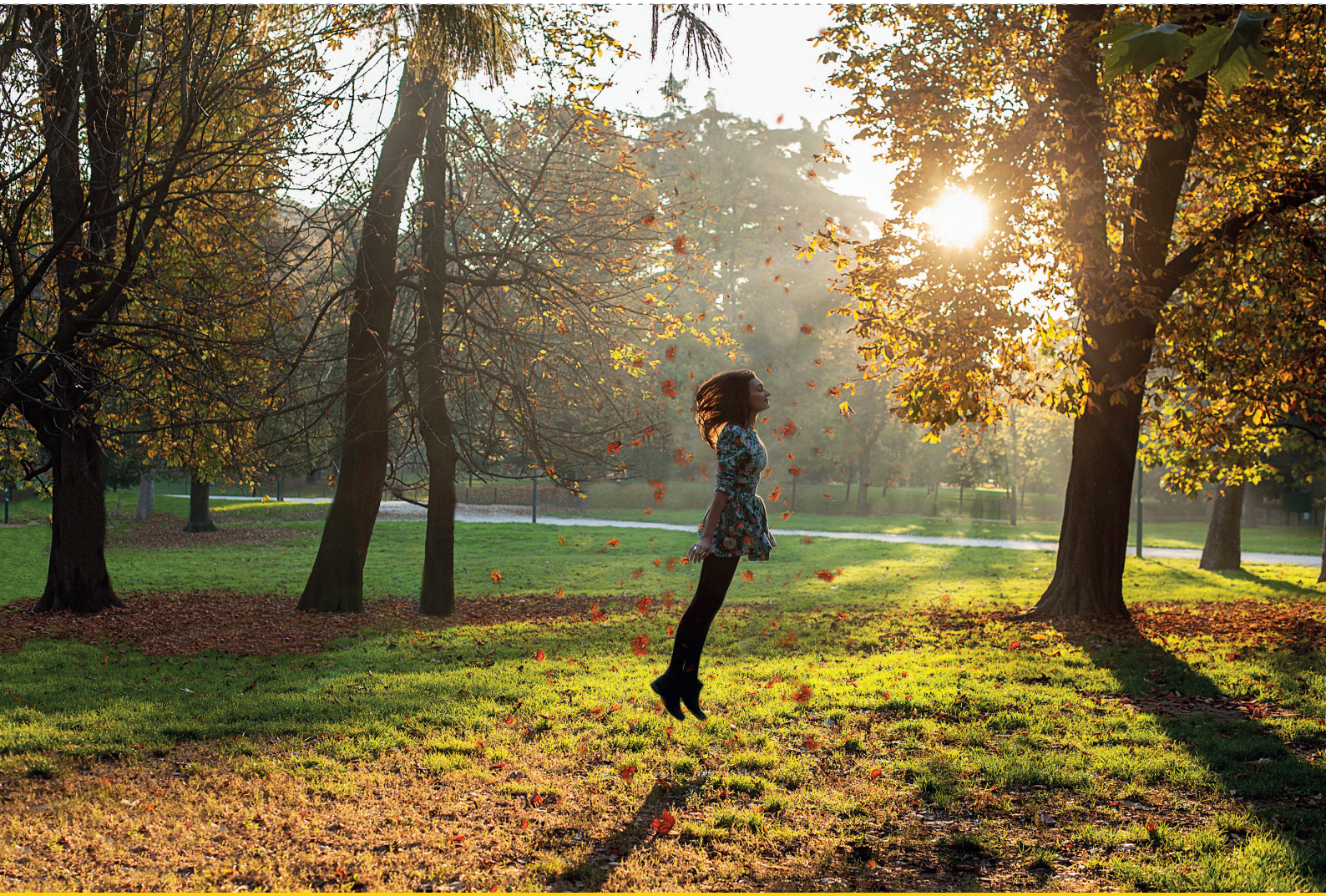
EEA Report | No 30/2016

Environmental indicator report 2016

In support to the monitoring of the 7th Environment Action Programme

ISSN 1977-8449



European Environment Agency

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Luxembourg: Publications Office of the European Union, 2016

ISBN 978-92-9213-832-5
ISSN 1977-8449
doi:10.2800/76896

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Production and editing support

Andy Martin, Antonio de Marinis, Antti Kaartinen, Carsten Iversen, Marco Veneziani, Marie Jaegly Kolar, Mauro Michielon, Pia Schmidt.

Acknowledgements

- Support from Trinomics B. V. and from the European Topic Centre on Waste and Materials in a Green Economy.
- Feedback from the European Environment Information and Observation Network (Eionet) given by national focal points and state of the environment national reference centres from 33 EEA member countries.
- Feedback from the European Commission (DG Environment and DG Climate Action).
- Feedback from EEA colleagues including Jock Martin, Johannes Schilling, Mike Asquith and Sigfús Bjarnason.

Foreword

With this report and its scoreboard of indicators, the European Environment Agency (EEA) is responding to the mandate given to it to support with indicators the monitoring of the General Union Environment Action Programme to 2020, 'Living well, within the limits of our planet' (7th EAP).

The scoreboard tracks progress towards the achievement of three of the nine priority objectives of the 7th EAP — natural capital; resource-efficient, low-carbon economy; and people's health and well-being — by 2020.

The analysis shows that EU environmental policies have been more successful in reducing pressures and improving efficiency than on reducing overall impacts on people's health and well-being or in ensuring the resilience of natural systems.

The approach taken in this report emphasises quantifiable objectives and indicators. These are mostly derived from reporting by EU Member States and their immediate neighbours to meet agreed commitments in existing policies at the EU and international levels. As such, the results should be considered alongside other EEA assessments, most notably its latest *European environment — state and outlook* report (SOER 2015). SOER 2015 provides an overview of the state of, trends in and prospects for the environment in Europe by combining quantitative, qualitative, broad and long-term perspectives in an integrated, comprehensive assessment.

It is becoming clear that dealing with the complex, inter-related priorities of the 7th EAP requires more integrated and systemic approaches to knowledge. Meeting the objectives of the United Nations Sustainable Development Goals (SDGs) by 2030, and of EU priorities such as the Circular Economy transition and the Energy Union, will also require understanding the synergies and trade-offs between the economy, the environment and human well-being. The opportunities for knowledge synergies across these policy domains are potentially considerable. A knowledge toolkit that goes beyond existing, established datasets, indicators and assessments is needed to avail of such opportunities.

In this regard, the EEA and its partners in the EU Environment Knowledge Community (EKC) are designing a new knowledge agenda in line with priority objective 5 of the 7th EAP. The work of the EKC is guided by innovations that facilitate information production, sharing and integration. A key objective is to provide new knowledge and indicators by 2020, in order to improve understanding of how to achieve more integrated and systemic long-term objectives. Examples of EKC projects include natural capital accounting, applying the concept of planetary boundaries at the European level, climate adaptation, emerging risks, environmental foresight and citizen science.

In the coming 2–3 years, I look forward to these and other innovations providing indicators and analysis that support the monitoring and evaluation of all the priority objectives of the 7th EAP, while informing our next 'State of the environment and outlook report' (SOER 2020) on progress towards the 7th EAP ambition of 'Living well, within the limits of our planet' by 2050.

Hans Bruyninckx

Executive Director
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Synopsis

S.1 Introduction

A General Union Environment Action Programme to 2020, 'Living well, within the limits of our planet', was adopted for the European Union (EU) in November 2013 by a co-decision of the European Parliament and the European Council. It came into force in January 2014. This programme is commonly known as the Seventh Environment Action Programme or 7th EAP.

The 7th EAP provides an overarching framework for EU environment policy planning and implementation to be achieved by 2020. It does this within the context of a vision for 2050 of 'Living well, within the limits of our planet' (see page 12 for more details). The programme contains nine priority objectives, of which three thematic priority objectives are considered central and having their achievement supported by other priority objectives. The thematic priority objectives are:

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

This report follows on from the EEA report *SOER 2015 — The European environment — state and outlook 2015*, and examines whether or not the EU is on the right path to achieve, by 2020, the 7th EAP's three thematic priority objectives ([1]). It does not address the other six priority objectives of the 7th 7EAP.

The report uses a set of 29 indicators to track past progress and provides an outlook to 2020 for each indicator. Table S.1 summarises the overall results in the form of an indicator scoreboard. The methodology for the scoreboard is described in the introductory chapter (see Box I.1); where available and appropriate, corresponding information on the EU's immediate neighbours is provided.

S.2 Key messages from the indicator scoreboard

The thematic priority objectives of the 7th EAP are wide-ranging, diverse and complex, reflecting today's environmental and societal challenges and those it is expected that Europe will face in the coming decades. It is simply not feasible to measure every possible variable within each objective. Rather, indicators are used as simple measurements to enhance understanding of what is happening. They do not attempt to reflect reality in all its complexity but, rather, give an idea of the direction of change over time and space. As such, they provide a practical and economical way to track and communicate progress. For example, emissions of greenhouse gases to the atmosphere and average global temperature are good indicators with respect to the highly complex issue of climate change. With this in mind, what messages can be derived from the scoreboard?

For **priority objective 1**, it can be discerned that the EU's **natural capital** is not yet being protected, maintained and enhanced in line with the ambitions of the 7th EAP. Natural capital sets the ecological limits for our socio-economic systems; it continues, nevertheless, to be degraded and depleted, and it is under a cumulative threat from the distributed impacts of habitat change, climate change, pollution, overexploitation of natural resources and invasive alien species. Some pressures have reduced, such as agricultural nitrogen loads, air pollutant emissions causing eutrophication, and the rate of loss of land to

([1]) The establishment of this report was inspired by Article 4.1 of the 7th EAP. This requires that the European Commission monitors the 7th EAP in the context of the regular monitoring process of the Europe 2020 Strategy and it stipulates that: 'This process shall be informed by the European Environment Agency's indicators on the state of the environment as well indicators used to monitor progress in achieving existing environment and climate-related legislation and targets such as the climate and energy targets, biodiversity targets and resource efficiency milestones'. The vast majority of these indicators correspond to aspects of the three thematic priority objectives of the 7th EAP.

Table S.1 7th EAP thematic priority objectives scoreboard

Indicator	EU indicator past trend	Indicative outlook of the EU meeting the selected objective by 2020
Priority objective 1: 'to protect, conserve and enhance the Union's natural capital'		
Exposure of terrestrial ecosystems to eutrophication due to air pollution (a)	▲	●
Gross nutrient balance in agricultural land: nitrogen	▲	●
Land take (a)	▲	●
Forest: growing stock, increment and fellings	▲	● (b)
Status of marine fish stocks	▲	●
Abundance and distribution of selected species (common birds (a) and grassland butterflies)	▲	●
Species of European interest	▲	●
Habitats of European interest	▲	●
Status of surface waters	N.A.	●
Priority objective 2: 'to turn the Union into a resource-efficient, green, and competitive low-carbon economy'		
Resource productivity	▲	●
Waste generation in Europe	▲	●
Recycling of municipal waste (a)	▲	●
Use of freshwater resources	▲	●
Total greenhouse gas emission trends and projections	▲	●
Share of renewable energy in gross final energy consumption	▲	●
Progress on energy efficiency in Europe	▲	●
Energy consumption by households	▲	●
Greenhouse gas emissions from transport	▲	●
Consumption of meat, dairy, fish and seafood	▲	●
Share of environmental and labour taxes in total tax revenues	▲	●
Employment and value added in the environmental goods and services sector	▲	●
Environmental protection expenditure in Europe	▲	●
Priority objective 3: 'to safeguard the Union's citizens from environment-related pressures and risks to health and well-being'		
Exceedance of air quality limit values in urban areas (nitrogen dioxide: NO_2; coarse dust particles: PM_{10}; ozone: O_3; fine particulate matter: $PM_{2.5}$)	▲ NO_2, PM_{10} ▲ O_3, $PM_{2.5}$	●
Emissions of the main air pollutants in Europe (sulphur oxides, nitrogen oxides, ammonia, non-methane volatile organic compounds, fine particulate matter) (a)	▲	●
Bathing water quality	▲	●
Number of countries that have adopted a climate change adaptation strategy and/or plan	N.A.	●
Exposure to environmental noise	▲	●
Production of chemicals, by hazard class	▲	●
Total sales of pesticides	▲	●

EU indicator past trend		Indicative outlook of the EU meeting the selected objective by 2020	
▲	Improving trend	●	It is likely that the objective will be met by 2020
▲	Stable or unclear trend	●	It is uncertain whether or not the objective will be met by 2020
▲	Deteriorating trend	●	It is unlikely that the objective will be met by 2020

Notes: (a) The indicator past trend is also available at EEA member country aggregate level and not just at the EU aggregate level. In all of these cases, the assessment (in terms of colour) remains the same for the EU and the EEA member country (including the EU) indicator past trend, with the exception of the ammonia emissions in the emissions of the main air pollutants indicator in which the EEA member country past trend deteriorated while the EU past trend improved.

(b) The focus of this outlook is solely on forest utilisation.

N.A. Non applicable. It is not possible to measure a trend. In the case of the status of surface water indicator, there is not yet time series available. In the case of the indicator on the number of countries that have adopted a climate change adaptation strategy and/or plan this is a measure of binary evidence.

artificial surfaces (e.g. buildings, roads), but they still exert a considerable negative impact on natural capital (e.g. loss of arable land and permanent crops).

In 2015, the mid-term review of the EU Biodiversity Strategy clearly showed that the EU is not on track to meet the objective of halting biodiversity loss by 2020 and restoring the potential of ecosystems to deliver services. The indicators on common birds and grassland butterflies show a continuing declining trend, and there is a high proportion of assessments of protected species (60 %) and of habitats (77 %) in an unfavourable conservation status. The EU's surface waters are also unlikely to meet the objective of achieving good status of waters by 2020, given pressures such as pollution, morphological changes, over-abstraction and hydrological changes affecting water flow. The use of Europe's seas is not sustainable, and the EU 2020 objective of healthy commercial fish populations is unlikely to be met for all marine waters.

The state and prospects of natural capital provide an indication of the environmental sustainability of our economy and society; to this effect, the outlook in terms of the EU meeting the ambitions of the 7th EAP by 2020 is not promising. Socio-economic activities such as agriculture, fisheries, transport, industry, urban sprawl and tourism exert considerable pressure on natural capital and illustrate the many demands on Europe's terrestrial and marine ecosystems. There is a close link between the socio-economic systems of production and consumption that provide for our material well-being and the threats and pressures to natural capital. Projections of economic growth and of increasing population suggest that these pressures are likely to grow, while the impacts of climate change are also expected to increase in magnitude. Therefore, there is a strong argument for fundamental transitions in these systems, in particular, when it comes to natural capital, and the food and urban systems.

Further efforts are required to **implement** existing EU environmental **legislation**. This is especially true for the Habitats and Birds Directives, the Water Framework Directive and the Marine Strategy Framework Directive and their links to EU sectoral policies such as the Common Agricultural Policy and the Common Fisheries Policy. Such integrated responses across different policy fields would reap co-benefits in the pursuit of the achievement of this and other 7th EAP priority objectives.

Further actions could also include **mainstreaming of environmental objectives into** the **socio-economic systems of production and consumption** that contribute most to pressures and impacts; further investments in knowledge to address the systemic nature of natural capital; and an **integrated approach to natural capital management** (centred on ecosystems) that considers the interdependence of ecosystems, human activities, and human well-being in order to manage trade-offs and co-benefits.

For **priority objective 2,** past trends are encouraging when it comes to assessing progress towards **resource efficiency** and the **low-carbon economy**. Resource productivity — the indicator that measures resource efficiency in terms of economic output per unit of material use — is improving, helped in part by reduced economic activity. Resource productivity is projected to continue improving from 2014 onwards, albeit at a rather low rate of just under 1 % per year. Municipal waste recycling rates have improved in nearly every country and there has been a slight reduction in waste generation. There is still much room for improvement in countries' performance against agreed targets, especially in the context of the 2015 European Commission circular economy package.

Freshwater resources are relatively abundant in Europe, albeit very unevenly distributed. Hotspots of water stress are likely to remain primarily in the Mediterranean and Iberian penninsula areas. This situation is also not expected to improve in future, given ongoing pressures from climate change and urbanisation, as well as agricultural and tourism activities.

The EU is on track to meet its 2020 **climate and energy targets.** The continuing implementation of climate and energy policies is also expected to enhance resource productivity by displacing fossil fuels in energy production with renewable energy sources and through improving energy efficiency.

The transport sector is the only sector for which there is doubt that it will be able to reduce its greenhouse gas emissions by 2020.

Environmental legislation has already played a key role in the process of turning the EU into a resource-efficient, circular and low-carbon economy. This can also be seen through the growth, in employment and value added, of the **environmental goods and services sector** of the EU economy. Environmental protection expenditure will continue to increase to 2020, strengthened by the EU's decision that at least 20 % of its 2014–2020 budget should be spent on mitigating climate change. This is likely to have a positive impact in the environmental goods and services sector, although global competition and recent reductions in domestic investments in the renewables sector make the prospects of growth uncertain.

There is also scope for further shifting of taxation from labour towards the environment (resource use and pollution) as another way to encourage job creation while incentivising resource efficiency improvements and low carbon solutions. Further progress is possible through **implementation** and **integrated and adaptive policy approaches** that can respond to changes, deliver multiple benefits including employment, and manage difficult trade-offs such as winners and losers in the transition process. Further investments by EEA member countries in accounting systems that link socio-economic activities to the use of natural resources and environmental pressures would help manage these trade-offs.

For **priority objective 3**, environmental pressures continue to contribute significantly to the overall **burden of disease** on people in Europe, according to the World Health Organization, in particular non-infectious diseases. This is despite substantial reductions in emissions of air and water pollutants in recent decades. Key current concerns include air quality and noise pollution in urban areas, especially from transport sources, as well as chronic, long-term exposure to complex mixtures of chemicals contained in products.

In general, bathing water is of high quality across the EU, the result of decades of effort and investment. Ongoing efforts to address sources of pollution through improvements in the sewerage system and reducing pollution from farms are expected to further increase the proportions of bathing waters that meet excellent and good quality standards by 2020. By contrast, climate change presents both direct and indirect threats to health, especially for children and the elderly, through impacts from extreme weather events such as flooding and heatwaves alongside changing patterns in the prevalence of infectious diseases.

The overall outlook towards this priority objective is uncertain. Further efforts are needed to **implement** existing environment and heath **legislation** and policies. Given the complexity of the environment and health interactions, coupled with uncertainties in the evidence base, further efforts will also be required to deliver positive environmental health outcomes through **integrated** and **precautionary policy approaches**, where substantial harms to society and ecosystems are avoided on the basis of early warnings from science, and where innovations towards safer, sustainable products and services are encouraged.

The proposal in the 7th EAP for the development of the EU strategy for a non-toxic environment provides the opportunity to set down a holistic approach, whereby the management of risks to ecosystem and human health is guided by consideration of both hazard and exposure.

The **urban environment** also provides an integrated focal point for addressing environment and health considerations coherently in urban planning, transport and climate change adaptation policies. Air pollution remains the number one concern at present, given the substantial contribution it makes to earlier than expected mortality. The car- and fossil fuel-based energy systems are at the core of the problem. Many cities are ahead of national and international efforts to change. There would be merit in investing more in gathering knowledge on the niche innovations that many cities are putting in place to support transitions. Such knowledge is not part of the indicator base used for this report.

When scanning **across the scoreboards** some patterns emerge. It is apparent that environmental policies have been more successful when focused on two key approaches: reducing pollution (chemicals) and improving resource efficiency. Ensuring the resilience of natural systems or reducing overall impacts on people's health and well-being have proven more challenging. It is also apparent that further efforts to implement existing legislation can improve progress towards meeting the thematic priority objectives of the 7th EAP. Greater and more coordinated implementation efforts would also deliver better data for the indicators, especially for the objectives relevant to ecosystems status and chemicals and health, for which the existing indicators are arguably the weakest available.

At the same time, the mainstreaming of environmental objectives into those socio-economic sectors that are the sources of environmental problems would bring further benefits for the environment and human health. Most of the more complex, and persistent, environmental challenges require action to be taken by socio-economic actors such as those in the energy, agriculture and transport sectors.

Actions taken in one thematic priority objective can spur progress towards meeting the other two objectives. For example, action taken to turn the EU into a resource-efficient, green and competitive low-carbon economy has the potential to decrease pressure on natural capital, reduce environmental risks to health and contribute positively to well-being. Increasing the efficiency of resource use and decreasing absolute use can lead to reductions in the extraction and exploitation of natural resources, with corresponding reductions in the impacts on biodiversity and ecosystems. Improved waste management and modal shifts in passenger transport (such as increased cycling instead of car use) can reduce the

environmental risks to health associated with waste and poor air quality in urban areas.

On the other hand, there are examples of innovations that alleviate pressures in one area but cause feedbacks that increase pressures elsewhere. For example, environmental gains from improvements in fuel efficiency in vehicles are often offset by increases in car ownership and kilometres driven. In such cases, there is a need to look for more integrative approaches such as designing measures that can be taken across production–consumption systems that fulfil societal functions (food, energy, housing, mobility). For instance, while improving management of the agricultural sector is essential in order to tackle various environmental problems, it would be important in the long run to also look at transforming our food system, such as changes in diet, more effective distribution chains, preventing food waste, etc., which could help to compensate for the yield penalties arising from more environmentally friendly agricultural production.

Better integration of policies will also support the delivery of more integrated indicators. Indicators and analysis that address these interlinkages with regard to their positive and negative effects would seem of greater importance at this time of resource constraints and greater scrutiny of the value of environmental policies.

S.3 In conclusion …

It is increasingly clear that dealing with the complex, inter-related priorities of the 7th EAP requires more systemic approaches to policies and knowledge. Take the food system, for example. Most environmental legislation is targeted at the primary production part of the economy, agriculture and fisheries. There are, however, important issues related to the consumption part of the food system, including food waste and the use of chemicals in food products. It could also be argued that producers carry a disproportionate burden of regulatory costs, while other actors in the food supply chain, such as those involved in manufacturing and retail, may not be sufficiently targeted by policy. A more equitable distribution of regulatory costs across the food system could be argued for, based on the gross value-added earned by different actors across the economy. Accounting techniques are emerging to support this type of analysis.

Taking a systems approach enables us to look at the food, energy and mobility systems in a more holistic way, including the many interdependencies between them. A systems approach helps us to understand complexity, linkages and cross-cutting issues. It involves analysing the system, not just in terms of its resource use and environmental impacts but also in terms of actors, institutions and governance.

There also appear to be opportunities associated with more ambitious environmental policy design and implementation. The spotlight chapter of this report illustrates that there is not necessarily a conflict between a country being highly competitive and its being highly ranked with regard to the stringency of its environmental policies and its eco-innovation record. That chapter also demonstrates that environmental policies can trigger eco-innovation and green finance, two key enabling factors in supporting the delivery of environmental goals and the transition to a green economy. In doing so, these factors can also contribute significantly to economic development and job creation, and hence the current EU priorities of putting the region back on the path of economic recovery and creating new jobs.

Looking beyond 2020, a greater magnitude of change will be required to achieve the EU's 2050 vision of 'Living well, within the limits of our planet' or its commitment under the UN 2030 Agenda to sustainable development. For example, the level of ambition of the environmental policies currently in place to reduce environmental pressures may not enable Europe to achieve long-term environmental goals such as the 2050 target of reducing greenhouse gas emissions by 80–95 %. The progress made by the EU over past decades on this and other environmental problems will need to accelerate, based on ambitious targets and smart investments, so that the 2050 vision can be realised in Europe and globally.

Introduction

I.1 The Seventh Environment Action Programme

The European Union (EU) and its immediate neighbours are bound to the rest of the world through multiple systems, enabling two-way flows of material resources, pollution, finance, innovations and ideas. Globalisation of the economy, fast-changing production and consumption patterns, deregulation of the finance sector, revolutions in information and biotechnology, as well as changing demographic and migration patterns are key facets of this interdependence.

As a result, Europe's ecological and societal resilience is expected to be significantly affected in coming decades by a variety of these and other megatrends — large-scale, high-impact and often interdependent social, economic, political, environmental or technological changes — that are unfolding within Europe and across the world and are expected to continue (EEA, 2015).

The General Union Action Programme to 2020 'Living well, within the limits of our planet' (EU, 2013) recognises this changing context and provides an overarching framework for EU environment policy planning and implementation including priority objectives to be achieved by 2020. The choice of objectives is guided by the programme's vision for 2050:

> '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.'

There are **three thematic priority objectives** to be met by 2020:

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

The Programme, also known as the Seventh Environment Action Programme or the 7th EAP, acknowledges that these objectives are interrelated and action taken to achieve one of them will often contribute to the achievement of the other objectives. For example, 'improving resource efficiency' will 'ease the pressure on natural capital', while 'enhancing the resilience of the Union's natural capital base' will 'deliver benefits for human health and well being'. Similarly, 'action to mitigate and adapt to climate change' will 'increase the resilience of the Union's economy and society', while 'stimulating innovation and protecting the Union's natural resources'.

In order to support the achievement of the three key priority objectives, the 7th EAP sets out a framework of four additional priority objectives that aim to deliver better **implementation** of legislation; better **information** by improving the knowledge base; more and wiser **investment** for environment and climate policy; and the full **integration** of environmental requirements and considerations into other policies. The 7th EAP also sets outs two priority objectives to more effectively address **urban** and **international** challenges.

Overall, the 7th EAP provides a strategic direction to environment and climate policy planning to 2020, while helping to implement the environment and climate change objectives and targets that the EU has already agreed.

I.2 The European environment — state and outlook report 2015

Every five years, the European Environment Agency (EEA) is mandated to provide a comprehensive overview of the state of, trends in and prospects for the environment in Europe. The latest report, *The European environment — state and outlook 2015* (SOER 2015), was published in March 2015 and concludes that, although environment policies have delivered many improvements, substantial challenges must be overcome if the EU is to realise its policy ambitions (EEA, 2015). The report also highlights that policies on improving resource efficiency have been more effective than those on ensuring ecological resilience and societal well-being. As such, the SOER 2015 provides an overarching, integrated view of the progress and prospects related to the state and outlook of Europe's environment.

This differs from the approach taken in this indicator report, the aim of which is to contribute to the monitoring of progress towards the 7th EAP — and to be more precise with regard to parts of the 7th EAP as explained in the Section I.3. In this report, the emphasis is on individual 2020 objectives and indicators in order to assess past trends and the prospects for meeting these objectives by 2020, rather than on a comprehensive and integrated assessment.

I.3 Environmental indicator report 2016: origin, scope, objectives and approach

The establishment of this report was inspired by Article 4.1 of the 7th EAP. This requires that the European Commission monitors the 7th EAP in the context of the regular monitoring process of the Europe 2020 Strategy (EC, 2010) and it stipulates that:

> 'This process shall be informed by the European Environment Agency's indicators on the state of the environment as well as indicators used to monitor progress in achieving existing environment and climate-related legislation and targets such as the climate and energy targets, biodiversity targets and resource efficiency milestones'.

The vast majority of these indicators correspond to aspects of the three thematic priority objectives of the 7th EAP. In addition, indicator availability outside these three priority objectives is fairly limited across the relevant bodies and institutions in Europe.

The scope of this indicator report, therefore, covers the three thematic priority objectives of the 7th EAP; it does not address the other six 7th EAP priority objectives. In effect, the aim of this report is to examine if the EU and its immediate neighbours are on target to achieving by 2020 the 7th EAP's three thematic priority objectives. This examination is based on a set of 29 indicators that were primarily selected from the indicators available from the EEA ([2]) and, where applicable, also from other sources, namely Eurostat. The EEA selected this set based on their relevance to tracking progress towards the main aspects of the 7th EAP's three thematic priorities — each priority objective of the 7th EAP contains a number of more specific directional objectives that reflect the main aspects of the priority objectives.

A common thread of the 7th EAP thematic priority objectives is that they build considerably on existing environmental legislation and policy initiatives, and promote their implementation. The indicator set reflects this. The indicators focus mostly on tracking progress towards existing environment and climate change 2020 targets, and other thresholds in environmental legislation and policy (e.g. 2020 milestones of the EU's 2011 'Roadmap to a resource efficient Europe' (EC, 2011)) of relevance to the priority objectives, in particular to the specific directional objectives.

The set of indicators underlie a scoreboard that provides a snapshot of progress towards the 7th EAP's thematic priority objectives.

Box I.1 further clarifies the scoreboard methodology and entries, including on the selection of the objectives against which progress is measured by the indicators.

Online indicator briefings provide more details by scoreboard indicator. The briefings discuss past trends and underlying reasons for these trends, the key challenges and prospects of meeting the selected objectives by 2020, as well as the challenges and opportunities beyond 2020. They also present country-level data (where available across EEA member

([2]) In 2015, the EEA mapped all available EEA indicators and those under development against the monitoring needs of each of the nine priority objectives of the 7th EAP. The mapping framework and results were made available by the EEA to the European Environment Information and Observation Network (Eionet) — the partnership network of the EEA and its member and cooperating countries — as well as to the European Commission Environment Directorate General (DG ENV). These results informed discussions across the EEA as well as with Eionet and DG ENV on the mapping framework and the indicator selection. The mapping exercise revealed that 99 % of the available EEA indicators corresponded to monitoring needs of the three thematic priority objectives of the 7th EAP. The results can be obtained on demand.

Box I.1 Scoreboard — entries and methodology

The scoreboard is organised according to the three thematic 7th EAP priority objectives and is a compilation of individual scoreboard lines, each corresponding to a selected indicator and presented in a dedicated online briefing. The lines present the following information:

- **Indicator name.**
- **EU indicator past trend**: This indicates whether the value measured by the indicator over a number of years (from a base year to the latest available year) shows an improving trend, a deteriorating trend or a stable trend (change of less than 3 %) or the trend is unclear (because of a high level of inter-annual variation). The time series is unique to each of the indicators and reflects data availability and base-year requirements associated with the chosen selected objective. Green triangles (▲) indicate an improving trend, red (▲) a deteriorating trend and yellow (▲) a stable or unclear trend.
- **Selected objective to be met by 2020**: The 7th EAP thematic priority objectives contain specific directional objectives to be met by 2020 — these are outlined in the first parts of paragraphs 28, 43 and 54 of the 7th EAP Decision (EU, 2013). These objectives, by their nature, are often qualitative and broad in scope and so it is not always easy to measure progress against them. The 2020 targets and other quantitative thresholds from the EU environmental legislation and policy that relate to key aspects of specific directional objectives were chosen rather as objectives to be met by 2020. In the absence of targets and other quantitative thresholds, specific (or parts of specific) directional objectives were selected instead if these were measurable and the indicators were readily available.
- **Indicative outlook of the EU meeting the selected objective by 2020**: This shows the indicative prospect of meeting the selected objective by 2020, using a traffic light system. The traffic light is green (●) if it is likely that the objective will be met, yellow (●) if this is uncertain and red (●) if it is unlikely that the objective will be met. The colours have been assigned on the basis of the available information specific to each indicator and to the corresponding selected objective. Overall, the colours were based on some combination of (1) the indicator-based trends observed over previous years; (2) the distance to target assessments (if available); (3) modelled estimates of future developments (if available); and (4) expert consideration of the effects of EU policies currently in place.

The scoreboard is aggregated foremost at the EU level. In cases for which aggregated information that also includes information on non-EU EEA member countries (Iceland, Liechtenstein, Norway, Switzerland and Turkey) is available, this is reflected in the 'indicator past trend'.

and EEA cooperating countries). Box I.2 shows the list of indicators and the corresponding report briefings. Annex 1 presents sources, examined time periods and expected updates of scoreboard indicators.

There is a chapter for each thematic priority objective. These chapters provide a broad brush assessment of progress, including further details on the reasons behind the observed trends and short-term prospects. These chapters also address some of the most important remaining challenges, as well as opportunities for synergies within and among policies.

In addition, the report includes a spotlight chapter that focuses on the transition to a green economy, and how eco-innovation and green finance can be enabling factors for meeting the resource-efficiency, low-carbon aspects of this transition.

The latest available year for most of the indicators used in this report is 2014, the first year in which the 7th EAP was in force. This report can therefore act as a baseline for tracking progress towards the achievements of the three thematic priority objectives.

The plan is to update regularly the indicators and scoreboard contained in this report. The form and frequency of the updates will be decided on the basis of stakeholder feedback after the launch of the report. The indicator set will remain stable, but not necessarily static, in future updates. For example, there is a range of relevant recent and ongoing developments, such as the development of the indicator set that will be used to measure progress towards the Sustainable Development Goals (UN, 2015). These processes will be reviewed to reflect relevant indicator developments in the report's indicator set.

This report is not the sole contribution by the EEA to the monitoring of the 7th EAP. The EEA maintains approximately 130 indicators (EEA, 2014) and performs numerous assessments that are pertinent to the monitoring of the 7th EAP. All of this information can be found on the EEA website (eea.europa.eu).

Box I.2 List of selected indicators and corresponding briefings by thematic priority objectives of the 7th EAP

Indicators	Briefings
Priority objective 1: To protect, conserve and enhance the Union's natural capital	
Exposure of terrestrial ecosystems to eutrophication due to air pollution	Eutrophication of terrestrial ecosystems due to air pollution
Gross nutrient balance in agricultural land: nitrogen	Agricultural land: nitrogen balance
Land take	Urban land expansion
Forest: growing stock, increment and fellings	Forest utilisation
Status of marine fish stocks	Marine fish stocks
Abundance and distribution of selected species (common birds and grassland butterflies)	Common birds and butterflies
Species of European interest	EU protected species
Habitats of European interest	EU protected habitats
Status of surface waters	Surface waters
Priority objective 2: To turn the Union into a resource-efficient, green and competitive low-carbon economy	
Resource productivity	Resource efficiency
Waste generation in Europe	Waste generation
Recycling of municipal waste	Recycling of municipal waste
Use of freshwater resources	Freshwater use
Total greenhouse gas emission trends and projections	Greenhouse gas emissions
Share of renewable energy in gross final energy consumption	Renewable energies
Progress on energy efficiency in Europe	Energy efficiency
Energy consumption by households	Household energy consumption
Greenhouse gas emissions from transport	Transport greenhouse gas emissions
Consumption of meat, dairy, fish and seafood	Food consumption — animal-based products
Share of environmental and labour taxes in total tax revenues	Environmental and labour taxation
Employment and value added in the environmental goods and services sector	Environmental goods and services sector: employment and value added
Environmental protection expenditure in Europe	Environmental protection expenditure
Priority objective 3: To safeguard the Union's citizens from environment-related pressures and risks to health and well-being	
Exceedance of air quality limit values in urban areas (nitrogen dioxide — NO_2; coarse dust particles: PM_{10}; ozone: O_3; fine particulate matter: $PM_{2.5}$)	Outdoor air quality in urban areas
Emissions of the main air pollutants in Europe (sulphur oxides: SO_2; nitrogen oxides: NO_x; ammonia: NH_3; non-methane volatile organic compounds: NMVOCs; fine particulate matter: $PM_{2.5}$)	Air pollutant emissions
Bathing water quality	Quality of bathing waters
Number of countries that have adopted a climate change adaptation strategy and/or plan	Number of countries that have adopted a climate change adaptation strategy/plan
Exposure to environmental noise	Environmental noise
Production of chemicals, by hazard class	Production of hazardous chemicals
Total sales of pesticides	Pesticide sales

1 Seventh Environment Action Programme priority objective 1:

To protect, conserve and enhance the Union's natural capital

1.1 Introduction

Priority objective 1 of the Seventh Environment Action Programme (7th EAP) is 'to protect, conserve and enhance the Union's natural capital' (EU, 2013). The objective recognises the fundamental role of natural capital in determining a society's economic prosperity and social well-being. This fundamental role is also reflected in the 7th EAP vision that 'by 2050 we live well, within the planet's ecological limits' and that 'natural resources are managed sustainably, and biodiversity is protected, valued and restored in ways that enhance society's resilience' (EU, 2013).

Natural capital encompasses biodiversity, including ecosystems, which provide essential goods and services, from fertile soil and multifunctional forests to productive land and seas, from good-quality freshwater and clean air to pollination, climate regulation and protection against natural disasters (EU, 2013). Priority objective 1 focuses on key aspects of 'ecosystem capital', while the 'abiotic capital' (such as minerals and renewable energy) is addressed by priority objective 2 of the 7th EAP, which deals with resource efficiency and a low-carbon economy.

Despite the fundamental importance of natural capital for economic development and the resilience of societies, the EU's natural capital is threatened by human activities and continues to be eroded and degraded (EEA, 2015a). The EU risks depleting its natural capital stock without fully understanding the value of what is lost. For example, the cost of not reaching the headline target of the EU Biodiversity Strategy to 2020 has been indicatively estimated at up to EUR 50 billion per year (COWI et al., 2011).

The economic and social risks and costs from continued degradation of ecosystems and their services are not properly integrated into our economic and social systems, and decision-making processes (EEA, 2015a and 2016b). Related knowledge systems, such as ecosystem accounting systems, need to be developed. A first step in this regard is to invest in approaches that enable the monitoring and assessment of the pressures on the EU's ecosystem capital (see Box 1.1 for more information on ongoing work on this), and how these pressures affect the flow of ecosystem services to the economy and society.

In order to protect Europe's natural capital, priority objective 1 includes seven main areas for action: (1) biodiversity and ecosystem services; (2) transitional and coastal waters and freshwaters; (3) marine waters; (4) the impact of air pollution on ecosystems and biodiversity; (5) land; (6) the nutrient cycle; and (7) forest. Achieving progress towards these main areas relies partly on the implementation of corresponding environmental legislation and policies. Key environmental legislation and policies related to this priority objective include the Biodiversity Strategy to 2020 (EC, 2011a), the Water Framework Directive (EU, 2000), the Marine Strategy Framework Directive (EU, 2008), the Air Pollution Thematic Strategy (EC, 2005) and the Resource Efficiency Roadmap (EC, 2011b).

For the purpose of this report, nine indicators (see Table 1.1) that relate to these seven main areas of action were chosen from the existing indicator base. These indicators focus primarily on 2020 objectives in existing legislation and policies that correspond to the objectives of the seven main areas of action under this priority objective. If quantitative objectives were not available, qualitative objectives from the priority objective itself were used if these were measurable and the indicators were readily available. Each indicator is supported by an online indicator-based briefing. The briefings provide an overall picture of progress; however, these are incomplete since they cover aspects of only the seven main areas of action. For example, ecosystems and their services are not covered, and for sustainable forest management, only forest utilisation is considered. In addition, the briefings do not offer an integrated and systemic view of the pressures and their effects on the EU's natural capital. This chapter provides additional relevant information in order to complement findings from the indicator briefings.

Box 1.1 EU efforts to better understand ecosystem capital

The ongoing work of the Mapping and Assessment of Ecosystems and their Services (MAES) initiative (see also Section 1.4) is improving our understanding of EU ecosystems in terms of their extent, condition and flows of services. The table below summarises the latest knowledge on the state of the EU's ecosystem capital in terms of trends in the pressures on EU ecosystems. Most ecosystem types are currently under pressure (as indicated by the box colours) and many pressures are expected to increase (as indicated by the direction of the arrows).

Ecosystem type	Habitat changes	Climate change	Overexploitation	Invasive alien species	Pollution and nutrient enrichment
Urban	↗	↑	↗	↗	↑
Cropland	↗	↑	↗	↗	↑
Grassland	↗	↑	↗	↗	↑
Woodland and forest	↘	↑	→	→	↗
Heathland, shrub and sparsely vegetated land	→	↑	→	↗	↗
Wetlands	→	↑	→	↗	↘
Freshwater (rivers and lakes)	→	↑	→	↗	↘
Marine (transitional and marine waters, combined)	↗	↑	→	↗	→

Key:

Projected future trends in pressure			
↘	→	↗	↑
Decreasing	Continuing	Increasing	Very rapid increase
Observed impact on biodiversity to date			
Low	Moderate	High	Very high

Source: EEA, 2016b.

1.2 Progress and 2020 outlook

The EU's natural capital is not yet being protected, conserved and enhanced in line with the ambitions of the 7th EAP objective, and these ambitions are very unlikely to be met by 2020 (EEA, 2015a). The degradation and erosion of the EU's natural capital, as also illustrated in Box 1.1 by the pressures on EU ecosystems, is evident from several recent knowledge products which comprehensively assess aspects of Europe's natural capital (EEA, 2015a, 2015b, 2015c, 2016a and 2016b; JRC, 2015).

Based on the 2020 policy objectives that were selected for the purpose of this exercise, the EU is not on track to meet priority objective 1 by 2020. Table 1.1 presents a scoreboard for each of the indicator briefings with a brief justification of the outlook towards 2020. Further information on the objectives and rationale behind the 2020 outlooks can be found online in the indicator briefings — the list of the priority objective 1 indicator briefings and their links is available in the end of this chapter.

The 2020 outlook for EU natural capital gives rise to serious concern, as many of the threats remain, with impacts from climate change and invasive alien species set to increase (EEA, 2016b). Even if pressures are reduced, they may remain considerable. In addition, there can be substantial time lags before declining pressures will translate into improvements in the state of natural capital. The threats of habitat change, natural resource overexploitation and pollution arise from our socio-economic systems (e.g. agriculture, fisheries, transport, industry and tourism), which provide for our material well-being (EEA, 2015a).

Air pollution harms both human and ecosystem health. Currently, the most important impact of air pollution on ecosystems and biodiversity results from excess nutrients; these cause eutrophication and are due to excess atmospheric nitrogen loads (EEA, 2014). Despite decreases in the air pollutant emissions that cause eutrophication, nitrogen inputs via the atmosphere in many areas still exceed levels that ecosystems can tolerate without being damaged. The area of EU ecosystems, in which critical loads for eutrophication were exceeded, was approximately 63 % in 2010, and the area of exceedance in the EU is projected to be about 54 % in 2020, assuming that current legislation is fully implemented. The ecosystem area exposed to eutrophication due to air pollution is expected to decrease in 2020 by about 31 % relative to 2000 levels. This falls short of the 2020 (relative to 2000) 43 % reduction milestone of the EU Thematic Strategy on Air Pollution. Nitrogen emissions to the air from agriculture and from transport sectors will remain significant contributors to eutrophication in terrestrial ecosystems, particularly grasslands. To reduce this pollution further, specific and targeted mitigation measures are needed. Dietary changes resulting in less meat and dairy farming and the reduced use of petrol and diesel in cars could also contribute to reductions (see AIRS_PO1.1, 2016 for further information).

Nitrogen losses from agricultural land affect soil, air and water quality, and have a considerable negative impact on biodiversity and ecosystems. The agricultural nitrogen balance has improved — the surplus of nitrogen applied has fallen by about 19 %, from 63 kg per hectare in 2000 to 51 kg per hectare in 2013. These improvements have occurred as a result of, for example, better farm management practices, in particular better fertiliser application techniques. However, on average, the EU still has an unacceptable surplus of nitrogen in view of losses to the environment, and further efforts are needed to manage the nitrogen cycle more sustainably (see AIRS_PO1.2, 2016 for further information).

Land take — the loss of land to the development of buildings, roads and other artificial surfaces — affects biodiversity, landscapes and the delivery of ecosystem services. For the EU as a whole, it is estimated that, on average, the annual land take between 2000 and 2012 was 888 km^2, which is not sustainable if the EU is to achieve the aim of no net land take by 2050, as called for in the 2011 'Roadmap to a resource efficient Europe' (EC, 2011b) and reiterated in the 7th EAP (EU, 2013). Nonetheless, the annual land take reduced between 2000 and 2006 (930 km^2 per year) and between 2006 and 2012 (845 km^2 per year), and this trend justifies the uncertain outlook towards 2020. The implementation of land recycling, compact urban development and place-based management will have to be scaled up in order to reduce the pressures (see AIRS_PO1.3, 2016 for further information).

Forests host a major part of biodiversity and provide a range of services, such as timber, carbon sequestration, water filtration and recreational opportunities. Sustainable forest management covers many aspects, such as maintaining biodiversity, productivity, regeneration capacity and vitality. One aspect is the sustainability of the production and use of forest resources in terms of the harvest of forests in relation to growth, known as the utilisation rate. Trends show that since 1990, the utilisation rate of forests has been below 100 % (around 60–70 %) for Europe indicating that the growing stock, i.e. the timber reserve, has remained at sustainable levels. The forest utilisation rate is expected to remain sustainable, but it will partly

Table 1.1 7th EAP priority objective 1 scoreboard

Indicator	EU indicator past trend	Selected objective to be met by 2020	Indicative outlook of the EU meeting the selected objective by 2020
Exposure of terrestrial ecosystems to eutrophication due to air pollution [a]	▲	Reduce areas of critical load exceedance with respect to eutrophication by 43 % from 2000 levels — Air Pollution Thematic Strategy	●
The area where ecosystems are exposed to eutrophication because of excess atmospheric nitrogen deposition has decreased. According to a scenario assuming that current legislation is fully implemented, it will, nevertheless, fall short of the 2020 objective			
Gross nutrient balance in agricultural land: nitrogen	▲	Manage the nutrient cycle in a more sustainable way (nitrogen) — 7th EAP	●
Overall, the agricultural nitrogen balance shows an improving trend. However, on average, the EU still has an unacceptable level of nitrogen losses from agricultural land to the environment and further efforts are needed to manage the nutrient cycle for nitrogen sustainably in the EU			
Land take [a]	▲	Keep the rate of land take below 800 km^2 on average per year from 2000–2020 in order to keep on track to achieve the aim of no net land take by 2050 — Resource Efficiency Roadmap	●
The EU annual average land take from 2000–2012 was above the 800-km^2 milestone. Nevertheless the average annual land take in 2006–2012 was less than in 2000–2006. It is uncertain if a further reduction will take place and at what rate			
Forest: growing stock, increment and fellings	▲	Forest management is sustainable — 7th EAP (focus solely on forest utilisation)	●
Since 1990, EU forests overall have been harvested at a lower rate than they have grown (at around 60–70 %), indicating sustainable forest management in relation to the forest utilisation rate. Despite expected increased harvesting of forests, the overall forest utilisation is expected to remain sustainable up to 2020			
Status of marine fish stocks	▲	Ensure healthy fish stocks — Common Fisheries Policy and Marine Strategy Framework Directive	●
The EU is improving the state of its commercial fish species in only North-east Atlantic and Baltic waters. As the 2020 objective of healthy commercial fish populations applies to all marine waters, it is unlikely to be met			
Abundance and distribution of selected species (common birds [a] and grassland butterflies)	▲	Meet the headline target of the EU Biodiversity Strategy: to halt the loss of biodiversity and the degradation of ecosystem services	●
It is highly unlikely that the objective will be achieved by 2020 given the continuing declining trends apparent for certain groups, such as grassland butterflies and farmland birds			
Species of European interest	▲	Ensure that 34.5 % of species assessments under the Habitats Directive are in a favourable or improved conservation status, and that 78 % of species assessments under the Birds Directive show a secure or improved status — EU Biodiversity Strategy	●
The EU has shown limited progress in improving the conservation status of EU protected species and the pressures on species remain. It is therefore unlikely that the 2020 target will be met			
Habitats of European interest	▲	Ensure that 34 % of habitat assessments under the Habitats Directive are in a favourable or improved conservation status — EU Biodiversity Strategy	●
The EU has shown limited progress in improving the conservation status of EU protected habitats and the pressures on these habitats remain. It is therefore unlikely that the 2020 target will be met			
Status of surface waters	N.A.	Achieve good status of transitional and coastal waters and freshwaters — Water Framework Directive	●
Considering the large proportion of surface waters failing to meet 'good' ecological status, it is unlikely that the objective of achieving good status of waters will be met by 2020			

EU indicator past trend		Indicative outlook of the EU meeting the selected objective by 2020	
▲	Improving trend	●	It is likely that the objective will be met by 2020
▲	Stable or unclear trend	●	It is uncertain whether or not the objective will be met by 2020
▲	Deteriorating trend	●	It is unlikely that the objective will be met by 2020

Notes: [a] The indicator past trend is also available at EEA member country aggregate level and not just at the EU aggregate level. In all of these cases, the assessment (in terms of colour) remains the same for the EU and the EEA member country (including the EU) indicator past trend.

The available time period and country coverage are specified in the corresponding charts in the online briefings.
N.A. Non applicable as the time series is not yet available.

depend on the demand for biomass as a renewable energy source, which is expected to increase beyond 2020 as part of the EU's efforts to make the transition to a low-carbon economy by 2050. Other aspects of forest sustainability not covered by the corresponding briefing give rise to concern. For example, climate change, pollution and encroaching human development pose an increased threat to the long-term stability and health of European forests in terms of their capacity to deliver ecosystem services (EEA, 2016a), and a high proportion of forest species and habitat assessments remain in an unfavourable conservation status (EEA, 2015c) (see AIRS_PO1.4, 2016 for further information).

The marine environment presents a particular challenge given the growth of maritime activities, such as the extraction of living (e.g. fish) and non-living resources (e.g. sand, gravel), transport and energy production (EEA, 2015b). The EU's marine ecosystems continue to display symptoms of degradation and loss of resilience (EEA, 2015b). With regard to safeguarding healthy commercial fish populations, around 58 % of fish stocks in Europe's seas are not in a healthy status. There are clear signs of the recovery of fish stocks for the North-east Atlantic and Baltic Seas, but the situation remains critical in the Mediterranean and Black Seas given the prevalence of overfishing and the significant lack of knowledge on the status of fish stocks. An integrated approach to the management and protection of Europe's seas, that follows ecosystem-based management principles, is needed to ensure healthy fish populations (see AIRS_PO1.5, 2016 for further information).

The cumulative impact of these pressures jeopardises the condition of the EU's natural capital, decreasing ecosystem resilience and affecting the capacity of the EU's natural capital to underpin prosperity and well-being. The trends and prospects in the state of certain aspects of the natural capital examined here and covered by this priority objective illustrate this general picture.

The mid-term review of the EU Biodiversity Strategy, adopted in October 2015, comprehensively assessed progress for the headline target and all six targets, and concluded that the EU is not on track to meet the objective of halting biodiversity loss and the degradation of ecosystem services by 2020 (EC, 2015a). Population trends in common birds and grassland butterflies, which are key current indicators for monitoring trends in biodiversity, show continual declines. A high proportion of protected species (60 %) and habitat (77 %) assessments were recently reported, under the Habitats Directive, to have an unfavourable conservation status, and the limited progress so far in improving the conservation status makes it unlikely that the 2020 targets on conservation status will be met. These negative trends are mainly due to the change — including loss, fragmentation and degradation — of natural and semi-natural habitats because of agricultural intensification and land abandonment, intensively managed forests and some loss of habitats to urbanisation (see AIRS_PO1.6, 2016; AIRS_PO1.7, 2016; AIRS_PO1.8, 2016 for further information).

Similarly, the pressures on transitional and coastal waters and freshwaters make it very challenging to meet the objective of achieving, maintaining or enhancing a good status of all surface waters. More than half of the surface water bodies in the EU are reported to have less than good ecological status. Surface water bodies in north-western Europe have the highest percentage of water bodies in less than good ecological status and/or the greatest potential for improvement. The pressures affecting water bodies, such as pollution, morphological changes, overabstraction and hydrological changes affecting water flow, will have to be addressed. In particular, diffuse pollution from agriculture remains a major problem (see AIRS_PO1.9, 2016 for further information).

The root cause of most of the pressures on Europe's natural capital ultimately comes from the socio-economic systems of production and consumption. In addition to further implementation of existing environmental legislation and policies, structural changes in these systems seem to be needed in order to sufficiently reduce the pressures on natural capital (in the EU and elsewhere) and thereby fully protect, conserve and enhance the EU's natural capital and put the EU on a path towards the 2050 vision of living well, within the planet's ecological limits (EEA, 2015a).

Given the high ecological footprint of European countries (EEA, 2015d), and the heavy reliance on the import of resources and goods from all over the world, it is also increasingly clear that the EU's negative impact on natural capital extends well beyond its borders (Lenzen et al., 2012; Lammerant et al., 2014; EEA, 2015a). Consequently, the EU's efforts to protect natural capital within its borders should ensure that pressures are not displaced abroad, and do not exacerbate the global erosion of natural capital (EEA, 2015a) and contribute to the transgression of global environmental limits (Steffen et al., 2015).

1.3 Synergies, challenges and opportunities

The three thematic priority objectives of the 7th EAP are interrelated and therefore need to be addressed together in a systemic and holistic way. Improving resource efficiency will be essential to the fundamental reduction of pressures on natural capital, while an enhanced natural capital base will deliver many benefits for human health and well-being (EU, 2013).

The close link between improving resource efficiency and protecting natural capital is provided by considering the pressures resulting from the intense agriculture in the EU. As illustrated previously, intense agriculture has a considerable negative impact on natural capital in the EU, and the current Common Agricultural Policy seems inadequate to sufficiently reduce the pressures on natural capital in line with the ambitions of the 7th EAP (EEA, 2015a). Instead, a more ambitious and long-term approach would aim to both increase environmentally friendly agricultural production and also consider transformations of our food systems (EEA, 2015a). Such an approach should also include a policy focus on food consumption through, for example, dietary changes, more effective distribution chains and food waste prevention. (EEA, 2015a). Shifting to more sustainable agriculture, such as organic farming, would both reduce environmental pressures and create more jobs, as it involves more labour-intensive (and resource-efficient) practises (EC, 2015b).

An integrated response across different policy fields is essential to reap co-benefits and to prevent unintended negative side-effects of isolated policy responses (e.g. bioenergy cropping, which can reduce greenhouse gas (GHG) emissions, but also increase pressures on natural capital) (EEA, 2015a). However, current measures, policies and strategies to address the erosion of natural capital at EU level are largely fragmented and independent of each other. To better manage natural capital, environmental objectives will increasingly need to be mainstreamed into sectors such as fisheries, agriculture, forestry, energy, food, transport and tourism. The systemic nature of the degradation of natural capital requires the management of human activities in an integrated, holistic way. In this context, ecosystem-based management — an integrated approach to management that considers the interdependence of human activities, ecosystems and human well-being, with a long-term outlook across different spatial scales — can help to tackle the systemic challenge of protecting natural capital (EEA 2015a).

The Bioeconomy Strategy is important for reconciling the demands for sustainable agriculture and fisheries, food security and the sustainable use of renewable biological resources for industrial purposes, while also ensuring biodiversity and environmental protection (EC, 2012).

The 2030 Agenda for Sustainable Development (UN, 2015) offers an opportunity for the integration of policies, as meeting the Sustainable Development Goals will require an understanding of the synergies and trade-offs between the economy, the environment and human well-being.

Green finance and eco-innovation — the focus of the spotlight chapter — also have an important role to play in the better management of the EU's natural capital, especially if there are to be clear market returns for the better management of the EU's natural capital. Green finance, such as the Natural Capital Financing Facility, a financial instrument that combines European Investment Bank and European Commission funding, will be important in helping to prove to the market the attractiveness of biodiversity and climate adaptation operations. Initiatives such as the open source platform Natural Capital Coalition can help the private sector to share innovations on the development of methods for natural capital valuation in business.

1.4 Other relevant knowledge

An integrated response to better manage natural capital across sectors will require investments in improving our knowledge base on the EU's natural capital.

Some key challenges to understanding the EU's ecosystem capital are the assessments of the extent, structure and condition of the different ecosystem types, and the assessment of the ecosystem service flows generated by these ecosystems. The importance of 'mapping and assessing ecosystem services, and understanding the role of biodiversity in underpinning such services' is clearly recognised in the 7th EAP (EU, 2013). The ongoing MAES initiative (Mapping and Assessment of Ecosystems and their Services), a collaboration between the European Commission Directorate General for the Environment (DG ENV), the European Environment Agency (EEA) and individual countries, has made important progress towards mapping and assessing the condition of Europe's ecosystems (EC, 2013 and 2014); for further information, also see Box 1.1. The next step for this initiative is to assess ecosystem service delivery by

assessing the ability of ecosystems to deliver ecosystem services given their conditions (EEA, 2016b).

The 7th EAP also recognises that 'the integration of the economic value of ecosystem services into accounting and reporting systems at Union and national level by 2020 will result in better management of the Union's natural capital' (EU, 2013). The incorporation of the EU's natural capital into accounting systems is necessary in order to integrate natural capital concerns adequately into our economic systems and decision-making. This will require investments in the development of a shared data platform for the integration of ecosystem-related data at the EU level. Ongoing work is strengthening the knowledge base on integrating the values of ecosystems and their services into accounting. For example, a joint project by the Environment Knowledge Community — currently consisting of the European Commission Directorate General for the Environment (DG ENV), Climate Action (DG CLIMA) and Research & Innovation (DG R&I), as well as Eurostat, the Joint Research Centre (JRC) and the European Environment Agency (EEA) — is underway to develop an integrated EU ecosystem accounting system (KIP-INCA, the Knowledge Innovation Project for an Integrated System for Natural Capital and Ecosystem Services Accounting).

The 7th EAP sets out the vision that 'by 2050 we live well, within the planet's ecological limits' and recognises the need to better understand environmental thresholds and planetary boundaries (EU, 2013). What does it mean for the EU to live within the limits of our planet? Planetary boundaries have been identified for the most pertinent human-induced global environmental challenges (Steffen et al., 2015). Knowledge is needed on how the EU can operate safely within these planetary boundaries. A joint project by Environment Knowledge Community partners is underway to help operationalise the planetary boundary concepts in an EU policy context (KIP-WiLoP, the Knowledge Innovation Project on 'Within Limits of the Planet').

The 7th EAP also identifies additional significant knowledge gaps and highlights areas that require particular attention in order to better manage natural capital. These include modelling tools to better understand complex issues related to environmental change, such as the impact of climate change and natural disasters; environmental thresholds and ecological tipping points; further research into systemic risks and society's ability to cope with them; filling gaps in relation to understanding how biodiversity adapts to climate change; and how the loss of biodiversity affects human health (EU, 2013).

Information on key aspects of the European knowledge base on biodiversity, ecosystems and their services is available from the Biodiversity Information System for Europe (BISE).

AIRS briefings — 7th EAP priority objective 1
(http://www.eea.europa.eu/airs/2016/natural-capital)

AIRS_PO1.1, 2016, *Eutrophication of terrestrial ecosystems due to air pollution*, European Environment Agency (http://www.eea.europa.eu/airs/2016/natural-capital/eutrophication-of-terrestrial-ecosystems).

AIRS_PO1.2, 2016, *Agricultural land: nitrogen balance*, European Environment Agency (http://www.eea.europa.eu/airs/2016/natural-capital/agricultural-land-nitrogen-balance).

AIRS_PO1.3, 2016, *Urban land expansion*, European Environment Agency (http://www.eea.europa.eu/airs/2016/natural-capital/urban-land-expansion).

AIRS_PO1.4, 2016, *Forest utilisation*, European Environment Agency (http://www.eea.europa.eu/airs/2016/natural-capital/forest-utilisation).

AIRS_PO1.5, 2016, *Marine fish stocks*, European Environment Agency (http://www.eea.europa.eu/airs/2016/natural-capital/marine-fish-stocks).

AIRS_PO1.6, 2016, *Common birds and butterflies*, European Environment Agency (http://www.eea.europa.eu/airs/2016/natural-capital/common-birds-and-butterflies).

AIRS_PO1.7, 2016, *EU protected species*, European Environment Agency (http://www.eea.europa.eu/airs/2016/natural-capital/eu-protected-species).

AIRS_PO1.8, 2016, *EU protected habitats*, European Environment Agency (http://www.eea.europa.eu/airs/2016/natural-capital/eu-protected-habitats).

AIRS_PO1.9, 2016, *Surface waters*, European Environment Agency (http://www.eea.europa.eu/airs/2016/natural-capital/surface-waters).

2 Seventh Environment Action Programme priority objective 2:

To turn the Union into a resource-efficient, green and competitive low-carbon economy

2.1 Introduction

The European policy priorities of resource efficiency and a low-carbon economy are 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 run (EEA, 2015a). The Seventh Environment Action Programme (7th EAP) aims to 'stimulate the transition to a green economy and to strive towards an absolute decoupling ([3]) of economic growth and environmental degradation' and put Europe on the path to the 2050 vision of 'Living well, within the limits of our planet' (EU, 2013).

Priority objective 2 of the 7th EAP is 'to turn the Union into a resource-efficient, green and competitive low-carbon economy' (EU, 2013). As such, it is wide ranging in scope, encompassing a large range of environment and climate related objectives and targets, both qualitative and quantitative. Actions address production and consumption and the whole value chain from raw materials to products through to business models and procurement.

Priority objective 2 builds on existing environmental legislation and policies, and full implementation of these is a fundamental step towards achieving the objective. In particular, the Waste Framework Directive (EU, 2008), the Renewable Energy Directive (EU, 2009), the Europe 2020 Strategy (EC, 2010), the Roadmap to a resource efficient Europe (EC, 2011a), the Roadmap for moving to a competitive low-carbon economy in 2050 (EC, 2011b), the Energy Efficiency Directive (EU, 2012), the 2030 climate and energy framework (EC, 2014; European Council, 2014), the circular economy package (EC, 2015a) and the Energy Union Framework Strategy (EC, 2015b), as they set objectives and targets and take forward relevant measures.

There are five main areas for action by 2020 under this priority objective: (1) resource efficiency, (2) waste, (3) climate and energy, (4) sustainable consumption and production, and (5) water efficiency. Effective action is supported by the 7th EAP's enabling framework which comprises another four priority objectives on implementation, information, investment and integration. Fourteen indicator-based briefings were created to contribute to the monitoring of this priority objective. The briefings focus primarily on the 2020 objectives (including targets) in existing environmental legislation and policies. If quantitative objectives were not available, qualitative 7th EAP objectives were used, as this combination provides an overall picture of progress. However, with such a diverse range of measures, the available indicator base cannot capture all aspects, but it can, nevertheless, give an indication of progress in the main areas for action.

2.2 Progress and 2020 outlook

When it comes to resource efficiency and the low-carbon economy, past trends are encouraging. The indicators show that, in many areas, efficiency is improving and society is finding ways to increase economic output relative to the associated environmental pressures. The scoreboard presented in Table 2.1 shows progress towards a series of 2020 objectives. Further information on the objectives and the rationale for the 2020 outlooks are contained in the individual online indicator briefings — the list of the priority objective 2 indicator briefings and their links is available in the end of this chapter.

European policies have put increased emphasis on dematerialising economic output and Europe has made progress in **decoupling resource use from economic growth**. The EU improved its material resource productivity by 35 % between 2000 and 2015, while gross domestic product (GDP) increased by 21 % and material resource use declined by 11 %. Material resource productivity has improved in all but three Member States, although it varies among countries by a factor of nearly 20, mainly because of the types of material resources available in, and

([3]) Relative decoupling occurs when resource use grows less rapidly than economic output, and absolute decoupling occurs when resource use declines while economic output grows.

the economic structures of, the particular country. Policies have contributed to this, including climate and energy policies, through displacing fossil fuels in energy production and improving energy efficiency. Other economic and technical factors have also played a role, including the changing structure of countries' economies, the effect of the economic downturn, globalisation and increasing reliance on imports, and even the nature of the indicator itself (EEA, 2016a). Therefore, it remains to be seen whether these improvements can be sustained, and the rate of increase in resource productivity has been projected to return to the more gradual rate seen prior to the economic downturn of just under 1 % per year (Cambridge Econometrics, 2014).

In addition, material resource efficiency is measured on a territorial basis and the indicator does not include materials embodied in imported goods (see AIRS_PO2.1, 2016 for further information). European consumption patterns remain resource intensive and, although increasing resource efficiency is essential to sustain socio-economic progress in a world of finite resources and ecosystem capacity, it is not sufficient on its own. Increasing efficiency is only an indication that output is growing more than resource use and emissions. Apparent efficiency improvements may partially be explained by relocation of material extraction and manufacturing to other areas of the world. Therefore, increasing resource productivity does not guarantee a reduction in environmental pressures in absolute terms, and a resource-efficient economy also requires absolute reductions in resource use (EEA, 2015a).

A circular economy in which nothing is wasted, as envisaged in the circular economy package (EC, 2015a), is also central to efforts to improve resource efficiency. **Waste prevention**, preparing for reuse and recycling enable society to extract maximum value from resources, reduce demand for virgin resources along with related energy use and reduce environmental impacts. Safely managing waste also prevents harm to health and the environment. Current trends show no significant change (only a small reduction of 2 %) in **waste generation** overall with variation

Table 2.1 7th EAP priority objective 2 scoreboard

Indicator	EU indicator past trend	Selected objective to be met by 2020	Indicative outlook of the EU meeting the selected objective by 2020
Resource productivity	▲	Improve economic performance while reducing pressure on natural resources — Roadmap to a resource efficient Europe	●
There was a decline in the use of materials and a rapid rate of increase in resource productivity following the economic downturn of 2007/2008. The rate of increase in resource productivity has been projected to return to the more gradual rate seen prior to the economic downturn of just below 1 % per year			
Waste generation in Europe ([a])	▲	Manage waste safely as a resource. Reduce absolute and per capita waste generation — 7th EAP	●
The historic trend shows variation in waste generation among sectors, with reduction in some, little change in others and some increases. This mixed picture suggests that the outlook to 2020 is unclear			
Recycling of municipal waste ([a])	▲	50 % of selected materials in household and similar waste to be recycled by each EU Member State — Waste Framework Directive	●
The amount of municipal waste being recycled has been steadily increasing. The outlook for reaching the 2020 target is mixed, with the above level of recycling already achieved by some Member States and others on course to do so. However, the target is some way off for others			
Use of freshwater resources	▲	Water abstraction should stay below 20 % of available renewable freshwater resources — Roadmap to a resource efficient Europe	●
While efficiency gains have been achieved, hotspots for water stress conditions are likely to remain given continued pressures such as climate change, increasing population and rapid urbanisation			
Total greenhouse gas emission trends and projections	▲	Reduce greenhouse gas emissions by 20 % compared with 1990 levels — 2020 Climate and Energy Package	●
The decreasing trend of greenhouse gases and the future evolution as projected by EU Member States indicate that the 2020 greenhouse gas reduction target will be met			

Table 2.1 7th EAP priority objective 2 scoreboard (cont.)

Indicator	EU indicator past trend	Selected objective to be met by 2020	Indicative outlook of the EU meeting the selected objective by 2020
Share of renewable energy in gross final energy consumption	▲	Reach a 20 % share of renewable energy in gross final energy consumption — Renewable Energy Directive	●
The EU has steadily increased the share of renewable energy in its gross final energy consumption. If the current pace of growth is maintained, the 2020 renewable energy target will be met			
Progress on energy efficiency in Europe	▲	Improve energy efficiency by 20 % (compared with a business-as-usual scenario) — Energy Efficiency Directive	●
The EU as a whole is currently on track to meet its energy efficiency target. This has been mainly due to the implementation of energy efficiency policies as well as the economic downturn. As economic growth returns, higher levels of ambition for some national targets and better implementation across the board will be required to keep Europe on track			
Energy consumption by households	▲	Reduce the overall environmental impact of production and consumption in the housing sector — 7th EAP	●
The energy consumption of households in the EU decreased. Policies in place and the targets set for energy consumption under the Energy Union process should help to maintain this trend up to 2020 and beyond			
Greenhouse gas emissions from transport	▲	Reduce the overall environmental impact of production and consumption in the mobility sector — 7th EAP	●
Past transport greenhouse gas emissions increased from 1990 to 2014 despite a decline between 2008 and 2013. It is uncertain if emissions will reduce by 2020, since according to projections by the EU Member States emissions will remain more or less stable between 2015 and 2020			
Consumption of meat, dairy, fish and seafood	▲	Reduce the overall environmental impact of production and consumption in the food sector — 7th EAP	●
Reducing the consumption of animal products and shifting to other sources of protein has the potential to reduce environmental impacts related to food. Consumption of meat, dairy, and fish and seafood products increased gradually between 1995 and 2008, but has stabilised since then. Levels of saturated fat and red meat consumption remain above dietary guidelines and result in high GHG and nitrogen emissions			
Share of environmental and labour taxes in total tax revenues	▲	Shift taxation from labour towards the environment — 7th EAP	●
For the EU as a whole, there has been no positive progress over the examined period and there are no indications of any change in the coming years			
Employment and value added in the environmental goods and services sector	▲	Promote a larger market share of green technologies in the Union and enhance the competitiveness of the European eco-industry — 7th EAP	●
Overall employment and value added continue to increase, although growth in the sector has slowed since 2011. The prospects of continued growth are uncertain and dependant on the sector competing with equivalent sectors in China and the USA, and continuing ambitious renewable energy and green growth policies in Europe			
Environmental protection expenditure in Europe	▲	Increase in public and private sector funding for environment- and climate-related expenditure — 7th EAP	●
Environmental protection expenditure has increased over the years and this seems likely to continue to 2020, strengthened by the EU's decision that at least 20 % of its 2014–2020 budget should be used on climate change activities			

EU indicator past trend		Indicative outlook of the EU meeting the selected objective by 2020	
▲	Improving trend	●	It is likely that the objective will be met by 2020
▲	Stable or unclear trend	●	It is uncertain whether or not the objective will be met by 2020
▲	Deteriorating trend	●	It is unlikely that the objective will be met by 2020

Notes: (a) The indicator past trend is also available at EEA member country aggregate level and not just at the EU aggregate level. In all of these cases, the assessment (in terms of colour) remains the same for the EU and the EEA member country (including the EU) indicator past trend.

The available time period and country coverage are specified in the corresponding charts in the online briefings.

across sectors and countries. Similarly, generation of municipal waste per capita in the EU has also declined slightly (5 %) and is decreasing in most countries. The overall improvements are most likely to have been due to a combination of various factors: efficiency improvements in production processes and management, changes in the structure of the manufacturing sector, an increase in activities in the services sector, a shift towards less-intensive waste-generating activities and the influence of statistical changes (see AIRS_PO2.2, 2016 for further information).

The EU is increasing the amount of **municipal waste** it recycles, thanks to investments in appropriate collection and handling, financial incentives to move away from landfilling of waste and landfill bans. The performance of EU Member States on the recycling of municipal waste varies, although data comparability is hindered by variation in data collection and definitions. Despite a strong performance from some Member States and clear progress being made in nearly all countries since 2004, in a number of Member States significant efforts are still needed to achieve the 2020 target (see AIRS_PO2.3, 2016 for further information).

Resource efficiency extends beyond material resources to include energy, water, air and land. Although **freshwater** is relatively abundant in Europe, water availability and socio-economic activity are unevenly distributed, leading to major differences in water stress levels across Europe. Efficiency gains for industrial and agricultural water use and to a lesser degree in public water supply networks have been achieved. However, hotspots for water stress conditions are likely to remain. These hotspots (primarily in the Mediterranean and Atlantic areas) are confronted with a difficult combination of a severe lack of, and a high demand for, freshwater. This is unlikely to improve in the future given continued pressures such as climate change, an increasing population and urbanisation. If water stress is to be reduced in areas of concern, further efficiency improvements, such as reducing leakage, will be required in all sectors, particularly agriculture and the management of the public water supply (see AIRS_PO2.4, 2016 for further information).

A fundamental step towards achieving a resource-efficient and low-carbon economy is ensuring that the EU meets its 2020 **climate** and energy targets and is on track towards meeting the longer term 2030 and 2050 targets. In the last two decades, the EU has made significant advances in the decoupling of carbon emissions from economic growth. Total greenhouse gas (GHG) emissions (excluding land use, land use change and forestry) in the EU decreased by 24 % between 1990 and 2014, with an increase in GDP of around 48 % over the same period. Recent analysis by the European Environment Agency (EEA) shows that the reduction in GHG emissions over this 24-year period was due to a variety of factors, including the growing use of renewables, the use of less carbon intensive fuels and improvements in energy efficiency, as well as to structural changes in the economy and the economic downturn (EEA, 2016b). The demand for energy to heat households has also been lower, as Europe, on average, has experienced milder winters since 1990, which has also helped reduce emissions. The decreasing trend of GHG emissions and their projected future evolution indicate that the 2020 GHG reduction target will be met (EEA, 2016c). However, in the longer term, EU Member States expect that the pace of these reductions will slow, bringing EU emissions to 26–29 % below 1990 levels by 2030. This will be insufficient to achieve the 40 % reduction target and thus remain on course for the 2050 objective of at least an 80 % reduction (see AIRS_PO2.5, 2016 for further information).

In relation to **renewables**, the EU has steadily increased its share of renewable energy, but the pace of progress has slowed down recently. This is due to a number of factors, including cuts in feed-in tariffs in some EU Member States and lower investment capacity as a result of the persistent economic downturn in others. Analysis of the EU Member State renewable energy action plans shows that if they follow their plans and the current pace of growth is maintained, the 2020 renewable energy target will be met (see AIRS_PO2.6, 2016 for further information). In relation to **energy efficiency**, the EU is currently on track to meet its 20 % target to reduce primary energy consumption by 2020 compared with the baseline level. This was driven by the economic downturn, as well as by the implementation of a wide range of energy efficiency policies. As economic growth returns, more intensive efforts to implement energy efficiency policies at national level will be necessary to ensure that the 2020 target is met (see AIRS_PO2.7, 2016 for further information).

Turning the EU into a green and competitive economy involves reducing the environmental impact of major sectors, and stimulating new activities and a shift in practices. **Food, housing and mobility** are responsible for almost 80 % of environmental impacts. Structural changes in production, technology and innovation, as well as consumption patterns and lifestyles, are needed to reduce the overall impact of production and consumption in these sectors. Available indicators for these areas are limited so selected aspects have been used as a proxy for overall environmental impact.

Transport is a major contributor to significant environmental pressures including climate change, biodiversity fragmentation, air pollutant emissions and noise. Climate change is one of the most significant environmental issues and the transport sector contributed a quarter of the total GHG emissions in the EU in 2014. Transport GHG emissions have increased since 1990, despite a decline between 2008 and 2013. It is uncertain if transport-related GHG emissions will reduce before 2020 casting doubt over whether or not the sector can reduce its overall environmental impact by 2020. The demand for both passenger and freight transport is expected to increase in the years ahead (EC, 2016a) making it challenging for this sector to reduce its overall environmental impact by 2020 (see AIRS_PO2.9, 2016 for further information).

The **housing** sector (construction and use) contributes to a number of environmental impacts, mainly through energy consumption during the use phase. Energy consumption in households has reduced since 2005. Policies on the energy performance of buildings and appliances are having an effect, but these efficiency gains have been partly offset by an increasing number of electrical appliances, larger homes and lower occupancy rates. However, the outlook to 2020 could be positive because of a combination of progress to date, the targets set for energy consumption under the Energy Union process and current policies to encourage reduction in energy use. The revisions of the Energy Efficiency and Buildings Directives should help with further reductions in energy consumption in buildings (see AIRS_PO2.8, 2016 for further information).

The **food** system is a major driver of environmental change, with implications for energy and water security. Air, soil and water pollution from agriculture remains considerable, and along with overexploitation of fish stocks, this negatively affects biodiversity and ecosystems, as highlighted in the previous chapter. The production and consumption of different foodstuffs have different environmental impacts, with meat and dairy products contributing to around a quarter of the environmental impacts of final consumption in the EU (Weidema and Wesnæs, 2008). The average per capita consumption of meat (all types), dairy and seafood products had been increasing in the EU-28 until 2008, but has since stabilised. The levels of saturated fat and red meat consumption remain above dietary guidelines, so further reductions in these and a shift to other sources of protein has great potential to reduce the overall environmental impact of food while also delivering health benefits (see AIRS_PO2.10, 2016 for further information).

Stimulating green growth and new activities requires market and policy incentives that foster **investments and innovation** and create jobs. Eco-innovation can lead to multiple benefits in terms of creating jobs, reducing environmental pressures and improving competitiveness. European environmental–economic accounts show that environmental protection expenditure has increased since 2003 and although overall expenditure was impacted after the economic downturn in 2008, public sector expenditure increased in absolute value until 2011 (see AIRS_PO2.13, 2016 for further information). This also influenced trends in the environmental goods and services sector. There has been considerable growth in this sector in employment and value added since 2000, mainly driven by the renewables sector. However, a combination of global competition, recent policy changes across European countries and a reduction in domestic investments in renewable energy has resulted in the stagnation of growth in the environmental goods and services sector since 2011 (see AIRS_PO2.12, 2016 for further information).

Both the 7th EAP and the Roadmap to a resource efficient Europe have an objective of shifting **taxation** from labour to environmental taxes. Shifting taxes from employment towards resource use and pollution offers a way to incentivise resource-efficiency improvements. However, there has been little progress in this regard and the share of environment taxes in total tax revenues has remained fairly consistent since 2003 (see AIRS_PO2.11, 2016 for further information). Progress regarding investment and innovation and the role of environmental policy is explored more fully in the spotlight chapter (Chapter 4).

The above analysis of trends in a resource-efficient and low-carbon economy illustrate that, although in many areas efficiency is improving, looking beyond 2020, a greater magnitude of change will be required to achieve 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' (EC, 2011c). 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, e.g. environmental gains from improvements in fuel efficiency in vehicles was offset by increases in car ownership and the number of kilometres driven. Therefore, there is a need to address, in an integrated way, the production-consumption systems that fulfil societal functions (e.g. food, energy, housing, mobility). The 7th EAP recognises this need, but actions are still focused on thematic environmental priorities. In addition, the level of ambition of the environmental policies currently in place to reduce environmental pressures may not enable Europe to achieve long-term environmental goals, such as the 2050 target of reducing GHG emissions by 80–95 % (EEA, 2015a).

2.3 Synergies, challenges and opportunities

The interrelated nature of the thematic priority objectives of the 7th EAP provides an opportunity to harness synergies, but also presents challenges in terms of addressing issues in an integrated way. As highlighted in the other chapters, the relationship between nature, the economy and society means that although our current patterns of production and consumption enhance our quality of life, they simultaneously put it at risk, as they result in environmental impacts on our natural capital, economy and well-being.

Actions to turn the EU into a resource-efficient, green and competitive low-carbon economy have the potential to decrease pressures on natural capital, reduce environmental risks to health and contribute positively to well-being. Increasing the efficiency of resource use and decreasing absolute use can lead to reductions in the extraction and exploitation of natural resources, with corresponding reductions in the impacts on biodiversity and ecosystems, thus contributing to enhancing the resilience of the natural capital base. Improved waste management and modal shifts in passenger transport can reduce the environmental risks to health associated with waste and poor air quality in urban areas.

As outlined in the spotlight chapter (Chapter 4), environmental policy can trigger eco-innovation and green finance, two key enabling factors for achieving priority objective 2 of the 7th EAP. This can, in turn, contribute significantly to economic development and job creation and, therefore, to the Juncker priority of generating growth and creating jobs. The spotlight chapter also illustrates that there is no conflict between being highly competitive and highly ranked with regard to eco-innovation and the stringency of environmental policies. The trends in the renewable energy sector show the important role that policies have played in supporting growth and job creation in this sector.

Environmental policy has a key role to play in the process of turning the EU into a resource-efficient, circular and low-carbon economy. The 7th EAP aims to improve environmental integration and policy coherence and although some progress has been made on the integration of, for example, climate and energy concerns into other policy areas, there is scope for more integrated and adaptive policy approaches that can respond to changes, deliver multiple benefits and manage difficult trade-offs (EEA, 2015a). The production and consumption systems that meet European needs can serve multiple and sometimes contradictory functions. Therefore, this transition will be best supported through more integrated policy approaches that address food, energy, housing and mobility, and consider the incentives that structure these systems and the opportunities to reconfigure them.

2.4 Other relevant knowledge

Much of the current knowledge base in the areas addressed by priority objective 2 is based on monitoring, data, indicators and assessments mainly linked to the implementation of legislation. This means that key aspects of priority objective 2, such as the material resource productivity of the economy, waste, GHG emissions and energy, are covered by available indicators. However, improving our understanding of progress in reducing the overall impacts of production and consumption in major sectors requires investing in knowledge development, in order to improve our understanding of the interplay between socio-economic and environmental factors; production and consumption patterns; and the costs and benefits of action and inaction.

Environmental–economic accounting has a key role to play here in providing information on the interlinkages between economic activity and environmental factors, and producing indicators for production, consumption and trade perspectives. The Regulation on European environmental economic accounts (EU, 2011; EU, 2014) is making an important contribution in this regard through the development and regular production of physical and monetary accounts in European countries.

The globalised nature of the European economy also means that our understanding of trends in Europe is informed by indicators that integrate a global perspective. To date, footprint indicators and accounting for materials, land, water and GHG emissions associated with imports have been developed mainly through research (e.g. Tukker et al., 2014; UNEP GRID et al., 2015). So although indicators are available, their regular production and use within the policy process remains limited.

There is still a need to translate the resource-efficient, low-carbon, green economy concept into a small set of indicators that can be used to measure progress and inform policymaking and decision-making. Developing such a set of indicators is challenging, given the large range of relevant environmental and climate policy objectives and targets, and the difficulties of measuring and monitoring externalities when social and environmental impacts are not reflected in market prices.

However, there are a range of highly relevant recent and ongoing developments. These include the Resource Efficiency Scoreboard (EC, 2016b), which is

used to monitor the implementation of the Roadmap to a resource efficient Europe; the development of a monitoring framework for the circular economy; and the development of the indicator set that will be used to measure progress towards the UN Sustainable Development Goals. There is merit in exploring synergies between these indicator initiatives and monitoring the 7th EAP. There are shared elements and development needs for all, for example, the need for an indicator on food waste.

To support the development of a monitoring framework for the circular economy package, the EEA has developed a simplified model of the circular economy (Figure 2.1), and identified the key characteristics and enabling factors of a circular economy (EEA, 2016d). This illustrates that established indicator approaches should also be complemented by other sources of knowledge. This is particularly relevant when it comes to enabling factors. Although some enabling factors can be monitored through indicators (e.g. information on the shift in the tax base is captured by environmental–economic accounts), for many others, such as business models and governance, a qualitative assessment may be more suitable. Therefore, monitoring progress, whether in the context of the 7th EAP or the circular economy, will require a combination of quantitative and qualitative information, and there are clear opportunities to improve our use of qualitative knowledge in this regard.

AIRS briefings — 7th EAP priority objective 2
(http://www.eea.europa.eu/airs/2016/resource-efficiency-and-low-carbon-economy)

AIRS_PO2.1, 2016, *Resource efficiency*, European Environment Agency (http://www.eea.europa.eu/airs/2016/resource-efficiency-and-low-carbon-economy/resource-efficiency).

AIRS_PO2.2, 2016, *Waste generation*, European Environment Agency (http://www.eea.europa.eu/airs/2016/resource-efficiency-and-low-carbon-economy/waste-generation).

AIRS_PO2.3, 2016, *Recycling of municipal waste*, European Environment Agency (http://www.eea.europa.eu/airs/2016/resource-efficiency-and-low-carbon-economy/recycling-of-municipal-waste).

AIRS_PO2.4, 2016, *Freshwater use,* European Environment Agency (http://www.eea.europa.eu/airs/2016/resource-efficiency-and-low-carbon-economy/freshwater-use).

AIRS_PO2.5, 2016, Greenhouse gas emissions, European Environment Agency (http://www.eea.europa.eu/airs/2016/resource-efficiency-and-low-carbon-economy/greenhouse-gas-emission).

AIRS_PO2.6, 2016, *Renewable energies*, European Environment Agency (http://www.eea.europa.eu/airs/2016/resource-efficiency-and-low-carbon-economy/renewable-energies).

AIRS_PO2.7, 2016, *Energy efficiency*, European Environment Agency (http://www.eea.europa.eu/airs/2016/resource-efficiency-and-low-carbon-economy/energy-efficiency).

AIRS_PO2.8, 2016, *Household energy consumption*, European Environment Agency (http://www.eea.europa.eu/airs/2016/resource-efficiency-and-low-carbon-economy/household-energy-consumption).

AIRS_PO2.9, 2016, *Transport greenhouse gas emissions*, European Environment Agency (http://www.eea.europa.eu/airs/2016/resource-efficiency-and-low-carbon-economy/transport-ghg-emissions).

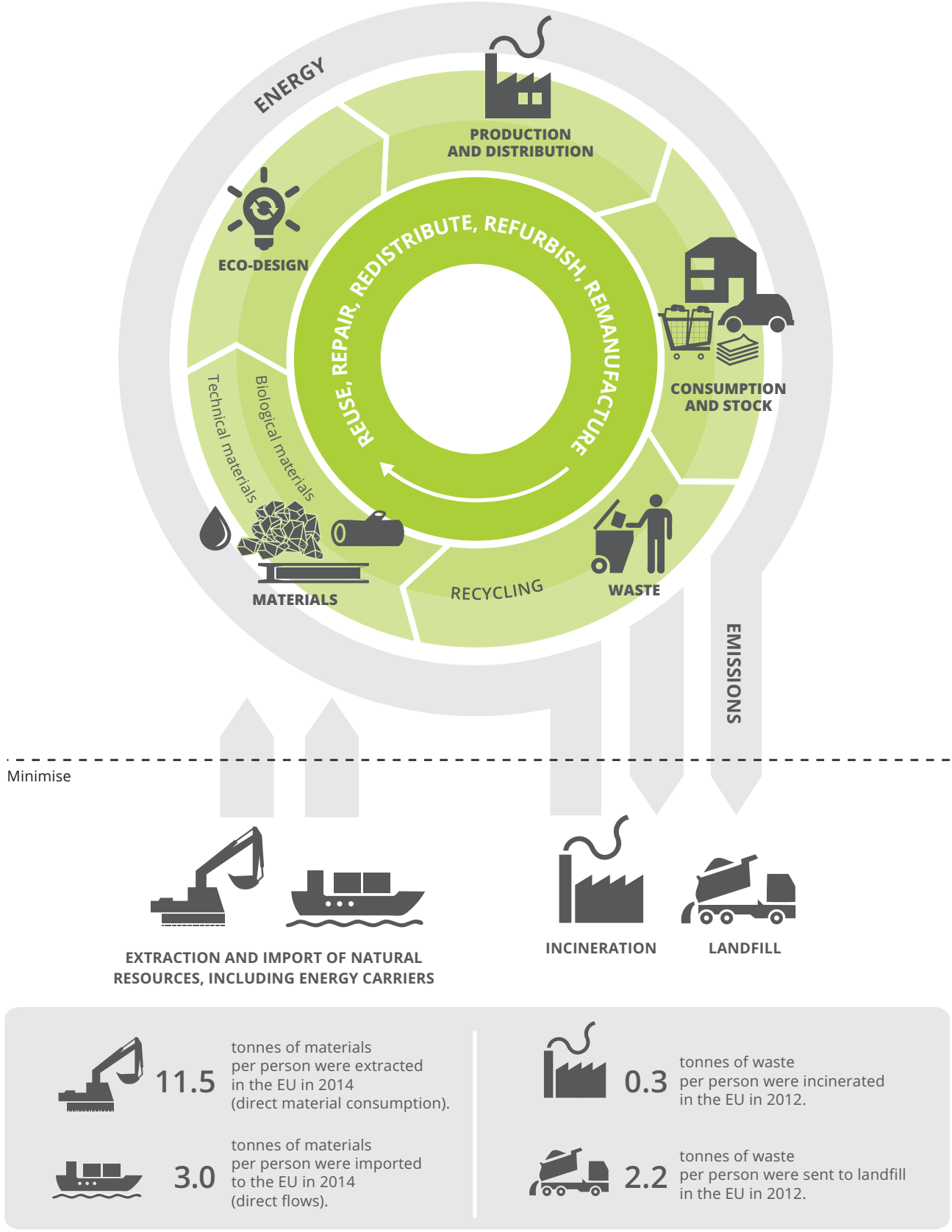
AIRS_PO2.10, 2016, *Food consumption — animal based products*, European Environment Agency (http://www.eea.europa.eu/airs/2016/resource-efficiency-and-low-carbon-economy/food-consumption-animal-based).

AIRS_PO2.11, 2016, *Environmental and labour taxation*, European Environment Agency (http://www.eea.europa.eu/airs/2016/resource-efficiency-and-low-carbon-economy/environmental-and-labour-taxation).

AIRS_PO2.12, 2016, *Environmental goods and services sector: employment and value added*, European Environment Agency (http://www.eea.europa.eu/airs/2016/resource-efficiency-and-low-carbon-economy/environmental-goods-and-services-sector).

AIRS_PO2.13, 2016, *Environmental protection expenditure*, European Environment Agency (http://www.eea.europa.eu/airs/2016/resource-efficiency-and-low-carbon-economy/environmental-protection-expenditure).

Figure 2.1 **A simplified model of the circular economy for materials and energy**



Source: EEA, 2016d, based on Eurostat, 2015a and 2015b.

3 Seventh Environment Action Programme priority objective 3:

To safeguard the Union's citizens from environment-related pressures and risks to health and well-being

3.1 Introduction

Recognising the intrinsic link between the state of the environment and quality of life, priority objective 3 of the Seventh Environment Action Programme (7th EAP) aims 'to safeguard the Union's citizens from environment-related pressures and risks to health and well-being' (EEA, 2013). Human health and well-being are intimately linked to the state of the environment. Good quality natural environments provide basic needs, in terms of clean air and water, fertile land for food production, and energy and material inputs for production. Access to green and blue spaces also provides important opportunities for recreation and supports well-being.

At the same time, the environment represents an important pathway for human exposure to polluted air, water and soil, environmental noise and chemicals. The impacts of climate change also pose immediate threats to health, in terms of heat waves and shifts in the patterns of infectious diseases and allergens. The World Health Organization (WHO) estimates that environmental stressors are responsible for 12–18 % of all deaths in the 53 countries of the WHO Europe Region (WHO, 2016a). Available evidence clearly demonstrates that disease can be prevented by improving the quality of the environment in key areas such as air, water and noise. At the same time, there is growing recognition of the need to shift from a focus on individual stressors to systemically reducing human exposure to multiple stressors (EEA and JRC, 2013).

Over the longer term, environmental changes, such as climate change, depletion of natural resources and biodiversity loss, have potentially wide-ranging effects on human health and well-being by threatening the environmental services that society depends upon. Recognition of the complex interactions between environment and health calls for approaches that focus on maintaining ecosystem resilience with the aim of securing the ecosystem services that support human health and well-being. The profound dependency of human society on supporting ecosystems lies at the very core of the 7th EAP vision that 'in 2050 we live well, within the planet's ecological limits' (EU, 2013).

Framed by this broader perspective, the 2020 objectives of this priority objective focus on reducing environmental health risks under seven key areas: (1) air quality; (2) environmental noise; (3) drinking and bathing water quality; (4) hazardous chemicals; (5) pesticides; (6) nanomaterials; and (7) climate change adaptation. Action in these areas is mainly driven by existing EU legislation and policy, in particular the Air Quality Directive (EU, 2008), the EU National Emission Ceilings Directive (NECD) (EU, 2001), the Environmental Noise Directive (EU, 2002), the Bathing Water Directive (EU, 2006a), the Drinking Water Directive (EU, 1998), the EU strategy on adaptation to climate change (EC, 2013a), the Regulation on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) (EU, 2006b) and the Directive establishing a framework for Community action to achieve the sustainable use of pesticides (EU, 2009a).

Seven indicators provide insight into progress in this regard. Two relate to air quality, focusing on the state of outdoor air quality and emissions of key pollutants to air, and one tracks bathing water quality. The analysis afforded by the available indicators is limited for the other areas. Monitoring of both the state and drivers of environmental quality and the subsequent development of indicators over the past 20–30 years has been driven by the need to track progress towards targets and other thresholds in the environmental acquis. As such, the indicator on environmental noise does not measure progress towards the somewhat broader strategic objectives set out in the 7th EAP, but rather towards thresholds in the Environmental Noise Directive (EU, 2002).

Regarding the risks from hazardous chemicals and pesticides, available indicators focus on chemical volumes that are only indirectly related to risks. The indicator on climate change adaptation tracks policy responses at national level, without providing insight into their effectiveness in building resilience to climate change. Indicators are not available to assess progress towards drinking water quality standards, to track improvement in indoor air quality, or to determine whether the safety concerns related to nanomaterials are effectively addressed in legislation.

The online briefings that correspond to the seven indicators provide insight into the current situation and progress towards the objectives related to some of the main areas addressed by this priority objective. However, the picture remains incomplete, due to a lack of robust data on areas such as chemicals and climate change adaptation. This overview synthesises the briefings and complements the indicator-based assessment, and provides a more integrated assessment of progress.

3.2 Progress and 2020 outlook

The prospect for achieving the 2020 7th EAP priority objective of safeguarding EU citizens from environment-related pressures and risks to health and well-being is uncertain due to a number of gaps in the available evidence.

The scoreboard presented in Table 3.1 summarises the conclusions of the seven indicator-based online briefings — the list of the priority objective 3 indicator briefings and their links is available in the end of this chapter. On the one hand, the quality of EU bathing waters continues to increase and the EU is on track to meet commitments to reduce emissions of key pollutants to air. On the other hand, current trends in outdoor air quality and noise suggest that they will remain serious health challenges, particularly in urban areas.

For three areas, the available indicators do not allow a clear conclusion on progress to be drawn. An assessment of progress towards minimising the risks from both hazardous chemicals and pesticides is hampered by the lack of comprehensive evidence regarding the two dimensions of chemical risk, hazard and, in particular, exposure. Progress on climate change adaptation is measurable only in terms of policy processes, and not in terms of the resilience of European society.

The current status and trends towards achieving objectives on air quality, noise, bathing water, chemicals and climate change adaptation are discussed in more detail below.

With regard to air quality, the indicator on the exposure of the urban population to exceedances of selected air quality standards provides a picture of the proportion of the urban population in the EU exposed to potentially harmful concentrations of selected air pollutants in excess of both EU standards and the WHO guidelines. Despite reductions in concentrations of coarse dust particles and nitrogen oxide and no significant change in ozone and fine particulate matter, air quality standards for these pollutants are not being met in many urban areas. Around a sixth of Europeans currently living in urban areas are exposed to air pollutant levels exceeding some EU air quality standards. Moreover, up to 96% are exposed to levels of some air pollutants deemed damaging to health by the WHO's more stringent guidelines (EEA, 2016a). With regard to rural air pollution, exposure to coarse dust particles, fine particulate matter and nitrogen oxide is considerably lower than in urban and suburban areas. In contrast, ozone concentrations are generally highest in rural locations, with the WHO guideline for ozone exceeded in the vast majority of rural background stations in 2013. Air pollution is the single largest environmental health risk in Europe, and is responsible for more than 400 000 premature deaths in the EU each year, as well as harming crop growth, ecosystems and the built environment (EEA, 2016b).

It appears unlikely, based on current trends and on the high and widespread levels of exceedances, that the selected EU air quality standards will be met by 2020, while complying with the WHO guidelines, explicitly mentioned in the 7th EAP, is even less likely. Further action will be needed, in particular in relation to road traffic and residential combustion in urban areas (see AIRS_PO3.1, 2016 for further information).

With regard to the longer term, there is a need for policymakers to respond to the evolving evidence base. As scientific understanding of the impacts of air pollution on health evolves, negative effects are being associated with increasingly lower levels of pollutants. Overall, the lower the levels of air pollution, the better the cardiovascular and respiratory health of the population will be, both in the long and short term (WHO, 2014a).

Air pollutant emissions are a key factor in determining air quality and ecosystem health. Ceilings for 2010 are set for emissions of key air pollutants (sulphur dioxide, nitrogen oxides, ammonia and non-methane volatile organic compounds) by the Gothenburg Protocol of the United Nations Economic Commission for Europe (UNECE) Convention on Long-range Transboundary Air Pollution (UNECE, 1979) and the NECD (EU, 2001). The Gothenburg Protocol further specifies emission reduction commitments for 2020 (UNECE, 2012) for the same four pollutants, as well as for fine particulate matter. Current projections suggest that the EU as a whole is on target to meet the 2020 Gothenburg Protocol emission reduction commitments. Nevertheless, there are still some countries that have not as yet attained one or more of their NECD 2010 emission ceilings (see AIRS_PO3.2, 2016 for further information).

Table 3.1 7th EAP priority objective 3 scoreboard

Indicator	EU indicator past trend	Selected objective to be met by 2020	Indicative outlook of the EU meeting the selected objective by 2020
Exceedance of air quality limit values in urban areas (nitrogen dioxide: NO_2; coarse dust particles: PM_{10}; ozone: O_3; fine particulate matter: $PM_{2.5}$)	▲ NO_2, PM_{10} ▲ O_3, $PM_{2.5}$	Meet Air Quality Directive standards for the protection of human health — Air Quality Directive	●
Despite reductions in concentrations in urban areas of coarse dust particles and nitrogen dioxide and no significant change in ozone and fine particulate matter, due to their high and widespread exceedance levels in urban areas it is unlikely that the air quality standards for these pollutants will be met by 2020			
Emissions of the main air pollutants in Europe (sulphur oxides: SO_2; nitrogen oxides: NO_x; ammonia: NH_3; non-methane volatile organic compounds: NMVOCs; fine particulate matter: $PM_{2.5}$) [a]	▲	Reduce air pollutant emissions in accordance with the requirements of the amended Gothenburg Protocol by the following percentages by 2005: SO_2 59 %, NO_x 42 %, NH_3 6 %, NMVOCs 28 %, $PM_{2.5}$ 22 % compared to 2005 levels	●
Air pollutant emissions have declined and current projections suggest that the EU is on target to meet the 2020 Gothenburg Protocol emission reduction commitments			
Bathing water quality	▲	Increase the number of bathing waters classified as 'excellent' or 'good' under the Bathing Water Directive	●
The share of bathing waters that meet excellent and good quality standards are likely to increase further due to implementation of the Bathing Water Directive, in particular the effect of measures on poor quality waters			
Number of countries that have adopted a national climate change adaptation strategy and/or plan	N.A.	Make decisive progress in adapting to the impact of climate change — 7th EAP	●
There has been an increase in the number of countries that have adopted a national adaptation strategy and/or plan and this is expected to continue. However information on the 'decisive progress' of these policies towards reducing vulnerability and enhancing resilience to climate change is limited, preventing firm conclusions with respect to the 2020 outlook			
Exposure to environmental noise	▲	Significantly decrease noise pollution — 7th EAP	●
Efforts to reduce environmental noise tend to be offset by an increase in the number of people being exposed to high noise levels, in particular due to increasing road and aviation traffic and an increase in the number of city inhabitants			
Production of chemicals, by hazard class	▲	Risks for the environment and health associated with the use of hazardous substances, including chemicals in products, are assessed and minimised — 7th EAP	●
While the production of chemicals that are hazardous to health has declined over the years, it is not possible to equate this to a reduction in the risks to environment and health and the outlook towards 2020 is therefore unclear			
Total sales of pesticides	▲	The use of plant protection products does not have any harmful effects on human health or unacceptable influence on the environment, and such products are used sustainably — 7th EAP	●
The selected indicator does not afford for an evaluation of progress towards the 2020 objective. Rather the analysis serves to highlight gaps in the knowledge base for assessing progress towards this objective			

EU indicator past trend		Indicative outlook of the EU meeting the selected objective by 2020	
▲	Improving trend	●	It is likely that the objective will be met by 2020
▲	Stable or unclear trend	●	It is uncertain whether or not the objective will be met by 2020
▲	Deteriorating trend	●	It is unlikely that the objective will be met by 2020

Notes: [a] The indicator past trend is also available at EEA member country aggregate level and not just at the EU aggregate level. The assessment (in terms of colour) remains the same for the EU and the EEA member country (including the EU) indicator past trend for all the examined air pollutant emissions except ammonia for which the EEA member country past trend deteriorated while the EU trend improved.

The available time period and country coverage are specified in the corresponding charts in the online briefings.

N.A. Non applicable: it is not possible to measure a trend for the 'number of countries that have adopted national climate change adaptation strategies and/or plans', since this is a measure of binary evidence, i.e. whether a policy has been adopted or not.

Noise exposure from transport sources and industry can lead to annoyance, sleep disturbance and related increases in the risk of hypertension and cardiovascular disease. Environmental noise causes at least 10 000 cases of premature death in Europe each year, with almost 20 million people annoyed and a further 8 million suffering from sleep disturbance. Almost 90 % of noise-related health impacts are associated with road traffic noise. In 2012, at least 125 million people, or one in four Europeans, were exposed to daily road traffic noise levels exceeding a level at which adverse effects are known to occur (EEA, 2014a). With regard to the key drivers, expanding transport networks and increasing traffic (road and aviation) continue to increase noise pollution, while trends towards increasing urbanisation lead to more people being exposed. Therefore, significant progress towards the 7th EAP 2020 goal is not expected (see AIRS_PO3.5, 2016 for further information).

In general, bathing water quality is of a high standard across the EU. In eight Member States, more than 90 % of bathing waters were of excellent quality in 2015. Therefore, the outlook towards the 7th EAP goal that by 2020 citizens throughout the Union will benefit from high standards of bathing water is positive. The quality of bathing waters is consistently improving over time as a result of investment in the sewerage system, better wastewater treatment and the reduction of pollution from farms (see AIRS_PO3.3, 2016 for further information).

A robust understanding of chemical risks requires data on both the hazard associated with specific substances and exposure. The available indicator shows that EU production of chemicals that are hazardous to health declined by 12 % overall between 2005 and 2014. In interpreting this in relation to chemical risk, the assumption is that a reduction in the production of chemicals that are hazardous to health equates to a reduction in the overall risk profile of chemicals incorporated into products and sold in the EU. However, the indicator does not account for the actual volume of chemicals that are hazardous to health incorporated into products consumed in the EU. In the context of a global shift in production towards third countries, substantial volumes of chemicals are imported into the EU in products. In addition, the indicator does not provide any information on emissions of chemicals along the chemical life cycle from production to waste, nor does it provide insight into the associated human and environmental exposure.

The downwards trend in the production of chemicals that are hazardous to health cannot therefore be equated to a reduction in chemical-related risks to the environment and health; therefore, the outlook towards 2020 is unclear. The continued implementation of REACH and legislation on the use of biocidal products (EU, 2012) and of pesticides is expected to contribute to improvements in chemical safety. Additional actions are required to address the health impacts of substances, known as endocrine disruptors, that affect human hormone systems, as well as the combination effects of chemicals and impacts on vulnerable groups (see AIRS_PO3.6, 2016 for further information).

Similarly, the indicator on the total sales of pesticides also provides a weak proxy for monitoring progress towards eliminating harmful effects on human health or unacceptable influences on the environment resulting from the use of pesticides. There was a slight increase in the total reported sales of pesticides in the EU between 2011 and 2014, suggesting that efforts to reduce dependency on pesticides under the Directive on the Sustainable Use of Pesticides have not yet been successful. However, the quantity of pesticides sold on the EU market cannot be directly equated to the risk to human health and the environment. Factors such as the hazardous properties of the pesticides and the associated use patterns play a significant role in determining these risks. The indicator also provides no insight into whether or not the use of pesticides is sustainable. Progress towards the 2020 objective on the risks to human health and the environment from pesticides is therefore unclear. The Regulation on pesticide statistics (EU, 2009b) is expected to deliver data in 2016 on the agricultural use of pesticides by crop for five-year periods, which should facilitate a better understanding of the risks to the environment and human health (see AIRS_PO3.7, 2016 for further information).

These indicators provide an incomplete picture, since data on the volumes of chemicals produced and pesticides sold provide only an imperfect proxy for exposure. In addition, the properties of certain chemicals cause them to persist in the environment and bioaccumulate in the food chain, which means that there will be a considerable time lag before reductions in emissions translate into reduced exposure. A complete analysis of progress towards reducing chemical risks would demand robust data on actual human and environmental exposure to specific chemicals, coupled with information on the hazards associated with those chemicals. With regard to exposure pathways, this would require data on drinking water quality and chemical contaminants, and on pesticide residues in food as potential pathways of human exposure to chemicals. Human biomonitoring (HBM) data would provide evidence of the actual chemical body burden of the European

population. However, EU-wide data are not currently available to support a more targeted analysis of actual human exposure to hazardous chemicals, as well as mixtures of chemicals, via multiple exposure pathways. Comparable and validated data on the presence of chemical contaminants in drinking water and food across EU Member States are not publically available, while data on the internal exposure of the human population are available for only a few Member States. Ongoing efforts to make existing data available and to address these gaps are discussed in Section 3.4 below.

With regard to action on climate change adaptation, a key step towards making Europe resilient to climate change involves the adoption of effective national adaptation strategies and national adaptation plans by countries. To date, 20 EU Member States have adopted a national adaptation strategy and nine have further developed a national adaptation plan. Norway, Switzerland and Turkey have also developed national adaptation strategies and national adaptation plans. Action on climate change adaptation is expected to continue up to 2020, with the establishment of related policies and the implementation of specific actions (EEA, 2014b). However, information on the progress of these policies towards reducing vulnerability and enhancing resilience is limited, and it remains too early to evaluate their effectiveness with regard to adapting to climate change in Europe. Therefore, the outlook towards 2020 for this 7th EAP objective remains unclear (see AIRS_PO3.4, 2016 for further information).

3.3 Synergies, challenges and opportunities

It is clear from the discussion of progress towards 2020 that there are a number of challenges related to safeguarding EU citizens from environmental risks to health, not least with regard to gaps in the knowledge base.

Until recently, our understanding of environmental risks to human health had been based on measuring the effects of exposure to single stressors via the environment, an example being the burden of disease that can be attributed to key air pollutants (WHO, 2014a and 2014b). However, the reality is that individuals are exposed to multiple stressors at any one time and that the impacts combine to affect health. For example, an urban resident may suffer from exposure to air and noise pollution, as well as heat island effects during temperature spikes associated with climate change. An individual's vulnerability to environmental risks is determined by interactions across a range of determinants, including age, socio-economic status, lifestyle and consumption patterns, as well as their genetic profile (WHO, 2016b). The linkages between multiple dimensions of environmental quality and the health and well-being of an individual are therefore complex, co-causal and confounded by a range of factors specific to that individual.

Building knowledge of the systemic risks to human health represents a key challenge for the environment and health field. Methods are needed to integrate information on the various pressures that an individual is exposed to, while at the same time accounting for other important health determinants. The influence of individual health determinants on vulnerability introduces considerable uncertainty into our overall understanding of how exposure to a poor-quality environment contributes to the overall disease burden of the population.

Another challenge relates to ongoing developments in the knowledge base. Evidence regarding the impacts of single stressors on health points to the phenomenon of 'harm expansion' over the long term, whereby the hazards associated with single exposures are shown over time to be more diverse and widespread than first anticipated (EEA, 2013a). For example, thresholds of concern for lead, mercury and bisphenol A have been repeatedly revised downwards in response to growing evidence of negative health effects from animal studies. Likewise, the WHO air quality guidelines have evolved downwards over time. The WHO first produced air quality guidelines in 1987 (WHO, 1987) and has updated the guidelines based on expert evaluation of current scientific evidence twice, in 1997 (WHO, 2000) and in 2005 (WHO, 2006); the guidelines for ozone and sulphur dioxide were revised downwards from 1997 and 2005. Although particulate matter was recognised as a health concern in 1987 and 1997, available information was not sufficient to set guidelines, which were introduced for particulate matter in only 2005 once evidence became available. The next revision of the WHO air quality guidelines is anticipated for 2018. In addition, the WHO is currently in the process of updating the 2009 guidelines for environmental noise (WHO, 2009 and 2016c). These historic downward trends in the exposure levels known to be associated with health impacts indicate that policies focused on minimising exposure to single stressors must be flexible enough to respond dynamically to evolving scientific evidence on the relationship between exposure and health.

The complexity of systemic risks to health, the related gaps and uncertainties in the current knowledge base, and the historic trend towards harm expansion in the environment and health dynamic warrant a precautionary approach to managing environmental risks to health. This is particularly relevant given the

potential for severe, often irreversible, health impacts on large proportions of the European population.

At the same time, the need for an integrated approach to managing environment and health interactions, as outlined above, also creates opportunities for synergies across policy domains and more broadly across the three priority objectives of the 7th EAP. In particular, the urban environment provides a focal point for integrating environmental health into urban planning and transport policies, in a context where 72 % of the EU population lives in urbans areas, including cities, towns and suburbs (EC and UN-Habitat, 2016). A model shift in urban transport away from passenger cars would reduce emissions of GHGs, while simultaneously reducing the impacts of key air pollutants and noise on health, and road traffic accidents (EEA, 2013b). Urban planning aimed at improving facilities for cycling and walking can help to reduce the health costs associated with physical inactivity (WHO, 2013). Climate change adaptation policies to boost green spaces in urban areas offer health benefits, through the avoidance of heat island effects and the promotion of well-being effects associated with increased access to green spaces (EEA, 2016c). Green infrastructure can also deliver environmental benefits in urban areas, including maintaining and improving ecological functions and conserving biodiversity (EEA, 2014c).

In terms of opportunities, legislation that is currently proposed or under development in the area of air quality, climate change and chemicals may provide a framework for future efforts on these issues. As part of the Clean Air Programme for Europe (EC, 2013b), the Commission has put forward a revised NECD, which proposes new national emission ceilings for 2020 and 2030. If agreed, the 2030 ceilings are expected to improve air quality in Europe in the longer term and reduce premature mortality. With regard to climate change, implementation of the recent Paris agreement (UNFCCC, 2015) may provide a push to enhance action on adaptation. Finally, the EU strategy for a non-toxic environment, anticipated for 2018, should set a long-term framework for the management of chemical risk, including a focus on vulnerable groups and the identification of emerging risks.

Nevertheless, these actions on single issues will not deliver the integrated approach required to tackle the dynamic among our social, economic and environmental systems more profoundly. Current resource-use patterns generate environmental pressures that expose the population to multiple risks to health (EEA, 2013c). Furthermore, biodiversity loss and climate change threaten the ecosystem services on which our health and well-being depend. Achieving tangible improvements in the relationship between the environment and health and well-being will require a more holistic approach to addressing upstream drivers of risks to health. For example, evidence indicates that people living in urban areas are exposed to multiple stressors, including noise and poor air quality, as well as urban heat island effects associated with climate change. The European Commission's report on 'Cities of Tomorrow' provides a vision of how to respond to challenges in urban areas and make cities 'green and healthy' through integrated and holistic governance approaches (EC, 2011). Policies will also have to respond to contextual trends, including an ageing and increasingly vulnerable EU population concentrated in urban areas, and well also need to address the unequal distribution of environment-related costs and benefits across society (EEA, 2015).

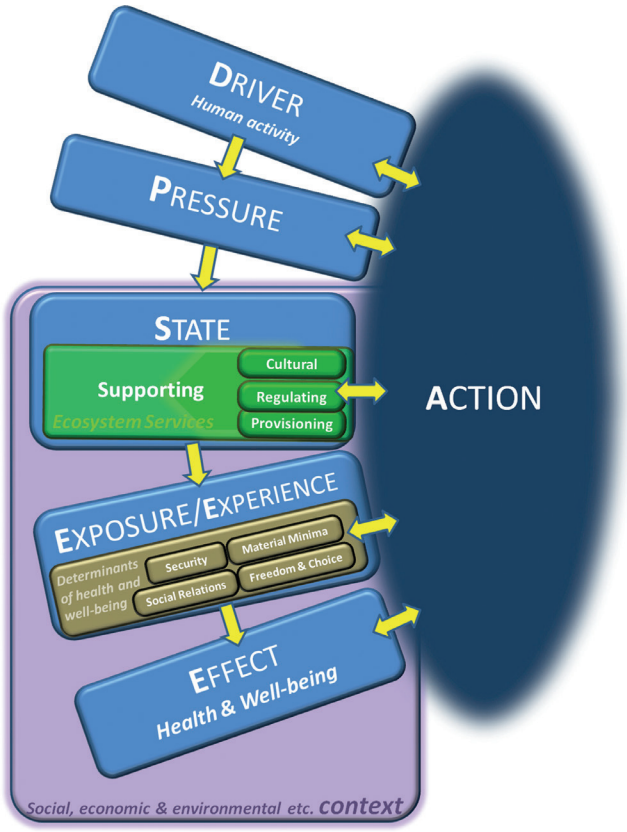
3.4 Other relevant knowledge

There are a number of areas of the environment, health and well-being nexus for which valuable new approaches and methods are under development and for which evidence is being generated to address knowledge gaps.

Recognition of the complexity of environment and health interactions creates the demand for more integrated assessments that can capture multiple stressors, as well as socio-economic determinants of health. In terms of conceptualising the relationship, the eDPSEEA (Ecosystems-enriched Drivers, Pressures, State, Exposure, Effect, Actions) model, presented in Figure 3.1, outlines the pathways through which drivers generate the pressures that disrupt ecosystem services and affect human health and well-being (Reis et al., 2015). The model can capture both local pathways, such as the effects of contaminated drinking water on the local population, as well as how drivers influence health and well-being through transboundary impacts on the environment, such as climate change. Importantly, the model recognises the broad range of cultural, regulating and provisioning services provided by ecosystems. In addition, the model acknowledges the social and economic context in which environment and health interactions play out. As such, it provides a framework for organising a broad array of evidence in a meaningful structure, in order to draw insights for policymaking.

The 'exposome' concept aims to capture the total sum of environmental exposures over an individual's lifespan, and provides a framework for organising a broad range of evidence including

Figure 3.1 **eDPSEEA — a conceptual framework for an integrated assessment of human and ecosystem health and ecosystem service provision**



Source: Reis et al., 2015.

exposure measurements and data on patterns and causes of disease (Sirous et al., 2016). A number of ongoing research projects build on the concept of the 'exposome', including HEALS ([4]), HELIX ([5]) and EXPOsOMICS ([6]). These activities have the potential to identify associations between environmental stressors and associated health outcomes across large populations, and so inform the development of coherent prevention strategies to mitigate the environmental burden of disease.

Priority objective 5 of the 7th EAP identified knowledge gaps in relation to chemical combination effects, endocrine disruptors and chemicals in products. Targeted HBM was identified as a tool that can serve the chemical policy making agenda by providing 'authorities with a more comprehensive view of actual exposure of the population to pollutants, especially sensitive groups such as children' (EU, 2013). HBM measures environmental contaminants in the human body, usually through analyses of blood, urine, hair, breast milk or other tissues. It provides an integrated measure of the level of exposure to chemicals through different pathways and exposure routes. As such, HBM is an important tool for generating evidence on the actual exposure of the human population to contaminants, and in some cases estimating potential health effects linked to the exposure. Analysed over time, HBM data allow the evaluation of trends in exposure and can be used to assess the efficiency of implemented policies (EEA and JRC, 2013).

In 2015, the European Commission launched a call for a European Human Biomonitoring Initiative, under the Horizon 2020 Societal Challenge on health, demographic change and well-being. The objective of this initiative is to create a joint European programme for the monitoring and scientific assessment of human exposures to chemicals and the potential health impacts in Europe, building on previous activities undertaken at EU and national levels. It is envisaged that the resulting project will deliver data on the exposure of the European population to chemicals via multiple pathways. These data will support the development of indicators to track human exposure to priority chemicals at concentrations considered harmful to health, and will include efforts to link exposure to health outcomes. In addition, the project is expected to generate evidence that directly addresses current policy questions, including questions regarding the exposure of the European population to mixtures of chemicals and endocrine disruptors.

The European Commission's 2012 communication on the combination effects of chemicals identifies a lack of knowledge on 'where, how often and to what extent humans and the environment are exposed to certain chemical mixtures and how exposure may change over time' (EC, 2012). HBM has a role to play in generating this knowledge, which could in turn enable a comprehensive and integrated assessment of cumulative effects of different chemicals, taking into account different routes of exposure. With regard to substances that disrupt the endocrine system, in 2016, the European Commission published a communication on endocrine disruptors, including scientific criteria for their determination (EC, 2016). This communication identifies the move to support the European Human Biomonitoring Initiative, under Horizon 2020, as key to providing solid scientific evidence for regulators and policymakers.

([4]) http://www.heals-eu.eu.
([5]) http://www.projecthelix.eu.
([6]) http://www.exposomicsproject.eu.

Finally, the Information Platform for Chemical Monitoring (IPCheM) ([7]) was recently developed by the European Commission, in order to provide online access to HBM data, as well as to environmental monitoring data and data on chemical substances in products and food and feed. This allows a cross-media analysis of exposure to a single substance and facilitates the identification of the most critical exposure pathways. IPCheM is also intended to support work to identify which mixtures of chemicals are present in the environment and in humans.

AIRS briefings — 7th EAP priority objective 3
(http://www.eea.europa.eu/airs/2016/environment-and-health).

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AIRS_PO3.3, 2016, *Quality of bathing waters*, European Environment Agency (http://www.eea.europa.eu/airs/2016/environment-and-health/bathing-water-quality).

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([7]) https://ipchem.jrc.ec.europa.eu.

4 Spotlight on priority objective 2: key enabling factors for a green economy transition

4.1 A green economy and environment policy

The transition to a green economy in Europe has been identified over recent years as one of the responses needed to secure the long-term sustainability of Europe and its neighbourhood (EEA, 2015). The Seventh Environment Action Programme (7th EAP) (EU, 2013) reflects the Union's commitment to transforming itself into an inclusive green economy. Achieving such a transition involves many dimensions (see Box 4.1).

This chapter analyses two enabling factors that can help that transition: eco-innovation and green finance, including the role of environmental policy in triggering these enabling factors and their potential to deliver environmental policy aims. The potential of these factors to improve the environment, and boost growth and jobs, and how this could be enhanced further, are also addressed.

To achieve this transition, it is ever more imperative that environmental policies are fully consistent and coherent with other policies in such a way that environmental objectives and targets are integrated into non-environmental policy domains — such as energy, transport, industrial, economic, fiscal and social policies — and vice versa ([8]).

Box 4.1 Green economy transition

The concept of the 'green economy' has emerged as a strategic priority for governments and intergovernmental organisations. In Europe, it features prominently in the 7th EAP alongside a range of other medium- and long-term EU programmes and strategies, including the Europe 2020 Strategy, the EU Framework Programme for Research and Innovation (Horizon 2020) and sectoral policies in areas such as transport and energy. Globally, the green economy concept is a central feature of the Rio 2012 conference outcome document 'The future we want' (UN, 2012).

The growing prominence of the green economy in EU policy reflects a recognition that the prevailing economic paradigm is inconsistent with Europe's long-term future, as encapsulated in the 7th EAP 2050 vision of 'Living well, within the limits of our planet'. Across the world, the transition to high levels of human development has been achieved by adopting production and consumption patterns that put a disproportionate burden on the environment. As a result, some countries today live well, while others live within the limits of the planet. None does both. The challenge therefore is to do both, i.e. to achieve growth within the planetary boundaries.

A 'green' economy is essentially one in which socio-economic systems are organised in ways that enable society to live well within planetary boundaries. The concept therefore has several dimensions. The first is a focus on increasing **resource efficiency**: identifying the innovations and approaches that enable society to extract maximum value from resources and minimise harmful emissions and waste.

Although essential, resource efficiency alone will not guarantee that natural capital stocks are maintained for future generations, or that economic activity delivers acceptable living standards and social cohesion. Efforts to enhance resource efficiency must therefore be complemented by a focus on **ecosystem resilience** and **people's well-being**. Most recent overall trends highlight that Europe's resource efficiency has improved in recent years, but this has not always translated into improved ecosystem resilience or reduced risks to health and well-being.

Creating a green economy will require fundamental transitions in the production–consumption systems that meet basic demands, such as for food, mobility, energy and housing. Doing so will depend not only on further development of environmental policies, but also on better implementation and integration of environmental and socio-economic policies, and the use of finance and fiscal policies to support major investments in innovation and infrastructure.

([8]) For an overview of EU environmental policy targets and objectives as well as the methodology applied in the analysis, see EEA, 2013 and 2016.

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

Embedded within these laws is a comprehensive set of legally binding targets and non-binding objectives related to the main environment and climate policy areas for the 2013–2050 period. Overall, there are 82 legally binding targets and 84 non-binding objectives to be met for the first time in the 2013–2050 period, and several of these address environmental, climate and socio-economic considerations together.

In addition, market-based instruments (MBIs) have been put in place to internalise the environmental and human health impacts of pollution from socio-economic activities. For example, MBIs (taxes and subsidies) feature in the energy area for greenhouse gas (GHG) emissions (trading permits), waste (producer responsibility schemes) and freshwater (cost-recovery charges).

Legislative instruments and MBIs, when implemented in tandem, are more effective at reducing pollution while simultaneously providing a range of socio-economic benefits. An example is the combination of energy taxes levied on transport fuels and the setting of emission reduction targets for new cars. Such policy interventions may lead to higher implementation costs in the short term, but may also trigger an increase in competitiveness in the longer term, as industries are forced to innovate, and may thereby lead to efficiency gains which offset the costs of complying with the policy measures (Porter, 1991).

Empirical studies assessing the impact of environmental and energy taxes on the diffusion of innovation support the Porter hypothesis (EEA, 2011) ([9]). Business managers have identified environmental legislation and enforcement as a significant driver for technological change (Ashford and Hall, 2011). The significance of policy interventions, particularly environmental taxes, is also acknowledged as they 'stimulate the development and diffusion of new technologies and practices' (OECD, 2010) and they 'are powerful tools to promote green investment and innovation' (UNEP, 2010), which are the two enabling factors for a green economy transition that are assessed further in the rest of this chapter.

4.2 Eco-innovation

The 7th EAP has called for measures to foster innovation in order to stimulate green growth. Innovation has always played a critical role, worldwide, in the transition process of economies, and has historically been directed to saving labour costs by increasing labour productivity. The increasing global competition for natural resources has seen the focus of innovation be redirected to increasing resource and energy productivity, i.e. emphasising resource and energy savings (Aiginger, 2016). These technological innovations are regularly described as green or eco-innovation.

Several studies have shown that 'environmental policies can stimulate innovation and investment in innovation' (Rayment et al., 2009). Detailed analysis undertaken by the Organisation for Economic Co-operation and Development (OECD) confirms this for environmental taxation schemes: they can provide the necessary incentives for introducing innovation and make them economically viable (OECD, 2010). Past trends reveal increased patenting activities at times of increased environmental policy activities. This was particularly visible after the adoption of the Kyoto Protocol in 1997, at which time there was a substantial increase in the patenting of renewable energy technologies (Johnstone et al., 2010 ([10]), and Figure 6.5 in EEA, 2014).

Eco-innovation contributes to the transition process towards a resource-efficient, green and competitive low-carbon economy primarily through improving resource and energy efficiency (EEA, 2014) ([11]). However, the transition trajectory depends on three different modes of innovation ambition:

([9]) According to the Porter hypothesis, strict environmental regulations can induce efficiency and encourage innovations that help to improve commercial competitiveness. The cost savings that can be achieved are sufficient to overcompensate for both the compliance costs directly attributed to new regulations and the innovation costs.

([10]) 'We find that public policy plays a significant role in determining patent applications...Broad-based policies, such as tradable energy certificates, are more likely to induce innovation on technologies that are close to competitive with fossil fuels. More targeted subsidies, such as feed-in tariffs, are needed to induce innovation on more costly energy technologies, such as solar power' (Johnstone et al., 2010).

([11]) Apart from technical innovation as discussed here, social and organisational innovation are also required for the transition process.

(1) incremental, (2) disruptive and (3) radical innovation (OECD, 2011). These three types of innovation ambition exhibit different characteristics and although there is a need for all three, policy programmes and instruments are available for only the first two (Smith, 2009).

Incremental innovations are dominant and an example is the introduction of carbon pricing schemes; they are perceived to be crucial for the transition towards a low-carbon economy (EEA, 2016). Radical or systemic innovation involves 'a full-scale shift in the technological regime of an economy, and can lead to fundamental changes in the economy's enabling technologies' (OECD, 2011) and is, therefore, associated with long-term risks regarding overall economic development. Policy programmes that seek such regime-shifting innovation do not currently exist (Smith, 2009) ([12]).

Eco-innovation brings substantial environmental improvements. The benefits of eco-innovation are, nevertheless, not restricted to environmental improvements ([13]). Eco-innovation can spur economic development and employment creation as new industries and markets are established, and can also often create export opportunities. Recent data reveal a robust increase in the value added and the creation of new jobs in the renewable energy sector ([14]) (see AIRS_PO2.12, 2016 for further information).

Analysis of the economic performance of the global environmental industry shows changes in the shares in world trade in recent years. For example, EU-15 ([15]) trade as a proportion of world trade decreased from 50 % in 2002 to 42 % in 2013 ([16]). A reduction has also been reported for the USA, Canada and Japan. These reductions have been counterbalanced by a substantial increase in China's share of world trade, which increased from 5 % in 2002 to 14 % in 2013. Furthermore, the demand for environmental protection goods also shifted from developed industrialised countries to emerging transition countries.

A more detailed analysis of the trade specification of countries revealed the significance of environmental policies in countries in which reductions in feed-in tariffs and less favourable subsidy conditions have led to an overall decline in investments (Gehrke and Schasse, 2015). This in turn highlights the need to have long-term consistency in the policy framework. A study analysing the influence of the policy mix on technological and structural change in renewable power generation technologies in Germany concluded that the expansion targets of renewable energies were 'one of the most important political drivers of innovation activities among manufacturers of renewable power technologies' (Rogge et al., 2015).

The significance of the policy framework for adopting environmental innovation is also apparent at the chemical-sector level, for which existing regulations or taxes are the core motivation (Table 4.1). The results, nevertheless, show some heterogeneity between countries. For example, , innovations were driven by regulation or environmental taxes in 61 % of innovative firms in the Czech Republic, but in only 29 % of innovative firms in the Netherlands. The current or expected demand for environmental goods and services also played an important role in driving innovations, while a relevant, but minor role was played by the availability or grants or subsidies for environmental innovations.

([12]) It may be argued that such radical or systemic innovation is needed for the transition, but its adoption may be difficult because of the sluggishness and apprehension for major changes from the status quo by political decision-makers, industry and civil society.

([13]) For more information on the environmental as well as on the non- environmental improvements of eco-innovation, see the Eco-innovation Action Plan of the European Commission, including the eco-innovation scoreboard at https://ec.europa.eu/environment/ecoap.

([14]) It should not be ignored that the increase in the economic development of the renewable energy sector is often at the expense of the conventional energy sector, i.e. the generation of electricity based on fossil fuels. Some studies that assess the net effect of creating jobs by the switch from fossil-fuel based generation to renewables found that the latter creates 'more job-years per GWH of energy output' (OECD, 2014a). However, closely associated with the question of net job creation is the topic of the skills level of the jobs, as the skills level can be used as a proxy for the salary of the job. A study scrutinising this topic in the USA concluded that investment in the clean energy sector will generate a higher proportion of lower skilled jobs than the traditional fossil-fuel sector (OECD, 2014a).

([15]) The EU-15 Member States are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Ireland, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.

([16]) Data are presented in the report of Gehrke and Schasse (2015), which was commissioned by the German Environmental Protection Agency. The data source is the UN COMTRADE database. See the report Gehrke and Schasse (2015) for a detailed discussion of the terminology and classification of environmental industry and environmental protection goods.

Table 4.1 Motivations driving environmental innovation adoption by firms in the chemical sector

Member State	Existing environmental regulations or taxes on pollution	Availability of government grants, subsidies or other financial incentives for environmental innovation	Current or expected market demand from your customers for environmental innovation
Belgium	53 %	19 %	29 %
Czech Republic	61 %	20 %	N.A.
France	52 %	9 %	35 %
Germany	35 %	8 %	32 %
Italy	47 %	8 %	25 %
Netherlands	29 %	17 %	29 %
Poland	38 %	7 %	21 %

Note: N.A. Not available.

Source: ETC/WMGE (2015a) based on Eurostat, Community Innovation Survey 2006–2008.

Finally, the growth in volume of the world market of environmental technologies is projected to continue. Although the results of projections do have an inherent degree of uncertainty, the overall trend shows a rapid increase in the volume of the global market for environmental technologies and resource efficiency, from EUR 2.5 billion in 2013 to about EUR 5.4 billion in 2025, i.e. an annual average increase of 6.5 % (BMUB, 2014) ([17]) ([18]). Therefore, maintaining the policy focus on facilitating the development of eco-innovation, including long-term consistency in the environmental policy framework, has the potential to not only enable the transition to a resource-efficient, low-carbon, green economy, but also to translate into benefits with regard to jobs and growth, given the current positive outlook of the world market for environmental technologies.

4.3 Green finance ([19])

Reliable access to sufficient funds and adequate finance will be essential for financing the transition to a resource-efficient, green and competitive low-carbon economy. Recent trends confirm that such investments into meeting established environmental objectives lead not only to environmental improvements, but also to socio-economic benefits (see Figure 4.1).

The estimated investments needed to meet today's systemic environmental challenges are immense at the European and global scales for achieving the Sustainable Development Goals (SDGs) agreed in September 2015, and for reducing GHG emissions in line with the global climate change strategy agreed in December 2015.

In the report of the Global Commission on the Economy and Climate (2014), it is estimated that the global investment needs for the world's urban, land use and energy systems will amount to more than USD 90 trillion for the period between 2015 and 2030 ([20]). Additional net costs of about USD 4 trillion are projected to be required for investments into energy efficiency and the deployment of low-carbon technologies, in order to support the transition from a business-as-usual scenario to a low-carbon economy and thereby avoid a lock-in to a high-carbon growth.

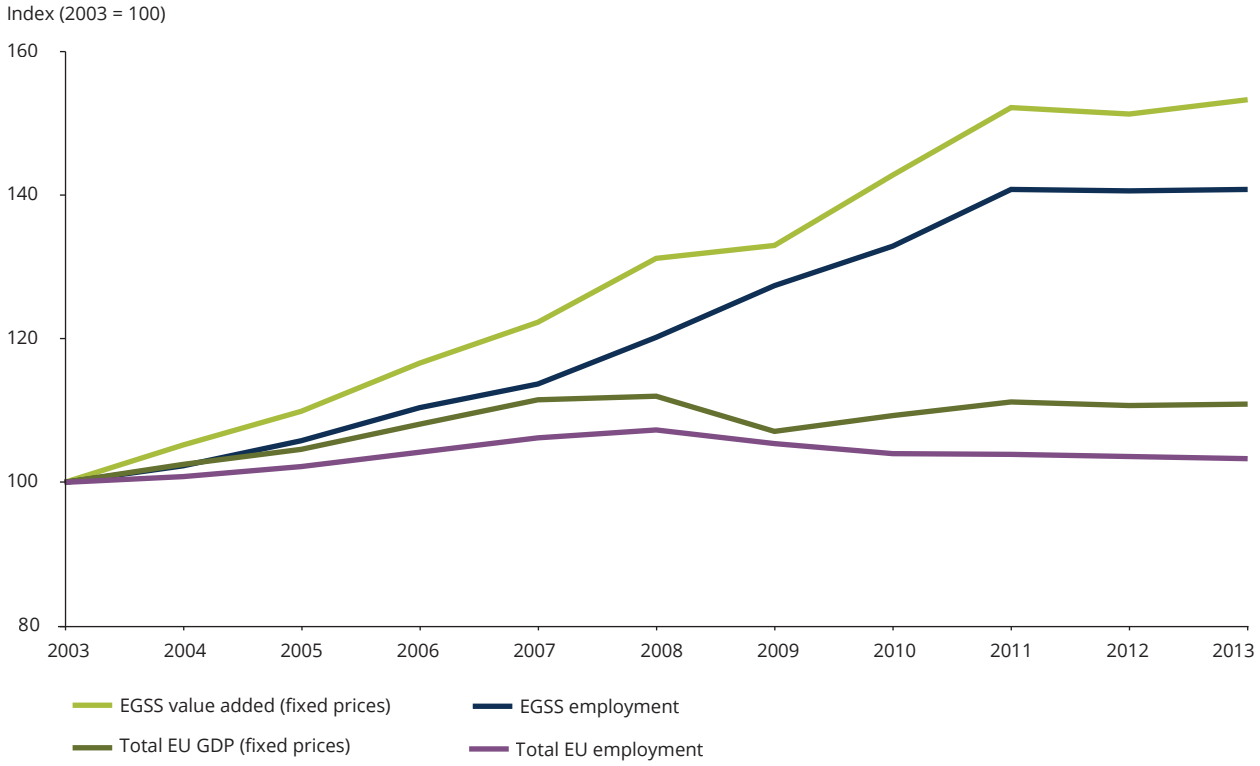
([17]) These data refer to the six lead markets: sustainable mobility; material efficiency; environmentally friendly power generation, storage and distribution; sustainable water management; waste management and recycling; and energy efficiency. The highest projected growth rates are in sustainable mobility (approximately 9 % per annum in the 2013–2025 period) followed by material efficiency (8 % per annum in the same period). The lowest annual projected growth rate is for energy efficiency (4 %), which was by far the leading global market, by revenue, in 2013.

([18]) The study also emphasises the importance of assessing the whole value chain given that environmental technology and resource efficiency are relevant to several industrial sectors. Estimates show that traditional industries, like electrical, mechanical and automotive engineering, and the chemical industry, have a share of about 43 % of the global market for environmental technology and resource efficiency. Therefore, it is essential to assess the economic importance of innovation in industries not only in the 'environmental sector' but also in traditional industries, as they produce and supply many intermediate inputs for the production of 'green tech' products (BMUB, 2014).

([19]) This section builds heavily on the research of Valeria Miceli (SEEDS and Catholic University of Milan), undertaken as part of the 2015 ETC/WMGE work programme (ETC/WMGE, 2015b).

([20]) Different estimates of the investment needs for achieving the SDGs and GHG emission reduction targets can be found in the literature and they vary widely. For example, Schmidt-Traub (2015) stated that 'incremental spending needs in low- and lower-middle-income countries may amount to at least USD 1.4 trillion per year'. All of the estimates of investment needs are based on projections and exhibit uncertainties. Nevertheless, they represent future challenges in terms of mobilising funds for the transition process.

Figure 4.1 Trends in employment and value added in the environmental goods and services sector (EGSS) compared with the average across the economy, in the EU



Source: AIRS_PO2.12, based on Eurostat data.

The important task is now to redirect further available financial resources towards the green economy transition and thereby overcome the risk of lock-in to a high-carbon economy.

There are different channels for directing financial resources to the green economy. Some are public, including specific initiatives undertaken by the EU and its financial institutions, and others are in the private domain, for example pension funds and socially responsible investments (EEA, 2014). Hybrid sources and sovereign wealth funds, and instruments, green bonds, the EU project bond initiative and the EU's initiative on building a Capital Markets Union, will also play a role.

Public funds will not be sufficient and therefore private finance will be needed. The European Fund for Strategic Investment (EFSI) aims to mobilise private investment (through an initial contribution of public funds from the EU and the European Investment Bank (EIB)) and to address market failures, and is one of the three strands of the Investment Plan for Europe, which was adopted in November 2014. An appraisal by the EIB of the performance of EFSI shows that the fund aims to trigger around EUR 100 billion of investment before 2020 in a range of different sectors, including energy, transport and the circular economy in Europe ([21]). These investments into new, and energy- and resource-efficient infrastructures could create jobs and reduce energy and resource consumption.

Investments into physical assets are not sufficient in themselves for fostering sustainable economic development. The shift of investments from tangible to intangible assets ([22]) is also essential in a knowledge-based economy 'which puts the knowledge base of firms in the centre of innovation and competition strategies' (Ebner and Bocek, 2015),

([21]) See http://ec.europa.eu/priorities/jobs-growth-and-investment/investment-plan_en (accessed 4 June 2016). The EIB approved 64 infrastructure and innovation projects for a total sum of EUR 9.3 billion between April 2015 and May 2016, and 29 % of the funds were allocated to projects in the environment sector, 13 % in the transport sector and 9 % to address improvements in environment and resource efficiency (EC, 2016b).

([22]) Tangible assets include both fixed assets, such as machinery, buildings and land, and current assets, such as inventories. Non-physical assets, such as patents, trademarks, copyrights, goodwill and brand recognition, are examples of intangible assets.

and in order to redirect capital flows 'towards critical priorities and away from assets that deplete natural capital' (UNEP, 2015). Indeed, over the last two decades, investments at the EU level into intangible assets have grown faster than investments into tangible assets.

One of the challenges of investment into sustainable infrastructure projects is the fact that such projects typically face higher up-front costs (6 % or more for individual projects (McKinsey & Company, 2016)). Stricter financial regulations at the global level may have additional negative effects on the required investments because the higher up-front capital costs make them more sensitive to the cost and availability of capital. This is because financial institutions are faced with higher capital requirements and leverage ratios under revised regulatory frameworks for banks (Basel III) and insurance companies (Solvency II Directive) ([23]) as the frameworks seek to reduce the risk of insolvency ([24]).

In addition, new business models that are included in the discussion of the promotion of the circular economy will require the adaptation of finance mechanisms. With a changed perspective towards selling services rather than products, the property rights of products are no longer transferred to the consumer (buyer), but, rather, will be kept by the producing company. Businesses will not receive payment at the beginning of the products' lifecycles, but during their period of use. The timing of cash flows will therefore be pivotal for the success of new business models in the circular economy (ING, 2015).

Debt is currently the primary financing source for circular economy investments. In addition, green bonds are emerging as an attractive, new, innovative model for accelerating the transition to the green economy (EEA, 2014). The green bond market includes private-public initiatives as well as the issuing of green bonds by private banks and companies.

The development of the issuance of green bonds has been a success story: between 2007 and 2012, the issuing of green bonds amounted to USD 8.5 billion (ETC/WMGE, 2015b), and in 2013, the total exceeded this accumulated figure and amounted to USD 11.5 billion; in 2014, there was a quantum leap to a total of USD 37 billion, while in 2015, USD 42 billion worth of green bonds were issued ([25]). Although the green bond market still represents only a small fraction of the overall bond market (EEA, 2014, and ETC/WMGE, 2015b), the mechanism is well suited to new business models and sustainable infrastructure projects that require substantial upfront investment and subsequently produce regular returns. Moreover, studies indicate that sustainable investment already generate the same financial performances as traditional investments (Friede et al., 2015).

One of the overarching challenges of financing long-term projects such as the green economy transition is the scarcity of 'patient' capital ([26]). Large parts of the investor community operate with a short-term perspective, so the initial phase of financing the green economy transition may well have to rely on government support, although the United Nations Environment Programme (UNEP) estimated that private capital sources are expected to cover up to 80 % of the amount required for the transition to a low-carbon economy (UNEP, 2013).

It should also be emphasised that time horizons differ for different types of institutional investors. Typically, pension funds and insurance companies are characterised by the longest horizons, mutual funds and private equity have medium- to long-term horizons, while hedge funds often have the shortest time horizons. Most institutional investors are characterised by medium- to long-term horizons, which is a critical dimension of a sustainable financial system ([27]).

At the same time, technological factors and incentive-driven short-termism characterise many financial markets. For Mark Carney, the Governor of the Bank of England, this is a 'tragedy of horizons', whereby new challenges to long-term prosperity, such as climate change, manifest themselves beyond the standard regulatory and market horizons and so need new financial approaches to solve them (Carney, 2015).

It is increasingly apparent that a key issue with respect to green finance in the context of enabling the transition to a green economy is the time delay between costs and benefits of environmental policy (EEA, 2014). Generally, the costs are being incurred

([23]) See for more information: Basel III at http://www.bis.org/bcbs/basel3.htm and Solvency II Directive at http://ec.europa.eu/finance/insurance/solvency/solvency2/index_en.htm.
([24]) Long-term investments in infrastructure are treated in a similar way to long-term corporate debts in these regulatory frameworks.
([25]) Data published by Climate Bonds Initiative (2015) and online at https://www.climatebonds.net/2016/01/2015-year-end-review-tall-trees-many-green-shoots-evolution-green-bond-market-continues-2015 (accessed 3 March 2016).
([26]) 'Patient capital' is an alternative term for long-term capital, and gained momentum with the increased interest in environmentally and social responsible enterprises (EEA, 2014).
([27]) See also the report 'Proposals for a Roadmap towards a Sustainable Financial System in Switzerland' (FOEN, 2016) suggesting measures for making the Swiss financial system more sustainable so that the financial system supports the transition to a green and inclusive economy.

in the short term while the benefits typically become apparent in the longer term. In addition, the preference of many financial investors is for short-term returns on their investments, while the new business models and sustainable infrastructure projects require substantial up-front costs in order to deliver regular benefits thereafter. A better understanding of these time horizon discrepancies and new financial approaches that could solve these may be necessary in order to unleash the necessary funds for financing the transition to a green economy.

This could, in addition, contribute to making the financial system itself more sustainable by directing funds in a more sustainable direction for the system itself. For example, Carney (2015) warned that investors may face 'huge' climate change losses as a carbon budget consistent with the '2 °C target' (i.e. the target of keeping the rise in global temperature to below 2 °C) would render the vast majority of reserves 'stranded' — oil, gas and coal that will be literally 'un-burnable' without expensive carbon capture technology, which itself alters fossil fuel economics (see also Carbon Tracker and the Grantham Research Institute on Climate Change, 2013, and HSBC, 2015). In addition, it must be stated that the non-financial sector carries carbon risks, too. Studies indicate that enhanced disclosure of the carbon intensity of non-financial firms helps to gradually redirect financial resources toward the transition to a low-carbon economy so as to keep transition costs manageable and reduce systemic risks (see ESRB, 2016). A disorderly transition to a low-carbon economy could therefore potentially destabilise markets and represent a financial stability risk.

4.4 Conclusion

The two previous sections demonstrated that environmental policy can trigger eco-innovation and green finance, two key enabling factors in supporting the delivery of environmental goals and the transition to a green economy. In addition, eco-innovation and green finance can contribute significantly to economic development and job creation, and therefore also to the EU priorities of putting the region back on the path of economic recovery and creating new jobs.

For eco-innovation and green finance to deliver their full potential, a stable and ambitious environmental policy frame is essential in order to give the right signals and the required long-term certainty for the relevant actors (innovative firms, investors) to act upon. Policy frameworks in support of these enabling factors would also be necessary to further facilitate their development and alleviate key obstacles that may hinder their expansion.

Table 4.2 provides a composite snapshot of country performance, drawing on established data sets with regard to key environmental and economic dimensions. The dimensions are independent from each other and there is no causality between the country rankings of the different dimensions (see also EEA, 2014).

The table shows, nevertheless, that countries can be highly competitive in the international business community, as well as being highly ranked with regard to eco-innovation and the stringency of their environmental policies, including environmental taxes and other MBIs.

This is in-line with the conclusions drawn by the OECD with respect to its environmental policy stringency indicator, namely that 'stringent environmental policies can be introduced without hurting overall productivity', 'there may be winners and losers, but any effects have tended to fade away quickly' and 'sending a strong signal to the market through stringent policies that do not create unnecessary barriers to entry and competition will allow new, cleaner technologies and business models to develop' (OECD, 2014b).

To conclude, the required short-term adjustments to the economy due to the introduction of an environmental policy measure should be considered within the context of not only the environmental benefits of the measure but also the wider economic and social benefits associated with the implementation of the measure.

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Table 4.2 Competitiveness and stringency of environmental policies and eco-innovation, by country

Country	Global Competitiveness Index (2015/2016) ([a])	Stringency of environmental policies (2012) ([b])	Eco-innovation scoreboard (2013) — EU-wide ranking
Switzerland	1	5	N.A.
Germany	4	10	3
Netherlands	5	2	13
Finland	8	3	1
Sweden	9	9	1
United Kingdom	10	4	5
Norway	11	6	N.A.
Denmark	12	1	4
Belgium	19	20	10
Luxembourg	20	N.A.	7
France	22	7	8
Austria	23	13	9
Ireland	24	26	11
Estonia	30	N.A.	16
Czech Republic	31	21	17
Spain	33	23	6
Lithuania	36	N.A.	20
Portugal	38	25	14
Poland	41	11	27
Italy	43	15	11
Latvia	44	N.A.	24
Malta	48	N.A.	18
Turkey	51	27	N.A.
Romania	53	N.A.	21
Bulgaria	54	N.A.	28
Slovenia	59	22	15
Hungary	63	18	22
Cyprus	65	N.A.	26
Slovakia	67	12	25
Croatia	77	N.A.	23
Greece	81	24	19

Note: The countries are listed in accordance with the World Economic Forum (WEF) ranking.

([a]) global ranking (out of 140 countries) — WEF.

([b]) ranking out of 27 OECD countries.

N.A. Not available.

Source: World Economic Forum (WEF) (http://reports.weforum.org/global-competitiveness-report-2015–2016/);
OECD — Environmental Policy Stringency (EPS) Index (https://stats.oecd.org/Index.aspx?DataSetCode=EPS ([28]));
Eco-Innovation Observatory (http://www.eco-innovation.eu ([29]).

([28]) The OECD EPS Index reflects the degree to which environmental policies put an explicit or implicit price on polluting or environmentally harmful behaviour. The index ranges from 0 (not stringent) to 6 (highest degree of stringency). The index is based on the degree of stringency of 14 environmental policy instruments, primarily related to climate and air pollution.

([29]) The Eco-Innovation Scoreboard was the first tool to comprehensively assess and compare eco-innovation performance across the EU Member States. The Eco-Innovation Scoreboard is an index based on indicators in five areas: eco-innovation inputs, eco-innovation activities, eco-innovation outputs, resource-efficiency outcomes and socio-economic outcomes.

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Annex 1 Scoreboard indicators: sources, time periods and expected updates

Indicator in scoreboard	Indicator source [a]	Time period	Update frequency	Expected update with data from more recent years
7th EAP priority objective 1				
Exposure of terrestrial ecosystems to eutrophication due to air pollution	EEA indicator CSI 005	2000–2020	Not known	Not known
Gross nutrient balance in agricultural land: nitrogen	Eurostat t2020_rn310	2000–2013	Annually	2017 to include 2014 data
Land take	EEA indicator CSI 014/LSI 001	2000–2012	Every 6 years	2021 to include 2012–2018 data
Forest: growing stock, increment and fellings	UNECE report [b] and EEA indicator SEBI 017	1990–2010	Every 4–5 years	2018 to include 2015 data
Status of marine fish stocks	EEA indicator CSI 032	Status 2008–2012, trend 2003–2012	Annually	2017 to include 2013 data
Abundance and distribution of selected species (common birds and grassland butterflies)	EEA indicator CSI 050/SEBI 001	1990–2013	Annually	2017 to include 2014–2015 data
Species of European interest	EEA indicator CSI 007/SEBI 003	2007–2012	Every 6 years	2020 to include 2013–2018 data
Habitats of European interest	EEA indicator SEBI 005	2007–2012	Every 6 years	2020 to include 2013–2018 data
Status of surface waters	EEA report [c]	By 2009	Every 6 years	2017 to include 2010–2015 data
7th EAP priority objective 2				
Resource productivity	Eurostat data set tsdpc100	2000–2015	Annually	2017 to include 2016 data
Waste generation in Europe	EEA indicator CSI 041	2004–2012	Every 2 years	2017 to include 2014 data
Recycling of municipal waste	EEA indicator WST 005	2004–2014	Every 2 years	2018 to include 2016 data
Use of freshwater resources	EEA indicator CSI 018	2002–2014	Annually	2017 to include 2015 data
Total greenhouse gas emission trends and projections	EEA report [d] and EEA indicator CSI 010	1990–2015 Data for 2015 are approximated estimates	Annually	2017 to include 2015 data and 2016 estimates
Share of renewable energy in gross final energy consumption	EEA indicator ENER 028	2005–2015 Data for 2015 are approximated estimates	Annually	2017 to include 2015 data and 2016 estimates
Progress on energy efficiency in Europe	EEA indicator ENER 026	2005–2015 Data for 2015 are approximated estimates	Annually	2017 to include 2015 data and 2016 estimates

Indicator in scoreboard	Indicator source ([a])	Time period	Update frequency	Expected update with data from more recent years
Energy consumption by households	Odyssee ([e])	2005–2014	Annually	2017 to include 2015 data
Greenhouse gas emissions from transport	EEA indicator TERM 002	1990–2014	Annually	2017 to include 2015 data
Consumption of meat, dairy, fish and seafood	EEA indicator SCP 020	1995–2011	Every 2–3 years	2018/2019 to include 2015/2016 data
Share of environmental and labour taxes in total tax revenues	Eurostat data set tsdgo410 and DG ECFIN ([f])	2003–2014	Annually	2017 to include 2015 data
Employment and value added in the environmental goods and services sector	Eurostat data set env_egs	2000–2013	Annually	2017 to include 2014 data
Environmental protection expenditure in Europe	Eurostat data set env_ac_exp2	2003–2013	Annually	2017 to include 2014 data
7th EAP priority objective 3				
Exceedance of air quality limit values in urban areas (nitrogen dioxide: NO_2; coarse dust particles: PM_{10}; ozone: O_3; fine particulate matter: $PM_{2.5}$)	EEA indicator CSI 004	2000–2014	Annually	2017 to include 2015 data
Emissions of the main air pollutants in Europe (sulphur oxides: SO_2; nitrogen oxides: NO_x; ammonia: NH_3; non-methane volatile organic compounds: NMVOCs; fine particulate matter: $PM_{2.5}$)	EEA indicator CSI 040	2005–2014	Annually	2017 to include 2015 data
Bathing water quality	EEA report ([g])	2011–2015	Annually	2017 to include 2016 data
Number of countries that have adopted a climate change adaptation strategy and/or plan	Climate-adapt ([h])	2005–2015	Annually	2017 to include 2016 data
Exposure to environmental noise	EEA indicator CSI 051 — forthcoming	2007–2012	Annually but without data for more recent years	2018 to include 2017 data
Production of chemicals, by hazard class	Eurostat data set env_chmhaz	2005–2014	Annually	2017 to include 2015 data
Total sales of pesticides	Eurostat data set aei_fm_salpest09	2011–2014	Annually	2017 to include 2015 data

Notes: ([a]) All EEA indicators and Eurostat data sets are accessible through the EEA www.eea.europa and Eurostat www.ec.europa.eu/Eurostat websites respectively.

([b]) UNECE report ECE/TIM/SP/37, Forests in the UNECE region.

([c]) EEA Report No 8/2012, *European waters — assessment of status and pressures*.

([d]) EEA Report No 29/2016, *Trends and projections in Europe 2016*.

([e]) http://www.indicators.odyssee-mure.eu/online-indicators.html.

([f]) https://ec.europa.eu/taxation_customs/business/economic-analysis-taxation/data-taxation_en.

([g]) EEA Report No 9/2016, *European bathing water quality in 2015*.

([h]) http://climate-adapt.eea.europa.eu/countries-regions/countries.

European Environment Agency

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In support to the monitoring of the 7th Environment Action Programme**

2016 — 55 pp. — 21 x 29.7 cm

ISBN 978-92-9213-832-5
doi:10.2800/76896

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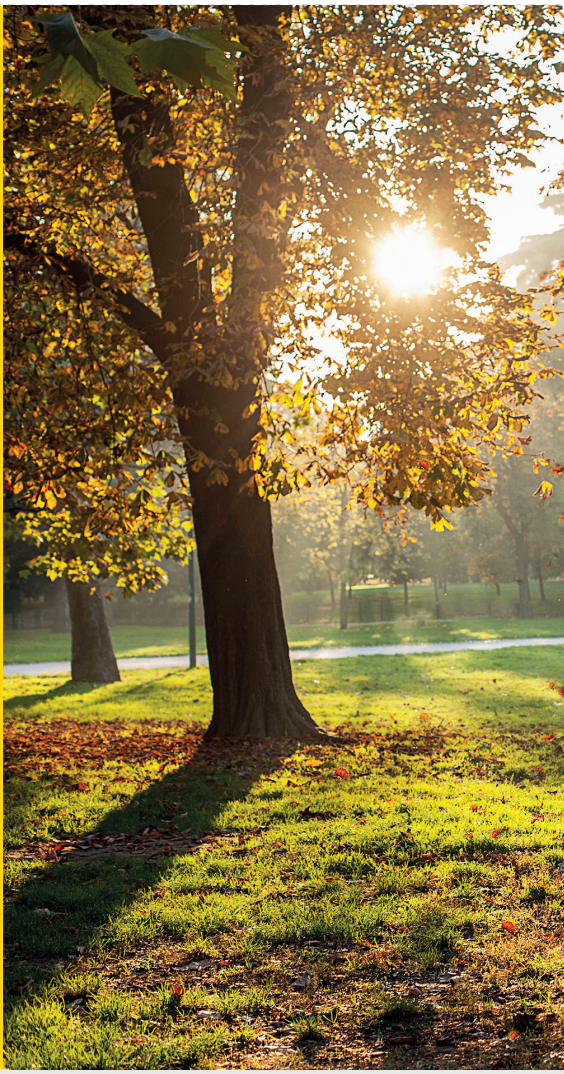

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