout Europe might enhance land uptake and fragmentation for infrastructure, at the same time contributing to pressures on resources and environmental quality.
No target	*Progress to policy targets:* No overall urban policy target; specific targets relevant to thematic policies (air, noise, etc.).
!	*See also:* SOER 2015 thematic briefings on land systems; resource efficiency; health and environment; transport; energy; consumption; climate change impacts and adaptation; waste; soil; air pollution; and freshwater quality.

Nearly 73% of the European population lives in cities, and this is projected to reach 82% in 2050 (UN, 2011; 2012b). Urban development in Europe, particularly the increasing trend in peri-urbanisation, can increase pressures on the environment and human health, for example through landscape fragmentation and air emissions from transport (EEA, 2006; IPCC, 2014a) (see also Section 4.10).

Environmental impacts on human health and well-being are particularly pronounced in urban settings where multiple pressures coexist. This can affect large populations, including vulnerable groups, such as the very young and the elderly. Potential exacerbation of those impacts due to climate change points to a need for dedicated adaptation actions.

On the other hand, compact urban development and more resource-efficient approaches to the built environment provide opportunities to alleviate environmental pressures and enhance human well-being. In addition, well planned urban areas providing easy access to natural, green environments may deliver health and well-being benefits, including protection from the impacts of climate change (EEA, 2009a, 2012i; EEA/JRC, 2013).

The proportion of urban green space differs between European cities (Map 5.2). However, the actual use of green spaces depends critically on their accessibility, quality, safety, and size. There are also marked cultural and socio-demographic variations in the perception of green space and attitudes towards its use (EEA/JRC, 2013).

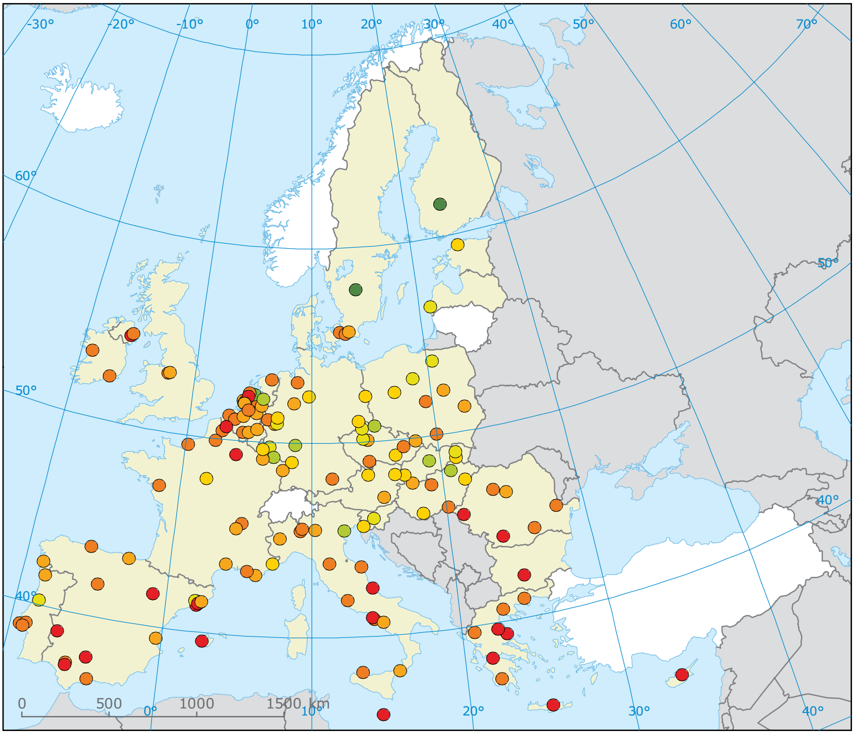
The importance of urban green spaces for human health and well-being is increasingly recognised, partly due to better understanding of ecosystem services (Stone, 2009; Pretty et al., 2011). The benefits of high quality green environments to physical health, mental and social well-being, and improved quality of life can be substantial, although the nature of these interactions is not fully understood (EEA/JRC, 2013; Depledge and Bird, 2009; Greenspace Scotland, 2008; Paracchini et al., 2014). Fragmentary evidence indicates that access to green environments contributes to reducing (income-related) health inequalities (Mitchell and Popham, 2008; EEA/JRC, 2013).

The EU Green Infrastructure Strategy (EC, 2013b), and improved approaches to spatial analysis (EEA, 2014u), can contribute to assessing the trade-offs and co-benefits of urban development. Efforts to promote innovative urban policies for healthier, denser, greener and smarter cities are under way, for example by designating cities as European Green Capitals (EC, 2014g).

Multifunctional green infrastructure plays a role in urban adaptation to climate change, affecting temperature regulation, increased biodiversity, protection against noise, reduction of air pollution, prevention of soil erosion, and prevention of flooding (EC, 2013b; EEA, 2012i). The early integration of adaptation measures, including green infrastructure, into urban planning can offer long-term, cost-effective solutions. However, such measures are not yet widely implemented (EEA, 2012i; IPCC, 2014a) (see also Section 5.7).

Further implementation of policies for sustainable urban planning and design is crucial to enhance the sustainability of EU cities (EU, 2013). Smart planning and governance mechanisms can influence mobility patterns towards more sustainable forms of transport and reduced transport demand. They can also enhance the energy efficiency of buildings, reducing environmental pressures and improving well-being at the same time (EEA, 2013a, 2013f).

Map 5.2 Share of green urban areas in EU-27 core cities



Percentage of green urban areas in EU-27 core cities

0–10 | 10–20 | 20–30 | 30–40 | 40–50 | 50–60 | 60–70 | 70–80 | No data | Outside data coverage

Note: Cities in their administrative borders (Eurostat, 2014i).

Source: EEA, 2010e.

5.8 Health impacts of climate change require adaptation at different scales

Trends and outlook: Climate change and related environmental health risks	
	5–10 year trends: Premature deaths due to heatwaves and changes in communicable diseases, linked to shifts in the distribution of disease-carrying insects (vectors) have been observed.
	20+ years outlook: Increasingly severe climate change and human-health impacts are projected.
No target	*Progress to policy:* The EU 2013 strategy and national strategies on climate change adaptation are being implemented and mainstreaming of climate change adaptation in policies addressing human health takes place to some extent (e.g. early warning and action plans for heatwaves).
!	*See also:* SOER 2015 thematic briefings on climate change impacts and adaptation; and health and environment.

In Europe, the health and well-being impacts of climate change are related mainly to extreme weather events, changes in the distribution of climate-sensitive diseases, and changes in environmental and social conditions (EEA, 2012a; IPCC, 2014a; EEA, 2013e).

The impacts of both observed and projected climate change on human and natural systems in Europe are not distributed equally (EEA/JRC, 2013; EEA, 2013c) (see Section 3.9). To address these challenges, adaptation actions are needed, taking into account the contrasting vulnerabilities of different regions and societal groups (IPCC, 2014a). Vulnerable population groups include the elderly and children, people with chronic diseases, socially deprived groups and traditional societies. The Arctic, the Mediterranean basin, urban areas, mountain and coastal areas, and river flood-prone areas represent particularly vulnerable regions (EEA, 2012a, 2013c).

Climate-related extreme weather events, such as cold spells and heatwaves, exert health and social impacts in Europe (EEA, 2010a, 2012a). The likely increase in the frequency and intensity of heatwaves, particularly in southern Europe, is projected to increase heat-attributable deaths unless adaptation measures are undertaken (Baccini et al., 2011; WHO, 2011a; IPCC, 2014a). Without adaptation, between 60 000 and 165 000 additional heat-related deaths per year in the EU are projected by the 2080s, depending on the scenario (Ciscar et al., 2011).

The effects of heatwaves can be exacerbated in congested urban areas with high rates of soil sealing and heat-absorbing surfaces (EC, 2012a), insufficient nocturnal cooling, and poor air exchange (EEA, 2012i, 2012a). While most health impacts are likely to occur in urban areas, little is known on the possible effects of future changes in built infrastructure on the heat-related disease burden (IPCC, 2014a). Heatwave warning systems have been developed in many European countries (Lowe et al., 2011), but evidence of the effectiveness of such measures remains limited (WHO, 2011b; IPCC, 2014a).

Coherent approaches to urban adaptation combine so-called 'green', 'grey', and 'soft' measures (EEA, 2013c). Adaptation strategies for 'grey' infrastructure, such as buildings, transport, water utilities, or energy utilities need to ensure that this infrastructure continues to function in a more resource-efficient manner (IPCC, 2014a). Some adaptation actions can be governed at a city level, such as heatwave warning plans (an example of a 'soft' measure). Other actions may require multilevel governance mechanisms, involving regional, national or international levels, as in the case of flood protection (EEA, 2012i).

In the absence of adaptive measures, projected increases in coastal flood risk and river flood risk (linked to sea-level rise and increases in extreme precipitation) will substantially increase damages in terms of economic losses and people affected. Impacts on people's mental health, well-being, employment and mobility could be extensive and profound (WHO and PHE, 2013).

The anticipated impact of climate change on the distribution and seasonal pattern of some infectious diseases, including those transmitted by mosquitoes and ticks, suggests a need to improve response mechanisms (Semenza et al., 2011; Suk and Semenza, 2011; Lindgren et al., 2012; ECDC, 2012a). The ecological, social and economic factors need to be considered together with climate change, when planning adaptation and response measures.

The risks can be illustrated by the northward expansion of ticks and vector-borne diseases, or by the eastward and northward extension of the Asian tiger mosquito, which is a vector of several viruses currently present in southern Europe (ECDC, 2012b, 2012d, 2009; EEA/JRC, 2013). Climate change affects animal and plant diseases (IPCC, 2014a), and the likely knock-on impacts on biodiversity call for integrated, ecosystem-based response approaches (Araújo and Rahbek, 2006; EEA, 2012a). Air quality, distribution of allergenic pollen (such as ragweed), or other existing environmental quality problems can be exacerbated by climate change.

Unless adequately addressed, regional differences in health impacts and adaptation capacities can aggravate existing vulnerabilities and deepen socio-economic imbalances in Europe. For example, if climate change has more severe effects on the economies of southern Europe than in other regions, this might enhance the existing disparity between regions in Europe (EEA, 2012a, 2013c; IPCC, 2014a).

To address these challenges the EU has adopted a strategy on climate change adaptation that also includes actions related to human health. Several countries have developed national climate change adaptation strategies, including health strategies and action plans (Wolf et al., 2014). These include early warning systems for heatwaves and enhanced surveillance of infectious diseases.

5.9 Risk management needs to be adapted to emerging environment and health issues

Trends and outlook: Chemicals and related environmental health risks	
	5–10 year trends: The impacts of some hazardous chemicals are increasingly being addressed. Endocrine disrupters and newly emerging chemicals are of growing concern. Knowledge gaps and uncertainty remain.
	20+ year outlook: Chemicals may have long lasting impacts, especially persistent and bio-accumulative chemicals. Implementation of EU and international policies is likely to reduce the chemical burden.
☐/☒	*Progress to policy targets:* Implementation of REACH continues. No policy targets have been set for chemical mixtures. Concern on the impact of newly emerging chemicals remains.
!	*See also:* SOER 2015 thematic briefings on freshwater quality; and health and environment.

Alongside persistent well known environmental health problems in Europe, new issues are emerging. These emerging health threats are typically linked with lifestyle changes, the rapid pace of global environmental change, and developments in knowledge and technology (see Chapter 2).

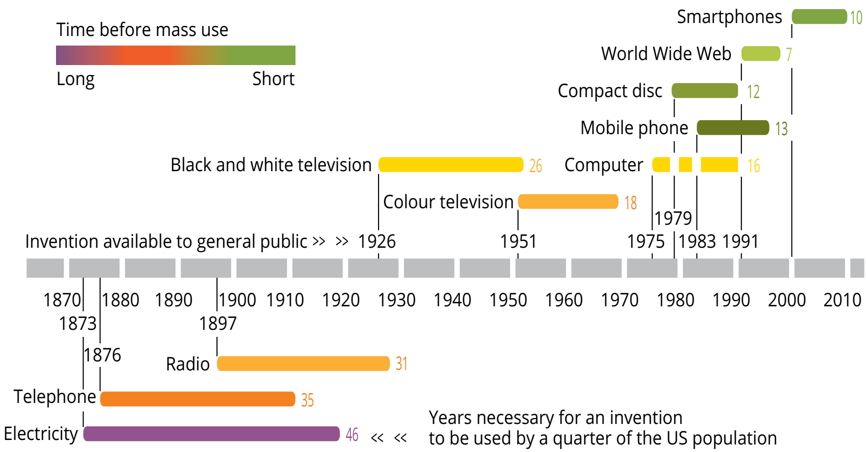
Technological developments have accelerated in recent years (Figure 5.4). Promising innovations, such as nanotechnology, synthetic biology and genetically modified organisms are being adopted by human society at an ever-increasing pace. As a result, people are exposed to a rapidly expanding array of substances and physical factors with largely unknown environmental and health effects. They include new chemicals and biological agents, light pollution and electromagnetic fields.

Chemicals in particular get growing attention in science and policy, due to their widespread occurrence and potential health impacts. According to the EU rapid alert system for non-food dangerous products (RAPEX), in 2013 chemical risks represented 20% of almost 2 400 notifications in different product categories, mainly in toys, textiles, clothing, and cosmetics (EC, 2014i).

One of the concerns is that low-level exposure of young children to certain mixtures of chemicals may affect health in adult life (Grandjean et al., 2008; Grandjean and Landrigan, 2014; Cohen Hubal et al., 2014). Particularly important in this regard are endocrine disrupting chemicals, which affect the body's hormonal system (WHO/UNEP, 2013). Several countries have already undertaken precautionary measures to reduce exposures to these chemicals, primarily in children and pregnant women (EEA/JRC, 2013), and endocrine disrupting chemicals are explicitly addressed in EU policy efforts towards creating a non-toxic environment (EU, 2013).

Exposure to mercury, a well-recognised toxic metal, also remains a public health concern in some parts of Europe, due to its effects on children's neurodevelopment (EEA/JRC, 2013). A new global convention on mercury (the Minamata convention) is expected to help gradually reduce that risk (UNEP, 2013). Consumption of contaminated seafood due to bio-accumulation of mercury and other persistent pollutants can pose health threats to vulnerable groups, such as pregnant women (EC, 2004b; EFSA, 2005; EEA/JRC, 2013).

Figure 5.4 **Shortening the time lapse before mass adoption of new technologies**



Source: Updated from EEA, 2010b, based on Kurzweil, 2005.

A better understanding of complex exposure patterns, and how these patterns are linked to lifestyle and consumption behaviours is crucial to better tackle accumulative risks and prevent health impacts, especially in vulnerable population groups.

As for chemicals, there is increasing recognition that the current paradigm, which considers substances on a chemical by chemical basis under the assumption of linearity of exposure-response relationship, underestimates risks to human health and to the environment (Kortenkamp et al., 2012; EC, 2012c). Cumulative risk assessment is needed, taking account of vulnerable groups, multiple exposures, potential interactions between chemicals, and effects at low levels of exposure (Kortenkamp et al., 2012; Meek et al., 2011; OECD, 2002).

In general, exploring the implications of new technologies needs to take into account a wide range of social, ethical and environmental impacts, as well as the risks and benefits of taking different courses of action. Oversight mechanisms based on the precautionary principle can anticipate and manage problems and opportunities, responding quickly to changing knowledge and circumstances (EC, 2011d; Sutcliffe, 2011; EEA, 2013k). While there is still a great need for more knowledge (Box 5.2), in many cases there is justification for precautionary policy measures.

Box 5.2 Data gaps hinder better knowledge on the effects of chemicals

Major gaps exist in the scientific understanding of the impacts of chemicals on health, partly due to the scarcity of data. Human bio-monitoring (determining chemicals in blood, urine and other tissues) plays a crucial role in filling this data gap. It can provide an integrated measure of human exposure to chemicals from different sources and through the different environmental pathways that chemicals take.

National and Europe-wide efforts, such as the (COPHES/DEMOCOPHES, 2009) projects, generate high quality, comparable human bio-monitoring data. Such activities merit further support to enhance the information and knowledge base and to better plan preventive measures. Efforts are also under way towards improving the accessibility of existing information on chemicals in environmental media, food and feed, indoor air and consumer products.

Understanding the systemic challenges facing Europe

6.1 Progress towards 2020 targets is mixed, and the 2050 visions and goals will require new efforts

The EEA's 2010 report *The European environment — state and outlook* (SOER 2010) drew attention to the urgent need for Europe to shift towards a much more integrated approach to addressing persistent, systemic environmental and health challenges. It identified the transition towards a green economy as one of the changes needed to secure the long-term sustainability of Europe (EEA, 2010d). Overall, the analysis presented so far in this report, summarised in Table 6.1, provides limited evidence of progress towards this goal.

As illustrated in Table 6.1, Europe's **natural capital** is not yet being protected, conserved and enhanced at the level required to achieve the ambitions of the 7th Environment Action Programme. For example, a high proportion of protected species (60%) and habitat types (77%) are considered to be in unfavourable conservation status, and Europe is not on track to meet its overall target of halting biodiversity loss by 2020, even though some more specific targets are being met.

Although reduced pollution has significantly improved the quality of Europe's air and water, loss of soil functions, land degradation and climate change remain major concerns. Looking ahead, climate change impacts are projected to intensify, and the underlying drivers of biodiversity loss are expected to persist.

Turning to **resource-efficiency and the low-carbon economy**, the short-term trends are more encouraging. European greenhouse gas emissions have decreased by 19% since 1990 despite a 45% increase in economic output. Fossil fuel use has declined, as have emissions of some pollutants from transport and industry. More recently, the EU's total resource use has declined by 18% since 2007, less waste is being generated and recycling rates have improved in nearly every country.

However, these trends should be interpreted in the wider socio-economic context. While policies are working, the 2008 financial crisis and subsequent economic recessions certainly contributed to the reduction of some pressures, and it remains to be seen whether all improvements will be sustained. In addition, many pressures remain considerable despite recent advances. Fossil fuels still account for three quarters of the EU energy supply, and European economic systems remain intensive in their use of material resources and water. Looking ahead, projected reductions of greenhouse gas emissions are insufficient to bring the EU on a pathway towards its 2050 decarbonisation target.

Regarding **environmental risks to health**, there have been marked improvements in the quality of drinking water and bathing water in recent decades and some hazardous pollutants have been reduced. However, air pollution and noise cause serious health impacts, particularly in urban areas. In 2011, about 430 000 premature deaths in the EU-28 were attributed to fine particulate matter ($PM_{2.5}$). Exposure to environmental noise has been estimated to contribute to at least 10 000 cases of premature deaths due to coronary heart disease and stroke each year.

Rates of endocrine diseases and disorders have also increased in line with more widespread use of chemicals. Looking ahead, the outlook for environmental health risks in coming decades is uncertain. Projected improvements in air quality are not expected to be sufficient to prevent continued harm to health and the environment. Moreover, health impacts resulting from climate change are likely to get worse.

When the trends presented in Table 6.1 are viewed collectively, several patterns emerge. First, policies have had a clearer impact in terms of improving resource efficiency than in ensuring ecosystem resilience. Reductions in environmental pressures associated with enhanced resource efficiency have not yet translated into a sufficient reduction of environmental impacts or improved ecosystem resilience. For example, although water pollution is declining, most freshwater bodies across Europe are not expected to achieve good ecological status by 2015. Second, in several instances the long-term outlook is less positive than recent trends might imply.

Table 6.1 An indicative summary of environmental trends

	5–10 year trends	20+ years outlook	Progress to policy targets	Read more in Section …
Protecting, conserving and enhancing natural capital				
Terrestrial and freshwater biodiversity	🟥	🟥	☐	3.3
Land use and soil functions	🟥	🟥	No target	3.4
Ecological status of freshwater bodies	🟧	🟧	☒	3.5
Water quality and nutrient loading	🟩	🟧	☐	3.6
Air pollution and its ecosystem impacts	🟩	🟧	☐	3.7
Marine and coastal biodiversity	🟥	🟧	☒	3.8
Climate change impacts on ecosystems	🟥	🟥	No target	3.9
Resource efficiency and the low-carbon economy				
Material resource efficiency and material use	🟧	🟧	No target	4.3
Waste management	🟩	🟧	☐	4.4
Greenhouse gas emissions and climate change mitigation	🟩	🟥	☑/☒	4.5
Energy consumption and fossil fuel use	🟩	🟥	☑	4.6
Transport demand and related environmental impacts	🟧	🟥	☐	4.7
Industrial pollution to air, soil and water	🟩	🟧	☐	4.8
Water use and water quantity stress	🟧	🟧	☒	4.9
Safeguarding from environmental risks to health				
Water pollution and related environmental health risks	🟩	🟧	☑/☐	5.4
Air pollution and related environmental health risks	🟧	🟧	☐	5.5
Noise pollution (especially in urban areas)	🟧	N.A.	☐	5.6
Urban systems and grey infrastructure	🟧	🟧	No target	5.7
Climate change and related environmental health risks	🟥	🟥	No target	5.8
Chemicals and related environmental health risks	🟥	🟧	☐/☒	5.9

Indicative assessment of trends and outlook		Indicative assessment of progress to policy targets	
🟥	Deteriorating trends dominate	☒	Largely not on track to achieving key policy targets
🟧	Trends show mixed picture	☐	Partially on track to achieving key policy targets
🟩	Improving trends dominate	☑	Largely on track to achieving key policy targets

Note: The indicative assessments presented here are based on key indicators (as available and used in SOER thematic briefings), as well as expert judgement. The corresponding 'Trends and outlook' boxes in the respective sections provide additional explanations.

These discrepancies can be explained by several factors, for example:

- pressures such as resource use and emissions remain substantial despite recent reductions;
- the complexity of environmental systems can cause a considerable time lag between reduced pressures and changes in environmental impacts and status;
- the impacts of external pressures (related to global megatrends and sectors such as transport, agriculture and energy) can counteract the effects of specific policy measures and local management efforts;
- technology-driven efficiency gains may be undermined by lifestyle changes or increased consumption, partly because efficiency improvements can make a product or service cheaper;
- changing exposure patterns and increased human vulnerabilities (for example linked to urbanisation, population ageing and climate change) can offset the benefits of reductions in overall pressures.

In summary, the systemic and transboundary nature of many long-term environmental challenges are significant obstacles to achieving the EU's 2050 vision of living well within the limits of the planet. Europe's success in responding to these challenges will depend greatly on how effectively it implements existing environmental policies and takes necessary additional steps to formulate integrated approaches to today's environmental and health challenges.

6.2 Meeting long-term visions and objectives requires reflection on prevailing knowledge and policy frameworks

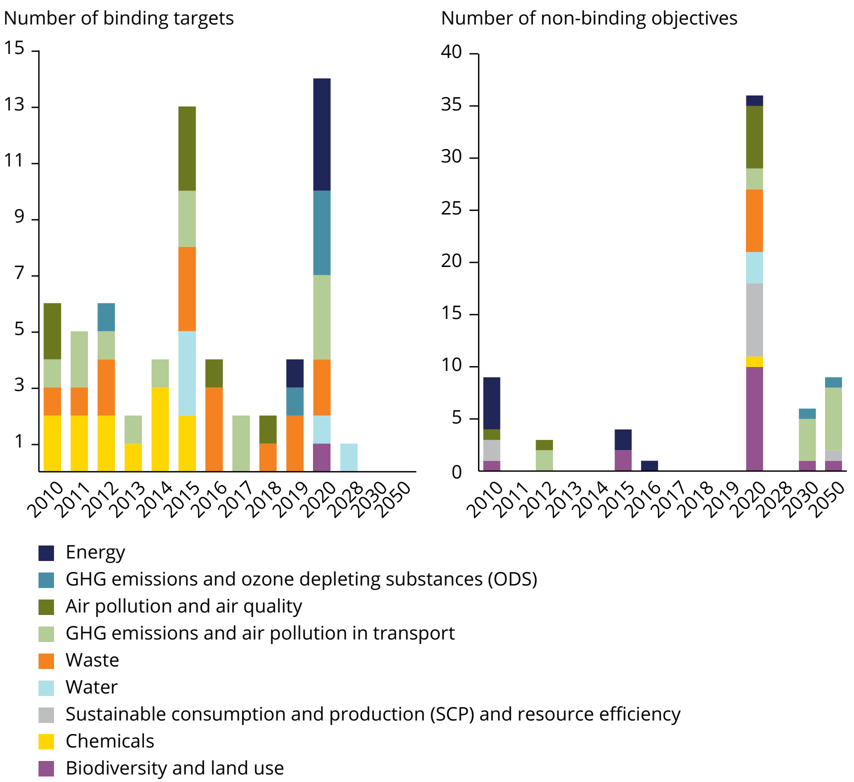
Managing these systemic environmental and health challenges requires reflection on existing policy frameworks along three lines: knowledge gaps, policy gaps and implementation gaps (Box 2.2).

The preceding chapters have identified a range of knowledge gaps regarding the relationships between ecosystem resilience, resource efficiency and human well-being. Some of these gaps are caused by an inadequate understanding of environmental processes and thresholds at both the European and global level and the consequences of exceeding these thresholds. Other gaps are as a result of a lack of knowledge in specific areas such as biodiversity, ecosystems and their services; the advantages and disadvantages of new technologies; and the complex interactions between environmental change, human health and well-being.

When it comes to policy gaps, the most important problems are the timeframes that current policy frameworks address (too few long-term binding targets); and their degree of integration. On the issue of timeframes, the EU in 2013 had an extensive set of 63 binding and 68 non-binding targets, with the majority to be achieved by 2015 and 2020 (Figure 6.1). Since then, both the EU and European countries have continued to set new objectives and targets for the period 2025 to 2050, partly in response to an enhanced understanding of systemic risks. However, this only occurs in a small number of policy areas and few of these new objectives and targets are legally binding. Past experience with target setting highlights the value of setting short and medium-term targets and actions to enable progress towards longer-term objectives.

On the issue of policy integration, the 7th Environment Action Programme aims to improve environmental integration and policy coherence. It emphasises that more effective integration of the environment in all relevant policy areas can reduce sectoral pressures on the environment and so help to meet environment and climate-related targets. Although some progress has been made on integration (e.g. climate and energy), policy measures still tend to be compartmentalised, especially in the domain of ecosystem-based management (e.g. agriculture and nature protection).

Figure 6.1 **Binding targets (left) and non-binding objectives (right) in EU environmental policies, by sector and target-year**



Source: EEA, 2013m.

The implementation gap is the gap between the initial stated policy intentions and the results delivered. This gap exists for a range of reasons, including procedural time-lags, knowledge gaps, and difficulties working across different governance levels. Previous chapters and other studies indicate that full and even implementation of existing environmental policy would be a sound investment for the future of Europe's environment and people's health, as well as for the economy (EU, 2013).

However, there is often a decade or more between the adoption of EU environment and climate policies and their implementation in countries. The environmental policy domain has more open infringement proceedings than any other EU policy sector. And the costs associated with failure to implement environment policies — including the costs of infringement cases — are high, and broadly estimated at EUR 50 billion a year (COWI et al., 2011). More implementation of what has already been agreed could deliver a wide array of socio-economic benefits often not captured by prevailing cost-benefit analyses.

Policy packages have been developed in recent years that aim to address these gaps. These have tended to be more successful in addressing knowledge and implementation gaps than policy gaps (in particular policy gaps related to integration) as they still tend to be focused on a single policy area. There is room for more coherent and adaptive policy approaches that can respond to changes, deliver multiple benefits, and manage difficult trade-offs.

6.3 Securing humanity's basic resource needs requires integrated, coherent management approaches

Recent analysis highlights the strong interdependence between the resource use systems that meet Europe's need for food, water, energy and materials. This interdependence can be seen in terms of these systems' underlying drivers, the environmental pressures they create, and their impacts. This underscores further the value of integrated approaches to action (EEA, 2013f).

For example, pesticides and excessive nutrients pollute surface water and groundwater bodies, necessitating costly measures to maintain drinking water quality. Irrigation for agriculture may add to water stress, and cultivation and drainage patterns affect regional flooding risks. Agricultural production affects greenhouse gas emissions, which in turn drive climate change.

Urbanisation also has implications for habitat fragmentation and biodiversity loss, as well as for vulnerability to climate change through enhanced flooding risks. Construction methods and settlement patterns have an immediate impact on the environment and considerable implications for energy and water use. With most environmental pressures from housing resulting from the use phase (heating, and transport to and from housing), there are clear links between housing and energy use.

Due to this interdependence, attempts to address these challenges can lead to unintended outcomes, with measures to alleviate pressures in one area often increasing pressures elsewhere. For example, a shift towards bioenergy cropping can reduce greenhouse gas emissions but can add pressures to land and water resources, potentially impacting biodiversity, ecosystem functions and landscape amenity values.

Managing numerous trade-offs and co-benefits necessitates an integrated response, yet current policy options to address these issues at European level are largely independent of each other. They would benefit from being implemented within a more integrated spatial and temporal perspective, bringing together ecosystem-based management and land-use planning.

A primary focus for such combined intervention could be agricultural policy, because current subsidies and support structures are not necessarily underpinned by resource efficiency principles (Box 6.2).

Box 6.2 Sectoral policies and the green economy

The unprecedented global demands for resources such as food, fibre, energy, and water make it imperative to use our natural resources much more efficiently and maintain the ecosystems from which natural resources are sourced.

There are major differences of approach in the key EU policies that aim at greater resource efficiency and sustainability. For example, although the ambitions for a low-carbon society have been translated into quantitative 2050 targets for the energy and transport sectors (see Chapter 4), the long-term perspective for agriculture and fisheries remains largely unclear.

Although food security is an underlying concern in both the Common Agricultural Policy and the Common Fisheries Policy, a coherent and common framework is still lacking. This is in spite of the fact that both agriculture and fisheries create similar pressures on the environment. For example, nutrient surpluses in intensive agriculture and aquaculture affect the water quality of coastal zones. Treating the environmental impacts of these two sectors in an integrated way would therefore merit consideration. This is increasingly recognised in overarching policy frameworks such as the 7th Environment Action Programme, the 2020 Biodiversity Strategy, and the Integrated Maritime Policy.

The recent reform of the Common Agricultural Policy has introduced new 'greening measures', and has tied subsidies to stricter cross-compliance with environment legislation. However, a more ambitious and long-term approach would be needed to address the resource efficiency of the agricultural sector in terms of productivity, land take, carbon capture, water use, and dependence on mineral fertilisers and pesticides.

As for the sustainability of fisheries, and despite the increasing attention to ecosystem-based management, the ecological status of fish stocks remains of major concern particularly in the Mediterranean and Black Seas. The Common Fisheries Policy aims to ensure that fishing and aquaculture are environmentally, economically and socially sustainable. But in practice, balancing short-term economic considerations and long-term environmental concerns remains challenging.

When it comes to food security, policy should also focus on food consumption, not just food production. For example, dietary changes, more effective distribution chains, and food waste prevention could potentially mitigate the environmental pressures of food provision, and — particularly in the case of agriculture — compensate for the yield penalties of more environmentally friendly production.

6.4 Globalised production-consumption systems pose major policy challenges

The increasing sophistication and scale of the production and consumption systems that meet European demand for goods and services create major challenges for policymaking and businesses, as well as opportunities for innovation. Driven by a combination of economic incentives, consumer preferences, environmental standards, technological innovation, development of transport infrastructure, and liberalisation of trade, production-consumption systems for many goods and services span the globe, engaging numerous actors (EEA, 2014f).

The globalisation of supply chains can reduce consumer awareness of the social, economic, and environmental implications of their purchasing decisions. This means that consumer choices may produce environmentally and socially undesirable outcomes, especially since market prices for end products typically do not reflect the full costs and benefits arising along the value chain.

Recent analysis of the production-consumption systems that meet European demand for food, electrical and electronic goods and clothing illustrates the complex mixture of environmental and socio-economic costs and benefits that can occur along supply chains (EEA, 2014f). These systems are particularly globalised and the EU is heavily reliant on imports of these goods. Increasing international trade has provided some benefits to European consumers. However, it also hampers identification and effective management of environmental and social problems related to European consumption.

Production-consumption systems can serve multiple and sometimes contradictory functions (see Section 4.11). This means that alterations to these systems will inevitably involve trade-offs. As a result, different groups are likely to have contrasting incentives for either facilitating or resisting change; and potential losers in change situations are often more vocal than winners (EEA, 2013k).

Adopting an integrated perspective can result in fuller understanding of production-consumption systems: the incentives that structure them, the functions they perform, the ways system elements interact, the impacts they generate, and the opportunities to reconfigure them (EEA, 2014f). Integrated approaches such as life-cycle thinking also help ensure that improvements in one area (such as more efficient production) are not offset by changes in other areas (such as increased consumption) (see Section 4.11).

Government efforts to manage the socio-economic and environmental impacts of production-consumption systems can face many obstacles. In addition to the difficulty that European policymakers face in dealing with trade-offs and in monitoring the impacts associated with highly sophisticated supply chains, they have relatively little scope to influence these impacts in other world regions.

The European policy framework is mostly targeted on impacts that occur within Europe and on the production and end-of-life stages of systems and products. Policies addressing the environmental impacts of products and their consumption are in their early stages, with the notable exception of those that deal with the energy efficiency of electrical and electronic goods. The use of information-based instruments such as eco-labels dominates, in part because international trade law limits the use of regulations and market instruments to influence production methods for imports. An overarching challenge is to find ways to reconfigure production-consumption systems and retain or increase their benefits, whilst reducing their social and environmental harms.

6.5 The wider EU policy framework provides a good basis for an integrated response, but action needs to match words

In response to the financial crisis many European countries adopted recovery policies in 2008 and 2009 with a green economy focus. Although the focus of policymakers has subsequently shifted to fiscal consolidation and sovereign debt crises, the latest survey of European citizen attitudes towards the environment shows that concern about environmental issues has not diminished. European citizens strongly believe that more needs to be done at all levels to protect the environment, and that national progress should be measured by environmental, social, and economic criteria (EC, 2014b).

The green economy is seen by the EU, UN and the OECD as a strategic approach to the systemic challenges of global environmental degradation, natural resource security, employment, and competitiveness. Policy initiatives in support of green economy objectives can be found across major EU strategies, including the Europe 2020 Strategy, the 7th Environment Action Programme, the EU Framework Programme for Research and Innovation (Horizon 2020) and sectoral policies, such as transport and energy.

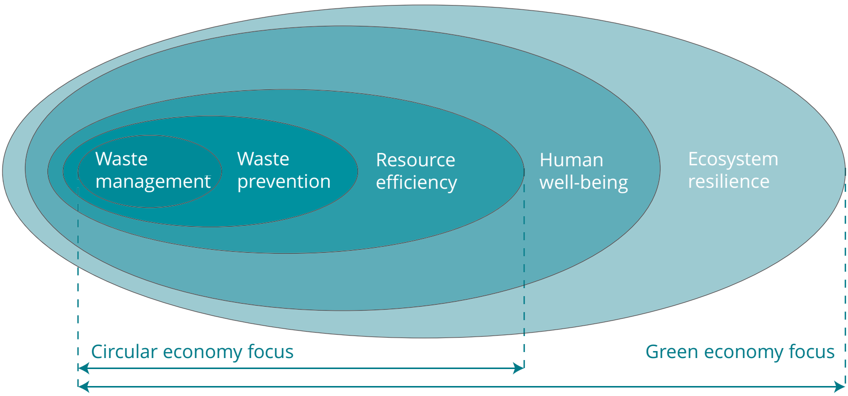
The green economy approach emphasises economic development that is resource efficient, within environmental limits and equitable across society. It requires economic, environmental and social goals to be pursued simultaneously. Prevailing policy practice remains mostly compartmentalised and shaped by established governance structures, so the opportunities that a green economy perspective offers in terms of addressing systemic challenges and harnessing synergies are still to be fully realised.

The wider perspective of the green economy provides a framework for the integration of current policies. For example, Figure 6.2 illustrates how European policy priorities relating to material resource use can be represented as a nested and integrated set of objectives. A circular economy focuses on optimising material resource flows by cutting waste to as close to zero as possible. This encompasses waste management and waste prevention within a resource efficiency context.

The green economy approach goes further than the circular economy, extending the focus beyond waste and material resources to how the use of water, energy, land and biodiversity should be managed in accordance with objectives for ecosystem resilience and human well-being. The green economy also addresses wider economic and social aspects, such as competitiveness and social inequalities regarding exposure to environmental pressures and access to green spaces.

Like previous reports on *The European environment — state and outlook* (SOER), this report demonstrates that environmental policy has delivered substantial improvements but that major environmental challenges remain. It provides a more detailed understanding of the challenges that Europe faces in achieving a transition to a green economy. In doing so it helps identify opportunities to respond to these challenges.

Figure 6.2 The green economy as an integrating framework for policies relating to material use



Source: EEA.

Responding to systemic challenges: from vision to transition

7.1 Living well within the limits of the planet requires a transition to a green economy

Established environmental and economic policies focused on efficiency improvements are necessary contributions to achieving the 2050 vision of living well within the limits of the planet but are unlikely to be sufficient in themselves. The transition to a green economy is a long-term, multi-dimensional and fundamental process that will require a move away from the current linear economic model of 'take-make-consume-dispose' which relies on large quantities of easily accessible resources and energy. This will necessitate profound changes in dominant institutions, practises, technologies, policies, lifestyles and thinking.

The transition to a green economy will involve reconciling the longer-term perspective of environmental policies with the relatively short-term focus of economic and social policies. With some justification, decision makers give issues such as tackling unemployment and dealing with social inequalities greater emphasis as society expects immediate action and results. Less emphasis is given to longer-term actions that deliver less immediate and visible benefits, such as actions to restore ecosystem resilience.

These different time scales pose a further challenge since achieving long-term visions and objectives crucially depends on short- and medium-term actions and investments. In terms of policy, the EU needs to ensure that its targets and objectives in the 2020–2030 timeframe provide a viable pathway to realising the 2050 vision (see Figure 1.1). The recently adopted 7th Environment Action Programme provides a coherent, systemic framework to broaden societal efforts towards these goals. It commits the EU to 'stimulate the transition to a green economy and to strive towards an absolute decoupling of economic growth and environmental degradation' with the 2050 vision 'intended to guide action up to 2020 and beyond' (EU, 2013).

7.2 Recalibrating available policy approaches can help Europe meet its 2050 vision

In current environment and climate policy, there are four prevailing, interrelated and complementary policy approaches that could be recalibrated to support a transition to a green economy. These four approaches can be summarised as: mitigate, adapt, avoid and restore. Each approach depends on different types of knowledge and governance arrangements and creates varying innovation needs. Considering these four approaches together in terms of existing policy implementation and future policy design, could help accelerate a transition towards a green economy (Figure 7.1).

Figure 7.1 Policy approaches for a long-term transition

Mitigate: Policies that mitigate environmental degradation focus on reducing environmental pressures or offsetting the harmful effects of resource use on people's health and ecosystems. They have been the dominant response in Europe since the 1970s and are efficient in addressing both 'specific' and 'diffuse' environmental challenges (Table 1.1). For example, regulations and economic instruments have abated pollution from known, stable sources and have improved resource efficiency by incentivising the development and uptake of cleaner technologies. Table 6.1 indicates several success stories.

If they are well designed, mitigation policies can benefit socio-economic objectives. For example, shifting taxes from employment towards resource use and pollution offers a way to offset the impact of shrinking workforces in coming decades, while also incentivising resource efficiency improvements. Environmental taxation is an underused policy instrument: revenues in the EU from these taxes fell from 2.7% to 2.4% of GDP between 1995 and 2012. Strengthening pollution abatement standards — most notably in the air pollution, climate, waste and water sectors — would likewise provide incentives for further research, technological innovation and trade in goods and services.

Adapt: Policies focused on adapting recognise that some environmental change is inevitable. These policies focus on how to anticipate the adverse effects of specific environmental changes and take action to prevent or minimise the damage they can cause. While this approach (and the term 'adaptation') is most often used in a climate change context, the core principles of such policies span most economic and social policy domains.

Policies aimed at adapting are highly relevant to areas such as biodiversity and nature protection; food, water and energy security; and managing the environment-related health implications of population ageing. Regional ecosystem-based management approaches (see Chapter 3) are an example of an adaptive approach which aims to use natural resources to secure the resilience of ecosystems and their services to society.

Avoid: Policies based on the precautionary principle, can help to avoid potential harm (or counter-productive actions) in highly complex and uncertain situations. The speed and scale of current technological developments often outstrips society's capacities to monitor and respond to risks before they become widespread. An EEA assessment of 34 cases where early warnings of risk were ignored argues that precautionary action could have saved many lives and avoided extensive damage to ecosystems. The assessment covered a variety of cases, including chemicals, pharmaceuticals, nano- and biotechnologies and radiation (EEA, 2013k).

The precautionary principle also brings opportunities for broader societal engagement on future innovation pathways. It provides a platform for more integrated risk governance and debate on questions such as the strength of evidence for action, the burden of proof and the trade-offs that society is willing to make against other objectives and priorities. This is especially relevant for emerging technologies, such as nanotechnologies, where the risks and benefits to society are both uncertain and contested.

Restore: Policies that aim to restore focus on remediating environmental degradation (where possible) or other costs imposed on society. They are used across most environmental domains and in economic and social policy areas. Societal actions focused on restoration can be used to improve ecosystem resilience, bringing multiple benefits to human health and well-being. They can also enable social and environmental goals to be pursued simultaneously. For example, investment in green infrastructure can address ecosystem resilience and increase access to green spaces.

Restoring can also include offsetting the regressive effects of environmental policies. For example, measures to reduce greenhouse gas emissions can increase energy bills, disproportionally affecting low income households (EEA, 2011b). In response, policy measures aimed at restoring resilience would focus on distributional issues and improving energy efficiency.

7.3 Innovations in governance can help harvest the links between policy approaches

The four policy approaches (mitigate, adapt, avoid and restore) are anchored by the four environment principles of the Treaty on European Union: polluter pays, prevention, precaution and rectification of damage at source. These approaches can be combined in several ways. For example, the principle of preventing environmental degradation involves the use of measures to mitigate and avoid problems, whereas dealing with the consequences involves the use of measures to adapt and restore. Fixing known problems can be supported by a combination of measures to mitigate and restore, whereas anticipating more uncertain, future problems would involve measures to avoid and adapt.

Striking the appropriate balances between these approaches while harnessing synergies through integrated implementation can shape the benefits that society could secure in coming decades. Policy packages that include objectives and targets explicitly recognising the relationships between resource efficiency, ecosystem resilience and human well-being, as well as the different time and space dimensions involved, would enhance integration and coherence and help to accelerate transitions.

New governance approaches have emerged in recent decades in response to the increasingly long-term and globalised environmental challenges. The primary governance response has been international agreements or the pooling of sovereignty in regional blocs, such as in the European Union. More recently, the limitations of intergovernmental processes at the global scale and the new opportunities created by technological and social innovations have driven more participatory network governance approaches, based on informal institutions and instruments. This in turn has driven increasing demands for transparency and accountability from governments and businesses.

The goals of non-governmental organisations have shifted in recent years from primarily aiming to steer government and intergovernmental processes, to also include development of environmental standards and monitoring trends (Cole, 2011). Crucially, businesses often have a commercial interest in the adoption of production standards that frequently underlie mitigation policies. In this respect, network governance approaches can help align the interests of different stakeholders — with non-governmental organisations proposing standards and businesses promoting them (Cashore and Stone, 2012).

For example, certification and labelling schemes enable firms to signal good practices to consumers as well as differentiate their products from those of competitors. Such approaches today help address known environmental problems, such as forest degradation, ecosystem fragmentation and pollution (Ecolabel Index, 2014) as well as issues where cause-effect relationships are less clear e.g. people's exposures to chemicals in consumer products.

In other situations, businesses favour harmonised mitigation standards in order to reduce production costs or to enable a 'level playing field' with competitors. The ongoing adoption across Asia, for example, of EU emissions standards for road vehicles illustrates both the desire for greater efficiencies in global production as well as the different roles and interactions between actors in environmental governance.

The rise of networks is also opening up opportunities at local level. As emphasised in Objective 8 of the 7th Environment Action Programme, cities and their networks have a particularly important role in environmental governance (see Box 1.1). Cities concentrate populations, economic and social activities and innovations of all sorts and so can be a laboratory for the integrated implementation of the four approaches outlined in Section 7.2. Enhanced networking of cities, as illustrated by the Covenant of Mayors (CM, 2014) can further multiply benefits by supporting the upscaling and diffusion of niche innovations to contribute to broader systemic change.

7.4 Today's investments are essential for effecting long-term transitions

The 7th Environment Action Programme identifies four key pillars of an enabling framework for transition to a green economy: **implementation, integration, information and investments**. The first two of these feature prominently in Chapters 3–5 and Table 6.1 as well as the approaches considered in Section 7.2. Effective implementation of horizontal instruments that focus on integration such as the Strategic Environmental Assessment Directive and Environmental Impact Assessment Directive, could play a stronger role in the context of long-term transitions. A third pillar, 'information', runs through the whole report and is addressed further in Section 7.5.

The fourth pillar relates to investments. Investment choices — and the availability of financial resources more broadly — are key enabling conditions for long-term transitions. This is partly because the systems that meet basic social needs such as water, energy and mobility rely on costly and long-lasting infrastructure. Investment choices can therefore have long-term implications for the functioning of these systems and their impacts, as well as for the viability of alternative technologies. Transitions thus depend in part on avoiding investments that lock in existing technologies, limit options, or hinder the development of substitutes.

The estimated financial needs for investments in green economy infrastructure and innovations at the European and global scales are enormous. Realising a low-carbon future in the EU is estimated to require EUR 270 billion annually for 40 years (EC, 2011a). There are opportunities to direct financial resources to support transitions through a number of channels. Some of these channels are public and include specific initiatives undertaken by EU financial institutions. Phasing out environmentally harmful subsidies that distort price signals can also influence investment choices and release public revenue for investment.

Other channels, for example pension funds, are to be found in the private sector. Some, such as sovereign wealth funds, mix public and private elements. As for the instruments these channels can invest in, there is great potential in hybrid instruments, including green bonds (EEA, 2014s). There is increasing interest in sustainable and responsible investment strategies with funds continuing to grow in recent years (Eurosif, 2014).

At the EU level, support for the green economy can be found in the EU's Multiannual Financial Framework 2014–2020, which provides for the investment of nearly EUR 1 trillion in sustainable growth, jobs, and competitiveness, in line with the Europe 2020 Strategy. At least 20% of the EU's 2014–2020 budget will be spent on transforming Europe into a clean and competitive low-carbon economy, using policies covering structural funds, research, agriculture, maritime policy, fisheries, and the LIFE programme.

Investments can also support the emergence and **upscaling of niche economic, technological and social innovations** that enable society to meet its needs in less harmful ways (Box 7.1). Investment in research and innovation has an important role, as does investment in facilitating the diffusion of new technologies and approaches. The EU's Framework Programme for Research and Innovation (Horizon 2020) has a primary focus on fostering innovation, and technological innovations in particular. It also addresses social innovation through several 'societal challenges', of which Societal Challenge 5 on climate action, environment, resource efficiency and raw materials, is of particular relevance.

The EU is explicitly committed to modernising its industrial base by accelerating the uptake of technological innovation. It has adopted a policy objective of reaching a 20% share of manufacturing industry in EU GDP by 2020. If eco-innovative solutions are pursued, this objective provides an opportunity to reconcile economic, employment, environment and climate objectives.

Alongside investments in new technologies, there is also a need for spending aimed at identifying, assessing, managing and communicating the risks that can accompany innovation. Historically, EU-funded public research has allocated less than 2% of funding to investigate potential health hazards of new technologies. Ratios of 5–15% would seem more prudent, depending on the relative novelty of the technology, and on its potential persistence, bioaccumulation and spatial ranges (Hansen and Gee, 2014).

Box 7.1 Innovations that can support long-term transitions towards sustainability

As part of the preparation of this SOER 2015 Synthesis report, the EEA convened a group of 25 stakeholders from science, business, policy and civil society to reflect on the prospects for the environment in Europe. During those discussions, the participants identified four clusters of innovations with potential to support transitions in the systems that provide Europe's food, mobility and energy.

Collaborative consumption focuses on the ways that consumers can obtain products or services more effectively and resource-efficiently. This may involve fundamentally changing the ways that consumer demands are met, including shifting from individual decisions to organised or collective demand.

Prosumerism reduces the distinction between producer and consumer and can be seen as a particular type of collaborative consumption. An example is distributed energy production systems, enabled by technological innovations such as smart metering and smart grids.

Social innovation entails developing new concepts, strategies and organisational forms to better meet societal needs. Both examples above are examples of social innovation, with prosumerism a social innovation that is enabled in part by technological innovation. Social innovation is a problem solving approach that carries strong potential for generating new social relationships, and is perhaps the most crucial element required for fostering sustainability transitions.

Eco-innovation and eco-design go further than technological innovation, to incorporate environmental considerations by either reducing the environmental impact of products or production processes, or incorporating environmental concerns into the product design and life cycle. Harvesting energy from food waste, multi-trophic agriculture, and retrofit building insulation from recycled paper products are just a few examples of eco-innovation and design.

Finally, fiscal measures have an important role in steering and incentivising investment. Eco-innovations can face difficulties competing with established technologies because market prices seldom reflect the full environmental and social costs of resource use. By adjusting prices, tax reforms can correct market incentives, as well as generating revenues that can be invested in eco-innovations. Reform of environmentally harmful subsidies is important, notably in the areas of agriculture and energy. For example, despite growing interest in promoting renewable energy, in 2012 Europe's fossil fuel and nuclear sectors still benefited from a significant number of support measures, adversely affecting public budgets in times of crisis (EEA, 2014e) .

7.5 Expanding the knowledge base is a prerequisite for managing long-term transitions

Expanding the environmental knowledge base can secure many goals. These include supporting better implementation and integration of environment and climate policy; informing investment choices, and supporting long-term transitions. An expanded knowledge base also ensures that policymakers and businesses have a sound basis for taking decisions that fully reflect environmental limits, risks, uncertainties, benefits and costs.

The current knowledge base for environmental policy is based on monitoring, data, indicators and assessments mainly linked to the implementation of legislation, formal scientific research and 'citizen science' initiatives. However, there are gaps between the available knowledge and that required to meet emerging policy demands. These gaps call for actions to widen the knowledge base for policy and decision-making in the coming decade.

Knowledge gaps are highlighted throughout this report. Gaps that merit particular attention relate to systems science; complex environmental change and systemic risks; how Europe's environment is affected by global megatrends; the interplay between socio-economic and environmental factors; feasible transitions in production-consumption systems; environmental risks to health; and the inter-relationships between economic development, environmental change and human well-being.

In addition, there are areas where knowledge development can support both policymaking and investment decisions, namely integrated environmental-economic accounts and derived indicators. This includes physical and monetary accounts for natural capital and ecosystem services and developing and applying indicators to complement and go beyond GDP.

The inclusion of long-term perspectives to support policy and decision-making raises further issues. Long-term environmental policy objectives have only explicitly been established in a few areas and new policies will require more information on possible future developments and choices in the face of greater risks and uncertainties. Such investments can have secondary benefits with respect to the better management of current policies.

Foresight methods such as horizon scanning, model-based projections and scenario development should be more widely used to enhance strategic planning. Forward-looking assessments and their inclusion in regular state of the environment reporting would enable better understanding of future trends and uncertainties, and improve the robustness of policy options and their consequences.

Further implementation of the Shared Environmental Information System principle of 'produce once use often', and the use of common approaches and standards (e.g. INSPIRE, Copernicus) can help streamline effort and release resources. Current environmental information systems should also incorporate new information on emerging themes and forward-looking information as knowledge gaps are addressed in the coming years.

Strengthening the science-policy-society interfaces and citizen engagement are important elements of transition processes. Effective stakeholder engagement is important for the development of future transition pathways and to improve the confidence of policymakers and the public in the evidence that underpins policy. The new and emerging issues arising from technological changes that outpace policy development have led to public concern. Adopting a systematic and integrated approach to risk management will require broader and more transparent scientific, political and societal debates and strengthen Europe's capacity to identify and upscale niche innovations in support of a transition.

As highlighted in Objective 5 of the 7th Environment Action Programme, the EEA has a particular role to play in strengthening the science-policy interface. Along with the European Environment Information and Observation Network (Eionet) it forms a partnership generating two-way quality assured environmental data and information by co-creating and sharing knowledge.

The steps identified in the 7th Environment Action Programme provide the foundation for a strategic reflection amongst stakeholders on knowledge development needs and priorities. This also includes consideration of the role and status of different types of knowledge and how they are linked to policymaking and transitions. The shared timeframe of the EU's 7th Environment Action Programme, Multiannual Financial Framework 2014–2020 and the Framework Programme for Research and Innovation (Horizon 2020) offers an opportunity to harness synergies between knowledge development needs and funding mechanisms.

7.6 From visions and ambitions to credible and feasible transition pathways

This report evaluates the European environment's state, trends and prospects in a global context. It provides a detailed understanding of the systemic characteristics of Europe's environmental challenges and their interdependence with economic and social systems. It analyses opportunities to recalibrate policies, governance, investment and knowledge in line with the 2050 vision of living well within the limits of the planet.

The transition to a green economy in Europe involves going beyond economic efficiency and optimisation strategies to embracing society-wide changes. Environment and climate policies have a central role within this wider approach. The 7th Environment Action Programme offers a clear vision and sense of direction. However, success in the short and longer-term requires acknowledgment of the role of sustainability approaches and solutions for dealing with the multiple challenges and systemic risks faced by Europe and the world.

The findings set out in this report are complemented by recent outputs from the European Strategy and Policy Analysis System which assessed the long-term political and economic environment facing Europe over the next 20 years, and Europe's policy options for dealing with them (ESPAS, 2012). They emphasised that Europe and the world are experiencing a period of accelerated change, in particular with respect to power, demographics, climate, urbanisation and technology. Tracking these trends and formulating response options will be fundamental to Europe's ability to deal with these challenges that have greater uncertainties as well as offering broader opportunities for system-level change.

The findings are also coherent with developments in the business community. For example, the latest assessment of global risks from the World Economic Forum identified three environmental risks among the ten risks of highest concern for business (WEF, 2014). The assessment calls for collaborative stakeholder action; better communication and learning amongst stakeholders; and new ways to incentivise long-term thinking. Individual businesses are also focusing on integrated resource management in a long-term perspective, for example, by evaluating the implications of the food-water-energy nexus for their prospects and developing new types of business models (RGS, 2014).

At the global level the Rio+20 conference in 2012 confirmed that the world needs new types of sustainable development policies in order to live within the limits of the planet (UN, 2012a). Better understanding of systemic challenges and their time dimension has in recent years led to the framing of global environmental issues in terms of tipping points, limits, and gaps. In climate change, arguably the most critical, complex and systemic challenge we are facing, these characteristics clearly coincide. The same can be said for ecosystem changes.

Overall, societies, economies, finance systems, political ideologies and knowledge systems fail to acknowledge or incorporate seriously the idea of planetary boundaries or limits. The Rio+20 declaration's objectives for a low-carbon society, ecological resilience, green economy, and equity are all intertwined with the core systems that societies depend on for their welfare. Embracing these realities and designing future actions accordingly could make transitions more credible and feasible globally.

European citizens strongly believe that the state of the environment influences quality of life and that more needs to be done to protect the environment. They favour action at European level and more prioritisation of EU funding to support environmentally-friendly activities. Europeans also support measuring national progress using environmental, social and economic criteria, and are in widespread agreement that environmental protection and efficient use of natural resources can boost economic growth, create jobs and contribute to social cohesion (EC, 2014b).

At the same time this increasingly shared understanding will not suffice. Combining this with an imperative sense of urgency would accelerate the translation of the 2050 visions and ambitions into feasible, but at the same time credible and concrete steps and pathways.

This report has come to the conclusion that traditional incremental approaches based on the efficiency approach will not suffice. Rather, unsustainable systems of production and consumption require fundamental rethinking in the light of European and global realities. The overall challenge for the next decades will be to recalibrate mobility, agriculture, energy, urban development, and other core systems of provision in such way that global natural systems maintain their resilience, as the basis for a decent life.

The systemic nature of the problems and dynamics identified here necessitates systemic solutions. There are currently a wide range of system lock-ins to be overcome, for example, in the fields of science, technology, finance, fiscal instruments, accounting practices, business models, and research and development. The future governance of transition pathways will need to balance efforts between addressing such lock-ins, while maintaining progress towards achieving short and medium-term goals and targets, and avoiding new lock-ins on the path to 2050 visions to the extent possible.

Designing actionable, credible and feasible transition pathways will involve a combination of ingenuity and creativity, courage, and greater shared understanding. Arguably, the most fundamental shift in modern society in the 21st century will be to reinvent what it means to have a high level of societal well-being, while accepting and embracing the limits of the planet. Otherwise there is an increasing risk that breaching tipping points and moving beyond limits might bring more disruptive and unwelcome pushes towards societal change.

In its 7th Environment Action Programme, Europe envisions that young children today will live around half their lives in a low-carbon society, based on a circular economy and resilient ecosystems. Achieving this commitment can put Europe at the frontier of science and technology but calls for a greater sense of urgency and more courageous actions.

This report offers a knowledge based contribution towards meeting those visions and goals.

Country names and country groupings

This report present a comprehensive report on the state of, trends in and prospects for the environment across all 39 member countries and cooperating countries of the European Environment Agency — to the degree possible.

As a European Union agency, the European Environment Agency follows the guide of the Commission's Interinstitutional style guide on country names. This style guide is available here: http://publications.europa.eu/code/en/en-370100.htm.

The country groupings presented here are based on the official classification used in the Interinstitutional style guide and the nomenclature used by DG Enlargement.

Region	Sub-regions	Sub-group	Countries
EEA member countries (EEA-33)	EU-28 (i.e. EU-27 + Croatia)	EU-15	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, the United Kingdom
		EU-12 + 1	Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia, plus Croatia
	EU candidate countries		Turkey, Iceland
	European Free Trade Association (EFTA)		Liechtenstein, Norway, Switzerland, (Iceland)
EEA cooperating countries (Western Balkans)	EU candidate countries		Albania, the former Yugoslav Republic of Macedonia, Montenegro, Serbia
	EU potential candidates		Bosnia and Herzegovina, Kosovo under UN SCR 1244/99

Note: For practical reasons the groups used are based on established political groupings (as of mid-2014) rather than environmental considerations. Thus there are variations in environmental performance within the groups and substantial overlaps between them.

Where it is meaningful, specific sections of this report may refer to regional groupings based on bio-geographical features to illustrate specific trends. However, where this is done the respective regional groupings and the underlying rationale is explained clearly.

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References

Araújo, M. B. and Rahbek, C., 2006, 'How Does Climate Change Affect Biodiversity?', *Science* 313(5792), pp. 1 396–1 397.

Baccini, M., Kosatsky, T., Analitis, A., Anderson, H. R., D'Ovidio, M., Menne, B., Michelozzi, P., Biggeri, A. and PHEWE Collaborative Group, 2011, 'Impact of heat on mortality in 15 European cities: attributable deaths under different weather scenarios', *Journal of Epidemiology & Community Health* 65(1), pp. 64–70.

Baker-Austin, C., Trinanes, J. A., Taylor, N. G. H., Hartnell, R., Siitonen, A. and Martinez-Urtaza, J., 2012, 'Emerging Vibrio risk at high latitudes in response to ocean warming', *Nature Climate Change* (3), pp. 73–77.

Balbus, J. M., Barouki, R., Birnbaum, L. S., Etzel, R. A., Gluckman, S. P. D., Grandjean, P., Hancock, C., Hanson, M. A., Heindel, J. J., Hoffman, K., Jensen, G. K., Keeling, A., Neira, M., Rabadan-Diehl, C., Ralston, J. and Tang, K.-C., 2013, 'Early-life prevention of non-communicable diseases', *Lancet* 381(9860) (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3849695) accessed 30 May 2014.

BIR, 2013, *World steel recycling in figures 2008–2012: Steel scrap — a raw material for steelmaking*, Bureau of International Recycling.

Bolin, B. and Cook, R. B., 1983, *The major biogeochemical cycles and their interactions*, Scientific Committee On Problems of the Environment (SCOPE).

Bonn, A., Macgregor, N., Stadler, J., Korn, H., Stiffel, S., Wolf, K. and van Dijk, N., 2014, *Helping ecosystems in Europe to adapt to climate change*, BfN-Skripten 375, Federal Agency for Nature Conservation.

Von Carlowitz, H. C., 1713, *Sylvicultura oeconomica*.

Carstensen, J., Andersen, J. H., Gustafsson, B. G. and Conley, D. J., 2014, 'Deoxygenation of the Baltic Sea during the last century', *Proceedings* *of the National Academy of Sciences* (http://www.pnas.org/content/early/2014/03/27/1323156111) accessed 1 April 2014.

Cashore, B. and Stone, M. W., 2012, 'Can legality verification rescue global forest governance?: Analyzing the potential of public and private policy intersection to ameliorate forest challenges in Southeast Asia', *Forest policy and economics* 18, pp. 13–22.

Cicek, N., 2012, 'EU Turkish cooperation on River Basin Management Planning — EU Accession process in Turkey'.

CICES, 2013, *Towards a Common International Classification of Ecosystem Services* (http://cices.eu) accessed 27 May 2014.

Ciriacy-Wantrup, S. V., 1952, *Resource conservation: economics and policies*, University of California Press, Berkeley, California, USA.

Ciscar, J.-C., Iglesias, A., Feyen, L., Szabó, L., Regemorter, D. V., Amelung, B., Nicholls, R., Watkiss, P., Christensen, O. B., Dankers, R., Garrote, L., Goodess, C. M., Hunt, A., Moreno, A., Richards, J. and Soria, A., 2011, 'Physical and economic consequences of climate change in Europe', *Proceedings of the National Academy of Sciences* 108(7), pp. 2 678–2 683.

Clougherty, J. E. and Kubzansky, L. D., 2009, 'A framework for examining social stress and susceptibility in air pollution and respiratory health', *Environmental Health Perspectives* 117(9), pp. 1 351–1 358.

Clougherty, J. E., Levy, J. I., Kubzansky, L. D., Ryan, P. B., Suglia, S. F., Canner, M. J. and Wright, R. J., 2007, 'Synergistic effects of traffic-related air pollution and exposure to violence on urban asthma etiology', *Environmental Health Perspectives* 115(8), pp. 1 140–1 146.

CM, 2014, 'The Covenant of Mayors', (http://www.covenantofmayors.eu/about/covenant-of-mayors_en.html) accessed 29 October 2014.

Cohen Hubal, E. A., de Wet, T., Du Toit, L., Firestone, M. P., Ruchirawat, M., van Engelen, J. and Vickers, C., 2014, 'Identifying important life stages for monitoring and assessing risks from exposures to environmental contaminants: Results of a World Health Organization review', *Regulatory Toxicology and Pharmacology* 69(1), pp. 113–124.

Cole, D. H., 2011, 'From global to polycentric climate governance', *Climate law* 2(3), pp. 395–413.

COPHES/DEMOCOPHES, 2009, *Human Biomonitoring for Europe — a harmonized approach*, COPHES Consortium to Perform Human Biomonitoring on a European Scale (http://www.eu-hbm.info/cophes) accessed 9 October 2012.

COWI, ECORYS and Cambridge Econometrics, 2011, *The costs of not implementing the environmental acquis*. Final report to European Commission Directorate General Environment., ENV.G.1/FRA/2006/0073.

Crutzen, P. J., 2002, 'Geology of mankind', *Nature* 415(6867), pp. 23–23.

Daily, G. and Ehrlich, P. R., 1992, 'Population, Sustainability, and Earth's Carrying Capacity', *Bioscience* 42(10), pp. 761–771.

Dalin, C., Konar, M., Hanasaki, N. and Rodriguez-Iturbe, I., 2012, 'Evolution of the global virtual 25 water trade network', *Proc. Natl. Acad. Sci* 109, pp. 5 989–5 994.

Depledge, M. and Bird, W., 2009, 'The Blue Gym: Health and wellbeing from our coasts', *Marine Pollution Bulletin* 58(7), pp. 947–948.

EC, 2004a, Communication from the Commission to the Council, the European Parliament and the European Economic and Social Committee — 'The European Environment and Health Action Plan 2004–2010', COM(2004) 416 final (SEC(2004) 729).

EC, 2004b, Information note: methyl mercury in fish and fishery products.

EC, 2005, Communication from the Commission to the Council, the European Parliament, the European Economic and Social committee and the Committee of the Regions — Thematic Strategy on the sustainable use of natural resources, COM(2005) 0670 final.

EC, 2007a, Communication from the Commission to the European Parliament and the Council — Addressing the challenge of water scarcity and droughts in the European Union, COM(2007) 0414 final.

EC, 2007b, White paper — Together for health: a strategic approach for the EU 2008–2013, COM(2007) 0630 final.

EC, 2010, Communication from the Commission 'Europe 2020 — A strategy for smart, sustainable and inclusive growth', COM(2011) 112 final.

EC, 2011a, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions — A Roadmap for moving to a competitive low carbon economy in 2050, COM(2011) 112 final, Brussels, 8.3.2011.

EC, 2011b, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions — Our life insurance, our natural capital: an EU biodiversity strategy to 2020, COM(2011) 0244 final.

EC, 2011c, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions 'Roadmap to a Resource Efficient Europe', COM(2011) 571 final.

EC, 2011d, DG Research workshop on Responsible Research and Innovation in Europe, 16–17 May 2011, Brussels.

EC, 2011e, White paper: Roadmap to a Single European Transport Area — Towards a competitive and resource efficient transport system, COM(2011) 144 final, Brussels, 28.3.2011.

EC, 2012a, Comission Staff Working Document. Guidelines on best practice to limit, mitigate or compensate soil sealing, SWD(2012) 101 final/2.

EC, 2012b, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions — A Blueprint to Safeguard Europe's Water Resources, COM(2012) 673 final.

EC, 2012c, Communications from the Commission to the Council: The combination effects of chemicals — Chemical mixtures, COM(2012) 252 final, Brussels 31.5.2012.

EC, 2012d, EU conference on endocrine disrupters — current challenges in science and policy, 11–12 June 2012, Brussels.

EC, 2012e, Global Resources Use and Pollution, Volume 1, Production, consumption and trade (1995–2008), EUR 25462 EN, European Commission, Joint Research Centre, Institute for Prospective Technological Studies.

EC, 2013a, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A clean air programme for Europe, COM(2013/0918 final , Brussels, 18.12.2013.

EC, 2013b, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: Green infrastructure — enhancing Europe's natural capital, COM(2013) 0249 final.

EC, 2013c, Guidelines on Climate Change and Natura 2000. Dealing with the impact of climate change on the management of the Natura 2000 network of areas of high biodiversity value, Technical Report — 2013 — 068.

EC, 2013d, Impact assessment on the Air Quality Package (summary), SWD/2013/0532 final.

EC, 2013e, 'Press release: Speech by Janez Potočnik — *New Environmentalism*, (http://europa.eu/rapid/press-release_SPEECH-13-554_en.htm) accessed 7 November 2014.

EC, 2013f, Proposal for a Directive of the European Parliament and of the Council on the limitation of emissions of certain pollutants into the air from medium combustion plants, COM(2013) 0919.

EC, 2014a, 'AMECO database', (http://ec.europa.eu/economy_finance/db_indicators/ameco/zipped_en.htm) accessed 2 September 2014.

EC, 2014b, Attitudes of European citizens towards the environment. Special Eurobarometer 416.

EC, 2014c, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions 'A policy framework for climate and energy in the period from 2020 to 2030', COM(2014) 15 final of 22 January 2014.

EC, 2014d, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions 'Towards a circular economy — A zero waste programme for Europe', COM(2014) 398 final of 2 July 2014.

EC, 2014e, Communication from the Commission to the European Parliment and the Council concerning a consultation on fishing opportunities for 2015 under the Common Fisheries Policy, COM(2014) 388 final

EC, 2014f, 'European Community Health Indicators (ECHI)', (http://ec.europa.eu/health/indicators/echi/list/index_en.htm#id2) accessed 14 March 2014.

EC, 2014g, 'European Green Capital', European Green Capital (http://ec.europa.eu/environment/europeangreencapital/index_en.htm) accessed 14 October 2014.

EC, 2014h, Proposal for a decision of the European Parliament and of the Council concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading scheme and amending Directive 2003/87/EC, COM(2014) 20/2, Brussels.

EC, 2014i, 'RAPEX facts and figures 2013. complete statistics. Rapid Alert System for non-food dangerous products (RAPEX), The Directorate-General for Health and Consumers of the European Commission.', (http://ec.europa.eu/consumers/consumers_safety/safety_products/rapex/reports/index_en.htm) accessed 27 August 2014.

EC, 2014j, 'The Roadmap's approach to resource efficiency indicators', (http://ec.europa.eu/environment/resource_efficiency/targets_indicators/roadmap/index_en.htm) accessed 20 May 2014.

ECDC, 2009, *Development of Aedes albopictus risk maps*, European Centre for Disease Prevention and Control, Stockholm, Sweden.

ECDC, 2012a, *Assessing the potential impacts of climate change on food- and waterborne diseases in Europe*, Technical Report, European Centre for Disease Prevention and Control, Stockholm, Sweden.

ECDC, 2012b, 'Exotic mosquitoes — distribution map — Aedes aegypti', (http://ecdc.europa.eu/en/activities/diseaseprogrammes/emerging_and_vector_borne_diseases/Pages/VBORNET_maps.aspx) accessed 22 November 2012.

ECDC, 2012c, *The climatic suitability for dengue transmission in continental Europe*, ECDC Technical Report, European Centre for Disease Prevention and Control, Stockholm, Sweden.

ECDC, 2012d, 'West Nile fever maps', (http://www.ecdc.europa.eu/en/healthtopics/west_nile_fever/West-Nile-fever-maps/Pages/index.aspx) accessed 6 November 2012.

ECDC, 2013, *Annual epidemiological report 2012. Reporting on 2010 surveillance data and 2011 epidemic intelligence data*, European Centre for Disease Prevention and Control, Stockholm, Sweden.

Ecolabel Index, 2014, 'All ecolabels', (http://www.ecolabelindex.com/ecolabels) accessed 4 September 2014.

EEA, 2006, *Urban sprawl in Europe: The ignored challenge*, EEA Report No 10/2006, European Environment Agency, Copenhagen, Denmark.

EEA, 2009a, *Ensuring quality of life in Europe's cities and towns*, EEA Report No 5/2009, European Environment Agency, Copenhagen, Denmark.

EEA, 2009b, *Water resources across Europe — confronting water scarcity and drought*, EEA Report No 2/2009, European Environment Agency, Copenhagen, Denmark.

EEA, 2010a, *Mapping the impacts of natural hazards and technological accidents in Europe: an overview of the last decade*, European Environment Agency, Copenhagen, Denmark.

EEA, 2010b, *The European environment — state and outlook 2010: Assessment of global megatrends*, European Environment Agency, Copenhagen, Denmark.

EEA, 2010c, *The European environment — state and outlook 2010: Freshwater quality*, European Environment Agency, Copenhagen, Denmark.

EEA, 2010d, *The European environment — state and outlook 2010: Synthesis*, European Environment Agency, Copenhagen, Denmark.

EEA, 2010e, *The European environment — state and outlook 2010: Urban environment*, European Environment Agency, Copenhagen, Denmark.

EEA, 2011a, *Earnings, jobs and innovation: the role of recycling in a green economy*, EEA Report No 8/2011, European Environment Agency, Copenhagen, Denmark.

EEA, 2011b, *Environmental tax reform in Europe: implications for income distribution*, EEA Technical report No 16/2011, European Environment Agency, Copenhagen, Denmark.

EEA, 2011c, 'European Soundscape Award', European Environment Agency, Copenhagen, Denmark.

EEA, 2011d, *Hazardous substances in Europe's fresh and marine waters — An overview*, EEA Technical report No 8/2011, European Environment Agency, Copenhagen, Denmark.

EEA, 2011e, 'NoiseWatch', (http://watch.eyeonearth.org/?SelectedWatch=Noise) accessed 10 November 2012.

EEA, 2011f, *Safe water and healthy water services in a changing environment*, EEA Technical report No 7/2011, European Environment Agency, Copenhagen, Denmark.

EEA, 2012a, *Climate change, impacts and vulnerability in Europe 2012 — an indicator-based report*, EEA Report No 12/2012, European Environment Agency, Copenhagen, Denmark.

EEA, 2012b, *Environmental indicator report 2012: Ecosystem resilience and resource efficiency in a green economy in Europe*, European Environment Agency, Copenhagen, Denmark.

EEA, 2012c, E*uropean waters — current status and future challenges: Synthesis*, EEA Report No 9/2012, European Environment Agency, Copenhagen, Denmark.

EEA, 2012d, *Invasive alien species indicators in Europe — a review of streamlining European biodiversity (SEBI) Indicator 10*. EEA Technical report No 15/2012, European Environment Agency, Copenhagen, Denmark.

EEA, 2012e, *The European environment — state and outlook 2010: consumption and the environment — 2012 update*, European Environment Agency, Copenhagen, Denmark.

EEA, 2012f, *The impacts of endocrine disrupters on wildlife, people and their environments — The Weybridge+15 (1996–2011) report*, EEA Technical report No 2/2012, European Environment Agency, Copenhagen, Denmark.

EEA, 2012g, *The impacts of invasive alien species in Europe*. EEA Technical report No 16/2012, European Environment Agency, Copenhagen, Denmark.

EEA, 2012h, *Towards efficient use of water resources in Europe*, EEA Report No 1/2012, European Environment Agency, Copenhagen, Denmark.

EEA, 2012i, *Urban adaptation to climate change in Europe*, EEA Report No 2/2012, European Environment Agency, Copenhagen, Denmark.

EEA, 2012j, *Water resources in Europe in the context of vulnerability*, EEA Report No 11/2012, European Environment Agency, Copenhagen, Denmark.

EEA, 2013a, *Achieving energy efficiency through behaviour change what does it take?*, EEA Technical report No 5/2013, European Environment Agency, Copenhagen, Denmark.

EEA, 2013b, *A closer look at urban transport TERM 2013: transport indicators tracking progress towards environmental targets in Europe*, EEA Report No 11/2013, European Environment Agency, Copenhagen, Denmark.

EEA, 2013c, *Adaptation in Europe — Addressing risks and opportunities from climate change in the context of socio-economic developments*, EEA Report No 3/2013, European Environment Agency, Copenhagen, Denmark.

EEA, 2013d, *Assessment of cost recovery through water pricing*, EEA Technical report No 16/2013, European Environment Agency, Copenhagen, Denmark.

EEA, 2013e, *Assessment of global megatrends — an update. Global megatrend 8: Growing demands on ecosystems*, (http://www.eea.europa.eu/publications/global-megatrend-update-8/at_download/file).

EEA, 2013f, *Environmental indicator report 2013 — Natural resources and human well-being in a green economy*, European Environment Agency, Copenhagen, Denmark.

EEA, 2013g, *European Union CO_2 emissions: different accounting perspectives*, EEA Technical report No 20/2013, European Environment Agency, Copenhagen, Denmark.

EEA, 2013h, 'Exposure of ecosystems to acidification, eutrophication and ozone (CSI 005) — Assessment published December 2013 — European Environment Agency (EEA)', (http://www.eea.europa.eu/data-and-maps/indicators/exposure-of-ecosystems-to-acidification-2/exposure-of-ecosystems-to-acidification-5) accessed 27 May 2014.

EEA, 2013i, 'Final energy consumption by sector (CSI 027/ENER 016)', (http://www.eea.europa.eu/data-and-maps/indicators/final-energy-consumption-by-sector-5/assessment-1) accessed 28 May 2014.

EEA, 2013j, 'Land take (CSI 014/LSI 001) — Assessment published June 2013 — European Environment Agency (EEA)', (http://www.eea.europa.eu/data-and-maps/indicators/land-take-2/assessment-2) accessed 27 May 2014.

EEA, 2013k, *Late lessons from early warnings: science, precaution, innovation*, EEA Report No 1/2013, European Environment Agency, Copenhagen, Denmark.

EEA, 2013l, *Managing municipal solid waste — a review of achievements in 32 European countries*, EEA Report No 2/2013, European Environment Agency, Copenhagen, Denmark.

EEA, 2013m, *Towards a green economy in Europe EU environmental policy targets and objectives 2010–2050*, EEA Report No 8/2013, European Environment Agency, Copenhagen, Denmark.

EEA, 2013n, *Trends and projections in Europe 2013 — Tracking progress towards Europe's climate and energy targets until 2020*, EEA Report No 10/2013, European Environment Agency, Copenhagen, Denmark.

EEA, 2014a, *Air quality in Europe — 2014 report*, EEA Report No 5/2014, European Environment Agency, Copenhagen, Denmark.

EEA, 2014b, *Annual European Union greenhouse gas inventory 1990–2012 and inventory report 2014*, EEA Technical report No 9/2014, European Environment Agency, Copenhagen, Denmark.

EEA, 2014c, 'Corine Land Cover 2006 seamless vector data', (http://www.eea.europa.eu/data-and-maps/data/clc-2006-vector-data-version-3) accessed 15 October 2014.

EEA, 2014d, *Effects of air pollution on European ecosystems. Past and future exposure of European freshwater and terrestrial habitats to acidifying and eutrophying air pollutants*, EEA Technical report No 11/2014, European Environment Agency, Copenhagen, Denmark.

EEA, 2014e, *Energy support measures and their impact on innovation in the renewable energy sector in Europe,* EEA Technical report No 21/2014, European Environment Agency, Copenhagen, Denmark.

EEA, 2014f, *Environmental indicator report 2014: Environmental impacts of production-consumption systems in Europe*, European Environment Agency, Copenhagen, Denmark.

EEA, 2014g, *European bathing water quality in 2013*, EEA Report No 1/2014, European Environment Agency, Copenhagen, Denmark.

EEA, 2014h, *European Union emission inventory report 1990–2012 under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP)*, EEA Technical report No 12/2014, European Environment Agency, Copenhagen, Denmark.

EEA, 2014i, 'Global megatrends update: 3 Changing disease burdens and risks of pandemics', European Environment Agency, Copenhagen, Denmark.

EEA, 2014j, *Good practice guide on quiet areas*, EEA Technical report No 4/2014, European Environment Agency, Copenhagen, Denmark.

EEA, 2014k, *Marine messages: Our seas, our future — moving towards a new understanding*, Brochure, European Environment Agency, Copenhagen, Denmark.

EEA, 2014l, *Monitoring CO_2 emissions from passenger cars and vans in 2013*, EEA Technical report No 19/2014, European Environment Agency, Copenhagen, Denmark.

EEA, 2014m, *Multiannual Work Programme 2014–2018 — Expanding the knowledge base for policy implementation and long-term transitions*, European Environment Agency, Copenhagen, Denmark.

EEA, 2014n, *National adaptation policy processes across European countries — 2014*, EEA Report No 4/2014, European Environment Agency, Copenhagen, Denmark.

EEA, 2014o, 'National emissions reported to the UNFCCC and to the EU Greenhouse Gas Monitoring Mechanism', (http://www.eea.europa.eu/data-and-maps/data/national-emissions-reported-to-the-unfccc-and-to-the-eu-greenhouse-gas-monitoring-mechanism-8) accessed 15 October 2014.

EEA, 2014p, *Noise in Europe 2014*, EEA Report No 10/2014, European Environment Agency, Copenhagen, Denmark.

EEA, 2014q, 'Nutrients in freshwater (CSI 020) — Assessment created October 2013 — European Environment Agency (EEA)', (http://www.eea.europa.eu/data-and-maps/indicators/nutrients-in-freshwater/nutrients-in-freshwater-assessment-published-5) accessed 27 May 2014.

EEA, 2014r, *Progress on resource efficiency and decoupling in the EU-27*, EEA Technical report No 7/2014, European Environment Agency, Copenhagen, Denmark.

EEA, 2014s, *Resource-efficient green economy and EU policies*, EEA Report No 2/2014, European Environment Agency, Copenhagen, Denmark.

EEA, 2014t, *Costs of air pollution from European industrial facilities 2008–2012 — an updated assessment*, EEA Technical report No 20/2014, European Environment Agency, Copenhagen, Denmark.

EEA, 2014u, *Spatial analysis of green infrastructure in Europe*, EEA Technical report No 2/2014, European Environment Agency, Copenhagen, Denmark.

EEA, 2014v, 'Total gross inland consumption by fuel (CSI 029/ENER 026)', (http://www.eea.europa.eu/data-and-maps/indicators/primary-energy-consumption-by-fuel-3/assessment-1) accessed 3 September 2014.

EEA, 2014w, *Trends and projections in Europe 2014 — Tracking progress towards Europe's climate and energy targets until 2020*, EEA Report No 6/2014, European Environment Agency, Copenhagen, Denmark.

EEA, 2014x, *Why did GHG emissions decrease in the EU between 1990 and 2012?*, EEA analysis, European Environment Agency, Copenhagen, Denmark.

EEA/JRC, 2013, *Environment and human health*, EEA Report No 5/2013, European Environment Agency and the European Commission's Joint Research Centre.

EFSA, 2005, *Opinion of the Scientific Panel on Contaminants in the Food Chain on a Request from the European Parliament Related to the Safety Assessment of Wild and Farmed Fish*. EFSA Journal, 236, pp. 1–118, European Food Safety Authority, Parma, Italy.

EFSA, 2013, *The European Union Summary Report on Trends and Sources of Zoonoses, Zoonotic Agents and Food-borne Outbreaks in 2011*, Scientific Report of EFSA, European Food Safety Authority, Parma, Italy.

Enerdata, 2014, 'Odyssee energy efficiency database', (http://www.enerdata.net/enerdatauk/solutions/data-management/odyssee.php) accessed 15 October 2014.

ESPAS, 2012, *Citizens in an interconnected and polycentric world — Global trends 2030*, Institute for Security Studies, Paris, France.

ETC/ICM, 2013, *Hazardous substances in European waters — Analysis of the data on hazardous substances in groundwater, rivers, transitional, coastal and marine waters reported to the EEA from 1998 to 2010*, Technical Report, 1/2013, Prague.

ETC/SCP, 2014, *Municipal solid waste management capacities in Europe*, ETC/SCP Working Paper No 8/2014, European Topic Center on Sustainable Consumption and Production.

ETC SIA, 2013, *Land Planning and Soil Evaluation Instruments in EEA Member and Cooperating Countries (with inputs from Eionet NRC Land Use and Spatial Planning)*. Final Report for EEA from ETC SIA.

EU, 1991, Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment, OJ L 135, 30.5.1991, pp. 40–52.

EU, 1998, Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption, OJ L 330, 5.12.1998, pp. 32–54.

EU, 2001a, Directive 2001/80/EC of the European Parliament and of the Council of 23 October 2001 on the limitation of emissions of certain pollutants into the air from large combustion plants, OJ L 309, 27/11/2001, pp. 1–21.

EU, 2001b, Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants, OJ L 309, 27.11.2001, pp. 22–30.

EU, 2002, Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise, OJ L 189, 18.7.2002, pp. 12–25.

EU, 2003, Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC, OJ L 275, 25/10/2003, pp. 32–46.

EU, 2006, Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), OJ L 396, 30.12.2006, pp. 1–849.

EU, 2008a, Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control, OJ L 24, 29.1.2008, pp. 8–29.

EU, 2008b, Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, OJ L 312, 22.11.2008, pp. 3–30.

EU, 2009a, Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC, OJ L 140/16.

EU, 2009b, Directive 2009/29/EC amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community, OJ L 140, 5.6.2009, pp. 63-87.

EU, 2009c, Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products, OJ L 285, 31.10.2009, pp. 10–35.

EU, 2009d, Regulation (EC) No 443/2009 of the European Parliament and of the Council of 23 April 2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO_2 emissions from light-duty vehicles, OJ L 140, 5.6.2009, pp. 1–15.

EU, 2010a, Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control), OJ L 334, 17.12.2010, pp. 17–119.

EU, 2010b, Regulation (EC) No 66/2010 of the European Parliament and of the Council of 25 November 2009 on the EU ecolabel, OJ L 27, 30.1.2010, pp. 1–19.

EU, 2012, Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC, OJ L 315/1, 14.11.2012.

EU, 2013, Decision No 1386/2013/EU of the European Parliament and of the Council of 20 November 2013 on a General Union Environment Action Programme to 2020 Living well, within the limits of our planet, OJ L 354, 20.12.2013, pp. 171–200.

EU, 2014a, Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment.

EU, 2014b, Regulation No 282/2014 of the European Parliament and of the Council of 11 March 2014 on the establishment of a third Programme for the Union's action in the field of health (2014-2020) and repealing Decision No 1350/2007/EC.

European Council, 2014, European Council (23 and 24 October 2014): Conclusions on 2030 Climate and Energy Policy Framework, SN 79/14, Brussels, 23 October.

Eurosif, 2014, *European SRI Study*.

Eurostat, 2008, 'Population projections 2008–2060: From 2015, deaths projected to outnumber births in the EU-27 — Almost three times as many people aged 80 or more in 2060 (STAT/08/119)', (http://europa.eu/rapid/pressReleasesAction.do?reference=STAT/08/119).

Eurostat, 2010, *Highly educated men and women likely to live longer. Life expectancy by educational attainment. Statistics in focus 24/2010*, European Union.

Eurostat, 2011, *Active ageing and solidarity between generations. A statistical portrait of the European Union 2012*, Eurostat, Luxembourg: Publications Office of the European Union.

Eurostat, 2014a, 'Annual freshwater abstraction by source and sector', (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_wat_abs&lang=en) accessed 2 September 2014.

Eurostat, 2014b, 'GDP and main components — volumes', (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_gdp_k&lang=en) accessed 3 September 2014.

Eurostat, 2014c, 'Generation of waste', (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_wasgen&lang=en) accessed 15 October 2014.

Eurostat, 2014d, 'Material flow accounts', (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_mfa&lang=en) accessed 27 May 2014.

Eurostat, 2014e, 'Material flow accounts in raw material equivalents — modelling estimates', (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_rme&lang=en) accessed 15 October 2014.

Eurostat, 2014f, 'National Accounts by 10 branches — aggregates at current prices', (http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nama_nace10_c) accessed 15 October 2014.

Eurostat, 2014g, 'Population on 1 January', (http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=tps00001) accessed 2 September 2014.

Eurostat, 2014h, 'Resource efficiency scoreboard', (http://epp.eurostat.ec.europa.eu/portal/page/portal/europe_2020_indicators/ree_scoreboard) accessed 8 March 2014.

Eurostat, 2014i, 'Urban Audit', (http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/city_urban).

FAO, 2009, *How to feed the world in 2050. Issue brief for the High-level Expert Forum, Rome, 12–13 October 2009*, Food and Agriculture Organization of the United Nations.

FAO, 2012, *World agriculture towards 2030/2050: the 2012 revision*, ESA Working Paper 12-03, United Nations Food and Agriculture Organization, Rome, Italy.

Forest Europe, UNECE and FAO, 2011, *State of Europe's forests, 2011: status & trends in sustainable forest management in Europe*, Ministerial Conference on the Protection of Forests in Europe, Forest Europe, Liaison Unit Oslo, Aas, Norway.

Gandy, S., Wiebe, K., Warmington, J. and Watson, R., 2014, S*econd Interim Project Report Consumption Based Approaches to Climate Mitigation: Data Collection, Measurement Methods and Model Analysis — GWS and Ricardo-AEA*.

Global Road Safety Facility, The World Bank and Institute for Health Metrics and Evaluation, 2014, *Transport for Health: The Global Burden of Disease From Motorized Road Transport*, IHME; the World Bank, Seattle, WA; Washington, DC.

Goodwin, P., 2012, *Peak travel, peak car and the future of mobility: Evidence, unresolved issues, policy implications, and a research agenda*, Working paper, International Transport Forum Discussion Paper.

Grandjean, P., Bellinger, D., Bergman, Å., Cordier, S., Davey-Smith, G., Eskenazi, B., Gee, D., Gray, K., Hanson, M., Van Den Hazel, P., Heindel, J. J., Heinzow, B., Hertz-Picciotto, I., Hu, H., Huang, T. T.-K., Jensen, T. K., Landrigan, P. J., McMillen, I. C., Murata, K. et al., 2008, 'The Faroes Statement: Human Health Effects of Developmental Exposure to Chemicals in Our Environment', *Basic & Clinical Pharmacology & Toxicology* 102(2), pp. 73–75.

Grandjean, P. and Landrigan, P. J., 2014, 'Neurobehavioural effects of developmental toxicity', *The Lancet Neurology* 13(3), pp. 330–338.

Greenspace Scotland, 2008, *Greenspace and quality of life: a critical literature review*. Prepared by: Bell, S., Hamilton, V., Montarzino, A., Rothnie, H., Travlou, P., Alves, S., research report, Greenspace Scotland, Stirling.

Guðmundsdóttir, 2010, 'WFD-Implementation Status 2010'.

Hansen, S. F. and Gee, D., 2014, 'Adequate and anticipatory research on the potential hazards of emerging technologies: a case of myopia and inertia?', *Journal of Epidemiology and Community Health* 68(9), pp. 890–895.

Hoff, H., Nykvist, B. and Carson, M., 2014, *Living well, within the limits of our planet? Measuring Europe's growing external footprint*. SEI Working Paper 2014-05.

IARC, 2012, *Diesel Engine Exhaust Carcinogenic*, Press release, 213, International Agency for Research on Cancer, Lyon, France.

IARC, 2013, *Outdoor air pollution a leading environmental cause of cancer deaths*, Press Release No 221, 17 October 2013, International Agency for Research on Cancer, World Health Organization, Lyon, France.

IEA, 2013, *World energy outlook 2013*, International Energy Agency, Paris, France.

IHME, 2013, *The Global Burden of Disease: Generating Evidence, Guiding Policy — European Union and European Free Trade Association Regional Edition*, Institute for Health Metrics and Evaluation, Seattle, WA.

IPCC, 2013, *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC, 2014a, *Climate change 2014: Impacts, adaptation and vulnerability*, Cambridge University Press, Cambridge, UK and New York, USA.

IPCC, 2014b, 'Summary for Policymakers'. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Jöhnk, K. D., Huisman, J., Sharples, J., Sommeijer, B., Visser, P. M. and Stroom, J. M., 2008, 'Summer heatwaves promote blooms of harmful cyanobacteria', *Global Change Biology* 14, pp. 495–512.

JRC, 2013, *Final report ENNAH — European Network on Noise and Health*, Scientific and Policy Report by the Joint Research Centre of the European Commission.

Kharas, H., 2010, *The emerging middle class in developing countries*, OECD Development Centre, Working Paper No 285, Organisation for Economic Cooperation and Development.

Kortenkamp, A., Martin, O., Faust, M., Evans, R., McKinlay, R., Orton, F. and Rosivatz, E., 2012, *State of the Art Assessment of Endocrine Disrupters*. Report for the European Commission, DG Environment.

Krausmann, F., Gingrich, S., Eisenmenger, N., Erb, K.-H., Haberl, H. and Fischer-Kowalski, M., 2009, 'Growth in global materials use, GDP and population during the 20th century', *Ecological Economics* 68(10), pp. 2 696–2 705.

Kurzweil, R., 2005, *The singularity is near: When humans transcend biology*, Viking, New York.

KWR, 2011, *Towards a Guidance Document for the implementation of a risk-assessment for small water supplies in the European Union, Overview of best practices*. Report to the DGENV European Commission (EC Contract number: 070307/2010/579517/ETU D2), Watercycle Research Institute.

Larsson, D. G. J., de Pedro, C. and Paxeus, N., 2007, 'Effluent from drug manufactures contains extremely high levels of pharmaceuticals', *Journal of Hazardous Materials* 148(3), pp. 751–755.

Lenzen, M., Moran, D., Bhaduri, A., Kanemoto, K., Bekcahnov, M., Geschke, A., and Foran, B., 2013, 'International trade of scarce water', *Ecological Economics* 94, pp. 78–85.

Lindgren, E., Andersson, Y., Suk, J. E., Sudre, B. and Semenza, J. C., 2012, 'Monitoring EU emerging infectious disease risk due to climate change', *Science* 336(6080), pp. 418–419.

Lowe, D., Ebi, K. L. and Forsberg, B., 2011, 'Heatwave Early Warning Systems and Adaptation Advice to Reduce Human Health Consequences of Heatwaves', *International Journal of Environmental Research and Public Health* 8(12), pp. 4 623–4 648.

Lucentini, L. and et al., 2009, 'Unprecedented cyanobacterial bloom and microcystin production in a drinking-water reservoir in the South of Italy: a model for emergency response and risk management'. In: Caciolli, S., Gemma, S., Lucentini, L., eds.: *Scientific symposium. International meeting on health and environment: challenges for the future. Abstract book*, Istituto Superiore di Sanità, Rome, Italy.

MA, 2005, *Millennium Ecosystem Assessment — Ecosystems and human well-being: health — synthesis report*, Island Press, New York, USA.

MacDonald, G. K., Bennett, E. M., Potter, P. A. and Ramankutty, N., 2011, 'Agronomic phosphorus imbalances across the world's croplands', *Proceedings of the National Academy of Sciences* 108(7), pp. 3 086–3 091.

Maes, J., Teller, A., Erhard, M., Liquete, C., Braat, L., Berry, P., Egoh, B., Puydarrieux, P., Fiorina, C. and Santos, F., 2013, *Mapping and assessment of ecosystems and their services — An analytical framework for ecosystem assessments under action 5 of the EU biodiversity strategy to 2020*, (http://www.citeulike.org/group/15400/article/12631986) accessed 28 May 2014.

Marmot, M., Allen, J., Goldblatt, P., Boyce, T., McNeish, D., Grady, M. and Geddes, I., 2010, *Fair society, healthy Lives. The Marmot review. Strategic review of health inequalities in England post-2010*, UCL, London, United Kingdom.

McLeod, K. and Leslie, H., eds., 2009, *Ecosystem-based management for the oceans*, Island Press, Washington, DC.

Meadows, D. H., 2008, *Thinking in systems: a primer*, Chelsea Green Publishing.

Meadows, D. H., Meadows, D. L., Randers, J. and Behrens, W. W., 1972, *The limits to growth*, Universe Books, New York, New York, USA.

Meek, M., Boobis, A., Crofton, K., Heinemeyer, G., van Raaij, M. and Vickers, C., 2011, 'Risk assessment of combined exposure to multiple chemicals: A WHO/IPCS framework', *Regulatory Toxicology and Pharmacology* 60(2), pp. S1–S14.

Mitchell, R. and Popham, F., 2008, 'Effect of exposure to natural environment on health inequalities: an observational population study', *The Lancet* 372(9650), pp. 1 655–1 660.

Murray, S. J., Foster, P. N. and Prentice, I. C., 2012, 'Future global water resources with respect to climate change and water withdrawals as estimated by a dynamic global vegetation model', *Journal of Hydrology* 448–449, pp. 14–29.

OECD, 2002, *OECD Conceptual Framework for the Testing and Assessment of Endocrine Disrupting Chemicals*, (http://www.oecd.org/env/chemicalsafetyandbiosafety/testingofchemicals/oecdconceptualframeworkforthetestingandassessmentofendocrinedisruptingchemicals.htm) accessed 20 November 2012.

OECD, 2012, *OECD Environmental Outlook to 2050*, Organisation for Economic Cooperation and Development, Paris, France.

OECD, 2014, *Economic policies to foster green growth*, (http://www.oecd.org/greengrowth/greeneco) accessed 27 May 2014.

Paracchini, M. L., Zulian, G., Kopperoinen, L., Maes, J., Schägner, J. P., Termansen, M., Zandersen, M., Perez-Soba, M., Scholefield, P. A. and Bidoglio, G., 2014, 'Mapping cultural ecosystem services: A framework to assess the potential for outdoor recreation across the EU', *Ecological Indicators* 45, pp. 371–385.

Pfister, S., Bayer, P., Koehler, A. and Hellweg, S., 2011, 'Projected water consumption in future global agriculture: Scenarios and related impacts', *Science of The Total Environment* 409(20), pp. 4 206–4 216.

Pretty, J. N., Barton, J., Colbeck, I., Hine, R., Mourato, S., MacKerron, G. and Woods, C., 2011, 'Health values from ecosystems'. In: *The UK National Ecosystem Assessment*, Technical Report, UNEP-WCMC, Cambridge, UK.

RGS, 2014, *The Energy Water Food Stress Nexus — 21st Century Challenges — Royal Geographical Society with IBG*, (http://www.21stcenturychallenges.org/challenges/the-energy-water-food-stress-nexus) accessed 6 November 2014.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H. J., Nykvist, B., de Wit, C. A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U. et al., 2009a, 'A safe operating space for humanity', *Nature* 461(7263), pp. 472–475.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H. J., Nykvist, B., de Wit, C. A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U. et al., 2009b, 'Planetary Boundaries: Exploring the Safe Operating Space for Humanity', *Ecology and Society* 14(2) (http://www.ecologyandsociety.org/vol14/iss2/art32/) accessed 29 May 2014.

Rulli, M. C., Saviori, A. and D'Odorico, P., 2013, 'Global land and water grabbing', *Proceedings of the National Academy of Sciences* 110(3), pp. 892–897.

Selander, J., Nilsson, M. E., Bluhm, G., Rosenlund, M., Lindqvist, M., Nise, G. and Pershagen, G., 2009, 'Long-Term Exposure to Road Traffic Noise and Myocardial Infarction', *Epidemiology* 20(2), pp. 272–279.

Semenza, J. C., Suk, J. E., Estevez, V., Ebi, K. L. and Lindgren, E., 2011, 'Mapping Climate Change Vulnerabilities to Infectious Diseases in Europe', *Environmental Health Perspectives* (http://www.ehponline.org/ambra-doi-resolver/10.1289/ehp.1103805) accessed 20 December 2011.

SERI, 2013, 'SERI Global Material Flows Database', (http://www.materialflows.net/home) accessed 2 December 2013.

Skoulikidis, N., 2009, *The environmental state of rivers in the Balkans — a review within the DPSIR framework*, 407(8), pp. 2 501–2 516.

Stone, D., 2009, 'The natural environment and human health', in: Adshead, F., Griffiths, J., and Raul, M. (eds), *The Public Health Practitioners Guide to Climate Change*, Earthscan, London, United Kingdom.

Suk, J. E. and Semenza, J. C., 2011, 'Future infectious disease threats to Europe', *American Journal of Public Health* 101(11), pp. 2 068–2 079.

Sutcliffe, H., 2011, *A report on responsible research and innovation*, prepared for the European Commission, DG Research and Innovation.

Sutton, M. A., Howard, C. M. and Erisman, J. W., 2011, *The European Nitrogen Assessment: Sources, Effects and Policy Perspectives*, Cambridge University Press.

The 2030 Water Resource Group, 2009, *Charting our water future*.

Tukker, A., Tatyana Bulavskaya, Giljum, S., Arjan de Koning, Stephan Lutter, Moana Simas, Konstantin Stadler and Richard Wood, 2014, *The Global Resource Footprint of Nations. Carbon, water, land and materials embodied in trade and final consumption calculated with EXIOBASE 2.1*, Leiden/Delft/Vienna/Trondheim.

Turner II, B. L., Kasperson, R. E., Meyer, W. B., Dow, K. M., Golding, D., Kasperson, J. X., Mitchell, R. C. and Ratick, S. J., 1990, 'Two types of global environmental change: Definitional and spatial-scale issues in their human dimensions', *Global Environmental Change* (http://www.public.asu.edu/~bturner4/Turner%20et%20al%201990.pdf).

UN, 2011, *Population distribution, urbanization, internal migration and development: an international perspective*, United Nations Department of Economic and Social Affairs.

UN, 2012a, General Assembly resolution 66/288: The future we want, A / RES/66/28, 11 September 2012, United Nations.

UN, 2012b, *World Urbanization Prospects — The 2011 Revision — Highlights*, New York.

UN, 2013, *World population prospects: the 2012 revision*, United Nations Department of Economic and Social Affairs, New York, USA.

UNECE, 1979, Convention on Long-range Transboundary Air Pollution, United Nations Economic Commission for Europe.

UNEP, 2012a, *Global environment outlook 5 — Environment for the future we want*, United Nations Environment Programme.

UNEP, 2012b, *The global chemicals outlook: towards sound management of chemicals*, United Nations Environment Programme, Geneva, Switzerland.

UNEP, 2013, Minamata Convention Agreed by Nations, (http://www.unep.org/newscentre/Default.aspx?DocumentID=2702&ArticleID=9373&l=en) accessed 18 February 2013.

UNEP, 2014a, *Assessing Global Land Use: Balancing Consumption with Sustainable Supply. A Report of the Working Group on Land and Soils of the International Resource Panel*. Bringezu S., Schütz H., Pengue W., O ́Brien M., Garcia F., Sims R., Howarth R., Kauppi L., Swilling M., and Herrick J.

UNEP, 2014b, *Green economy — What is GEI?*, (http://www.unep.org/greeneconomy/AboutGEI/WhatisGEI/tabid/29784/Default.aspx) accessed 27 May 2014.

UNFCCC, 2011, Decision 2/CP.17 of the seventeenth Conference of Parties on the Outcome of the work of the Ad Hoc Working Group on Long-term Cooperative Action under the Convention.

Vannportalen, 2012, *The Water Framework Directive in Norway*, (http://www.vannportalen.no/enkel.aspx?m=40354) accessed 26 August 2014.

Vineis, P., Stringhini, S. and Porta, M., 2014, 'The environmental roots of non-communicable diseases (NCDs) and the epigenetic impacts of globalization', *Environmental research*.

WEF, 2014, *Global Risks 2014 Ninth Edition*, World Economic Forum, Geneva, Switzerland.

WHO, 2006, *Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide. Global update 2005. Summary of risk assessment*, World Health Organization, Geneva, Switzerland.

WHO, 2008, *Protecting Health in Europe from Climate Change*, World Health Organization, Regional Office for Europe, Copenhagen, Denmark.

WHO, 2009a, *Guidelines on indoor air quality: dampness and mould*, World Health Organization, Regional Office for Europe, Copenhagen, Denmark.

WHO, 2009b, *Night noise guidelines for Europe*, World Health Organization, Regional Office for Europe, Copenhagen, Denmark.

WHO, 2009c, *WHO Handbook on indoor radon. Public health perspectives*, World Health Organization, Geneva, Switzerland.

WHO, 2010a, *Declaration of the Fifth Ministerial Conference on Environment and Health. Parma, Italy, 10–12 March 2010*, World Health Organization, Regional Office for Europe, Copenhagen, Denmark.

WHO, 2010b, *Guidance on water supply and sanitation in extreme weather events*, World Health Organization, Regional Office for Europe, Copenhagen, Denmark.

WHO, 2010c, *WHO guidelines for indoor air quality: selected pollutants*, World Health Organization, Regional Office for Europe, Copenhagen, Denmark.

WHO, 2011a, *Climate change, extreme weather events and public health*, meeting report, 29–30 November 2010, Bonn, Germany, World Health Organization, Regional Office for Europe, Copenhagen, Denmark.

WHO, 2011b, *Public health advice on preventing health effects of heat*, World Health Organization, Regional Office for Europe, Copenhagen, Denmark.

WHO, 2011c, *Small-scale water supplies in the pan-European region*, World Health Organization, Regional Office for Europe, Copenhagen, Denmark.

WHO, 2012, *Environmental health inequalities in Europe — Assessment report*, World Health Organization Regional Office for Europe, Copenhagen, Denmark.

WHO, 2013a, *Health 2020: a European policy framework supporting action across government and society for health and well-being*, World Health Organization Regional Office for Europe, Copenhagen, Denmark.

WHO, 2013b, *Review of evidence on health aspects of air pollution — REVIHAAP project technical report*, World Health Organization, Regional Office for Europe, Copenhagen, Denmark.

WHO/JRC, 2011, *Burden of disease from environmental noise*, World Health Organization, Regional Office for Europe, Copenhagen, Denmark.

WHO and PHE, 2013, *Floods in the WHO European Region: health effects and their prevention*, World Health Organization Regional Office for Europe and Public Health England.

WHO/UNEP, 2013, *State of the science of endocrine disrupting chemicals — 2012*, World Health Organization, United Nations Environment programme, Geneva, Switzerland.

Wiedmann, T. O., Schandl, H., Lenzen, M., Moran, D., Suh, S., West, J. and Kanemoto, K., 2013, 'The material footprint of nations', *Proceedings of the National Academy of Sciences* (http://www.pnas.org/content/early/2013/08/28/1220362110.short) accessed 15 May 2014.

Wolf, T., Martinez, G. S., Cheong, H.-K., Williams, E. and Menne, B., 2014, 'Protecting Health from Climate Change in the WHO European Region', *International Journal of Environmental Research and Public Health* 11(6), pp. 6 265–6 280.

World Bank, 2008, *Rising food and fuel prices: addressing the risks to future generations*, The World Bank, Washington DC.

World Bank, 2013, *Global Food Crisis Response Program*, (http://www.worldbank.org/en/results/2013/04/11/global-food-crisis-response-program-results-profile) accessed 1 April 2014.

WRAP, 2012, *Decoupling of waste and economic indicators*, Final report, Waste & Resources Action Programme, United Kingdom.

WWF, 2014, *Living Planet Report 2014 — Species and spaces, people and places*.

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