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GLOBAL ENVIRONMENT OUTLOOK

GEO-6

ASSESSMENT FOR THE

PAN-EUROPEAN

REGION

(rev. 1)

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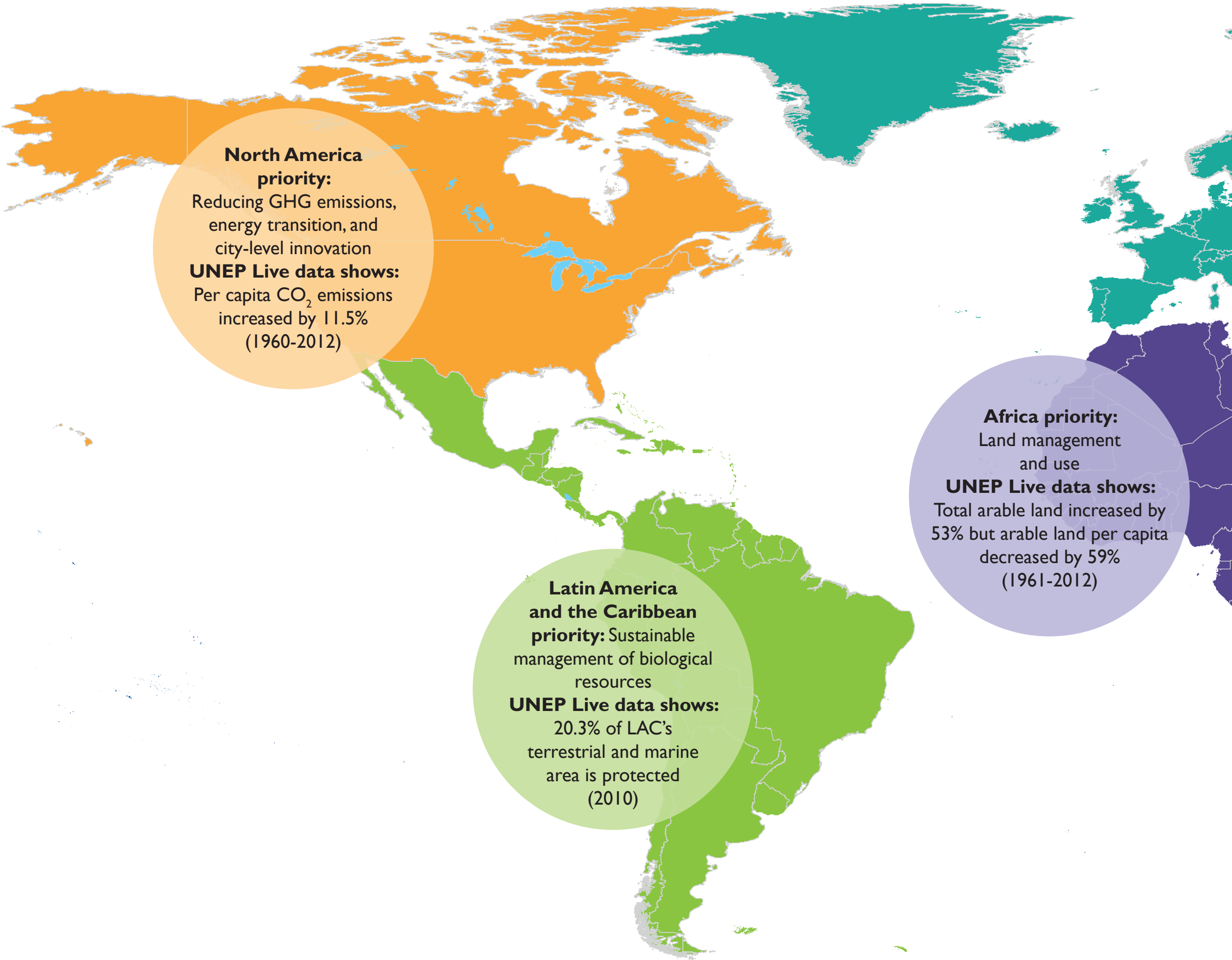
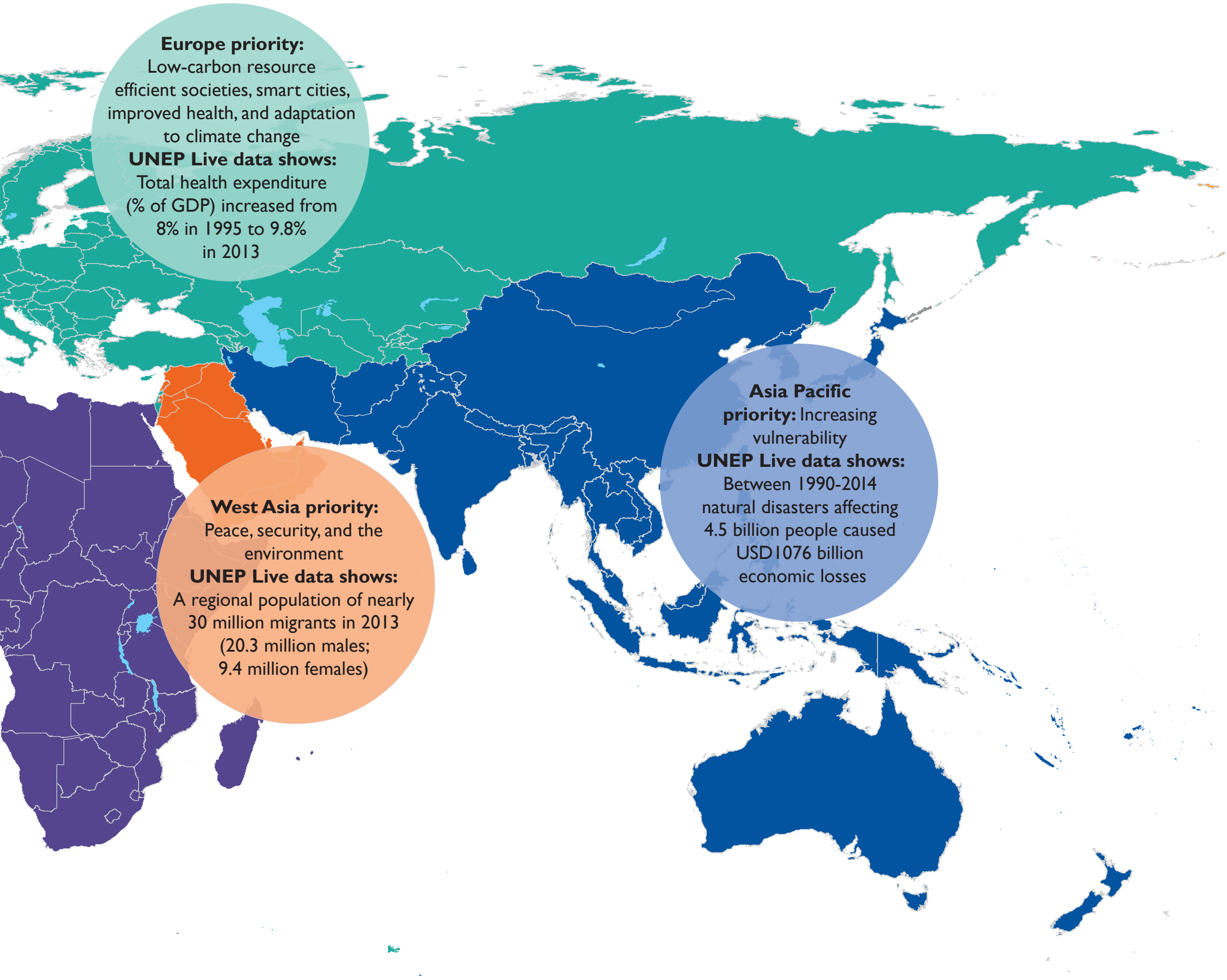

North America priority:
Reducing GHG emissions, energy transition, and city-level innovation
UNEP Live data shows:
Per capita CO_2 emissions increased by 11.5% (1960-2012)
Latin America and the Caribbean priority: Sustainable management of biological resources
UNEP Live data shows:
20.3% of LAC's terrestrial and marine area is protected (2010)
Africa priority:
Land management and use
UNEP Live data shows:
Total arable land increased by 53% but arable land per capita decreased by 59% (1961-2012)


Europe priority:
Low-carbon resource efficient societies, smart cities, improved health, and adaptation to climate change
UNEP Live data shows:
Total health expenditure (% of GDP) increased from 8% in 1995 to 9.8% in 2013
West Asia priority:
Peace, security, and the environment
UNEP Live data shows:
A regional population of nearly 30 million migrants in 2013 (20.3 million males; 9.4 million females)
Asia Pacific priority: Increasing vulnerability
UNEP Live data shows:
Between 1990-2014 natural disasters affecting 4.5 billion people caused USD1076 billion economic losses

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Foreword UNEP Executive Director

The sixth *Global Environment Outlook (GEO-6) Assessment for the pan-European region* paints a comprehensive picture of the environmental factors contributing to human health and well-being at the regional level. Backed by a large body of recent, credible scientific evidence, region-wide consultations and a robust intergovernmental process, the assessment demonstrates that regional and global multilateral environmental agreements have improved environmental conditions in the pan-European region. It also highlights the complexity of the interlinked environmental, social and economic challenges now confronting decision makers.

The launch of the *GEO-6 Assessment for the pan-European region* comes at a critical time. The world is on a new course to combat climate change and unleash actions and investment towards a low carbon, resource-efficient, resilient and sustainable future. At the same time, the 2030 Agenda for Sustainable Development provides a clear pathway to a world in which everyone can enjoy prosperity within the ecological limits of the planet.

Clean air, water, resilient ecosystems and sound management of chemicals and waste are essential for a healthy planet and healthy people. Closing resource-use loops through the promotion of circular economy principles will be a necessary part of the solution, providing much-needed jobs and economic sustainability.

The transition towards an inclusive green economy in the pan-European region presents a significant opportunity, which will require the active engagement of a "coalition of the willing" at all levels of society. It demands a fundamental redesign of energy, food, mobility and urban systems, as well as a change in lifestyles. Countries in the region have much to contribute to the shaping of a shared vision of the future.

I would like to extend my gratitude to the large body of policymakers, leading scientists and representatives from major stakeholder groups and partners who contributed to this comprehensive and illustrative assessment report. I extend an invitation to all countries in the region to engage with this report and use the opportunity provided to transform the vision of the 2030 Agenda for Sustainable Development and its Sustainable Development Goals into a reality for the pan-European region.

Achim Steiner

United Nations Under-Secretary-General and
Executive Director, United Nations Environment Programme

Foreword UNECE Executive Secretary

The sixth *Global Environment Outlook (GEO-6) Assessment for the pan-European region* is of great scientific and political importance, as it highlights the state and trends of the environment and enhances the science-policy dialogue underpinning the policy and decision-making processes in the region.

In 2011, environment ministers gathered at the Seventh Environment for Europe Ministerial Conference in Astana recognized the many challenges to keeping the pan-European environment under review. Obstacles included the lack of reliable, relevant, easily accessible, comparable and up-to-date data and information, and insufficient cooperation and exchange of information among stakeholders. For this reason environment ministers committed to establishing a regular process of environmental assessment for the entire pan-European region based on a Shared Environmental Information System — an approach to link all existing data and information flows relevant at the country and international levels in support of a regular environmental assessment process.

The *GEO-6 Assessment for the pan-European region* will be launched at the Eighth Environment for Europe (EfE) Ministerial Conference in Batumi, Georgia, in June 2016. It demonstrates the effective follow-up to decisions taken by States participating in the EfE process and supported by the Economic Commission for Europe (ECE) and the United Nations Environment Programme (UNEP) secretariats. The ECE Committee on Environmental Policy has decided that in the future the ECE Working Group on Environmental Monitoring and Assessment would serve as the regional environmental information and assessment network of networks, working with the UNEP GEO experts and the European Environment Agency's (EEA) European Environment Information and Observation Network to formulate the regional priorities and scope for the pan-European assessments.

The pan-European Shared Environmental Information System is already in place and is starting to organize, regularize and coordinate the regional environmental knowledge base. This process is essential for measuring progress towards the achievement of the 2030 Agenda for Sustainable Development and its Sustainable Development Goals.

I am pleased we have worked on this assessment in collaboration with UNEP and with the assistance of the EEA — as the three organizations have recently agreed a common approach to support national, regional and global reporting on the state of the environment. We are grateful to all of those involved in this effort to use the data and information available to produce the *GEO-6 Assessment for the pan-European region*.

Christian Friis Bach

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Key Findings and Policy Messages

Overall picture

The *GEO-6 Assessment for the pan-European region* argues for more urgent action, both through existing policies and the implementation of the 2030 Agenda for Sustainable Development (2030 Agenda), to address the challenges that the region is facing.

Regional and global multilateral environmental agreements have improved regional environmental conditions, access to information and public participation. Further improvements are feasible through better implementation and improved access to justice.

The region's resource footprint is unsustainable, owing to its overuse of natural resources and its trading patterns with other regions. Ecological, societal and economic resilience will be negatively affected in coming decades by global megatrends that are largely outside the region's direct control and influence.

Environmental challenges are now more systemic, multifaceted, complex, uncertain and intertwined with socioeconomic factors. Globally, limits have been crossed for four out of nine planetary boundaries due to human-induced changes: climate change, biosphere integrity, land-system change, and biogeochemical flows (nitrogen and phosphorus). Poor air quality, climate change, unhealthy lifestyles and the disconnection between society and natural environments increasingly affect human health in the region and give rise to new risks.

Resilient ecosystems, efficient resource use, clean air, sufficient clean water, sustainable management of chemicals and waste and sustainable cities are essential for a healthy planet and healthy people. However, neither environmental policies alone nor economic and technology-driven efficiency gains will be sufficient to achieve sustainability. More ambition is needed. The 2030 Agenda and its Sustainable Development Goals recognize this reality.

Living within planetary boundaries will require fundamental transitions in energy, food, mobility and urban systems and entail profound changes in predominant institutions, practices, technologies, policies and lifestyles. New governance coalitions involving national and subnational levels of government, businesses and citizens are urgently needed.

The transition to a truly inclusive green economy must be built on resilient ecosystems, clean production systems, healthy consumption choices, reduced negative distributional effects of environmental policies and improved overall environmental justice for all.

Positive long-term outlooks call for an urgent shift from incremental to transformational change in order to: decarbonize energy and transport systems and reduce other harmful emissions; restore ecosystems; decouple resource use, including material footprints, from overall economic performance; "green" public and private sector procurement; strengthen environmental responsibility in business; and incentivize lifestyle changes.

Key findings

Climate change is one of the largest threats to human and ecosystem health and to achieving sustainable development. It is also an accelerator for most other environmental risks. Growing impacts include melting ice, sea level rise, increasing flood and drought frequency, degrading ecosystems, loss of biodiversity, soil function and food productivity, changing disease vectors and exacerbated air pollution impacts on health.

Greenhouse gas emissions in the European Union are stable or declining, but in the South Eastern European subregion they are increasing. Largely through efficiency gains, emissions have decreased in the majority of sectors except for transport, refrigeration and air conditioning. Further mitigation actions should be targeted at transport, agriculture, energy and raw materials, as part of the transition to a circular economy.

To stay within range of 2ºC–1.5ºC temperature increases and already foreseen impacts, strengthened government action at the national and subnational levels, as well as multistakeholder coalitions, are needed on mitigation and adaptation, including accounting for emission footprints. Adaptation priorities include: improved water management, notably with regard to coastal floods; growing crops suited for increased temperatures; and building green infrastructure to enhance resilience to extreme weather, particularly in urban areas.

Air quality is the largest health risk to the pan-European population, with disproportionate effects on children, the elderly and the poor. Over 500,000 premature deaths in the region were attributable to ambient air quality and 100,000 to indoor air quality in 2012. More than 95 per cent of the urban population are exposed to pollution above the World Health Organization guidelines. Excessive deposition of nitrogen continues to damage ecosystems. Lifestyles, consumption and transport patterns have the most influence on air quality in the region.

Many parts of the region have seen improvements in air quality over recent decades thanks to effective regulations that reduced pollutant emissions. Many of the sectors that impact on air quality also contribute to greenhouse gas emissions. Particulate matter and ozone are the most important pollutants contributing to adverse outdoor air quality.

The bodies under the Convention on Long-range Transboundary Air Pollution and its protocols have been successful in connecting scientific evidence with policy actions. The available evidence supports further policy actions on integrated air quality and climate policies. Policies should also prioritize lifestyle changes and efficiency measures, reductions in emissions at their source and emerging risks, such as ozone and newly identified health effects. Research efforts are required to bridge the considerable knowledge gap on indoor air pollution.

Biodiversity loss and ecosystem degradation continue apace, despite increased conservation and restoration efforts. The main regional pressures are from increased landuse change, particularly agricultural intensification, urbanization and habitat fragmentation by transport infrastructure. In Western and Central Europe, only 38.4 per cent of the original species abundance remains, while 77 per cent remains in the Russian Federation.

Full implementation of the European Union Natura 2000 network, in conjunction with the Emerald Network and the Pan-European Ecological Network, is needed. Together with increased synergies with other existing environmental policy instruments, this would alleviate pressures by providing protection for a broad range of terrestrial and aquatic ecosystems, habitats, species and landscapes of pan-European importance.

Integrating biodiversity and ecosystem considerations into all aspects of spatial planning would further enhance protection efforts, as would new regulations for land and soil protection. Ecosystem-based management approaches offer a cost-effective means to alleviate the multiple pressures on biodiversity, especially from food and forestry production, consumption and tourism.

Chemical pollution impacts on human health and ecosystems across the region, with hazardous chemicals of particular concern owing to their toxicity, shortcomings in their management and a lack of transboundary controls. Other priority concerns include endocrine disruptors in consumer products, hazardous substances in electronic and electrical products, environmentally persistent pharmaceuticals and nanomaterials.

Mercury pollution in the region is still significant, and new emerging issues such as some toxic chemicals in consumer products pose challenges yet to be tackled. Heavy metals and persistent organic pollutant concentrations in air, sediment and soil have on average been reduced across the region, though hotspots remain. Parts of Eastern Europe, the Caucasus and Central Asia have legacy stockpiles of obsolete pesticides, as well as a continued reliance on heavy and highly resource-intensive industries and chemical-intensive agriculture.

Full and coherent implementation of the three global conventions on chemicals would improve management controls and reduce risks for human health and ecosystems. The Globally Harmonized System of Classification and Labelling of Chemicals has not yet been fully implemented. The regulations on products pertaining to chemicals must be improved. More policy attention is needed to early signals from science.

Waste volumes continue to grow. Disposal of waste in landfills is the major environmental challenge in several parts of the region, despite progress with recycling in many countries. Handling of waste from electrical and electronic equipment is a growing concern, with control of transboundary movements insufficient under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.

Reducing food waste in the region is a key challenge. About a third of European farmland is currently used to grow food that is thrown away. Food waste mainly occurs at the distribution and consumption stages in Western and Central Europe, whereas production processes generate most losses in other parts of the region. Plastics waste management is a major challenge given limited recycling options, lack of sustainable substitutes and growing concerns about marine litter.

The waste hierarchy is widely accepted as a guiding framework to increase economic value from resource use and to reduce waste. Closing resource-use loops through the promotion of circular economy principles offers further pathways to minimize waste and maximize resource use.

Freshwater pollution — mainly from agriculture — to surface waters and groundwaters is the main reason for poor water quality, also affecting coastal areas and regional seas. Between urban and rural communities there are large differences in the levels of access to sanitation and safe drinking water. There are also large differences within the region regarding the collection and treatment of wastewater.

Irrigation, over-abstraction and highly polluted return flows threaten groundwater supplies, most notably in Central Asia. The chemical status of water is generally improving in the European Union, but progress is slow for diffuse pollution. Microplastics and emerging contaminants — such as brominated flame retardants, certain veterinary and human pharmaceuticals and anti-fouling biocides — have made their way into all the pan-European seas, via rivers. In several transboundary river basins, water allocation challenges are increasing.

The ECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes and the European Union Water Framework Directive are the most important instruments, alongside bilateral and multilateral conventions on transboundary river, lake and groundwater basins, such as the Danube. Improved coordination between energy, agriculture, biodiversity and water policies can further improve water quality and quantity, as well as support climate change adaptation objectives and increase ecosystem resilience.

Coastal, marine and ocean resources are overexploited for multiple reasons and with wide-ranging impacts. The major threats are urbanization, agriculture, fisheries, transport, industrial development, chemical products and effluents, and energy production. Efforts to reduce pollution loads are overwhelmed by more systemic challenges, such as climate change.

Biodiversity loss and habitat degradation of marine ecosystems continues, heightening the risks of the irreversible loss of ecosystems' resilience and services. Nutrients loads also remain high. The impacts of new pollutants, including plastic wastes and marine litter, are growing. Climate change impacts are increasing and include acidification, sea level rise and shifting species vectors caused by warming waters.

Due to the multitude of socioeconomic-ecological links, threats and negative impacts, there is a need for a more integrative approach to national, supranational, interregional and global policy responses and transnational cooperation. Ecosystem-based management approaches offer promising, cost-effective ways to deal with the cumulative negative effects of human activities.

Land-use change is leading to the deterioration of the physical and chemical properties of soils, thereby causing water and air pollution. Soils are also under threat from climate change, erosion, contamination, salinization, floods and landslides, which in turn threaten food and nutrition security. Urban sprawl causes the loss of arable land, natural habitats and biodiversity.

The loss of green areas in cities has exacerbated climate change effects and caused deterioration in the physical and mental health and cognitive development of children. The externalization of pan-European land demands means that for every hectare of land used in the region, four are used elsewhere to meet the final demand in the region's economies.

Legislation in this area is considered inadequate throughout the pan-European region. Sustainable land management policies are needed to deal with multiple threats and impacts. Promoting practices such as organic farming, agroecology and integrated soil fertility management would sustain crop production systems. Restoring green areas and installing green roofs and "living walls" would mitigate climate change impacts in cities.

Governance, knowledge and outlooks

The pan-European environmental governance system that has emerged over the past three decades shows important differences between countries, as well as gaps and unexploited opportunities for synergies between policies and priority areas. Enhanced cooperation is essential to address the multiple systemic, transnational and transboundary problems and the global challenges that are expected to impact the region in coming decades.

Further environmental progress can be achieved in the coming years through improved implementation of existing policies. In the longer term, an array of global megatrends coupled with continuing unsustainable systems of production and consumption are expected to exacerbate environmental pressures and impacts.

Global megatrends expected to affect the longer-term environmental outlook include: diverging population and migration trends; increasing urbanization; more global competition for resources; an increasingly multipolar world; and climate change. Some of these trends offer opportunities for new innovations; others increase the risks of resource scarcities and conflicts.

The pan-European outlooks suggest in particular the need to halve material resource use in Western Europe and to stabilize it elsewhere. Other outlooks for the region point to increasing water stress in Southern Europe and Central Asia, a significant loss of biodiversity and ecosystem services across the region, acute climate change impacts on coastal and agriculture systems and further human health impacts from air pollution and exposure to chemicals. Increasing policy coherence across these thematic areas could improve the longer-term outlook overall.

Environmental degradation has also exacerbated social problems and increased social and economic injustices and inequalities. Improvements have been achieved through legal frameworks for public participation in decision-making. These need strengthening urgently, given the rate and scale of current and expected further degradation in coming decades.

Successful models of **environmental governance** should be built upon well-designed policies, their implementation and enforcement, pay close attention to early signals from science and society and ensure adequate oversight capacities and investments in knowledge systems, e.g., data, indicators, policy evaluation and sharing platforms. Greater investments are needed in environmental accounting systems to ensure external costs are addressed, and in foresight processes to identify possible future risks, opportunities and conflicts.

Greater application of the **"precautionary principle"** can reduce risks in a world where thresholds and limits are being breached and where endpoints are increasingly uncertain. Achieving progress under greater uncertainty requires coalitions between government institutions, businesses and civil society, to agree on pathways for tackling different societal risks. Vertical coordination between national and local policy levels will be instrumental in accelerating the transition towards sustainable development models in urban areas.

The **Sustainable Development Goals** should be seen as providing a strategic opportunity for environmental policy to contribute to transformative processes as well as a support mechanism for strengthening adaptive capacities and resilience within societies on all levels, instead of a cost factor and constraint on development and competitiveness. Operationalizing the Sustainable Development Goals will require ambitious quantitative targets and indicators so that progress towards sustainability can be tracked properly to ensure convergence on a shared regional vision and ambition within planetary boundaries.

There is no doubt that achieving a healthy planet and healthy people requires urgent transformation of the current systems of production and consumption that most contribute to environmental degradation and inequalities in human health and well-being.

Introduction

Through this assessment, the authors and the United Nations Environment Programme (UNEP) secretariat are providing an objective evaluation and analysis of the pan-European environment designed to support environmental decision-making at multiple scales. In this assessment, the judgement of experts is applied to existing knowledge to provide scientifically credible answers to policy-relevant questions (UNEP 2015a). These questions include, but are not limited to the following:

- What is happening to the environment in the pan-European region and why?
- What are the consequences for the environment and the human population in the pan-European region?
- What is being done and how effective is it?
- What are the prospects for the environment in the future?
- What actions could be taken to achieve a more sustainable future?

The decision to undertake regional assessments was taken at the Global Intergovernmental and Multi-stakeholder Consultation (IGMS) in Berlin, 21-23 October 2014, where participants of the IGMS expressed the desire that the sixth edition of the Global Environment Outlook (GEO-6) assessment should "build on regional assessments" that would be conducted in similar fashion to the global GEO process (UNEP 2014a). The mandate for the IGMS meeting was provided by Member States attending the first session of the United Nations Environment Assembly (UNEA 1) held in June 2014. In their statement Member States requested:

> *"the Executive Director, within the programme of work and budget, to undertake the preparation of the sixth Global Environment Outlook (GEO-6), supported by UNEP Live, with the scope, objectives and procedures of GEO-6 to be defined by a transparent global intergovernmental and multi-stakeholder consultation informed by document UNEP/EA.1/INF/14, resulting in a scientifically credible, peer-reviewed GEO-6 and its accompanying summary for policy makers, to be endorsed by the United Nations Environment Assembly no later than 2018;"*

In addition, Member States also requested:

> *"the Executive Director to consult with all United Nations Environment Programme regions regarding their priorities to be taken up in the global assessment;"* (UNEP 2014b)

Environment for Europe

The ministers of the environment from the pan-European region at the Seventh "Environment for Europe" (EfE) Ministerial Conference, held in Astana (Kazakhstan) on 21-23 September 2011, committed to establish a regular process of environmental assessment for the pan-European region based on a Shared Environmental Information System (SEIS). The regional knowledge base created through SEIS uses platforms such as *UNEP Live*, which links with other global, sub-regional and national platforms to provide access to environmental data and information that are regularly published by countries.

This regional assessment is based on established political and institutional processes and mechanisms that exist in the region. As such, and following a decision by the United Nations Economic Commission for Europe (UNECE) Committee on Environmental Policy (CEP), the *GEO-6 Assessment for the pan-European region* is being launched at the Eighth Environment for Europe (EfE) Ministerial Conference in Batumi (Georgia) in June 2016. The two main themes for the EfE Ministerial Conference are: greening the economy in the pan-European region; and improving air quality for a better environment and human health.

The international policy agenda after Rio+20

At the 2012 United Nations Conference on Sustainable Development (Rio+20), world leaders approved *The Future We Want*, the Conference's outcome document, which recognized that the green economy in the context of sustainable development and poverty eradication is one of the important tools available for achieving sustainable development. The implementation of green economy policies should contribute to eradicating poverty, as well as to sustained economic growth, enhanced social inclusion, improved human welfare and creating opportunities for employment and decent work for all, while maintaining the healthy functioning of the Earth's ecosystems. *The Future We Want* also called for a wide range of measures including the launching of a process to provide actionable goals, targets and indicators for Sustainable Development, to be implemented by 2030.

The resulting *2030 Agenda for Sustainable Development – Transforming our world: the 2030 Agenda for Sustainable Development* – with its *17 Sustainable Development Goals (SDGs) and 169 targets* – was the outcome of the United Nations Sustainable Development Summit held in New York (USA) on 25-27 September 2015. The United Nations General Assembly subsequently adopted the 2030 Agenda for Sustainable Development at its 70th session. The SDGs are universal and apply to all countries, and thus to every nation in the pan-European region. They are an integrated international policy agenda for the coming years addressing linked environmental, social and economic challenges that humanity is facing.

A parallel and closely related process is the international effort undertaken through the United Nations Framework Convention on Climate Change (UNFCCC) which, following the 21st Conference of the Parties (COP-21) in December 2015, culminated in the *Paris Agreement* in which Parties agreed the urgent need to address the significant gap between the aggregate effect of Parties' mitigation pledges in terms of global annual emissions of greenhouse gases by 2020, and aggregate emission pathways consistent with holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C. The results of this Conference will affect many dimensions of environmental change in the decades ahead, and thus on the global environmental outlook at multiple levels, from planetary to regional and local.

In addition, the *Sendai Framework for Disaster Risk Reduction* 2015-2030 was adopted at the Third United Nations World Conference on Disaster Risk Reduction held in Sendai (Japan) in March 2015. The expected goal and outcome by 2030 is: "The substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries." The pan-European region is exposed to disasters including flooding and droughts exacerbated by climate change and also geophysical hazards, and thus countries in the region will need to align themselves to support the delivery of the goals and targets within the framework.

Regional priorities

The regional priorities for the pan-European region were identified and agreed through the Regional Environmental Information Network (REIN) Conference of 13-17 April 2015 in Istanbul (Turkey). Five regional priorities were agreed: climate change, air quality, biodiversity, chemicals and waste, and freshwater. For the regional assessment to support the scope of the forthcoming global GEO-6 assessment, two additional thematic areas were considered: 'coastal, marine and oceans' and 'land'.

In addition, the relationship between the environment and human health and well-being[1], and the 2030 Agenda for Sustainable Development, were recognized as two important overarching themes for the region.

1 Health will be understood in its holistic meaning, as defined by the World Health Organization: "*health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*" (WHO 1948). Despite coming to age, the definition holds a modern view on health, promoting new notions such as subjective well-being and happiness, supporting alternative options for measuring health (UNDP 2015).

The UNEP pan-European region

Sub-region	Countries
Western and Central Europe	Andorra, Austria*, Belgium*, Bulgaria*, Croatia*, Cyprus*, Czech Republic*, Denmark*, Estonia*, Finland*, France*, Germany*, Greece*, Holy See, Hungary*, Iceland^, Ireland*, Italy*, Latvia*, Liechtenstein, Lithuania*, Luxembourg*, Malta*, Monaco, the Netherlands*, Norway, Poland*, Portugal*, Romania*,San Marino, Slovakia*, Slovenia*, Spain*, Sweden*, Switzerland, the United Kingdom*
South Eastern Europe	Albania^, Bosnia and Herzegovina, the Former Yugoslav Republic of Macedonia^, Montenegro^, Serbia^
	Turkey^
	Israel
Eastern Europe and the Caucasus	Armenia, Azerbaijan, Belarus, Georgia, Republic of Moldova, Ukraine
	Russian Federation
Central Asia	Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan

(*) EU-28 Member States
(^) Candidate countries to the European Union

The above regional priorities and themes have been used to guide this analysis, which also took into account the two main themes for the EfE Ministerial Conference: greening the economy in the pan-European region and improving air quality for a better environment and human health.

Regional diversity

The UNEP pan-European region extends from the Atlantic to the Pacific and from the Mediterranean Sea to the Arctic Ocean, and comprises 54 countries. The region is diverse in terms of cultural, social, economic, environmental and political attributes.

While the pan-European region is home to some of the wealthiest nations of the world and innovative environmental policy initiatives (see Chapter 2), some countries in the region continue to experience poverty and environmental degradation (UNDP 2015). In reality, resource consumption, environmental impacts of economic activity and the policies set in place to address them vary greatly among sub-regions.

The GEO-6 Assessment for the pan-European region

The GEO-6 Assessment for the pan-European region is built on existing national, sub-regional and thematic assessments, including *The European environment - state and outlook 2015* report (EEA 2015a) produced by the European Environment Agency (EEA) in 2015.

The indicator and analysis framework used in the GEO and EEA assessments is the DPSIR model. This is made up of five categories of interaction: (D) changes that exert pressure (P) on the environment, which as a consequence cause changes in the state (S) of the environment, leading to impacts (I) on society and the planet, and societal and political responses (R) (Stanners *et al.* 2007). Further information regarding the analytical framework and the approach to the assessment is provided at the beginning of Chapter 2.

The regional assessment is structured in four main chapters:

- **Chapter 1** provides the regional context and priorities, and analyses the two over-arching themes in the context of the pan-European region.

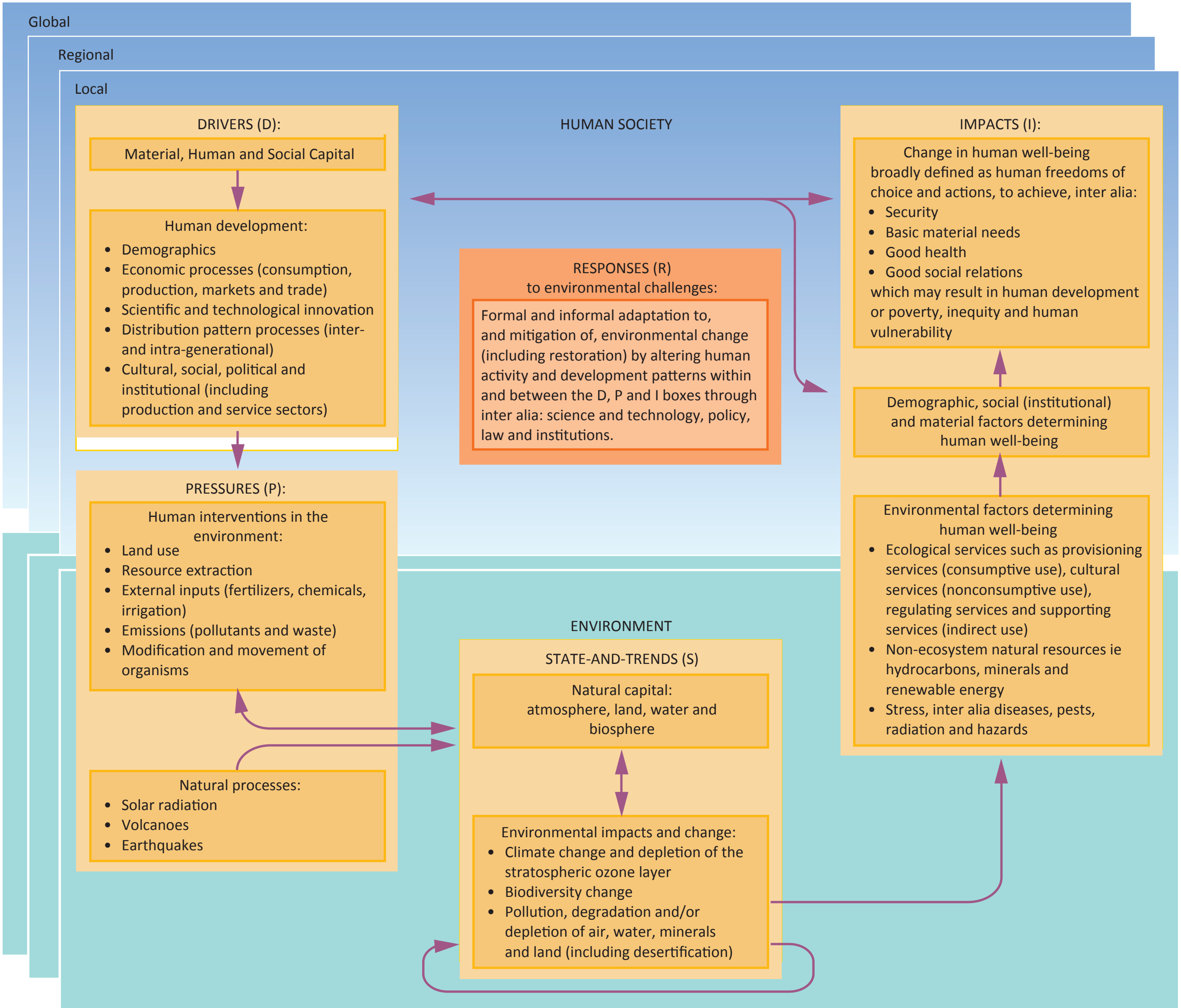
- **Chapter 2** establishes the state of the environment in the region following the five regional priorities and, in addition, the two thematic areas of coastal, marine and oceans, and of land. This chapter also analyses the key trends for each environmental theme and assesses policy responses in the region.

- **Chapter 3** presents opportunities and options to strengthen environmental governance in the pan-European region, taking into account its potential role as an enabler to support the transition towards an inclusive green economy.

- **Chapter 4** reviews the main trends that will affect the region's environment in the future and suggests outlooks for the region to achieve a more sustainable future.

The data underpinning the assessment can be found in UNEP Live (*uneplive.unep.org*). The full assessment is also available through UNEP Live as a PDF and as an eBook.

GEO DPSIR conceptual framework



Source: Adapted from UNEP 2012

CHAPTER 1

Regional Context and Priorities

1.1 Regional context and priorities

1.1.1 The pan-European region and the 2030 Agenda for Sustainable Development

Main messages: Regional context and priorities

- Pan-European environmental regional priorities – climate change, air quality, biodiversity, chemicals and waste, and freshwater – are all captured in the 2030 Agenda for Sustainable Development including the SDGs and their targets. Likewise, specific targets under the SDGs also cover the two additional themes: coastal, marine and oceans, and land.
- The SDGs place the environmental priorities of the pan-European region in an integrated global framework for sustainable development that facilitates coherent policy formulation. The SDG targets and their indicators provide tools to measure progress in achieving the goals, and to support the follow-up and review process for the commitments made.
- Each country in the pan-European region will need to determine its own path to the SDGs, converging from different starting points.
- The pan-European region is a leader in mechanisms for follow-up and review that will become increasingly important with the SDGs and their indicators: peer review such as Environmental Performance Reviews conducted by OECD and UNECE; reports to multilateral environmental agreements; the balance of legislation, executive action, enforcement and judicial review; the independent role of civil society organizations; and the role of the media and public opinion. The pan-European region can continue to be a pioneer in institutional innovation, balancing supra-national coordination and subsidiarity as appropriate, while building regional solidarity and cohesion in implementing the SDGs.

The pan-European region and the international policy agenda

In 2014, the United Nations Secretary-General stated, "*sustainable development must be an integrated agenda for economic, environmental, and social solutions. Its strength lies in the interweaving of its dimensions. This integration provides the basis for economic models that benefit people and the environment; for environmental solutions that contribute to progress; for social approaches that add to economic dynamism and allow for the preservation and sustainable use of the environmental common; and for reinforcing human rights, equality, and sustainability. Responding to all goals as a cohesive and integrated whole will be critical to ensuring the transformations needed at scale.*" (UN 2014)

To this end, pan-European environmental policy is evolving to reflect and incorporate the 2030 Agenda for Sustainable Development within its regional context. In planning a transition to an inclusive green and circular economy, a broad set of policy interventions aims at expanding the safe operating space for socio-economic development in the region, while respecting planetary boundaries. Policies such as the European Union's (EU) Europe 2020 strategy, which includes a lead initiative for a resource-efficient Europe (EC 2010) are designed to enable the flow of public and private investment in sectors of the economy that are low carbon and resource efficient, and that create green and decent jobs.

One of the region's international responsibilities is to calculate its share of global consumption and use of resources, including those originating from beyond the pan-European region, in relation to planetary boundaries (Steffen *et al.* 2015; Rockström *et al.* 2009) and the sustainability of human society (Hoekstra and Wiedmann 2014). This means defining the region's global footprint (Tukker *et al.* 2015, UNEP 2015b; UNEP 2015c; Wiedmann *et al.* 2015; Tukker *et al.* 2014; UNEP 2013). Work has already begun on enabling

◄ Credit: Shutterstock/Rudmer Zwerver

the region to debate the criteria for establishing its equitable share of the global effort to meet the SDGs by 2030. These will need to take account of differentiated responsibilities between sub-regions and between countries within the pan-European region, as described in the SOER 2015 report (EEA 2015a). To achieve environmental sustainability, the sum total of all these shares for all regions should remain within planetary boundaries. (**More...1**)

1.1.2 The challenge of the Sustainable Development Goals

The SDGs are accepted by all countries and are applicable to all, developed and developing, wealthy and poor. Different national realities will require different responses to achieve the global goals. Each goal reflects one dimension of the human planetary system evolving in space and over time, aiming together for that dynamic balance that is the sustainability of the whole system. These are universal goals and targets which involve the entire world. They are integrated and indivisible and balance the three dimensions of sustainable development. One goal should not be achieved at the expense of another goal, making an integrated approach vital.

The universality of the SDGs is their strength. They capture issues common to all countries, and emphasize their interdependencies. In a globalized world, the actions of one country affect another, be it through overconsumption, corruption, emissions causing climate change, mismanagement or illegal trade. The SDGs also call for the respect of global standards in the fields of human rights, labour and the environment.

In the SDGs, all countries in the pan-European region have directly committed to an integrated set of globally determined, measurable goals and targets. On 11 March 2016, the United Nations Statistical Commission (UNSC) agreed the proposed global indicator framework for the goals and targets as a practical starting point. It recognized that the development of a robust and high quality framework is a technical process that will need to continue over time, and also emphasized that the global indicators proposed are for global follow-up and review of the 2030 Agenda for Sustainable Development and are not necessarily applicable to all national contexts. Indicators for regional, national and sub-national levels will be developed at the regional and national levels.

The SDGs go far beyond the traditional silos in which issues are placed and actions taken. All the SDGs have an environmental dimension to some of their targets, and half of the targets are relevant to the environment. While some SDGs address problems that are more acute in other regions, they all have relevance to parts of the region and to subsets of its population. They therefore provide a useful and policy-relevant framework for an environmental outlook.

From the perspective of the GEO reporting process, the integration of environmental aspects into the SDGs covers three key complementary areas (EEA 2015a):

- those SDGs on climate, water, oceans and ecosystems, biodiversity and land that focus on the environmental resources, processes and boundaries that define the planetary health on which human well-being and development depend, and that reflect Europe's natural capital and environmental priorities;

- those on poverty and health that place people at the centre, where environmental challenges represent threats to human health and well-being, and where environmental solutions can reinforce human progress; and

- those on sustainable energy and sustainable consumption and production, which address the transition to an inclusive green economy with resource-efficient, low-carbon development that builds rather than undermines pan-European and global sustainability.

The final two goals concern institutional and governance issues and the means of implementation.

Table 1.1.1: Regional priorities and themes in relation to the SDGs

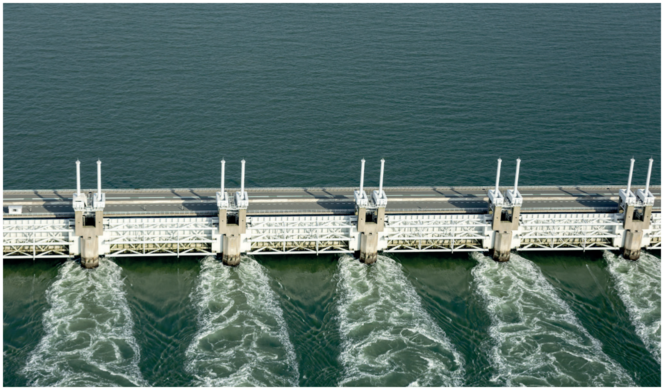
Regional priorities and themes	Sustainable Development Goals
CLIMATE CHANGE	Goal 13 on urgent action to combat climate change and its impacts
AIR QUALITY	Targets 3.4 on non-communicable diseases; 3.9 on illnesses from air pollution; 11.6 on air quality in cities; 11.7 on safe public spaces.
BIODIVERSITY	Goal 15 includes halting biodiversity loss; Targets 2.5 on maintaining genetic diversity; 6.6 on water-related ecosystems; 14.2 and 14.5 on marine and coastal ecosystems.
CHEMICALS & WASTE	Targets 3.9 on hazardous chemicals and pollution; 3.d on health risks; 6.1 on safe drinking water; 6.3 on water pollution by hazardous chemicals; 9.2 on sustainable industrialization; 9.4 on clean technologies; 11.6 on cities and municipal waste management; 12.3 on food waste; 12.4 on life cycle chemical management; 12.5 on waste prevention, reduction, recycling and reuse; and 14.1 on reducing marine pollution and nutrient pollution.
FRESHWATER	Goal 6 on ensuring the availability and sustainable management of water and sanitation for all-
COASTAL, MARINE AND OCEANS	Goal 14, including Target 14.4 on overfishing and illegal, unreported and unregulated fishing.
LAND	Target 2.3 on small-scale food producers; 2.4 on sustainable food production systems; 14.1 on land sources of pollution.

1.1.3 The Sustainable Development Goals and the environmental priorities for pan-European sustainability

The transformative nature of the 2030 Agenda for Sustainable Development calls for an integrated approach to sustainable development. The environment features in the goals and targets, and the pan-European environmental priorities and themes considered for this assessment are clearly reflected across the integrated set of SDGs (Table 1.1.1).

The SDG framework highlights the cross-linkages between issues and the co-benefits that can come from an integrated approach.

Climate change action is both an SDG and the subject of the Paris Agreement under the UNFCCC. Meeting the pan-European share of this goal will require ambitious greenhouse gas reduction targets such as those already set by the EU (EU 2015); accelerating the transition to renewable energies; and technology innovation and planning for adaptation. Western Europe should acknowledge that those of its livestock and agricultural systems that are oriented to intensive production are in conflict with the need for greenhouse gas reductions. As a classic cross-cutting issue, climate change will require a policy shift to food security, local production and agricultural diversity rather than just food quantity, and waste reduction.



Storm surge barrier Oosterscheldekering, the Netherlands
Credit: Shutterstock/ Aerovista Luchtfotografie

Regional policies should also recognize the importance of ecosystem health and biodiversity for resilience in the face of climate change. Since climate change and sea-level rise are expected to displace large numbers of people, Western Europe should learn from the challenges it is currently facing with migration and prepare for a larger-scale response in implementing responsible migration.

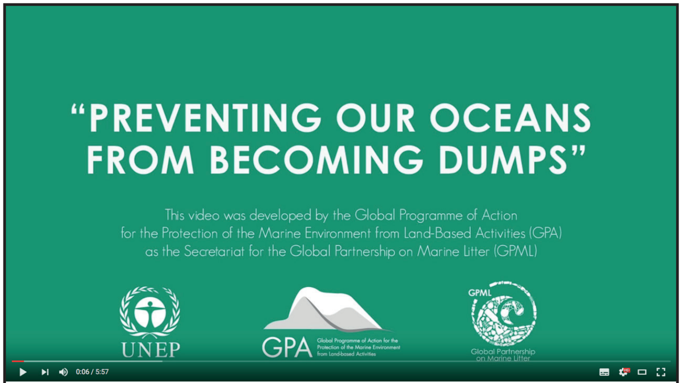
On **air quality**, Western Europe has already made substantial progress in controlling some forms of transboundary air pollution, including through a regional convention (the UNECE Convention on Long-range Transboundary Air Pollution), but urban air quality is still a major problem with significant health impacts, and a high priority for the pan-European region.

European **biodiversity** continues to degrade despite major efforts to protect it. The pan-European region has challenges in land use, fragmentation of natural areas and freshwater biodiversity in its rivers. To meet the goals and targets established under the SDGs' process, it will be necessary to integrate biodiversity considerations into all aspects of planning at regional, national and local levels, and to incorporate the economic benefits of ecosystem services.

Chemicals and wastes are an important issue in the pan-European region, and these are addressed in several targets across seven different SDGs. Since trade in chemicals is global, and chemical pollution and wastes transcend regional boundaries, the pan-European region should support global approaches, including research on new and emerging chemical risks to human health and the environment, finding alternatives to problematic chemicals and industrial processes, facing up to the challenge of nuclear wastes and addressing the growing problem of plastic pollution (Ellen MacArthur Foundation 2015). Plastic pollution can only be addressed through sustainable design, improved resource efficiency, substitution with less persistent materials and transitioning to a circular economy with better collection and separation and recycling of plastic waste, alongside product life extension through reuse, refurbishment and remanufacturing.

Plastic bottles and containers prepared for recycling.
Credit: Shutterstock/photka

Video: UNEP Global Partnership on Marine Litter 2015 - "Preventing our Oceans from becoming Dumps"



https://www.youtube.com/watch?v=uCXEHrmEYpM&list=PLZ4sOGXTWw8Gpj8uvJQv53FXiHsCbSoWM

The pan-European region's challenges for **freshwater** include reducing pollution from hazardous substances and improving treatment; addressing the poor chemical status of groundwater due to agriculture; increasing water use efficiency and sustainability with integrated water resources and watershed management; anticipating the risk under climate change of water shortages in southern Europe and

Central Asia and flooding everywhere in Europe; addressing the links between poverty and access to safe drinking water and modern sanitation for the marginalized parts of the population; transboundary water cooperation[2]; and acknowledging the importance of natural ecosystems for water management.

For **coastal, oceans and marine** issues, some of the critical issues for Western Europe include improving coastal zone management and climate change adaptation in the face of rapid sea-level rise; contributing to environmental impact assessment and sustainable regulation of offshore and deep-sea mineral extraction; and addressing plastic pollution and other sources of marine litter (GESAMP 2015). One specific challenge is ocean fishing by pan-European fleets. For the region to contribute to responsible fisheries at the global level, it will be necessary to reduce pan-European fishing globally to sustainable levels, remove subsidies that lead to excess fishing capacity, address inequalities between small- and large-scale fisheries, and support the scientific management of global fisheries in which pan-European boats are present.

For pan-European **land**, many parts of which are densely populated, there are conflicts between agriculture, settlement patterns, infrastructure development and other land uses under current policies, with a continuing and unsustainable conversion of productive land to other uses. The pan-European region faces issues of food security, the present encouragement of large-scale intensive agricultural production at the expense of more sustainable farming practices, and the best uses for agricultural land in the region. The challenge is to increase the environmental carrying capacity of the available land and to manage land use coherently, with eco-regional planning and biodiversity conservation. Since farmland is being abandoned and villages are shrinking in many rural areas, an effort is needed to provide rural populations with such sustainable activities as environmental stewardship and landscape management, and to ensure that indigenous populations have secure ownership and access to land and natural resources.

2 including through the 1992 UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes, the 1997 UN Convention on the Law of Non-navigational Uses of International Watercourses, and regional river basin conventions.

1.1.4 The Sustainable Development Goals with people at the centre

The following SDGs, addressing human health and welfare, also have substantial environmental dimensions.

Goal 1 addresses poverty and the pan-European region does have its poor, even if in some cases the poverty is only relative. Indeed, there has been a recent significant increase in poverty linked to economic crises and austerity programmes. As the poor may contribute to, and are often victims of, environmental degradation and biodiversity loss, the elimination of poverty frequently supports environmental goals.

While poverty is still a challenge in the region, it also has a significant role in addressing poverty elsewhere, and should contribute its fair share to the global fight against poverty. Western Europe in particular needs to recognize its unintended effects on poverty in other countries, through consumption patterns that result in a demand for resources from outside of the region and influence prices and investment, effectively depriving less advantaged populations in resource-rich developing countries of land and resources.

Similarly, Goal 2 on hunger, food security, nutrition and sustainable agriculture is important for regional and planetary environments. Pan-European agriculture has both sustainable and unsustainable dimensions. Western Europe is increasingly dependent on food imports to meet its needs, and exports to support its economy, increasing its vulnerability to a global food crisis. There are challenges to maintaining its relatively high-cost productive agricultural base in a global market. Consideration also has to be given to the impact of European environmental and food standards on agriculture in other regions.

From a nutritional perspective, Western Europe is home to leading multi-national agribusinesses, and has a food industry that has consolidated agriculture and retail food systems at the expense of national food security. One result is a loss of dietary diversity and a reduction in staple diet constituents with a consequent decline in food grain and livestock diversity. Processed food products have health impacts, with some dietary-related conditions such as obesity becoming increasingly common in the pan-European region, generating health costs that seriously impact economies. Some parts of the region need to encourage healthier diets and eating less, while for others hunger is still a priority. These problems illustrate how policies designed to address a limited set of goals or only one dimension of sustainable development can impede progress on other goals and have overall negative impacts on human well-being (UNEP 2015d).

Human health and the environment are intimately related. To respond to Goal 3 on healthy lives and well-being, the pan-European region faces a set of environmental health challenges discussed in Section 1.2 and addressed in the European Environment & Health process. A new planetary boundary has been identified for the release of novel substances including chemicals, nanoparticles, genetically modified organisms (GMOs) and other industrial products for which the risks have not been adequately researched (Steffen *et al.* 2015). European research and regulation, incorporating the precautionary principle, will be important in addressing these.

Goal 4 on education is relevant to developing solutions to environmental challenges in the region. Encouraging environmental health, sustainable consumption and responsible lifestyles requires the integration of these aspects into educational programmes. Education is needed to encourage citizens to understand how their own interests and welfare depend on the integrated set of SDGs. This is highlighted in Target 4.7 on education for sustainable development and sustainable lifestyles. To make the transition to an inclusive green (and circular) economy, the region will need to provide education and training for green jobs, mainstream green skills into all qualifications and retrain workers from activities in decline.

The final social goal, Goal 5 on gender equality, captures the important role of women in environmental decision-making, whether as consumers, farmers and workers or researchers and policy-makers. Mothers are normally the first educators of children and, along with fathers, are transmitters of societal values, so their early role in environmental education is crucial in building a more sustainable future. There are also parts of the pan-European region still concerned by equal rights for women to economic resources, natural resources and land ownership. Without such access, women cannot exercise their environmental responsibilities effectively.

1.1.5 Sustainable Development Goals for the transition to an inclusive green and circular economy

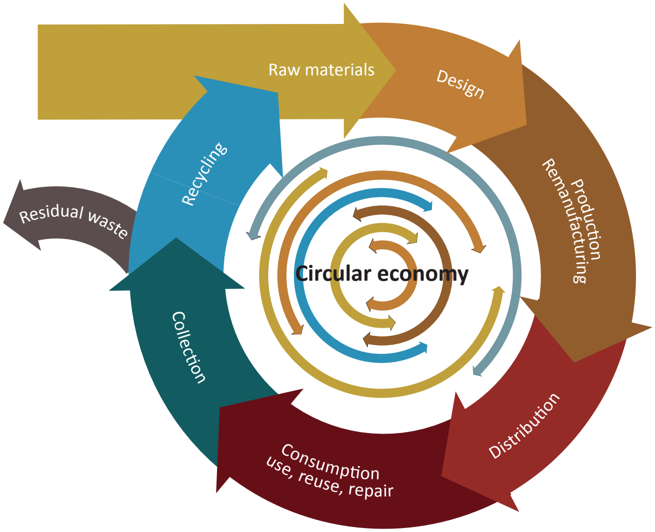
The present economy is a major driver of pan-European and global unsustainability, with excessive resource consumption and growing economic inequality. A number of SDGs covering energy, economic growth, employment, industry, inequality, human settlements and sustainable consumption and production could form the basis of a new dialogue on an environmentally responsible transition to an inclusive green and circular economy.

Goal 8 is the main economic goal concerned with economic growth and employment. As a world economic leader, Western Europe could become a model in the redesign of the world economy, aiming for an economic system that maximizes human well-being rather than growth as such, combined with implementing Target 17.19 on measurements of progress in sustainable development beyond gross domestic product (GDP).

This means transitioning the pan-European region to an inclusive green economy (UNEP 2015e) that incorporates energy and natural resource efficiency, and context-driven effectiveness, to provide both resource security and equitable access, such as in a circular economy (Figure 1.1.1).

A circular economy would include absolute decoupling of economic growth from resource use (UNEP 2015c), including through sustainable consumption and production, conserving

Figure 1.1.1: The Circular Economy



Source: Acceleratio n.d.

critical raw materials with a sophisticated metallurgical infrastructure (UNEP 2013), promoting recycling (as well as product reuse, refurbishment and remanufacturing), and the conversion of food, hazardous, electronic (UNEP 2015g), plastic and other wastes into resources, as well as the minimization of residual wastes such as marine litter.

This would be supported by actions under the Pan-European Strategic Framework for Greening the Economy, developed with support from the United Nations Economic Commission for Europe (UNECE) secretariat and the United Nations Environmental Programme (UNEP). The framework describes opportunities and challenges for greening the economy in the pan-European region, as well as possible paths to sustainability and steps to promote cooperation among countries in the region to support the transition to a green economy.

This transition should also include green and decent jobs for everyone, especially youth, with more flexible careers; and green investment, with the removal of harmful subsidies and better debt management. An immediate challenge is to manage the transition of human and material resources from unsustainable economic activities and those that do not contribute to human well-being to those that do. The impact of the region's economy on the rest of the world through resource extraction, imports and climate change needs to be included. Western Europe will also have to adapt its economic thinking to its demographic profile as an aging community.

This concept is further elaborated in Goal 12 on sustainable consumption and production which is particularly relevant to Western Europe, and which will require fundamental transitions in the systems of production and consumption (EEA 2015a). As an over-consuming region relative to planetary carrying capacity, Western Europe will need to redefine the ways in which it creates economic value so that it increases the well-being of its citizens within an appropriate per-person share of global consumption (UNEP 2015f). This needs to be supported by education for responsible lifestyles as called for in the UNECE Strategy for Education for Sustainable Development, so that its citizens

Young woman shopping selectively in a supermarket
Credit: Shutterstock/Robert Kneschke

come to see the advantages of meeting their needs without excess. Some of the characteristics of this new system will be the absolute decoupling of productivity from energy and material flows, achieving optimal sizes for communities, companies and economies rather than endless growth, closed cycles of critical raw materials, and decentralization and subsidiarity.

Energy is fundamental to development, but the present material civilization has been built on unsustainable energy subsidies for fossil fuels. Goal 7 on energy balances the need for access to energy for development of the poorer parts of the planet with the urgent need to decarbonize society to protect the world from the effects of climate change.

Renewable energy in the pan-European region
Credit: Shutterstock/msgrafixx

For the pan-European region, the challenge is to be a leader of the energy transition. Progress has already been made in some countries in developing renewable energy and phasing out fossil fuels, but more is needed to increase energy efficiency, reduce consumption, phase out environmentally harmful subsidies and ensure energy security. There are already 1.2 million jobs in renewable energy in the EU (IRENA 2015) (**More...2**).

A key of the economy is Goal 9 on inclusive and sustainable industrialization and supporting infrastructure. In the pan-European region, this will include encouraging sustainable forms of transport, industrial ecology as a contribution to a circular economy and greater environmental responsibility in business. Since much industrial activity has been delocalized to other regions, a true picture of Western Europe's environmental impact should include the environmental footprint of imported products. A specific challenge for infrastructure is the need to adapt ports and coastal areas to sea-level rise. Rising costs resulting from the consequences of climate change are unavoidable, but anticipation and adaptation will be much cheaper than disaster relief and reconstruction.

More fundamentally, many environmental costs are externalized or ignored in the present system, and need to be internalized to integrate them into decision-making processes Present economies, whether market-based or centrally planned, use natural resources unsustainably, producing an inconsistency between the SDGs for growth and for biocapacity renewal, whether for agriculture or

Green buildings, Warsaw library
Credit: Shutterstock/ ID: katatonia82;RossHelen

natural resource sustainability. The international legal and regulatory framework for industry should combine wealth creation with social and environmental responsibility to make these compatible.

Much economic activity is concentrated in cities, and the pan-European region today is largely an urban society. The resulting sustainability challenges are addressed in Goal 11 to make cities and human settlements inclusive, safe, resilient and sustainable. Meeting this goal will involve green urbanization producing smart, efficient, low-carbon cities and towns, with urban communities at optimal scales. The immediate pan-European challenge is the transitioning of existing cities, with new sustainable construction, the retro-fitting of old buildings and the transformation of food, land use, energy and transportation systems. Environmental improvements should include creating green corridors and belts for urban biodiversity, and integrating cities into the wider ecological landscape, including encouraging urban agriculture. The region also needs to develop new economic activities for rural areas and villages, while networking communities with transport and communications to ensure their integration in the larger social fabric.

A culture of consumption
Credit: Shutterstock/ Dmitrijs Dmitrijevs

One ambitious objective is Goal 10 to reduce inequality within and among countries. The growing crisis of economic inequality in many pan-European countries is driving overconsumption and social dysfunction, and creating significant barriers to confronting climate change and promoting environmental sustainability. This goal will help to address the inequitable sharing of limited environmental resources. There are applications for this goal at many levels: reducing inequality between the pan-European region and other regions, between countries within the region, within countries, and between rural and urban communities.

1.1.6 Sustainable Development Goals for institutions, governance and means of implementation

The final two goals are about means as much as ends. Goal 16 on peaceful and inclusive societies, justice and accountable institutions at all levels covers a number of environmental priorities. To achieve this, the pan-European region will have to address the underlying environmental drivers of tension, which can include access to water and other resources including energy, and environmentally-driven migration. The goal calls for strengthening environmental governance and eliminating corruption, which often undermines environmental management.

To meet the last goal, Goal 17 on means of implementation and partnership, the pan-European region will need to build an SDG monitoring and assessment network, modeled on a Shared Environmental Information System (SEIS) for the region, and identify data gaps and harmonization challenges. It should pioneer innovative technologies to simplify and standardize data collection, assessment and monitoring. It is well placed to support other regions to meet the SDGs, and to build global data collection, monitoring and review frameworks.

1.1.7 Institutional and social organization and innovation

The countries of the pan-European region are diverse in their stages of development, economies, cultures and value systems, resource endowments and governance institutions, and reflect a similar diversity at the world level. Their pathways to sound environmental management and sustainability will inevitably be different, even as they converge on the same goals. Yet their proximity also means that they have many things in common, including environmental resources and impacts, trade and population movements. All this will require innovation in multi-level environmental governance, whether it be for shared river basins, energy markets, sustainable consumption and production, pools of capital and labour, transport and communications, ecosystem services and migratory species, or research and knowledge management.

The 2030 Agenda for Sustainable Development (UN 2015) calls for assessments of progress on the SDGs at the national, regional and global levels. Each nation will need to internalize the SDGs to determine their aspirations and their share of the global ambition, and decide on their own targets and indicators within the global framework. The pan-European region as a whole will also need to decide on the appropriate scales and mechanisms for regular regional assessments.

Western Europe is one of the leading sub-regions of the world in its capacity to implement the SDGs. It has a range of institutional mechanisms and multilateral agreements, and decades of experience with environmental policy instruments, as well as a strong scientific and data collection capacity and experience in using indicators. This experience in using indicators is continuously improving across the region and its sub-regions through the UNECE Working Group on Environmental Monitoring and Assessment (WGEMA) and Joint Task Force on Environmental Indicators (JTFEI) processes in support of SEIS.

The pan-European region is also a leader in mechanisms for follow-up and review that will become increasingly important with the SDGs and their indicators: peer review such as Environmental Performance Reviews conducted by the Organization for Economic Co-operation and Development (OECD) and UNECE; reports to multilateral environmental agreements; the balance of legislation, executive action, enforcement and judicial review; the independent role of civil society organizations; and the role of the media and public opinion.

The SDGs could provide a new vision and narrative around which to strengthen unity across the region. The pan-European region can continue to be a pioneer in institutional innovation, balancing supra-national coordination and subsidiarity as appropriate, while building regional solidarity and cohesion in implementing the SDGs.

1.2 Healthy Planet, Healthy People

Main messages: Healthy Planet, Healthy People

- Addressing the interlinkages between environmental sustainability and human health and well-being, and building resilient ecosystems will be essential to meeting the SDGs that place people and well-being at their centre.
- Many of the gains in human development over the last century have been made at the cost of ecosystems, both within and outside the region, and the later effects of this now cause ill-health. The effects of climate change, air and water pollution, chemical exposure, biodiversity loss and ecosystem degradation all contribute to the environmental burden of disease.
- Outdoor air pollution remains a major problem, especially in cities of the region. The prevalence of mental and non-communicable diseases (NCDs) is also significant, and the region is the most affected globally. Even though the causality of NCDs is complex, prevention can often be achieved by providing healthy environments and promoting healthy lifestyles, with decreased exposure to harmful agents.
- There is a need to detoxify, decarbonize and decouple resource use from economic performance, and support lifestyle changes in order to build ecosystem resilience and deliver an integrated, inter-sectoral and inter-generational approach to improve human well-being and environmental sustainability.
- The harmful environmentally-related impacts on human health could be reduced by integrated, multi-stakeholder public health actions; implementing ecosystem-based solutions; preventing exposure to harmful agents; increasing exposure to healthy green urban environments; encouraging healthy lifestyles; and using strategic environmental assessment and other impact assessment tools to assess relevant policies, plans, programmes and projects.

1.2.1 Environmental sustainability and human health and well-being

Addressing the interlinkages between human health and well-being[3] and healthy ecosystems[4] will be essential to meet the SDGs. All five of the pan-European regional priorities - climate change, biodiversity, air quality, freshwater and chemicals and wastes - influence human health and well-being and by preserving, improving or restoring environmental quality, multiple benefits and policy goals can be achieved.

1.2.2 A changing disease scenario in a changing environment

Human health depends on healthy environments

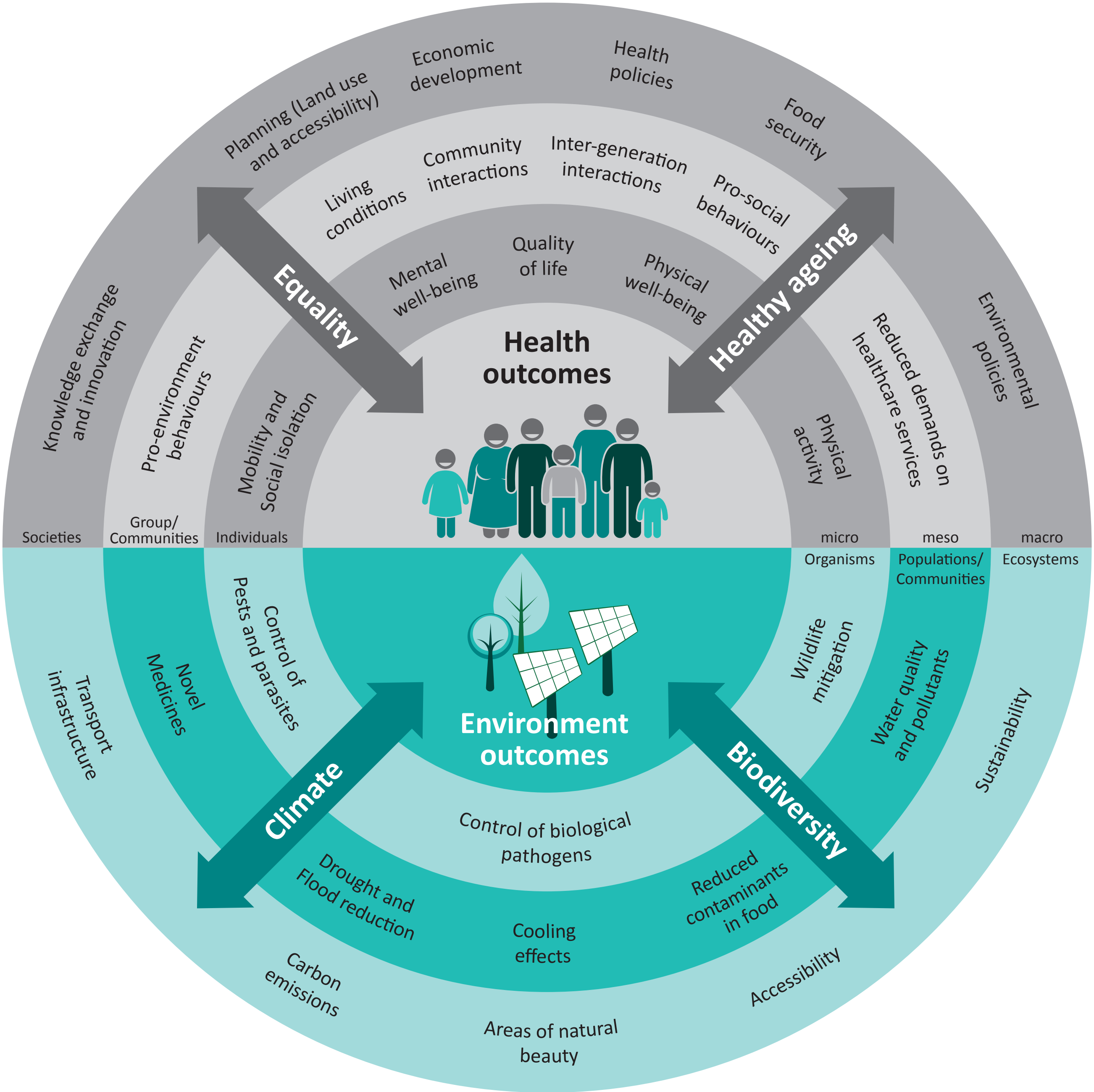
A healthy environment underpins human health and well-being (More...3). This relationship is a complex web of interactions; the understanding and recognition of these interactions should be further enhanced at the national and pan-European scale to achieve a healthier society for all (Figure 1.2.1) (More...4).

Over the last century, improved hygiene and considerable medical progress have substantially reduced morbidity

3 Health will be understood in its holistic meaning, as defined by the World Health Organization: "*health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*" (WHO 1948). Despite coming to age, the definition holds a modern view on health, promoting new notions such as subjective well-being and happiness, supporting alternative options for measuring health (UNDP 2015).

4 The Millennium Ecosystem Assessment (MA 2005a) defines an ecosystem as: "*dynamic complex of plant, animal, and microorganism communities and the non-living environment, interacting as a functional unit. Humans are an integral part of ecosystems*". Within this context an ecosystem is considered healthy "*if it is stable and sustainable— that is, if it is active and maintains its organization and autonomy over time and is resilient to stress*" (Costanza 1992).

Figure 1.2.1: Overview and examples of interlinkages between the environment and human health



Source: ECEHH n.d.

and mortality from infectious diseases. However, these interventions can, due to over- or misuse, become unbalanced and the direction reversed, resulting in, for example, multi-resistant pathogens and auto-immune diseases. Anti-microbial resistance is a natural phenomenon, but the occurrence increases with inappropriate use of anti-microbial drugs; for example, in animal husbandry and by poor infection prevention and over-prescription, as well as waste from the pharmaceutical industry. The consequences are detrimental, as without efficient treatment options, common infections can become lethal and the success of organ transplantation, cancer chemotherapy and major surgery are compromised. Coordinated policies and regulations are required across the region, such as investing more in health promotion and disease prevention and including the avoidance of the overuse of antibiotics, rather than interventional health care. Such coordinated actions should include an environmental perspective, both in terms of preventing hazards and by creating healthy living environments for all.

The rise of life-style related and NCDs, including mental disorders, puts further stress on health systems and economic, social and natural resources (Horton 2013) (**More...5**). Four out of five Europeans die from NCDs and the region is, so far, the most affected globally (WHO 2015a). Many of these deaths could be avoided by integrated, multi-stakeholder public health actions, preventing exposure to harmful agents and promoting healthy environments and lifestyles (WHO 2015a; Hanson *et al.* 2011). This was acknowledged by health ministers participating at the European Environment and Health Process, and included in the *Parma Declaration* (WHO 2010a) and in *Health 2020* (WHO 2015a).

Greater efforts are needed to reduce the high burden of environmentally-related disease and to address the unequal distribution between countries, as well as the disproportionate effects on poor and vulnerable groups. New approaches, such as One Health[5], may be useful for encompassing the interdependencies between human, animal, and plant health and well-being (**More...6**).

1.2.3 Climate change - a threat that should be addressed to protect health

The threat to human health from climate change is so great that it could undermine the last 50 years of gains in development and global health, according to the 2015 Lancet Commission on Health and Climate Change (Watts *et al.* 2015). The consequences for the pan-European region's environment, health and economy are significant and only remotely foreseeable (McMichael 2013), with the highest load on poor and vulnerable populations, and with accumulating negative impacts on coming generations (IPCC 2014).

Health impacts caused and exacerbated by climate change

Pan-European health is already affected by climate change (D'Ippoliti *et al.* 2010; Garcia-Herrera *et al.* 2010; Dear *et al.* 2005). Impacts of climate change affect health through floods, heat waves, droughts, reduced agricultural productivity, exacerbated air pollution and allergies and vector, food and water-borne diseases. In addition, less direct processes will affect health in currently unpredictable ways (Figure 1.2.2). These impacts include climatic influences on mosquito populations, bacterial proliferation rates and changes in freshwater flows and quality (Bourque and Cunsolo Willox 2014; McMichael 2013; McMichael *et al.* 2006; Smith *et al.* 2014).

5 'One Health' is a concept with the aim to "improve health and well-being through the prevention of risks and the mitigation of effects of crises that originate at the interface between humans, animals and their various environments" and for that purpose to "promote a multi (cross) sectoral and collaborative approach and a 'whole of society' approach to health hazards, as a systemic change of perspective in the management of risk" (One Health Global Network 2012). This approach has been formally endorsed by the European Commission, the US Department of State, US Department of Agriculture, US Centers for Disease Control and Prevention (CDC), World Bank, World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), World Organization for Animal Health (OIE), United Nations System Influenza Coordination (UNSIC), various Universities, NGOs and many others (One Health Global Network 2012; CDC 2010).

Floods: Between 2000 and 2014 there were 337 riverine, flash or coastal floods in the pan-European region. These floods caused the death of more than 1 500 people, affected more than 7 million people and caused more than US$88 billion in damages. The largest number of fatalities (172 deaths) was reported for a flash flood event that hit 31 410 inhabitants in the Russian Federation in 2012. The largest number of affected inhabitants (1.6 million) was reported in Serbia in May of 2014 (Guha-Sapir *et al.* 2015).

Flood damage in Serbia
Credit: Shutterstock/ Dusan Milenkovic

Heat waves: In 2003, the pan-European region suffered its strongest heat wave ever, with more than 70 000 excess deaths across 12 European countries (Garcia-Herrera *et al.* 2010; Fouillet *et al.* 2006). Heat-related morbidity and mortality are projected to increase, particularly in southern parts of the region. Events are also expected to increase in currently less hot parts of the region (Hajat and Kosatky 2010, Hajat *et al.* 2010). The issue is expected to grow with increasing urbanisation, due to the urban heat island (UHI) effect (Oke 1973).

Drought: The EM-DAT database reports 25 drought occurrences in the pan-European region for the time period 2000 to 2015, which affected 8.67 million people (Guha-Sapir *et al.* 2015; Below *et al.* 2007).

Agricultural productivity: Productivity is projected to decrease in the Mediterranean area, South Eastern Europe and Central Asia. Crop yields may decrease by up to 30 per cent in Central Asia by the middle of the 21st century. This scenario would lead to malnutrition, especially among the rural poor, and hence increased health inequalities (EEA 2008; Lehner *et al.* 2006).

Allergies: Over the last 30 years, global warming has extended the pollen season in Europe by an average of 10 -11 days. The amount of airborne pollen is also increasing, especially in urban areas. This increase may account for part of the increase in prevalence of respiratory allergies (Ziello *et al.* 2012). The spread and establishment of species is also affected, introducing new aeroallergens in previously unaffected areas (**More...7**).

Tick-borne diseases: Lyme *borreliosis*, transmitted by ticks, is the most common vector-borne disease in the pan-European region, with more than 90 000 cases reported annually. The links between climate change and Lyme's disease are uncertain, but global warming has increased the risk by allowing ticks to survive at higher altitudes and at more northern latitudes (Jaenson and Lindgren 2011; Danielová *et al.* 2009).

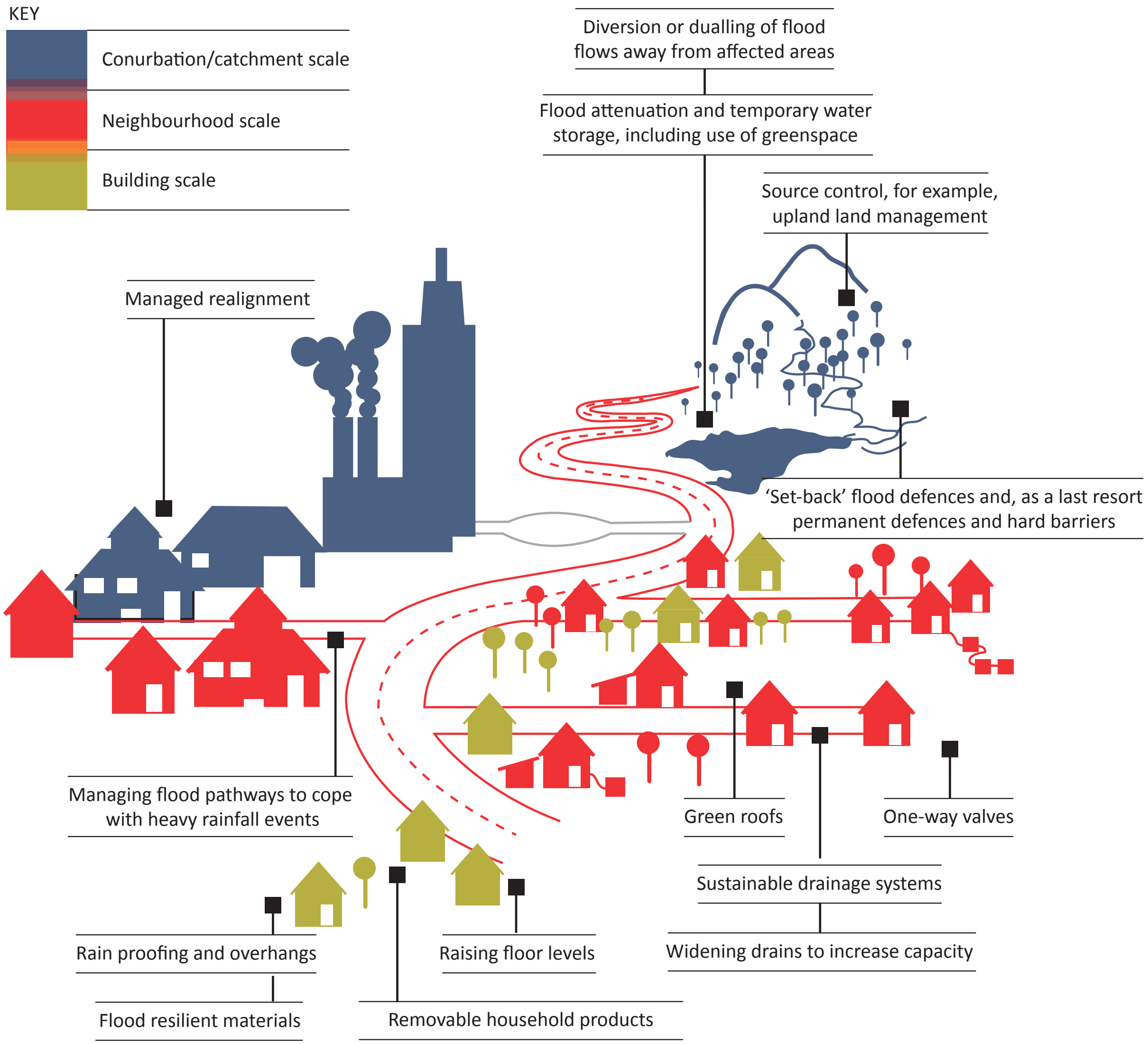
Mosquito-borne diseases: Malaria, caused by the mosquito-borne parasite *Plasmodium*, is another increasing threat (Ejov *et al.* 2014). Malaria is unlikely to re-establish itself in Europe, but may be introduced sporadically due to global travel and trade, and the risk of spreading increases with global warming (**More...8**).

Pathogens: In warmer climates, several pathogens' chances to survive and thrive increase, which affects the incidence of food- and water-borne diseases. For example, by 2071-2100, climate change could cause temperature-related cases of *Salmonella* infection to increase by 50 per cent (Watkiss and Hunt 2012).

Responding to climate change and improving health

As a response to expected climate change effects on health, 32 of the pan-European countries have drawn up national health vulnerability, impact and adaptation assessments (**More...9**). Efforts to adapt to climate change are required at several scales (Figure 1.2.2).

Figure 1.2.2: Examples of actions and techniques available to increase adaptive capacity



Source: EEA 2013

Responses to climate change mitigation and adaptation have both direct and indirect health benefits; for example, burning fewer fossil fuels reduces respiratory diseases and active transport, while walking and cycling cut pollution and road traffic accidents and reduce rates of obesity, diabetes, coronary heart disease and stroke (Bone and Nurse 2010). There are also health co-benefits from changes in diet, such as eating less red meat. Another benefit is the reduction of health inequalities, as the poorest would benefit the most from general environmental improvements (Benmarhnia *et al.* 2015; IPCC 2014; Jonsson and Lundgren 2015). Together, climate change mitigation and ecosystem-based adaptation promise to create a win-win situation for the region, while being a cost-efficient strategy to tackle today's disease burden (Bone and Nurse 2010) (**More...10**).

1.2.4 Biodiversity and ecosystem services - a fundament for health

Biodiversity is a key environmental determinant of human health (Figure 1.2.3). The existence of a broad variety of genetic material, plants and animal species is the ultimate precondition for human life. Biodiversity loss therefore undermines healthy development (**More...11**) and ultimately human existence (Chivian and Bernstein 2009). Biodiversity

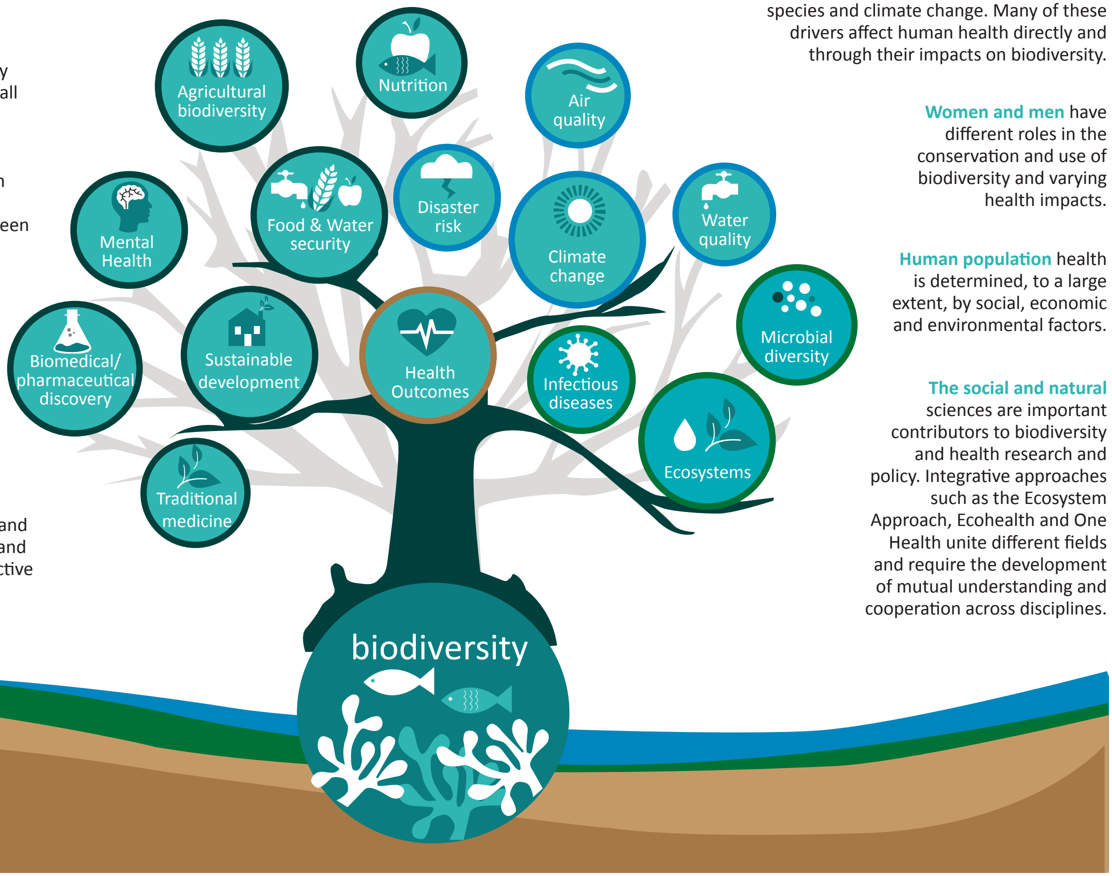
Figure 1.2.3: Biodiversity is the fundament for all life on the planet

Health "is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."

Biological diversity (biodiversity) is "the variability among living organisms from all sources including, interalia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."

Biodiversity underpins ecosystem functioning and the provision of goods and services that are essential to human health and well being.

The links between **biodiversity and health** are manifested at various spatial and temporal scales. Biodiversity and human health, and the respective policies and activities, are interlinked in various ways.



Direct drivers of biodiversity loss include land-use change, habitat loss, over-exploitation, pollution, invasive species and climate change. Many of these drivers affect human health directly and through their impacts on biodiversity.

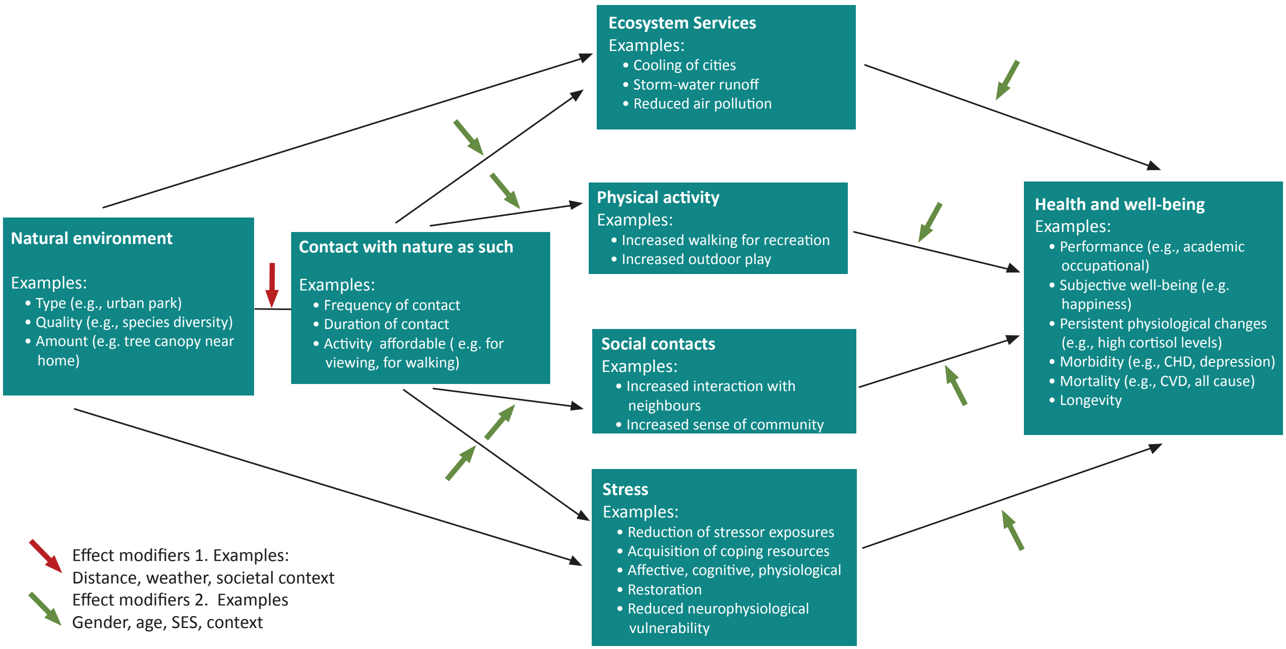
Women and men have different roles in the conservation and use of biodiversity and varying health impacts.

Human population health is determined, to a large extent, by social, economic and environmental factors.

The social and natural sciences are important contributors to biodiversity and health research and policy. Integrative approaches such as the Ecosystem Approach, Ecohealth and One Health unite different fields and require the development of mutual understanding and cooperation across disciplines.

Source: WHO and CBD 2015

Figure 1.2.4: Examples of pathways and mediators between natural landscapes and health



Source: Adapted from Hartig *et al.* 2014

underpins all ecosystem services, guaranteeing supply of environmental goods and services, such as nutrients and food, clean air and freshwater.

Biodiverse landscapes provide health and well-being

Biodiversity at the large scale, the richness of species on a community and landscape level, provides health and well-being through several pathways. A recent meta-analysis revealed that disease prevalence (among animals, humans and plants) is often higher in less diverse systems (Civitello *et al.* 2015). A biodiverse natural environment also offers several other psychological and physiological health benefits (Hartig *et al.* 2014) (Figure 1.2.4). In addition, many pharmaceuticals are derived from micro-organisms, and modern medicine continues to rely on biodiversity which contains raw materials for developing new drugs (David *et al.* 2015).

Biodiversity loss impacts health

Biodiversity is negatively impacted by intensive crop agriculture and livestock systems (Machovina *et al.* 2015), urbanisation, over-exploitation such as over-fishing, pollution, invasive species and climate change. Although the region experiences an increase in forested areas, forest degradation may also contribute to biodiversity loss (UNECE and FAO 2015; FOREST EUROPE 2015). Declining biodiversity can increase the likelihood of the local transmission of infectious diseases and alter exposure across the region (Keesing *et al.* 2010; LoGiudice *et al.* 2003). Loss of pollinating species can reduce crop yields, potentially increasing under-nutrition (Eilers *et al.* 2011; IPBES 2016). It also reduces provision of healthy foods such as fruits, vegetables and nuts, thereby indirectly contributing to reliance on less healthy food and a subsequent increase in NCDs. Recognizing the biodiversity-health link provides grounds for integrating health and environmental indicators into assessments.

1.2.5 Environmental pollution still has major health impacts

Air pollution

The most recent data (WHO 2016; Maas and Grennfelt eds. 2016; EEA 2015b) show that air quality is now the single largest health risk to the population in Europe, with more than 95 per cent of the urban population exposed to air pollution in exceedance of European standards and WHO Air Quality Guidelines (**More...12**). Figure 1.2.5 shows concentrations of PM_{10} in 2013 and exceedences of the 2005 daily limit value (50 µg/m3), as set out in the Air Quality Directive (EU 2008). Over 500 000 premature deaths in the region were attributable to ambient air quality and 100 000 to indoor air quality in 2012 (EEA 2015a; WHO 2014).

The map shows the 90.4 percentile of the data records in one year, representing the 36th highest value in a complete series. It is related to the PM_{10} daily limit value, allowing 35 exceedances over 1 year of the 50 $\mu g/m^3$ threshold. The red and dark-red dots indicate stations with exceedances of this daily limit value. Only stations with > 75 per cent of valid data have been included in the map.

Smog in Ostrava, Czech Republic
Credit: Shutterstock/ Mino Surkala

Air pollution also continues to damage vegetation and ecosystems (Tilman and Isbell 2015). For ecosystems, excess deposition of nitrogen is a major cause of species loss, growth in grasses and eutrophication, while current ozone concentrations reduce potential wood and crop production in the region by up to 15 per cent (UNECE 2015).

Improving air quality

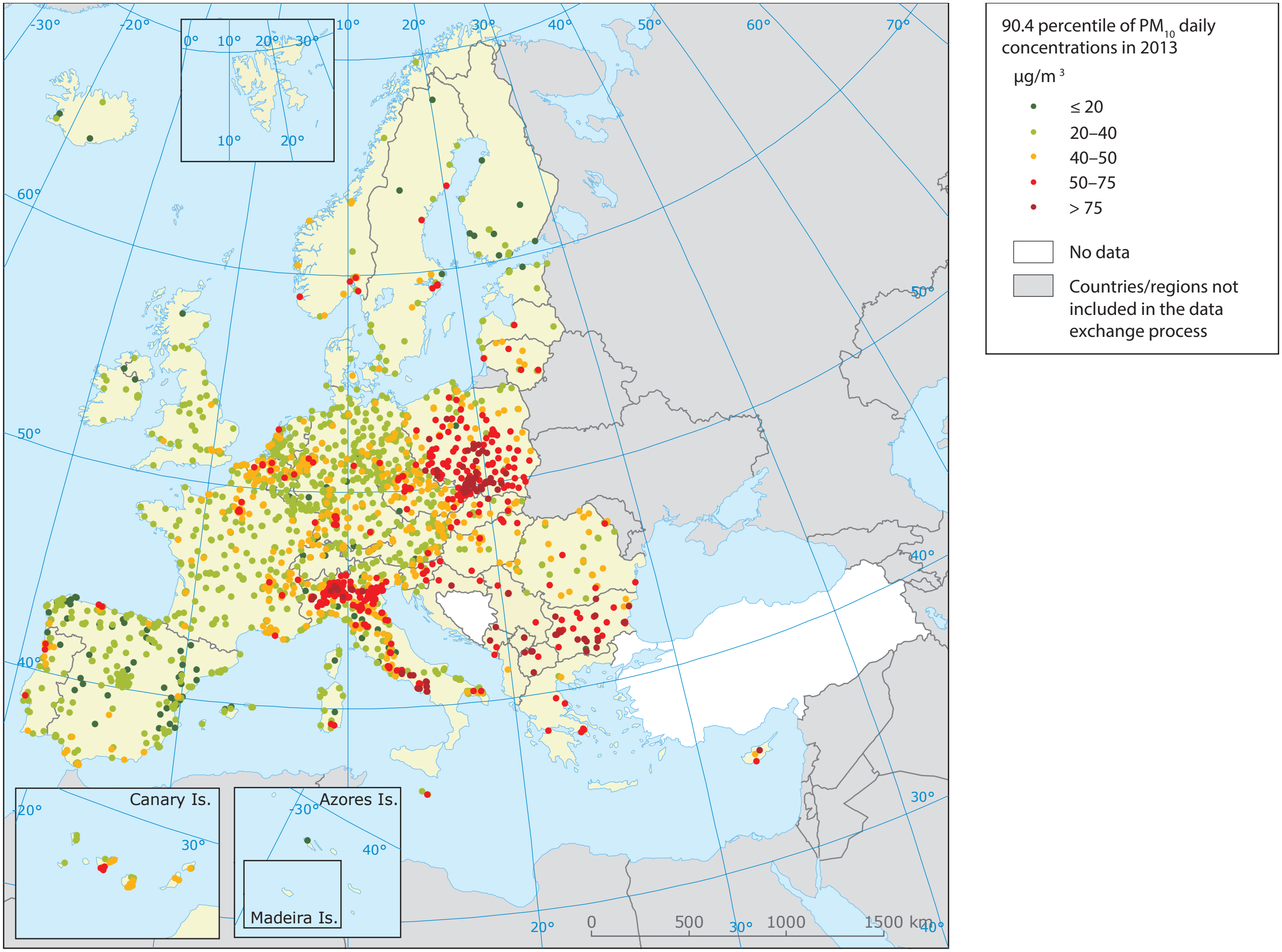
Many parts of the region have seen improvements in air quality over recent decades as a result of reducing emissions and regulatory interventions (Maas and Grennfelt eds. 2016). Continued improvements in air pollution levels are expected under current legislation, but beyond 2030 only slow progress is expected (EEA 2015b). Additional measures are required to achieve the long-term objective of air pollution levels that are below thresholds of harmful effects on human health and the environment. This includes increasing capacity to monitor and report. Other pollutants such as tobacco smoke and noise are also relevant to the region (**More...13**).

Access to safe drinking water and sanitation

In the WHO European region, 97 million people still lack access to piped household drinking water supplies, posing risks to health. The Caucasus and Central Asia are the only sub-regions globally where access to improved drinking water has declined (1990-2012) (WHO 2015b). In most countries, use of piped water has increased faster in rural areas, but urban coverage remains higher. In the Caucasus and Central Asia, less than 40 per cent of rural dwellers use piped water on premises (UNICEF 2015). Arsenic and high levels of carcinogenic disinfection by-products in drinking water are of concern in a few countries (Richardson *et al.* 2007; Villanueva *et al.* 2007).

More than 62 million people in the region still lack access to *adequate sanitation facilities* (UNICEF 2015), which makes them vulnerable to water-related diseases, such as cholera, viral hepatitis A and typhoid. It has been estimated that in the region's low- and and middle-income countries, about 10 people a day die from diarrhea caused by inadequate water, sanitation and hand hygiene (WHO 2015b; Prüss-Ustün *et al.* 2014). Although the situation is improving, some countries in the regions even saw a loss in the number of sanitation facilities between 1995 and 2010 (Figure 1.2.6).

Figure 1.2.5: Concentrations of PM_{10} in 2013

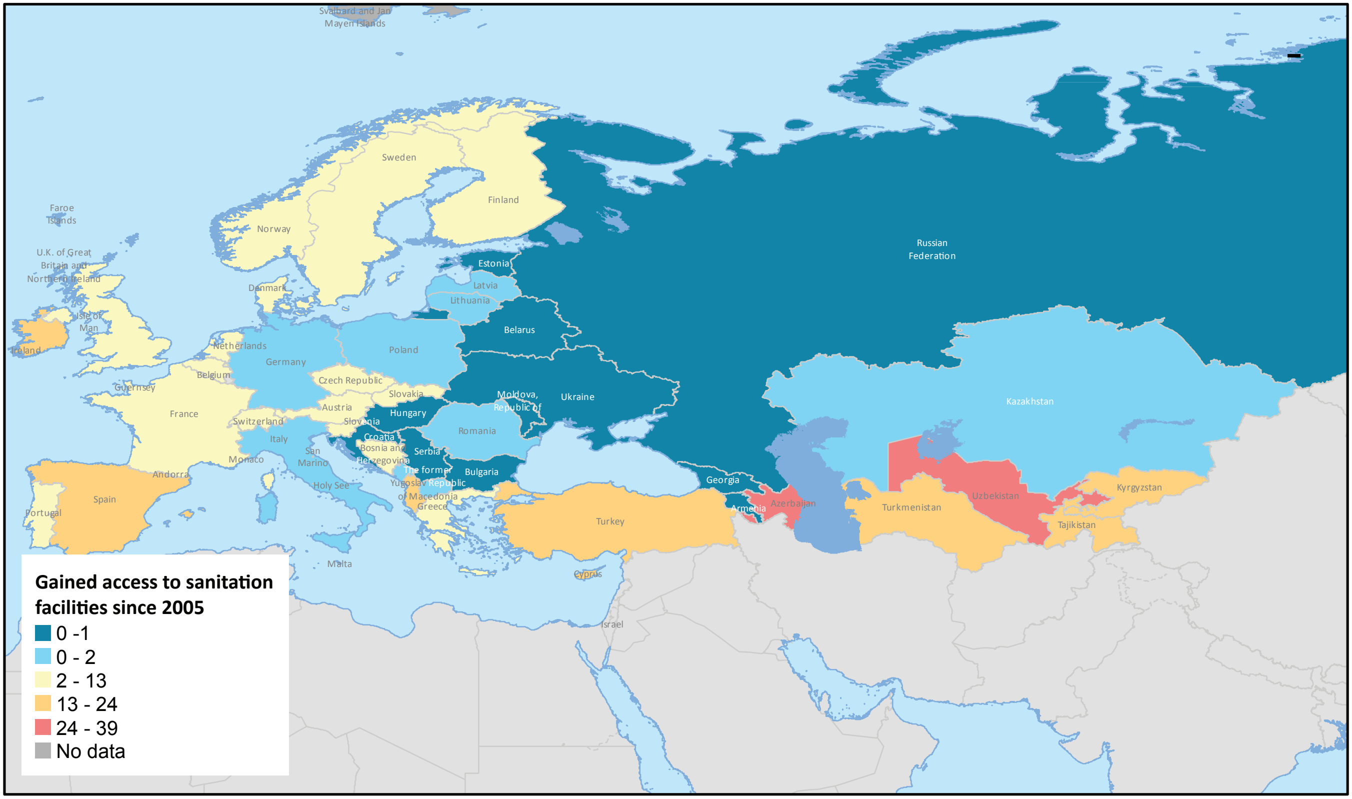


Source: Based on Air Quality e-reporting database, EEA 2015b

The darker blue colour indicates a loss, with the most aggravated situation in Georgia (-19 per cent) and Ukraine (-15 per cent). The light blue colour indicates no change, light yellow small gains, orange large gains and red very large gains, seen particularly in Caucasus and Central Asia, including Israel (the latter outside the map frame). Iceland, also outside the map frame, has seen large gains.

Cleaner water and better sanitation could prevent up to 30 million cases of water-related diseases each year. The *Protocol on Water and Health to the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes* entered into force in 2005 and is coordinated by WHO/Europe and the UNECE. The objective of the Protocol is to promote the protection of human health and well-being through improving water management and preventing, controlling

Figure 1.2.6: Proportion of the 2010 population that gained access to sanitation facilities since 2005



Source: IHPH 2013

and reducing water-related disease. Twenty-six countries are now parties to this agreement and many more cooperate on the Protocol's platform.

Exposure to chemicals and increasing waste

The production of chemicals has doubled during the last decade and is expected to continue growing. With increasing exposure, and pollution of air, water, food and soil, adverse effects on health are expected to rise.

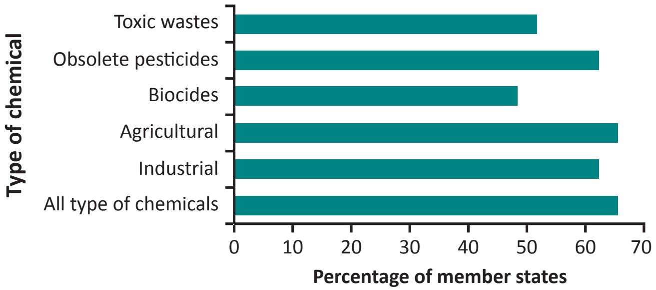
Toxic chemicals pose various health risks, such as damage to reproductive, immune and endocrine systems, neurocognitive impairments, development disorders, carcinogenic mutations and chronic diseases (Wang and Achkar 2015; Grandjean and Landrigan 2014; Lewis *et al.* 2013; Steliarova-Foucher *et al.* 2004) (**More...14**).

Many chemicals are damaging during the foetal period, posing risks on subsequent generations and also throughout the life course (Wild *et al.* 2013; Tomatis 1979). Increasing evidence shows that exposure to a mixture of chemicals can be harmful, although each separate agent may be below threshold levels for toxicity (Kortenkamp 2014) (**More...15**).

Meeting the *Parma Declaration* (WHO 2010a) goals for chemical safety requires further action. Existing policies and plans are not sufficiently comprehensive and the variation is large between countries (Figure 1.2.7). In addition, further research for filling knowledge gaps in the area is required. A long-term approach is the "*Exposome*" (Wild 2005), highlighting the need for complete and integrated environmental exposure assessments, including chemicals and health risks posed by a mixture of components and bio-cumulative threats (**More...16**).

Biomonitoring programmes, Health Impact Assessments (HIAs) and risk management of priority substances, such as mercury, lead, persistent organic pollutants (POPs), asbestos, polycyclic aromatic hydrocarbons (PAH), chlorinated solvents, along with carcinogenic, mutagenic and reprotoxic chemicals, should be supported and improved.

Figure 1.2.7: Types of chemicals addressed by policies and plans in the region



Source: WHO 2015c

There is a strong need to establish overall chemical management systems in the region. Expert guidance and basic legislation should be put in place to implement the *Globally Harmonized System of Classification and Labelling of Chemicals (GHS, UNECE),* supporting also the Strategic Approach to International Chemicals Management (**More...17**).

The way urban, industrial and waste electrical and electronic equipment (WEEE) are managed and their implications for human health is a priority in the pan-European region. Waste can cause major environmental and health problems due to toxic contents. An increasing waste burden counteracts sustainability and a circular economy. Waste exposure impairs people's daily lives and results in health hazards such as cancer and cardiovascular, respiratory and neurological diseases (Mattiello *et al.* 2013; Marsili *et al.* 2009; Rushton 2003). Although the management of waste is improving, the amount of WEEE is growing.

1.2.6 Food systems, health and the environment

Food connects ecosystems and health

Basic health is dependent on optimal nutrition and food security, which depends on maintaining soil quality, availability and food diversity. Food production and consumption have major impacts on both health and environment. The impact of changing diets over time on land requirements is demonstrated in Figure 1.2.98.

Disruption of food systems and health by disconnecting from the environment

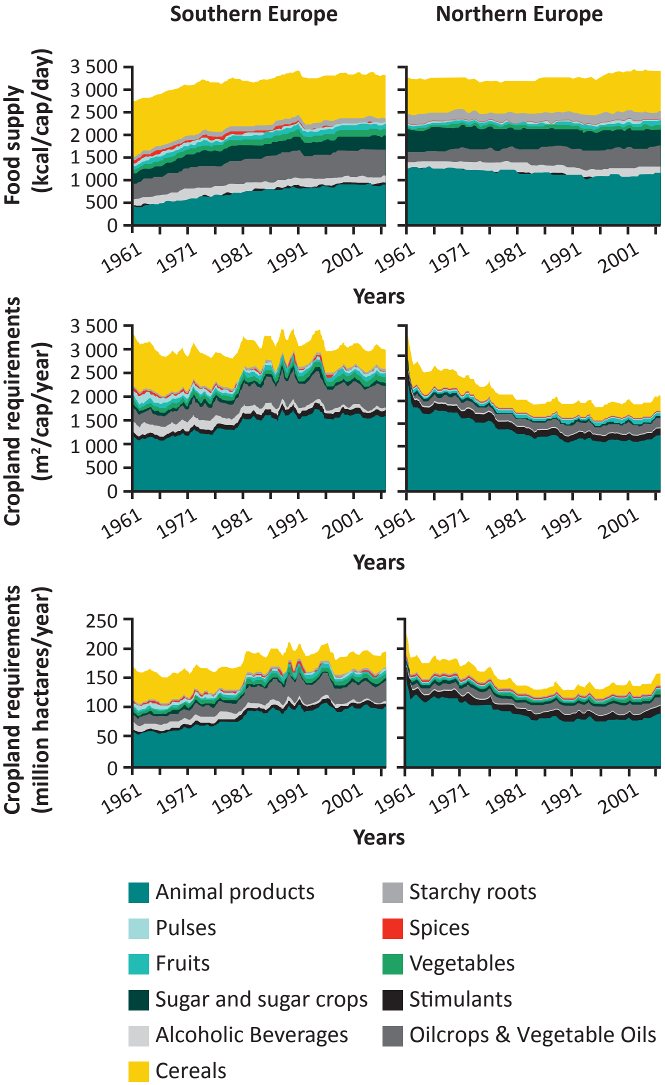
Broken or disrupted food systems negatively influence both environment and health. Analysis of the Global Burden of Disease Study 2010 (WHO 2013a) shows that diet is a major health issue in the pan-European region. Malnutrition including undernutrition, micronutrient deficiencies, overweight and obesity, as well as NCDs resulting from unhealthy diets, have high social and economic costs for individuals, communities and governments.

The development of agriculture and ecosystem exploitation has differed greatly across the region, and has led to dysfunctional systems due to issues such as food waste, inefficient agriculture and abandoned productive lands in Central Asia due to loss of subsidies and uneconomic systems. In Western Europe, a vast amount of productive land has been lost to sealing and degradation by development for increasing urbanisation and infrastructure (**More...18**). The current intense pattern of use in Western Europe is driving deterioration and pollution of soil and surface water, food quality and diversity (**More...19**).

Non-sustainable and sustainable food systems

High meat demand and dependency on crop agriculture for livestock make current food systems unsustainable (Foley

Figure 1.2.8: Implications of changes in per-capita food supply for cropland requirements, per capita and million hectares in Southern Europe and Northern Europe



Source: Kastner *et al.* 2012

2013; Foley 2011). Food waste amounts to 33 per cent (1.3 billion tonnes a year) of all food produced, meaning that 28 per cent of farmland is used to grow food that is thrown away (EEA 2012; FAO 2011). Food and drink production also contribute to large amounts of GHG emissions. Other unsustainable factors are dependence on fertilizers, herbicides and pesticides, conflicting water demands and polluted soil.

Whether genetically modified organisms (GMOs) and crop varieties provide an answer to the food system challenge is currently the subject of debate, as whilst this technology could protect against pests and pathogens, its overall ecological impacts might bring significant problems to ecosystems and biodiversity.

However, important developments and innovations are being made in breeding techniques, (More…20) supervised by the European Academies Science Advisory Council (EASAC) for policy advice (EASAC 2015).

Ecological intensification, using land and resources in ways that minimise negative ecosystem impacts while maintaining agricultural productivity, is another proposed way for a sustainable increase of crop yields (FAO 2013) (More…21).

Locally-sourced food should provide long-term benefits to both environment and health in the pan-European region (More…22). Also, organic food systems should be considered in terms of co-benefits and cost-efficiency (More…23). Such initiatives should be followed, in order to increase knowledge

Table 1.2.1: Approaches for developing sustainable food systems

Approaches	Examples
1. Sustainable dietary guidelines	Merge nutrition and environmental advice More plants, fewer animals
2. Tackle consumer culture	Tax advertising (not information) Nudging Cultural messages based on the SDGs
3. Common sustainable food policy	Higher monetary incentives to primary growers for shorter supply chains More horticulture, less agri(meat)culture

and evidence and to initiate implementation for sustainable production.

Three major tracks have been identified for developing sustainable food systems (Lang 2015) (Table 1.2.1).

1.2.7 Creating sustainable urban health

Most people live in cities in Europe

In 2005, about 70 per cent of Europe's population lived in cities and up to 80 per cent are expected to do so by 2030 (UNDESA 2011). The degree of urbanisation varies widely, with the western part of the region being more urbanised than the eastern part and Central Asia (Figure 1.2.9), though those regions are expected to see a rapid urbanisation in coming decades. This puts pressure on cities' infrastructures - such as housing, green spaces, electricity, drinking water and sanitation - and may adversely affect residents' quality of life.

The highest urbanisation level is to be found in Belgium (97 per cent), while the Caucasus and Central Asia are less urbanised, ranging down to 35 per cent in Kyrgyzstan. Iceland and Israel, both outside the map are both highly urbanised (93 per cent and 92 per cent respectively).

Urban environment-health interactions are multi-faceted and interactive (Figure 1.2.10). Increasing urbanisation requires integrated health and environmental management in order to make cities liveable for all and reduce harmful impacts.

Figure 1.2.9: Percentage of population being urbanised in each country, 2010

Source: IHPH 2013

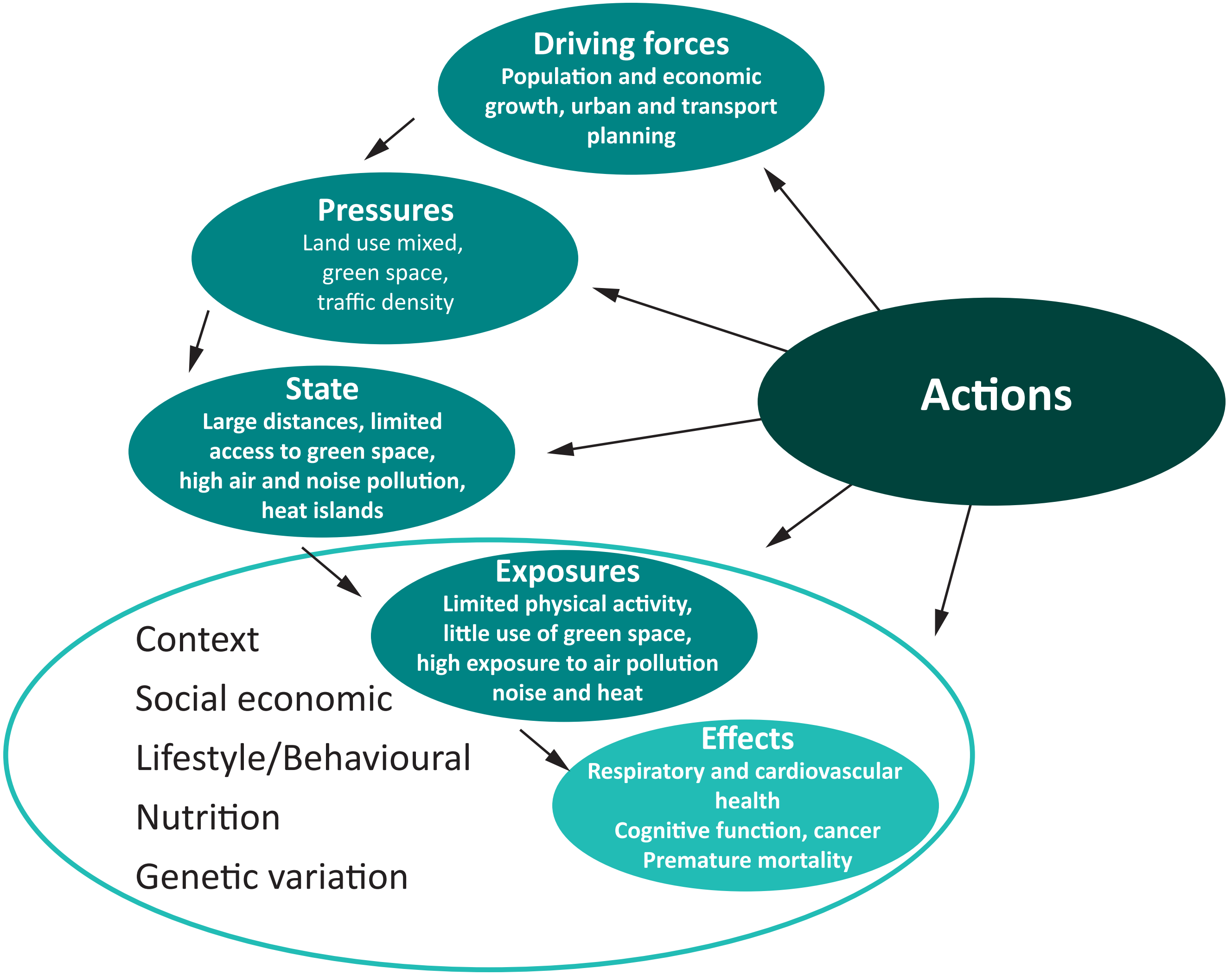
The city creates wealth, but also disease and health inequalities

While cities are centres of innovation and wealth creation, they also have high pollution levels and other adverse environmental exposures including noise and UHI. Additionally, mental disorders are more common than in rural areas (Krabbendam and Van Os 2005; Peen *et al.* 2010).

To achieve healthy cities further action needs to be taken for better visions and concerted research and action involving all stakeholders, providing more holistic solutions.

Many urban dwellers use *passive transportation* and do not reach recommended physical activity levels (Mueller *et al.* 2016; Nieuwenhuijsen 2015), with increased prevalence of

Figure 1.2.10: A model of environment-health interactions in cities



Source: EU 2015

NCDs as a consequence. The removal of open and green spaces, following densification, also impairs public health by reducing opportunities for physical activity, stress recovery and other urban ecosystem services (Donovan *et al.* 2015; Donovan *et al.* 2013) especially in deprived areas, which tend to be more grey and barren (Joshi *et al.* 2005). The aspects of physical activity and green spaces have been approached from an urban planning perspective in, for example, Copenhagen (Denmark), aiming for a CO_2 neutral city by 2025, and Astana (Kazakhstan), planning for an urban green cover of above 50 per cent (**More...24**).

Urbanisation creates income and opportunity disparities between socioeconomic groups, boosting social tensions and health inequalities (Hawkins *et al.* 2013). Spatial distribution of health threats and assets need to be considered when planning for healthy cities, and tools for monitoring and localising health inequalities in cities should be developed (**More...25**).

Systematic approaches and increased interactions and collaboration between different sectors and disciplines; for example, urban and transport planners, environment, energy

Table 1.2.2: Policy objectives for healthy urban planning

Spheres of the Health Map	Objectives for Healthy Urban Planning
1. People	• providing for the needs of all groups in the population • reducing health inequalities
2. Life-style	• promoting active travel • promoting physically active recreation • facilitating healthy food choices
3. Community	• facilitating social networks and social cohesion • supporting a sense of local pride and cultural identity • promoting a safe environment
4. Economy and population	• promoting accessible job opportunities for all sections of the economy • encourag ing a resilient and buoyant local economy
5. Activities accessible to all	• ensuring retail, educational, leisure, cultural and health facilities are provided • providing good quality facilities, responsive to local needs
6. Built environment	• ensuring good quality and supply of housing • promoting a green urban environment supporting mental well-being • planning an aesthetically stimulating environment, with acceptable noise levels
7. Natural environment	• promoting good air quality • ensuring security and quality of water supply and sanitation • ensuring soil conservation and quality • reducing risk of environmental disaster
8. Global ecosystems	• reducing transport-related greenhouse gas emissions • reducing building-related greenhouse gas emissions • promoting substitution of fossil fuel use by renewable energy • adapting of the environment to climate change

The two "Sphere 1" objectives relate to the principle of "health for all" and cut across all the other objectives.
Source: WHO 2010b

and public health, are urgently needed to reduce the current disease burden related to urban living (Bettencourt *et al.* 2007).

Resilient and health-promoting cities: an ongoing trend?

Urban planning is essentially a public health phenomenon (Table 1.2.2), as also expressed in the *Health in all Policies* (HiAP) approach (WHO 2010a). This relation is increasingly being recognised in some cities and in concepts such as Healthy *Cities*, *Green Cities* and *Sustainable Cities*. Healthy urban planning is also a theme of the UNECE Committee on Housing and Land Management (CHLM) and its subsidiary body, the Working Party on Land Administration (WPLA). The Geneva UN Charter on Sustainable Housing and Strategy for *Sustainable Housing and Land Management* 2014-2020 is also related. This means that aspects of health promotion are included in planning and design of spaces and green infrastructure approaches are considered, recognising health benefits from green spaces providing nature-based solutions for sustainable health and environments (**More...26**).

1.2.8 The integrated approach for health and environment: actions and strategies

Achieving the SDGs and an integrated approach

Health is intrinsically part of sustainability. Health is only expressed explicitly in goal 3, "Ensure healthy lives and promote well-being for all at all ages", though improved health is dependent on the achievement of the other 16 goals. Several SDGs contain health-related targets, recognizing it as a precondition, an outcome and an indicator for sustainable development. Therefore, the successful implementation of the SDGs will lead to improvements in human health and well-being. However environmentally-related health problems persist and continue to emerge. These currently - and will continue to - compromise efforts to achieve the SDGs in general and SDG 3 in particular.

Environmental health determinants should be emphasized and added to social and cultural determinants, creating a system of socio-ecological determinants for policy solutions. Impact assessments can be helpful tools for identifying health outcomes (**More...27**). Integrated, inter-sectoral and inter-generational approaches to address environmental and health effects need to be implemented both in policy and practice (**More...28**). The WHO's call for Health in all Policies (*HiaP*) (Leppo *et al.* 2013) and its implementation can be further strengthened in countries in the region and will support the integrated approach.

Four integrated actions and strategies are suggested at the global level to improve human health and well-being through environmental sustainability; these are equally applicable to the pan-European region based on the regional priorities:

Detoxify: The region needs to continue to address air pollution especially in cities; for some parts of the region, improving access to safe drinking water and access to sanitation facilities remains important to improve health; as well as implementing the sound management of chemicals and improving waste management and reduction of wastes.

Decarbonize: The region needs to continue to move away from reliance on fossil fuels and avoid locking in carbon through unsustainable built development and infrastructure. Sustainable energy, agricultural and transportation systems combined with a continued focus on sustainable cities will contribute significantly to improving human health and well-being.

Decouple resource use and change lifestyles: Higher levels of development tend to come at a higher cost to the environment. Decoupling of resource use from environmental impacts - in particular pollution and wastes - as part of the transition to an inclusive green economy is required. Education for sustainable development has a significant role to play in enabling the shift towards sustainable consumption patterns, responsible consumer behaviour and stronger engagement of society in healthy lifestyles, which in turn will support improved human health and well-being.

Enhanced ecosystem resilience and protecting natural capital: In the pan-European region, the need to restore, conserve and enhance natural capital remains at the core of improving human health and well-being for now and for future generations. Sustainable agriculture and fishing, restoration of degraded and abandoned lands, reversal of the continued loss of biodiversity and degradation of ecosystem services, combined with a greater appreciation of the intrinsic value of nature, will all support an improved environment and health outlook. The region also needs to build resilience, reduce vulnerabilities and develop preparedness to address changing disease scenarios based on a changing environment.

See references to Chapter 1

See links to Chapter 1

A successful Europe is a healthy Europe

The SDGs present a further opportunity to reinforce progress and implement the goals set out through the European Environment and Health process. Consideration needs to be given to evaluating the region's success in transitioning to a sustainable future relative to human health and well-being and resilient ecosystems, rather than economic growth. Measures such as the Inclusive Wealth Index capture a much broader perspective from which to understand the relationship between a healthy environment and a healthy society.

CHAPTER 2

Environmental State and Trends

2.1 National state of the environment reporting

2.1.1 Shared Environmental Information System

A large amount of data across the 54 countries of the region relating to the state of Europe's environment exists for policy-making and public use. In 2008, the European Commission (EC) called for a Shared Environmental Information System (SEIS) to be established (EC 2013a, 2008a); this was followed up by a decision at the Seventh "Environment for Europe" (EfE) Ministerial Conference, held in Astana (Kazakhstan) on 21-23 September 2011, to establish a regular process of assessment, and to develop SEIS across the region and associated performance indicators (UNECE 2014a, 2011a).

The 7th EfE Ministerial Conference was held in Astana (Kazakstan) in 2011
Credit: Shutterstock/ppl

The aim of SEIS is to connect existing databases and information flows, make data more accessible, support regular progress reviews and assessments by national authorities, increase the comparability of indicators, facilitate sharing amongst information networks and harmonise environmental monitoring requirements for Multilateral Environmental Agreements (MEAs) and internationally agreed environmental goals (IaEGs). SEIS is now being used to facilitate access to data and information in common formats for 67 data sets across seven thematic areas, including: air pollution, air quality and ozone depletion (25); climate change (4), water (20), biodiversity (4), land and soil (2), energy (4) and waste (8) (UNECE 2015a). These are linked to the performance of each Economic Commission for Europe (ECE) Member State to provide information to global and regional MEAs.

Authorities across the region regularly publish national state of the environment (SOE) reports. The EEA draws on the national reports from its 33 member countries (28 EU Member States plus Iceland, Liechtenstein, Norway, Switzerland and Turkey) and six co-operating countries in the west Balkans and used these to produce *The European environment - state and outlook 2015 report* (EEA 2015a). For the wider pan-European region, the UNECE undertakes Environmental Performance Reviews (EPRs) for its Member States in Central Asia (5), Eastern Europe and the Caucasus (7), South Eastern Europe (1) and Western and Central Europe (2). The most recent include the third cycle EPRs of Belarus (UNECE 2016a) and of Georgia (UNECE 2016b), that also address policy frameworks for greening the economy and describe specific green economy initiatives in each country.

The majority of countries across the region also provide online access to their data and reports in at least one UN language as well as their own national language, thus increasing public access and sharing, for example *Kazakhstan's SOE report 2011-2014*, *the Kyrgyz Republic's SOE* and the *ECOPORTAL* hosted by the Interstate Commission on Sustainable Development (ICSD) in Central Asia. National initiatives and online platforms established by countries in Eastern Europe, the Caucasus and Central Asia (EECCA), aimed at increasing public access to state of environment information and data, are continuously being improved under the scope of relevant processes supported by UNECE, UNEP and the EEA towards the implementation of SEIS in the pan-European region.

◄ Credit: Shutterstock/Soloviova Liudmyla

2.1.2 Overall pan-European State of Environment findings

The latest findings for the 33 EEA member and six cooperating countries in the region show that whilst there has been progress in controlling air and water pollution, risks to human health, plus short-term encouraging trends in resource efficiency and decoupling resource use from economic growth, there remain unfavourable or negative trends in soil productivity, land degradation and biodiversity loss, with climate change impacts projected to intensify (EEA 2015a). Air quality, noise pollution and exposure to chemicals continue to cause serious health problems. The outlook for coming decades therefore remains uncertain.

For EECCA countries, EPRs by UNECE indicate some positive trends in biodiversity conservation and forest management. However, throughout the EECCA countries, air and water pollution, greenhouse gas emissions, over-abstraction and water losses, wastewater and solid waste management remain problematic. The causes are multiple, and include poor economic growth, inefficient technologies in industries, poor infrastructure, insufficient institutional funds, lack of legal underpinning, low enforcement and lack of awareness. The effects of climate change, especially drought, desertification and soil erosion are especially critical in Central Asia.

Air pollution in cities is a health concern for the entire region
Credit: Shutterstock/BeeZeePhoto

The benefits of tackling negative environmental trends in terms of improvements in sustained economic growth and human health have been well described, for example in air quality (Henschel *et al.* 2012). Worldwide there has been a reduction over the decade 2002-2012 in deaths attributable to infectious, parasitic and nutritional diseases (31 per cent to 20 per cent), due to more people having access to safe water and sanitation and fewer households using solid fuels for cooking. Nonetheless, there has been a rise in deaths due to non-communicable diseases (NCDs) attributable to the environment (22 per cent) (Pruss-Ustun *et al.* 2016). In Europe environmentally related deaths in 2012 were 538 000 for OECD countries and 877 000 for non-OECD countries (Pruss-Ustun *et al.* 2016).

There is also wide agreement in the international community, that stricter environmental standards do not necessarily alter trade flows or foreign investment decisions or determine international competitiveness. However, well-designed policies and effective institutions to enforce legislation, monitor change and implement actions to avoid environmental degradation and the possibility of crossing certain critical thresholds is required.

In the sections that follow, the five regional priorities: climate change, air quality, biodiversity, chemicals and waste, and freshwater; and the two additional thematic areas 'coastal, marine and oceans' and 'land' are presented using the DPSIR framework (**More…29**), underlining current trends, impacts, and policy responses.

2.2 Climate change

Main messages: Climate change

- Climate change is one of the largest threats to human and ecosystem health and to achieving sustainable development; it is exerting multiple and interlinked pressures on the environment that are having adverse effects on environmental, social and economic sustainability.
- The EU has been at the forefront of introducing ambitious mitigation-related policies, and the results can already be witnessed in terms of a decline in emissions by 21 per cent between 1990 and 2013, with an absolute decoupling from GDP that increased by 45 per cent over the same period. In Eastern Europe, Caucasus and Central Asia emissions are now increasing although still below the 1990 level. Only South Eastern Europe is experiencing an increase of emissions by 175 per cent since 1990.
- To meet the Paris Agreement's goal of holding the increase in the global average temperature to well below 2 °C above preindustrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above preindustrial levels, more action will be needed across the region on mitigation, including consideration of exports of emissions in mitigation strategies and targets.
- More effort will be required in the pan-European region to ensure that adaptive measures are applied to priority areas such as: water management including irrigation; agriculture through improved cultivars suited for warmer climates; human health in respect to infectious diseases; and the protection of terrestrial and marine biodiversity and ecosystems.
- Carbon capture and storage in the EU appears unlikely to deliver the planned contribution to the overall carbon reductions required to meet the 2050 climate targets. Emerging carbon capture and utilisation technologies offer an alternative approach that is gaining interest and have the potential to be built into the circular economy.

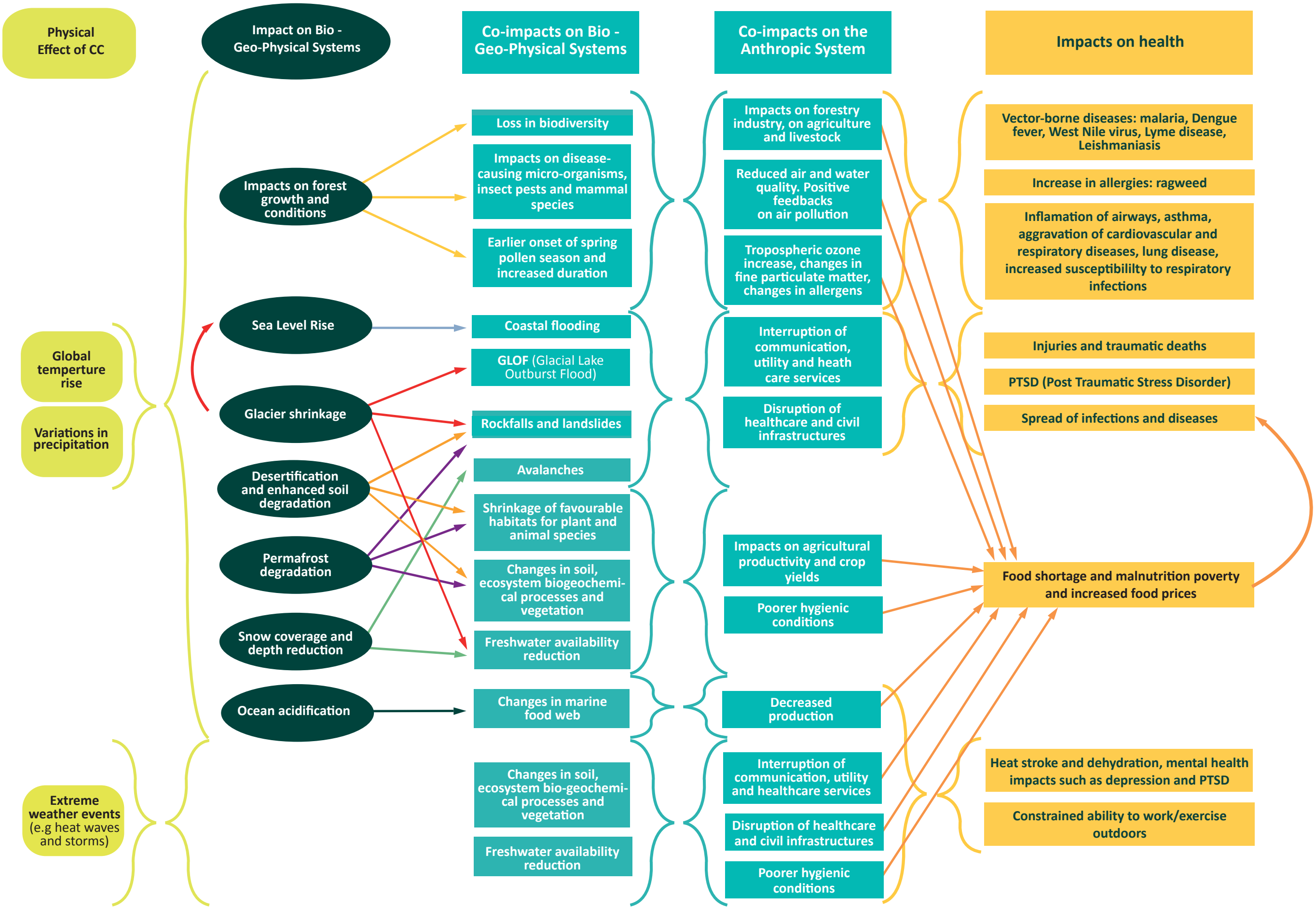
2.2.1 Climate change: one of the largest threats or health opportunities of our time?

Climate change has been described as the "largest health threat of the 21st century" (Costello *et al.* 2009). Human health and ecosystems are affected in many ways by climate change through a multiplicity of pathways, including the supply of food and nutrition, premature deaths due to heat waves, floods and other extreme weather events, to ecosystem changes that can increase exposure to allergens and enhance the spread of disease (Figure 2.2.1). Section 1.2 elaborates on these in greater detail. As an example, the heat wave experienced in 2010 in the northern hemisphere resulted in 54 000 cumulative excess deaths in the Russian Federation during July and August (Safronov *et al.* 2015). While individual events cannot be completely attributed to anthropogenic climate change (Trenberth *et al.* 2015; Rahmstorf and Coumou 2011) or internal variability (Dole *et al.* 2011), it is clear that the frequency of such events and health impacts will increase as the climate warms (Trenberth *et al.* 2015; IPCC 2014a). Therefore, mitigation and adaptation policies will help deliver significant improvements not only in public health (Wang and Horton 2015), but also in terms of human well-being and ecosystem functioning.

2.2.2 Regional climate-related changes and outlooks

Temperature and precipitation: Across the region, there has been a linear trend in temperature rise from 1980–2009, showing a 0.19–0.31°C per decade warming, with lower

Figure 2.2.1: Overview of the links between different impacts of climate change: from physical effects to impacts on bio-geo-physical and anthropic systems and on health

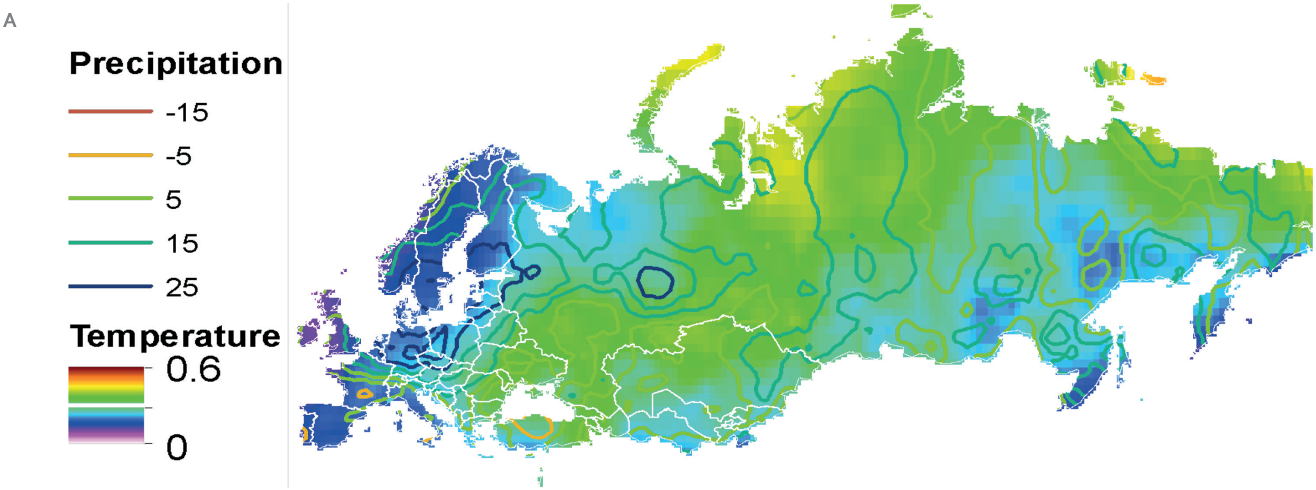


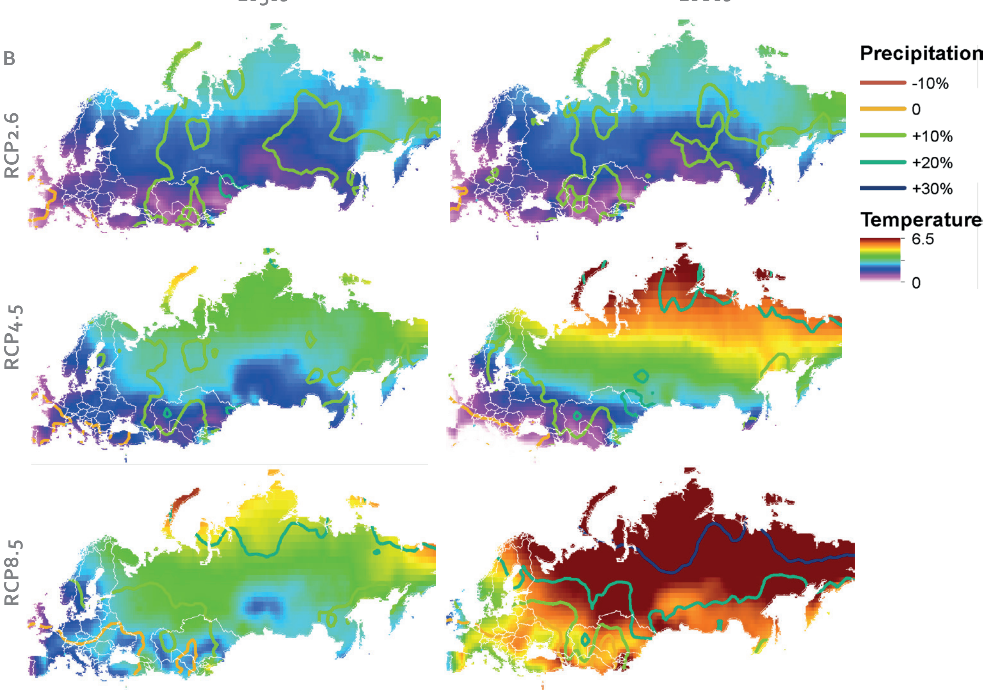
Source: Adapted from Watts *et al.* 2015

recorded temperature increases in the west and higher in the east. Over the same period, annual precipitation increased by 13–16 mm per decade over Northern and Central Europe, 5 mm in Central Asia and 2 mm in the Caucasus (Figure 2.2.2a).

Snow and ice: Since 1850, glaciers in the European Alpine region have lost approximately two thirds of their volume, with a clear acceleration since 1980 (Haeberli *et al.* 2013; World Glacier Monitoring Service 2013; Diolaiuti *et al.* 2011; EEA 2004). The largest ice area reduction is associated with small glaciers of <1 km^2 that are important contributors to Alpine water resources (Citterio *et al.* 2007), due to their whole surface area becoming year-round ablation zones (Kaser and Osmaston 2002). Outside the European Alpine chain (i.e. glaciers in Norway, Iceland, Svalbard and the Altai mountains and elsewhere), the changes are smaller (Smiraglia *et al.* 2015), with some glaciers in Norway unchanged or increasing in size, although the general trend

Figure 2.2.2a and b: Recent and projected regional trends in temperature and precipitation.





Explanation: A: trends in the surface air temperature (°C per decade) and annual precipitation (mm per decade) for 1981-2010; B: GCM projections of future change in mean annual temperature (°C) and annual precipitation (mm). The mean over 16 Coupled Model Inter-comparison Project Phase 5 (CMIP-5) general circulation models (GCMs) run under the three representative concentration pathways scenarios RCP2.6 (top panel), RCP4.5 (middle panel), and RCP8.5 (bottom panel) emissions scenarios is presented. Temperature change is computed as the difference between the future and base (1981–2010) data; precipitation isolines are a ratio between the future and current data.

of glacier recession is there as well (Andreassen *et al.* 2008; Nesje *et al.* 2008). Glacier retreat contributed to a global sea-level rise of 0.8mm per year in 2005-2009 (Vaughan *et al.* 2013), significantly modifying regional hydrology and

Retreating glacier in the French Alps
Credit: Shutterstock/patjo

In 2011, high tide flooded the San Andres neighbourhood in Canary Islands, Spain – a consequence of rising sea levels
Credit: Shutterstock/CANARYLUC

contributing to loss of geo- and biodiversity (Haeberli *et al.* 2013). Under current climate conditions, snow cover is present for more than 70 per cent of the year in the Russian Federation northward of 60°N, except in the lowland areas west of the Yenisei River; but across the pan-European region it has been diminishing, especially in mountain areas (Beniston *et al.* 2011; CH 2011).

Substantial, near-surface permafrost degradation has been observed, especially in the Russian Federation where >60 per cent of the land is permafrost, with thaw-depth deepening leading to destabilised landforms, vegetation and infrastructure (EEA 2015c; Zhang 2008; Smith and Burgess 1999) (**More...30**). There has also been a fast warming of the upper layers of European Alpine permafrost by 0.5 to 0.8°C (Harris *et al.* 2003), and during the extremely hot and dry summer of 2003, many rock-fall events originated from permafrost in steep bedrock, leaving massive ice-exposed detachment zones (Gruber and Haeberli 2007).

Soil carbon: As a result of this freeze-thaw activity, the amount of soil-bound carbon has now been estimated to be more than three times what was previously thought; this is due to deep-soil mixing and microbial decomposition of stored carbon in sediments deposited over hundreds of thousands of years (Schuur 2013). Permafrost degradation and warmer soils provide positive feedback to the climate, triggering further release of greenhouse gases (GHG) and contributing to additional warming (UNEP 2012a; Michaelson *et al.* 1996).

Sea level rise: Most coastal regions in the pan-European region are experiencing sea level rise, with the exception of the northern Baltic Sea and the northern Atlantic coast. (**More...31**) Rising sea levels will present increased risks, including from storm surges and beach erosion.

Desertification and soil degradation: Although the level of desertification is lower in much of the pan-European region than in neighbouring regions, in Southern, Central and Eastern Europe, approximately 14 million ha (8 per cent of the territory) has a very high or high sensitivity to desertification, and more than 40 million ha have moderate sensitivity. This impacts on soil productivity and hence biodiversity and agriculture (**More...32**). In Central Asia, very high irrigation levels and water losses are exacerbating desertification. In Uzbekistan, for example, in 2007, 88 per cent of the population lived in areas under threat from desertification, a figure likely to increase due to climate change (UNECE 2010).

Climate change outlooks: Climate models show that trends in temperature and precipitation change under a strong mitigation emissions scenario versus a no-policy scenario (Figure 2.2.2b), with the largest anomalies seen at northern latitudes. These changes will have an impact on the existing natural and human systems, and create new risks for the region's economies, natural resources and human well-being.

Future projections show losses of glaciers in alpine areas of up to 98 per cent depending on the highest GHG scenarios, with several mountain glaciers disappearing within a few decades (Radic *et al.* 2013; Xu *et al.* 2012); sea level rise of 0.32 ± 0.05 metres by 2050 continuing over the course of the century (EEA 2014a; Rignot *et al.* 2011) shrinking of the Greenland plateau and thermally-induced expansion of water, yielding a multi-millennial sea level change of 1-3 metres per degree Celsius of warming; and a 50 per cent reduction in snow cover by the end of the century. The development of snowpack later in the year or a shorter duration of snow cover will occur as the climate warms, leading to increased soil freezing, increased fine root and microbial mortality, loss of soil nitrogen, change to surface water pH and hydrological disruption.

Schuur (2011) hypothesized that the extreme warming scenario RCP8.5 (i.e. +2.5°C Arctic warming by 2040, and +7.5°C by 2100) will degrade 9-15 per cent of the top three metres of permafrost by 2040, increasing to 47-61 per cent degradation by 2100 and 67-79 per cent by 2300. The potential carbon release from this degradation is estimated to be about 30-63 Gt (expressed as CO_2-equivalent) over the next three decades, reaching 234-380 Gt by 2100 and 549-865 Gt over several centuries. These values are 1.7-5.2 times larger than reported in modelling studies employing similar warming scenarios (Schneider von Deimling *et al.* 2012.

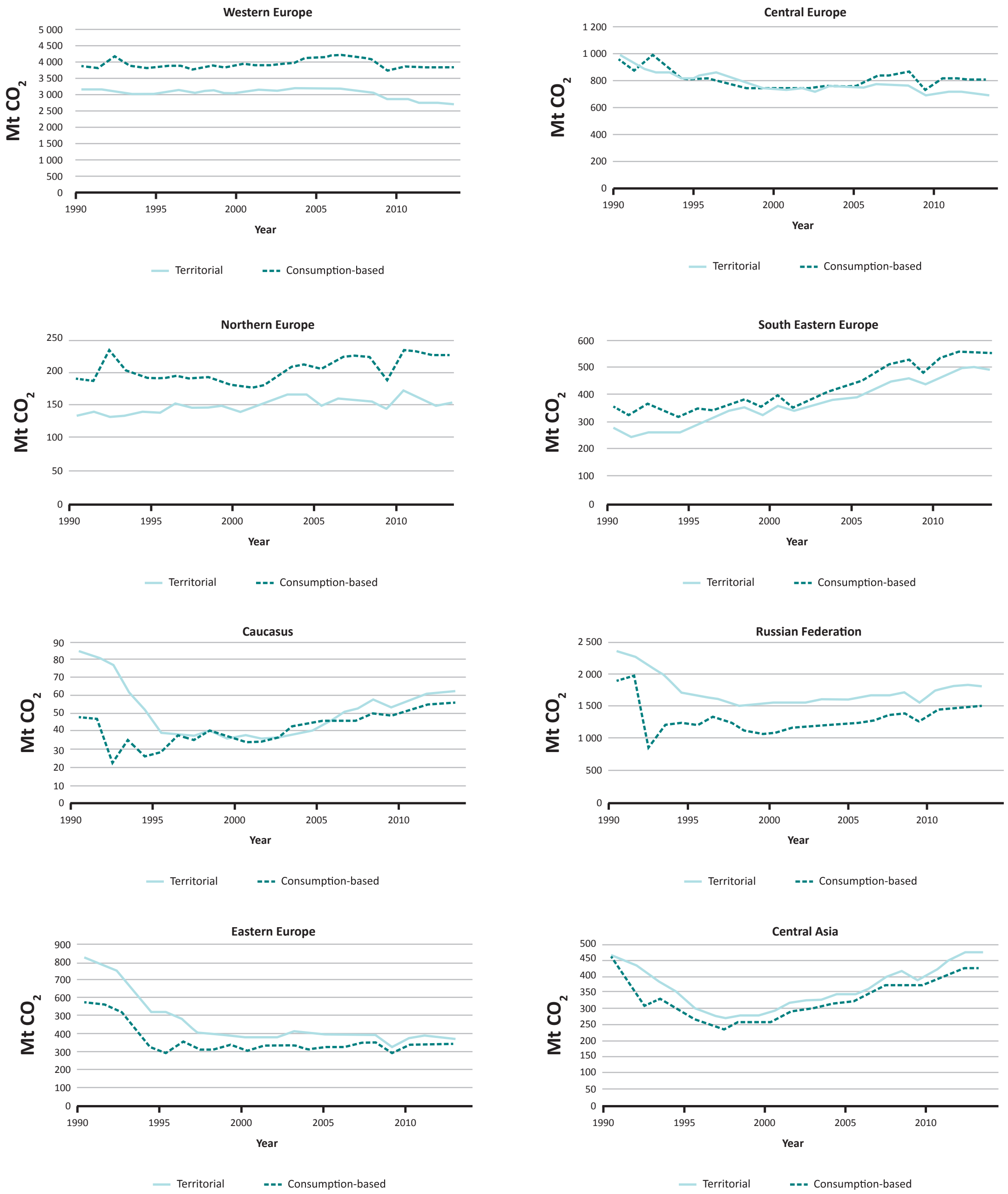
2.2.3 Region-wide greenhouse gas emissions

Since 1990, there has been an absolute decoupling in the EU between GDP and GHG emissions. Whereas the former has increased by 45 per cent, the latter has decreased between 1990 and 2013 by 1 203 million tonnes (21.2 per cent) (EEA 2015d). The EEA's analysis concludes that this was due to growing shares of renewables, less carbon intensive fuels such as natural gas in the energy mix, improvements in energy efficiency, significant reductions in the residential sector and the recession of 2008-2009. GHG emissions decreased in the majority of sectors, except for transport, refrigeration and air conditioning. The largest aggregate level reductions occurred in industrial electricity and heat production. Reductions in emissions from nitrous oxide (N_2O) and methane (CH_4) are also substantial, reflecting lower levels of mining activities and lower numbers of agricultural livestock, as well as lower emissions from managed waste disposal on land and from agricultural soils.

Reductions in greenhouse gas emissions in the region can be largely attributed to the growing shares in renewable energy
Credit: Shutterstock/Eugene Suslo

Across the region, territorial and consumption-based emissions (that is, the emissions embodied in a country's final consumption regardless of where they are produced (EEA 2015; Davis and Caldeira 2010) have also broadly declined or stabilised in Central, Eastern, Western and Northern Europe and the Russian Federation since the 1990s. However in South Eastern Europe (including Turkey), the Caucasus and Central Asia, they have been growing significantly, with South Eastern Europe experiencing an increase of 175 per cent between 1990 and 2012 (Figure 2.2.3). The largest emitter is Western Europe followed by the Russian Federation, with 40 per cent and 27 per cent of the total pan-European emissions for 2013 respectively (Global Carbon Project 2011; Peters *et al.* 2011).

Figure 2.2.3: Territorial and consumption-based carbon dioxide emissions in pan-European sub-regions, 1990–2013



Source: Global Carbon Project 2011; Peters *et al.* 2011.

A regional decomposition analysis of the drivers of greenhouse gas emissions (**More...33**) reveals that a major obstacle to a low-carbon economy is the increasing per-capita consumption of final goods and services. If all other factors had remained the same as in 1995, annual emissions would have increased by more than 1.0 Gt by 2009 in Western, Central and Northern Europe. In Western and Central Europe, technological improvements, higher energy efficiency, renewable energy sources and changes in the input structure of production have all helped to reduce emissions' growth. Furthermore, Western Europe has also contributed to technological improvements and the transfer of climate change mitigation technologies to other regions, particularly to the Asia and the Pacific region.

Changes in the structure of trade contributed to a small reduction of total pan-European emissions through the substitution of domestic production by imports, whereas for South Eastern Europe they contributed to an overall growth in emissions. Although rising per-capita consumption of final goods and services tends to increase emissions, changes in consumer choices for goods with lower embodied carbon have translated into lower total emissions. This is especially the case within the Russian Federation, where emissions have stabilised. Population growth has also contributed to the increase in emissions in region, but not in the Russian Federation nor in Central Europe.

Consumer choice plays a significant role in lowering GHG emissions
Credit: Shutterstock/Peter Bernik

2.2.4 Key impacts of climate change

The growing impacts of climate change on human and environmental systems in Europe include: declining agricultural productivity; increased risk of floods and droughts; threats to food security; increased demand for water; and negative effects on biodiversity (Kebede *et al.* 2015) (Figure 2.2.4). In Central Asia and the Russian Federation, increased desertification and water stress, permafrost thawing, movement and loss of key species, such as in the steppic regions, are all key emerging issues which will have impacts on the Russian Federation's grain belt (Dronin and Kirilenko 2011), along with land degradation in Central Asia.

Drought and decrease in agricultural productivity are some of the key impacts of climate change observed in the pan-European region
Credit: Shutterstock/New Punisher

2.2.5 Policy responses

Climate policy leadership

There have been substantial advances in climate policies over the past decade by EU Member States and several other countries in the region (EEA 2015d; EEA 2015e). The EU, Norway, the Russian Federation, Switzerland and Ukraine accepted legally-binding emissions targets under the first commitment period of the UN Framework Convention on Climate Change (UNFCCC) Kyoto Protocol, while the EU, Iceland, Liechtenstein, Monaco, Norway, Switzerland and Ukraine also accepted targets under the second Kyoto commitment period, up to 2020.

Figure 2.2.4: Key observed and projected impacts from climate change for the main regions in Europe

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

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

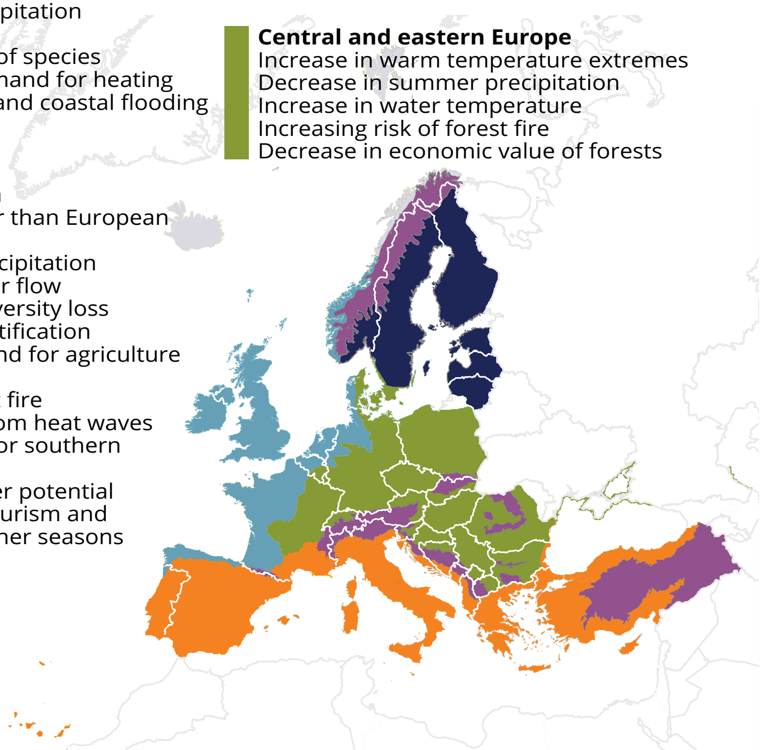
North-western Europe
Increase in winter precipitation
Increase in river flow
Northward movement of species
Decrease in energy demand for heating
Increasing risk of river and coastal flooding

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

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

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

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



Source: EEA 2012a

All other countries in the pan-European region have participated in the UNFCCC/Kyoto process, though in many cases without binding emissions targets, and in the Montreal Protocol to protect the stratospheric ozone layer that also contributes to reducing greenhouse gas emissions (Velders *et al.* 2007).

The EU has also been committed to finding climate change solutions (IEA 2014a) and assisting other countries to deliver on their commitments (Fischer and Geden 2015). The policy measures already adopted (**More...34**) are expected to deliver a 20 per cent emissions' reduction by 2020, when compared to 1990 levels (EC 2015a), rising to 40 per cent and potentially more by 2030 for the EU as a whole, although there remain some issues that impede their effectiveness when implemented by Member States (EC 2014a).

Every country in the region participated in the UNFCCC Paris Agreement (**More...35**), and submitted an Intended Nationally Determined Contribution (INDC), using either a base year target for GHG or a base year scenario, along with an intensity target. However, as the UNEP Emissions Gap Report shows, even with the added impetus of INDCs, the global emissions gap between the current policy projections and the emission levels consistent with the 2°C maximum remains substantial (UNEP 2015a).

Progress in the EECCA region

The development of climate change mitigation policy in many EECCA countries is still under development. To date, policies have lacked robustness or have not been supported by a strong institutional base, and consequently, have been poorly integrated into the economy (CAN 2015). In general, all sub-regional GHG emission reductions can be attributable to the economic decline of the 1990s, rather than implementation of low-carbon strategies.

Barriers to a lower carbon economy include the high energy intensity of some sub-regional economies, which tend to significantly exceed the average for Western Europe, weak energy efficiency governance and energy pricing policies that do not encourage investment in efficiency measures. Many of the EECCA countries have not taken advantage of the benefits of well-elaborated medium- to long-term energy strategies or policy-setting mechanisms (IEA 2014b). Thus far, half of the EECCA countries have targets for renewable energy generation, but few have specific mechanisms for its development, other than the introduction of green tariffs in Kazakhstan and Ukraine.

Further policy options and opportunities

Countries in the pan-European region could play an even larger role in making the Paris Agreement succeed. This is urgently needed in order to maintain an effective reference point for the multitude of local, national and regional measures seeking to meet global targets and thus support progress towards relevant SDGs. Many countries in the region, notably those that have no formal targets under the second commitment period of the Kyoto Protocol, could adopt and implement more ambitious INDCs, including national laws and regulations, in order to move towards per person and per unit of GDP emission levels that line up with the front-runners in the region.

There are many still unexploited opportunities to use enhanced international cooperation and funding to achieve stronger mitigation and adaptation measures in the poorer countries of the region. One of many examples is Uzbekistan, which is one of the most carbon-intensive countries in the world, and where international cooperation and funding could play a key role in reducing carbon-based energy subsidies and increasing investment in renewables and energy efficiency. For example, the European Investment Bank, which is the world's largest public financial institution, plans to increase support for renewables and energy efficiency and reduce funding for carbon-based energy production.

Public institutions and institutional investors have begun to pull out of carbon-stranded assets – assets that may lose economic value before the end of their expected lifetimes, mainly as a result of changes in regulations and technology. Market forces, environmental concerns and societal norms are considered significant factors contributing to shifting to low-carbon assets. The Fourth Swedish National Pension

Fund (AP4) and the *Fonds de Réserve pour les Retraites* (FRR) in France are examples of funds (re)allocating assets to low-carbon strategies. Greater efforts in this direction would clearly support GHG efforts at local to regional levels.

To fill the gap that still exists between global-level commitments and what is needed to stay within the 1.5ºC warming target by the end of the century, existing top-down mechanisms should be complemented with bottom-up initiatives in all countries of the pan-European region. A wide range of local-to-regional initiatives and measures have also emerged. These seek to facilitate implementation of existing commitments, but also to support further progress. For example, in the *Covenant of Mayors*, the mainstream pan-European movement involving local and regional authorities, individual mayors voluntarily commit to increasing energy efficiency and the use of renewable energy sources in their territories. As noted above, stronger national level commitments are needed to encourage bottom-up initiatives.

2.2.6 Climate change risks, adaptation actions and priorities

According to data from global re-insurance companies (Munich Re 2015), the number of natural disasters and related expenses appears to be increasing. While changes in frequency and sometimes signal strength might be associated with (regional) climate change – it is almost impossible to prove a direct specific relationship because of the limited number of statistically-significant cases and the mostly moderate climate change impacts likely to be expected for 2010–2020 – observational data tend to support the hypothesis that event frequencies and intensities are growing in the region. It is beyond doubt, however, that the related costs of recovery from extreme events are increasing, both for individuals and for societies. Monetary resources for important mitigation and adaptation investment or for improved public infrastructure are scarce.

Adaptation and mitigation are complementary strategies against climate change risks; adaptation can be both spontaneous or a deliberate intentional adaptive response (IPCC 2014a), but if not well-planned may increase vulnerability (Frantzeskaki and Loorbach 2010; Loorbach 2010; Carpenter and Brock 2008). Whilst mitigation policies are negotiated, decided and implemented at global-to-local levels, adaptation policies are dealt with mainly at national to local levels.

Contemporary house boats in Amsterdam are one form of adaptation adopted by the Netherlands
Credit: Shutterstock/DutchScenery

Currently, adaptation initiatives and their evaluation are still at an early stage in the region (EEA 2015c), and even though policies have been set up in most countries, they remain modest and differ strongly in ambition and implementation. Within the pan-European area, international coordination of adaptation measures is only just beginning, with the exception of the EU, in which efforts by the Netherlands and the UK are particularly advanced.

More effort will thus be required to ensure adaptive measures are applied to priority areas including: water management including irrigation; agriculture through improved cultivars suited for warmer climates; human health in respect to infectious diseases; and the protection of biodiversity, ecosystems and forests (Figure 2.2.5). Urban adaptation will also be needed to increase resilience to extreme weather events, particularly to high temperatures (Georgescu *et al.* 2014).

Figure 2.2.5: Top five adaptation priorities in the pan-European region

Source: National Adaptation Strategies, National Action Plans, UNFCCC reports and EEA 2014b

Shale gas drilling in the province of Lublin, Poland
Credit: Shutterstock/Nightman1965

2.2.7 Emerging issues

Shale gas using hydraulic fracturing

The exploration of unconventional fossil energy sources, including shale gas using hydraulic fracturing (fracking), has increased substantially in certain parts of the world such as North America, contributing to lower energy prices (BP 2015). Estimates suggest that unconventional gas, augmented by imported Liquid Natural Gas, could supply 60 per cent of Europe's gas (EC 2012a). However, concerns over the use of water and chemicals and the release of methane from the fracking process exist (European Parliament 2014), and shale gas does not appear to offer a climate benefit (IEA 2012). With unclear economic advantages and the goals set out in the Paris Agreement (UNFCCC 2015), meaningful exploitation of shale gas in Europe appears unlikely.

Carbon capture and storage and Carbon capture and utilization

Several recent climate analyses rely heavily on carbon capture and storage (CCS) to achieve ambitious climate goals requiring sequestration of 120 Gt CO_2 between 2015 and 2050 globally (12.2 Gt in Europe), CCS rates of 2 Gt/year by 2030, and 7 Gt/year by 2050 (IPCC 2014a; IEA 2013).

With cumulative worldwide storage of 0.05Gt CO_2 to date by CCS, including two projects in the EU-28 (IEA 2013; EC 2013b), such long-term scenarios seem unrealistic. For the EU-28, most scenarios assume that 19-32 per cent of electricity generation will use CCS to meet the 2050 climate targets (EC 2011a), a goal which will require an increase in European CCS capacity of 16-80 times over the next 30 years (EC 2013c).

The conversion of CO_2 into useable products including fuels, carbon capture and utilization (CCU), offers an alternative approach that is gaining interest. In 2014, 220 Mt CO_2 were used in the world-wide manufacture of plastics (Bennett *et al.* 2014), compared to the 130 Mt CO_2 anticipated in 2016 for use in the production of urea (CSLF 2013). The potential of CCU to complement CCS for producing a wide range of products including polymers and construction aggregates has been recognised in the EU and world-wide (SETIS 2016; Armstrong and Styring 2015). The CO_2 required could be captured by retrofitting cement and steel plants (Perez-Fortez *et al.* 2014). Further work in this area is required, including the important relationship between CCU and the developing "hydrogen economy".

Therefore, the inherent limitations of "end of-pipe" solutions such as CCS re-enforce the need to reduce GHG and exploit alternative management options for CO_2, especially in the circular economy.

Carbon Capture and Utilisation with Manufactured Aggregates

A recently available CCU process is the mineralisation of CO_2 in solid waste to produce products that can be used in construction. The technology used is an accelerated version of "natural carbonation", whereby CO_2 gas is converted to calcium carbonate (limestone). The managed process can be used to manufacture, for example, a carbonated aggregate that can be a substitute for virgin stone. The process is being applied to air pollution control residues in a zero emissions plant near Bristol (UK).

The aggregates have a structure similar to natural oolitic limestone and can be made from different solid wastes to meet European "end of waste" regulations and materials performance standards. By 2019, production capacity is anticipated to be 0.5 Mt/year, in which ca. 50 kt/year of waste CO_2 will be permanently captured (**More...36**).

Relevant Data and Indicators: *EEA; UNEP Live (EU, Central Asia); UNECE; UNFCCC*

2.3 Air quality

Main messages: Air quality

- Air quality is now the largest environmental health risk to the pan-Europe population. The proportion of the population living in areas exceeding WHO air quality guideline values varies by pollutant, with over 87 per cent of the EU population exposed to high levels of fine particles ($PM_{2.5}$) and 98 per cent to high levels of ozone (O_3)[6]. Pollutants of concern include particulate matter, ozone and nitrogen dioxide. Over 500 000 premature deaths were attributable to ambient air quality and 100 000 to indoor air quality in 2012. Air pollutants continue to damage ecosystems and the built environment, and also influence climate change.
- Human behavior, lifestyle, consumption patterns and transport options override all other factors that influence air quality in the pan-European region. Yet lifestyle changes have enormous – and cost-neutral – potential to improve the situation, compensating for often very expensive technological "fixes".
- Current legislation will deliver only slow progress beyond 2030 therefore additional policies and measures to improve air quality are essential. New legislation is particularly needed for pollutants such as black carbon (soot) and ultrafine particles, which can induce or exacerbate various diseases, but are currently unregulated.
- Advanced understanding of the benefits and feasibility of better air quality control measures and implementation of the best-available technology in industry, vehicles, ships, agriculture and installations for domestic combustion, could dramatically improve current conditions.
- There are a range of persistent bio-accumulative and toxic substances affecting indoor air quality which are found in household products and that are a concern for human health. There is a considerable knowledge gap and only rudimentary legislation in place for indoor air pollution, especially in private homes. Educational awareness programmes may help to reduce exposure to indoor air pollutants.

6 EEA, 2015. Air Quality in Europe: 2015 Report. EEA Report 5/2015. European Environment Agency (EEA), Copenhagen

2.3.1 Clean air is essential for human health and ecosystem functioning

Clean air is essential for human well-being and ecosystem health. Over the past century, releases of gases and particulates derived from industrial processes and other human activities have led to significant changes in the composition of the atmosphere, many of which have been linked to detrimental effects on human health, ecosystems and the built environment. The most recent data (Maas and Grennfelt eds. 2016; Pruss-Ustun *et al.* 2016) show that air quality is now the largest health risk to Europe's population. The proportion of the population living in areas exceeding WHO air quality guideline values varies by pollutant, with between 87-93 per cent of the EU population exposed to high levels of fine particles ($PM_{2.5}$), 61-83 per cent to PM_{10}, and 97-98 per cent to high levels of ozone (O_3)[7]. The latest estimate of premature deaths associated with the environment is 12.6 million people worldwide, representing 23 per cent of all deaths annually (Pruss-Ustun *et al.* 2016). Air pollution is a significant contributory factor. For ecosystems, excess deposition of nitrogen is a major cause of species loss, growth in grasses and eutrophication, while acidification and ozone concentrations have reduced potential wood and crop production in the pan-European region by up to 15 per cent (Maas and Grennfelt eds. 2016; EEA 2015f).

Today, all major primary and secondary air pollutants (i.e. directly emitted to the atmosphere or formed in the

7 EEA, 2015. Air Quality in Europe: 2015 Report. EEA Report 5/2015. European Environment Agency (EEA), Copenhagen

Box 2.3.1: Major air pollutants of concern in the pan-European region

- *Particulate matter (PM)*: emitted directly and formed in the atmosphere. Primary forms arise from natural sources such as sea salt, naturally suspended dust, pollen and volcanic ash and from anthropogenic sources such as household burning of solid fuels, road transport and heat and power production. Secondary particulate matter is formed from precursor gases, including sulphur dioxide (SO_2), nitrogen oxides (NO_x), ammonia (NH_3) and volatile organic compounds (VOCs), that react and coalesce to form secondary inorganic aerosols. PM includes ultrafine particles, < 0.1 micrometres in diameter which are emitted from traffic, domestic heating and industrial processes; they have little mass but high numbers and surface area concentrations, and a high content of elemental and organic carbon.
- *Black carbon (BC)*: made up of the light-absorbing carbon constituent of aerosol particles, and emitted directly from the incomplete burning of fossil fuels, biomass and biofuels, particularly from diesel vehicles, mobile machinery, ships, residential heating (e.g. small coal or wood burning stoves) and open biomass burning (e.g. forest fires or burning of agricultural waste) (EEA 2015f; UNEP and WMO 2011).
- *Ground level ozone (O_3)*: a secondary pollutant, formed through chemical reactions in the presence of sunlight and heat between emissions of precursor gases including nitrogen oxides (NO_x) and non-methane volatile organic compounds (NMVOCs) from transport, industrial activities and solvents and organic carbon, carbon monoxide (CO) and methane (CH_4) at the continental scale.
- *Nitrogen oxides (NO_x)*: emitted from power plants and vehicles and mainly comprised of nitrogen monoxide (NO).
- *Sulphur oxides (SO_x)*: emitted from domestic heating, power generation and transport and from volcanoes as a natural source.
- *Methane (CH_4)*: emitted from agriculture, waste management and energy production and although not strictly a pollutant, it is a precursor of ground level O_3.
- *Polycyclic aromatic hydrocarbons (PAH) including as benzo(a)pyrene (BaP)*: emitted from the incomplete combustion of fuels, fires and domestic heating, in particular wood- and coal-burning, waste burning, coke and steel production and road traffic. As with other persistent organic pollutants, these can undergo reversible atmospheric deposition and so "re-pollute".
- *Hazardous chemicals including POPs and heavy metals including:* mercury (Hg), as well as arsenic (As), cadmium (Cd), lead (Pb) and nickel (Ni) are emitted from combustion of fossil fuels, waste incineration and metal incineration.

atmosphere from precursor gases (Box 2.3.1)) are regulated or monitored on a systematic basis by national governments and assessed by two key regional bodies, the EEA and UNECE. The effects of these pollutants can be both localized, for example, particulate matter (PM) and ozone (O_3) impacts on human health, and regional and hemispheric, for example, the effects of ozone and black carbon on the radiative balance of the planet. Significant concentrations of secondary pollutants in fine particles in cities are also caused by long-range transport of ammonia, sulphur and nitrogen oxides. The complexity of the reactions and the chemical behaviour of pollutants under different atmospheric conditions means that climate change will have a significant impact in the future on air quality in the region (EEA 2015f; UNEP and WMO 2011).

2.3.2 Multiple drivers of air pollution

Multiple drivers have been identified that impact on air quality in the pan-European environment, but lifestyles and consumption patterns, including transport are having the greatest effects. Some related sectoral policy-driven changes, such as the abolition of leaded gasoline across the region and the implementation of clean air acts have had immediate and positive effects.

Population growth and increasing energy demand

While dwindling and ageing populations characterize most sub-regions in the pan-European region, they are increasing in Central Asia. In conjunction with urbanization, steady albeit uneven increases in material well-being are resulting in higher energy demand per person. This includes demands for heating and cooling in houses and business premises, increasing amounts of consumer goods and agricultural products, greater vehicle usage and mobility, all with related emissions. A wealth of products, often cheap but with sub-standard energy efficiency, further contributes to rising energy consumption and emissions. More ambitious advances in implementing renewable energy systems would deliver more than just air pollution reduction. With lifetimes of many decades for most conventional power plants, any related investment will improve air quality for similar periods. At the same time, their implementation would facilitate decentralized energy supply systems, even in the vast remote areas of Central Asia.

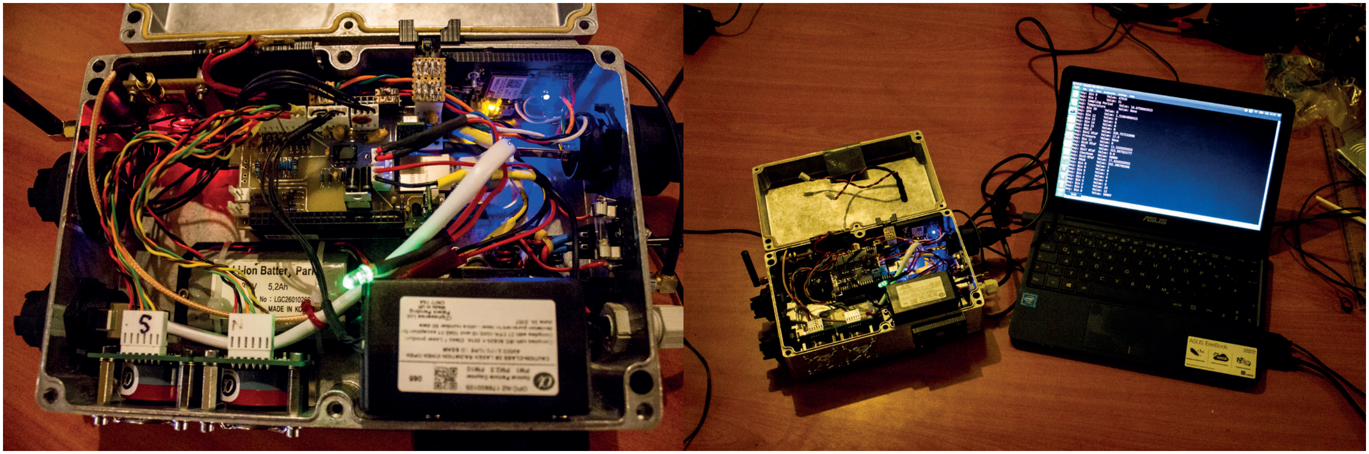
Economic activities

The main sources of emissions include fuel combustion in thermal power generation; incomplete combustion of organic carbon from traffic, waste incineration and biomass burning; domestic home heating, in particular wood and coal-burning; cremation; shipping; vehicle and road wear; mining and primary production; incineration of waste and sewage sludge; steel and other metal production, electroplating and other metal manufacturing; cement production; oil refining; and agriculture.

Industry, especially in parts of the EU, has successfully reduced emissions to levels similar to the early twentieth century, while for the most part the gross value added has increased. The main regulatory tool that has been used in the EU to drive emission reductions forward is the Industrial Emissions Directive, under which there are obligations for more than 50 000 large installations to minimize their emissions to the atmosphere, water and soil. In 2009, there was a decline in emissions in line with the global recession, suggesting that decoupling is not complete. At the same time, the extent of on-site storage space has declined, leading to heavier traffic as materials and goods are held on roads along the supply chain. Thermal recycling (incineration) still poses challenges in various parts of the pan-European region due to sub-standard technologies and related emission profiles.

Lack of technology for energy efficiency and pollution reductions

Sub-standard building norms, mainly in respect of insulation, heating and cooling systems, outdated fuel consumption and emission control in vehicles, and a preponderance of long-outdated industrial technologies, affect many non-EU countries.



Open design UNEP Air Quality Monitor
Credit: Alexander Ikawah

While there are many reasons for such delays in investment in state-of-the-art technology, associated sub-optimal situations can change quickly once regulations and/or efficient control tools are in place. Perceived price and cost issues are soon overcome, since modern technological solutions are generally superior not only in respect of their pollution characteristics, but also in terms of longevity and performance. At the same time, any upgrade to higher-level technologies is job generating, increasing demand for better education and skills.

Transport

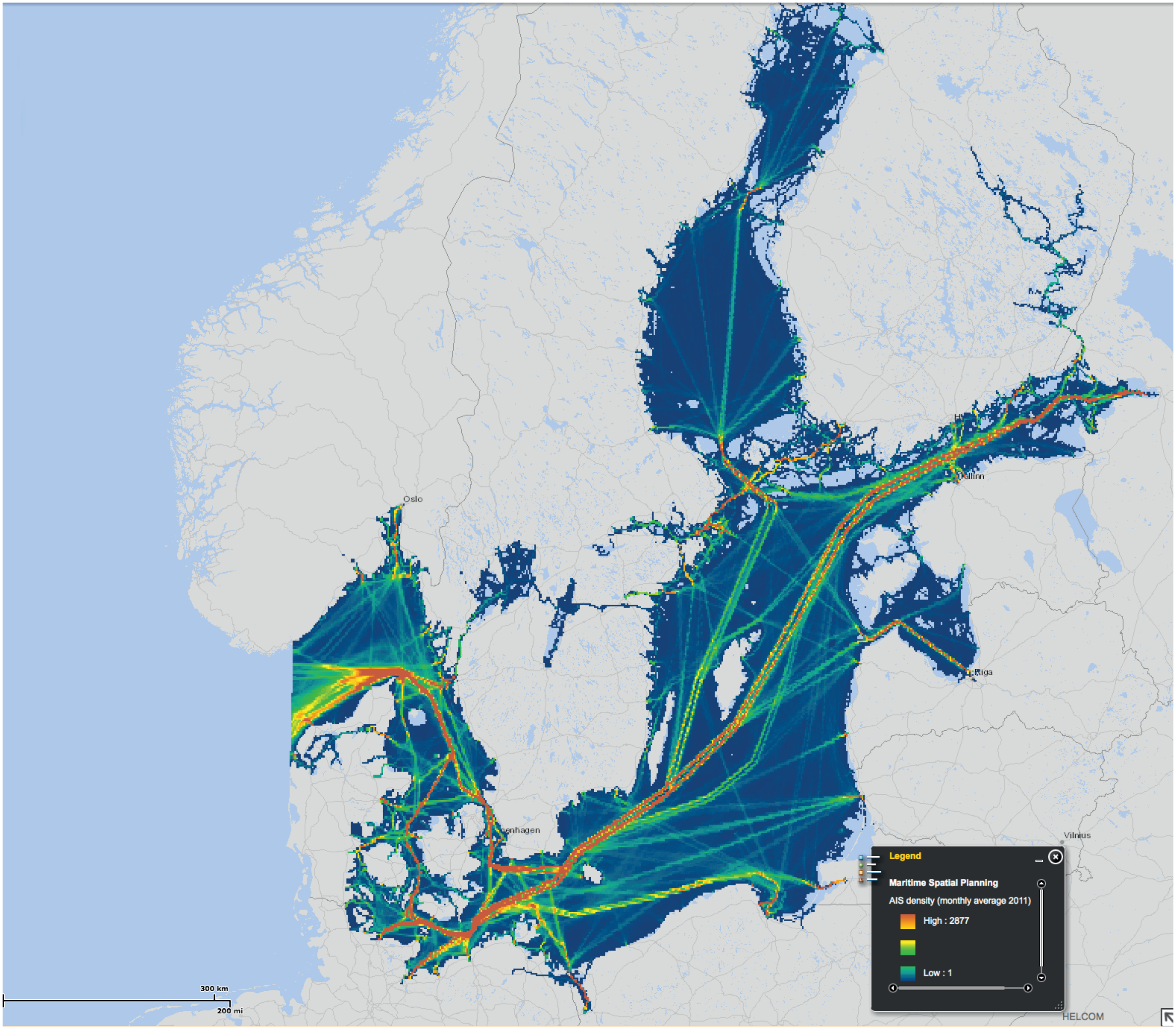
Transport volume growth has generally followed economic growth. In the EEA-33 countries, emissions from the transport sector have declined over the past decade, with the greatest reductions in SO_x (74 per cent in EEA-33) and NMVOCs (60 per cent in EEA-33); however NO_x, emissions have not decreased sufficiently to meet EU air quality standards. Private vehicle transport in the EU increased and, despite the introduction of vehicle emissions standards, this remains an important source of air pollution and GHG in the majority of urban environments, exceeding in some cases the share from industrial point sources (EEA 2015f, 2014c). The increase in the European diesel vehicle fleet, as a result of policies designed to reduce CO_2 emissions per kilometre compared to gasoline vehicles, has led to more emissions of PM and NO_x per kilometre than gasoline cars, and in some cases this has led to high concentrations of NO_2 measured close to traffic. Non-exhaust and exhaust emissions also contribute to total PM primary emissions, and it has been estimated that by 2020, nearly 90 per cent of total PM emissions from road traffic will come from non-exhaust sources (Rexeis and Hausberger 2009).

International shipping within European seas, particularly along well-travelled shipping routes and in harbour city environments, contributed in 2010 up to 50 per cent of total NO_x, 75 per cent of total SO_x and 15 per cent of total $PM_{2.5}$, as a result of outdated engine technologies, highly polluting crude oil products and emissions of large amounts of soot, gas and aerosols (EEA 2015f). Here, significant improvements should become apparent from 2015 onwards because of the prescription of cleaner fuels (0.1 per cent sulphur) (IMO 2015). Current satellite technology allows very high resolution mapping anywhere needed and on demand, and some national ship transport and control technologies are available (GCC 2012; NASA 2012) (Figure 2.3.1).

Air travel in the EU grew by nearly 10 per cent between 2010-2011 while stabilizing in 2012, with emissions of GHG in the EEA-33 more than doubling since 1990. Unfortunately, this increase in air traffic is neutralizing progress in cleaner aircraft engines. At cruising altitudes, emissions of nitrogen oxides directly contribute to ozone formation in the troposphere (Lee *et al.* 2010; Gauss *et al.* 2006).

Greater vehicle usage and a growing demand for energy are some of the drivers of air pollution in the pan-European region
Credit: Shutterstock/Photosebia; Bokstaz

Figure 2.3.1: Baltic Sea, ship routes and traffic density



Source: GCC 2012

Low fuel quality in non-EU countries

The increasing fleet of utility and private vehicles, and of ships, has noticeably increased total fuel consumption; this is of particular concern in non-EU countries in the region which tend to have sub-standard transport systems and above-average fuel consumption per unit. While this situation could theoretically be changed very rapidly through the introduction of higher fuel standards, there appears to be little movement in this direction so far, even though there are benefits from higher-quality fuels, as demonstrated, for example, in the POSEIDON MED project (Poseidon 2015).

Infrastructure development

Grey infrastructure, such as roads, railways, buildings and utilities, determines the efficiency hence use of resources and energy and pollution levels of cities. Western European traditions and lifestyles in generally much older cities still very much adhere to smaller scales and an emphasis on quality of life. In these settings, smart urban design is including green spaces and air corridors to create better air exchange and natural cooling. There are also efforts to save energy by encouraging the use of sustainable transport, for example, by using efficient, reliable and affordable collective transport and providing convenient walking and cycling infrastructure, which has the additional benefit of reducing health costs due to major improvements in urban dwellers' quality of life.

At the other end of the scale, the pan-European region has two mega-cities with populations above 10 million (Istanbul and Moscow), several big cities (Berlin, London and Paris) and one large metropolitan area (Rhine-Ruhr). Much of the infrastructure of these urban areas requires modernization, renovation and restructuring of infrastructure, as well as efficient, affordable public transport services.

Similar problems also exist in many of the mono-industrial cities in the region with dense agglomerations of heavy industry or mining complexes, particularly in Eastern Europe and Central Asia. In such areas, urban development is coupled to sub-standard building regulations, insufficient insulation, poor waste disposal and treatment, increased vehicle traffic and related pollution, adding to point source pollution from factories and power plants.

Natural sources of air pollution and natural disasters

Natural sources of emissions include pollen releases and volcanic activity. Windstorms, droughts and large-scale wildfires contribute significantly to increased emissions of soot, carbon oxides and a sequence of organic compounds and particulate matter. Sand and dust storms are of serious concern, especially in parts of Central Asia, the Russian Federation and Turkey. This concern is also shared by other regions.

2.3.3 Clean air is still at risk

Multiple pressures persist, with partly linked consequences for air quality. These include direct air pollution through various types of emissions and indirect sources such as traffic, land-use change, land degradation and overuse of ground water.

Emissions

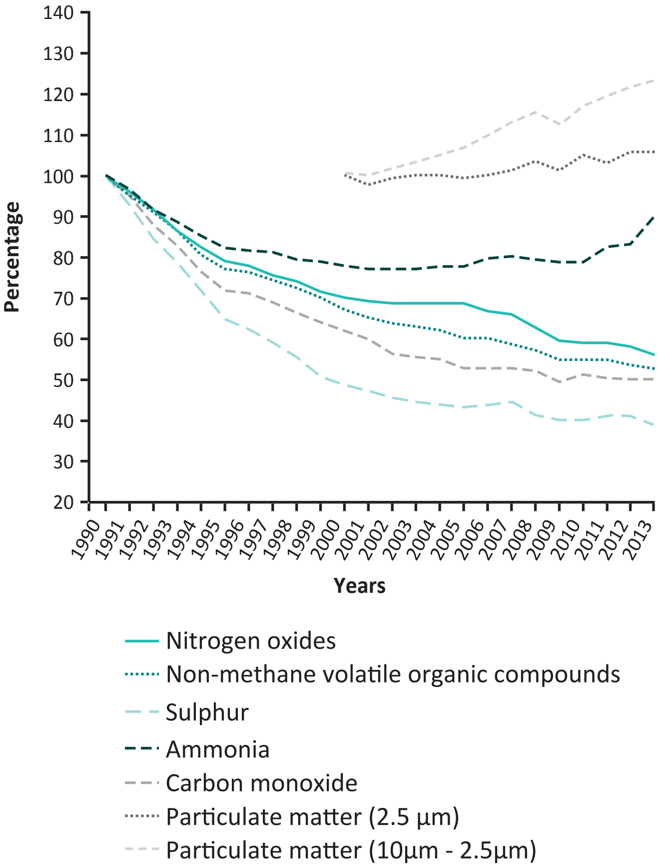
While industrial emissions, sulphur dioxide, nitrogen dioxide and particulate matter are generally decreasing in the EU, land-use related emissions, nitrogen oxides and particulate matter persist at high levels and are still increasing in the rest of the pan-European region (Fuzzi *et al.* 2015; Monks *et al.* 2015). The same is true for incineration technologies, which may emit a wide range of pollutants including dioxins and furans, and of trace metals under conditions of sub-standard technologies. These sources, because of high-temperature processes, may release pollutants that move higher up in the troposphere, resulting in long-range transport (LRT). Domestic emissions have mainly local effects, mostly from incomplete combustion in heating and cooking systems, soot and particulate matter. These appear to be mostly restricted to parts of Eastern Europe and Central Asia. Agricultural practices have highly differentiated effects (such as from emissions of particulate matter and agrochemicals) with the lowest emissions from conservation farming and the highest from industrial agricultural practices. Construction activities release particulate matter and degassing, mainly from various building materials. More pronounced drought periods in the Mediterranean region and in more northern parts of Central Asia will probably further increase the release of soil-borne particles, decreasing visibility and raising particulate concentrations since wash-out processes occur less frequently.

Industrial agriculture releases more air pollutants than conservation farming
Credit: Shutterstock/Mariusz Szczygiel

Levels of regulated emissions in the EU-28 and EEA-33 countries as a whole and all primary and precursor emissions making up PM, O_3 and NO_2 have been decreasing; over the past decade (2004-2013); ranging from 6 per cent for NH_3 to 58 per cent SO_x. The exception is the total emissions of NH_3 (in the EEA-33 countries) which increased by 7 per cent over the same period (EEA 2015f). For the pan-European region as a whole, statistics from UNECE Convention on Long-range Transboundary Air Pollution show reductions in emissions from 1990-2013 of -63 per cent of total SO_x, -43 per cent of total NO_x, -18 per cent of total NH_3, -47 per cent of total nmVOCs, and +3 per cent of total $PM_{2.5}$ (Maas and Grennfelt eds. 2016) (Figure 2.3.2).

However, primary emissions are not limited to local sources. The magnitude and impact of hemispheric and intercontinental scale transport is determined by the global distribution of emissions, and their spatial relation to the major meteorological transport pathways, including their speed and temperature. Thus in several European cities, a significant level of fine particles comes from long-range transport. Intercontinental transport is also an issue for some toxic metals, such as mercury, persistent organic pollutants (including vPvB - very persistent and very bio-accumulative

Figure 2.3.2: Emission trends in the ECE region (excluding Canada and the United States of America)



Source: Maas and Grennfelt eds. 2016

pollutants), and the precursor gases of ozone (Dutchak *et al.* 2013). Tackling air pollution will thus continue to require national and international co-ordination.

Improper land-use practice and land degradation

Land-use practices can lead to a broad spectrum of changes with potentially negative consequences for air quality, including changes in albedo and other land surface characteristics, including surface sealing, land management, soil degassing, use of pesticides, pathogens from monocultures plus degradation, desertification and related particulate releases and transport.

Overuse of groundwater

Groundwater overuse and abstraction decrease groundwater levels and alter aquifer characteristics such as storage capacity and pore chemistry. In areas with extensive surface water usage and those with reduced groundwater recharge, such deterioration inevitably leads to higher drought risks and desertification. This in turn may lead to soil loss and the release of particulate matter, which can carry pesticide metabolites and trace elements through the atmospheric transport pathway.

2.3.4 Air quality has improved – but much remains to be done

Multiple drivers and pressures lead to major differences in ambient and indoor air quality, with many issues requiring local and regional approaches, complemented by continental or supranational action. The most recent national reports in the region indicate that there have been improvements in ambient air quality, with exceedances of some pollutants now rare (Maas and Grennfelt eds. 2016; EEA 2015f). However, despite this progress, there remain considerable challenges to reduce the significant impacts on human health and ecosystem functioning (Section 1.2).

Ambient air quality

In response to considerable efforts in air pollution reduction measures over recent decades in Western European countries, ambient air quality has improved (EEA 2015f). However, widespread exceedances of the established air quality standards can still be observed. Depending on the atmospheric species of interest, there may be several reasons for excessive emissions, for reductions that are smaller than anticipated and for exceedances of air quality levels. Strong increases in anthropogenic activities can overwhelm achievements in reducing emission levels, or long-range transport of air pollutants may significantly increase background concentrations. Trends in three of the most common air pollutants in the pan-European region, ozone, ultrafine particles and ambient particulate matter, are described below. Details on others - sulphur dioxide, ammonia, nitrogen dioxide, methane, trace metals, persistent organic pollutants and volatile organic compounds - are provided here (**More...37**).

Despite the considerable reductions of precursor emissions (around 30 per cent for nitrogen oxides and 28 per cent for non-methane volatile organic compounds for the EU in 2003–2013), there has not been an equivalent reduction in ground-level ozone concentrations, with the overall result that the ozone health-related threshold value was exceeded more than 25 times in 2013 in 18 EU countries (EEA 2015). This is partly due to the reduction in NOx emissions in urban areas and the reduced titration of ozone by reaction with nitrogen monoxide (NO), as well as climate change, emissions of NMVOCs from plants and large-scale fires. Urban ozone levels are generally less of an issue, since the highest concentrations are usually found downwind from ozone precursor source regions (Solberg *et al.* 2004). Individual urban industrial hot spots remain active, however.

Due to the complex photochemical formation of ozone, emission reductions have led to a large-scale, albeit less pronounced, reduction in maximum ozone values in Western Europe (Derwent *et al.* 2010). At the same time, mean ozone levels at background stations, those not directly exposed to emissions of precursors, only show a leveling-off of their growth rate in recent years (Parrish *et al.* 2012), since other processes such as long-range transport and transport from the stratosphere also play a role.

Volatile organic compounds are precursors for ozone formation and secondary organic aerosols. Their concentrations and composition depend on the source type, which differs between ambient sources such as traffic, industry or natural factors, and indoor air sources such as consumer products, cleaning agents, furniture, paints, flooring and smoking. Non-methane volatile organic compound emissions fell by 27 per cent between 2000 and 2011 in the EU (Guerreiro *et al.* 2014).

Numerous organic carbon compounds are volatile enough to be present in the atmosphere. Each has its own intrinsic chemical behaviour and exhibits a different atmospheric reactivity (Carter and Atkinson 1989). This must be taken into account to understand the relation of the emissions to the oxidative capacity of the atmosphere and air quality.

On a global scale, natural emissions of non-methane volatile organic compounds equal or exceed anthropogenic emissions, although anthropogenic sources usually dominate in urban areas (Guenther *et al.* 2000).

Ultrafine particles are smaller than 0.1 micrometres in diameter. They have little mass but are high in numbers and surface area concentrations, and have a high content of elemental and organic carbon. Ambient ultrafine particles are built from gases or originate from combustion processes. In urban areas, they are emitted mainly from anthropogenic sources, for example, traffic, domestic heating and industrial processes (Ning *et al.* 2007). In contrast to particulate matter up to 10 and 2.5 micrometres in size (PM_{10} and $PM_{2.5}$), comprehensive data on exposure to ultrafine particles are rather scarce in the region. Recent studies in six European cities (Augsburg (Germany), Chernivtsi (Ukraine), Dresden (Germany), Leipzig (Germany), Ljubljana (Slovenia) and Prague (Czech Republic)) measured annual mean concentrations of particles with diameters of 10–100 nanometres and found 6 000–14 000 particles per cubic metre, with concentration maximums of around 100 000 particles per cubic metre near roads with high traffic density, and evidence of detrimental cardio-respiratory effects (UFIREG 2014; Franck *et al.* 2011; Birmili *et al.* 2009; Stölzel *et al.* 2007). Their potential adverse effects on human health are of great concern because of their specific properties. The transport and removal of particles from the air and their deposition within the respiratory system are governed by their size, which is partly associated with their source and related chemical composition. As self-cleaning mechanisms in human airways do not work effectively for these particles, ultrafine particles are able to enter the bloodstream and reach the human brain. Other studies found evidence for cardio-respiratory effects of ultrafine particles (Franck *et al.* 2011; Stölzel *et al.* 2007), but dose-response relationships and the mechanisms that induce harm need further research.

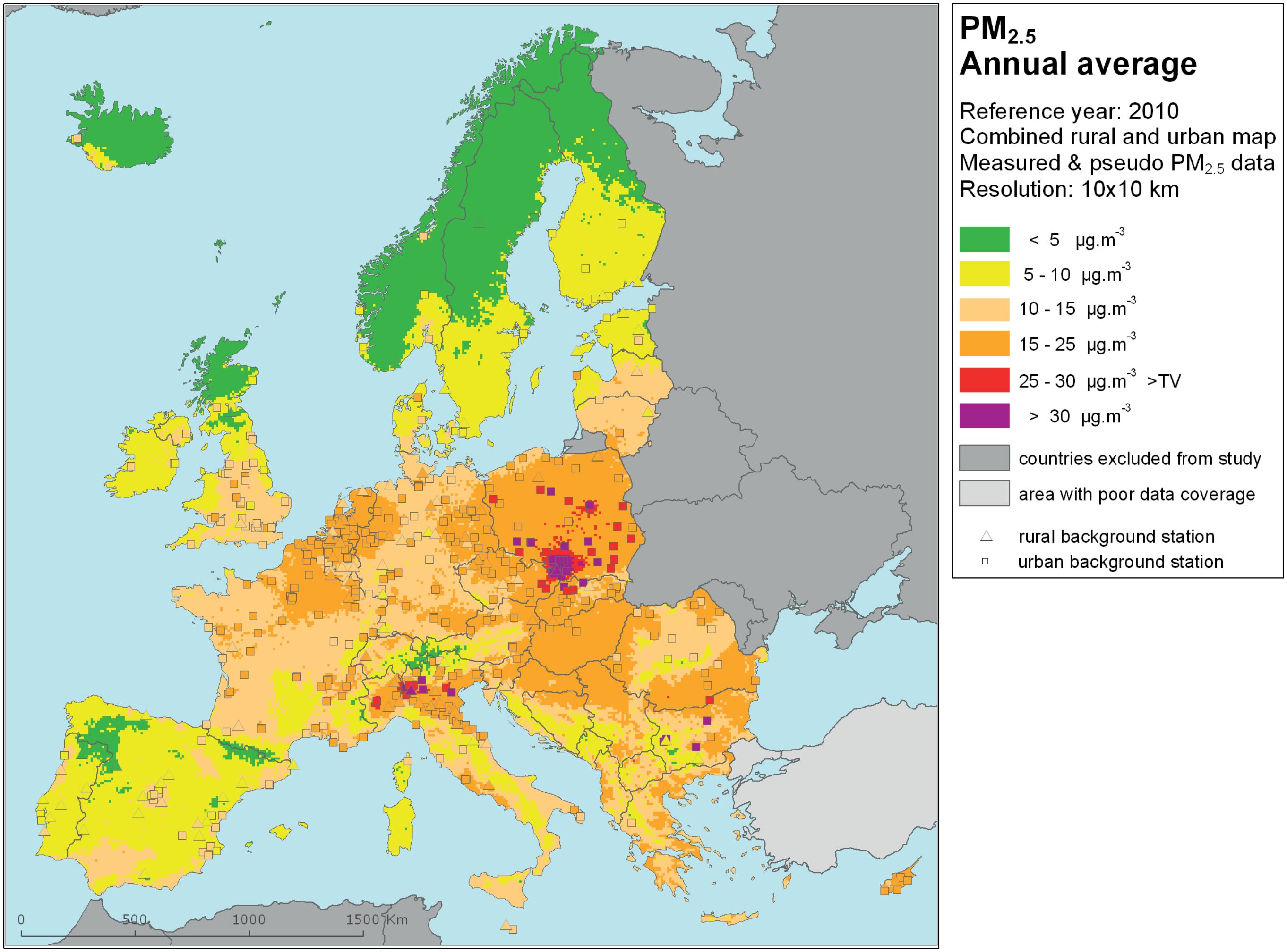
Particulate matter is a complex mixture of particles from various sources, of different sizes and different chemical composition. In addition to well-characterized inorganic compositions such as metals and ions, intensive work

Industrial processes contribute to the emission of ultrafine particles
Credit: Shutterstock/Bildagentur Zoonar GmbH

has been published on the chemical characterization of secondary organic aerosols (Hallquist *et al.* 2009). Exposure to $PM_{2.5}$ and PM_{10} are defined by their mass concentrations. Limit and target values are available in most countries worldwide, including in the pan-European region, (**More...38**) and adverse health effects have been described in numerous studies (Rückerl *et al.* 2011).

Ambient particulate matter is a recognized threat to public health on a global scale, not only in highly polluted environments (WHO 2013). Adverse health effects due to particulate matter exposure have already been observed at concentrations slightly above background levels, 3–5 micrograms per cubic metre (Fuzzi *et al.* 2015). Inorganic secondary particulate matter can most effectively be reduced by controlling the corresponding emissions of sulphur dioxide, nitric acid and ammonia (Fuzzi *et al.* 2015). The response of the atmospheric aerosol system to emissions can be highly nonlinear, and varies between locations as well as between seasons. Secondary organic aerosols are often the single most important component of fine particulate matter in cities in the region (Fuzzi *et al.* 2015), with Southern and Eastern Europe showing higher proportions of mineral dust and black carbon. Mass concentrations of particulate matter are showing a decreasing trend in the EU (Barmpadimos *et al.* 2012). Nevertheless, around 87-93 per cent of the

Figure 2.3.3: Western and Central Europe and South Eastern Europe, annual average $PM_{2.5}$ values



Source: EEA 2013a

EU urban population is still exposed to unacceptably high average annual concentrations of $PM_{2.5}$ compared with WHO guideline levels. Under current legislation, PM_{10} pollution hotspots will remain in Eastern Europe and major Western and Central European cities such as Milan (Italy), Paris (France) and Warsaw (Poland) (Kiesewetter *et al.* 2015).

Polycyclic aromatic hydrocarbons are formed mainly during incomplete combustion of carbonaceous material (Zhang and Tao 2009; Breivik *et al.* 2007). They are subject to long-range atmospheric transport (Halsall *et al.* 2001) and are considered carcinogenic. Concentrations both in air and in precipitation are decreasing: benzo(a)pyrene concentrations were reduced between 1996–2009 by 36 per cent in air and

63 per cent in precipitation (Tørseth *et al.* 2012). However, exposure to benzo(a)pyrene concentrations above target values is still significant and widespread in the EU, especially in Central Europe (Guerreiro *et al.* 2014). Generally, benzo(a) pyrene pollution is an increasing problem in the other pan-European sub-regions, especially in areas where domestic coal and wood burning is common (Guerreiro *et al.* 2014).

As global temperature and carbon dioxide levels rise, plant pollination cycles have become longer and more intense and neophytes contribute to pollen exposure (Frei and Gassner 2008). This results in an increasing number of respiratory allergies and asthma.

Global increase in temperature has affected plant pollination cycles contributing to longer and more intense pollen exposure and affecting people with allergies and asthma
Credit: Shutterstock/Beneda Miroslav

Air is an important exposure route for pathogens, including viruses, bacteria, endotoxins, fungi, spores and allergens such as pollen. Exposure to mould spores as well as microbial volatile organic compounds depends on housing conditions, but may also be promoted by low air-exchange rates resulting from energy-saving measures such as double glazing. Various adverse health effects result from this exposure, including the development and exacerbation of allergic diseases (Mendell *et al.* 2011; Gehring *et al.* 2010). A meta-analysis on the prevalence of dampness and mould in housing stock, including published data from 31 pan-European countries, concluded that 10.3 per cent of the homes had indoor mould (Norback and Cai 2015)

Indoor air quality

Variations in indoor air quality can be extreme because of the high diversity of indoor sources, differences in individual behaviour and national peculiarities, for example, there are a range of persistent bio-accumulative and toxic substances (PBT - persistent, bioaccumulative and/or toxic substances and vPvB - very persistent and very bioaccumulative such as Polybutylene Terephthalate) that are identified under the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH) regulations, that exist in household equipment that can become volatile through heating and extended use. Other examples of vPvB are POPs such as DDT and Toxaphene. The contribution of indoor air pollutants to total airborne human exposure is therefore difficult to assess, but it generally plays an important role. Around 100 000 premature deaths were attributable to household air pollution in the pan-European region in 2012 (WHO 2014a).

Ambient and indoor air quality, the two environments that together define individual exposure for humans, differ markedly in status. While indoor air can be strongly influenced by individual behaviour, and may vary from household to household, ambient air quality is defined by multiple sources that are subject to behavioural influences but much less to individual control. Both environments still appear to generate more problematic issues in Eastern Europe. Such challenges are in principle easy to meet with the implementation of state-of-the-art technologies.

2.3.5 Air quality has considerable impacts on human and ecosystem health

Ambient air pollution negatively impacts ecosystems in various ways, as well as work place and indoor environments. Both direct and indirect effects of climate change may enhance such impacts.

Ecosystem health and services

Ecosystems, when exposed to airborne substances and atmospheric deposition, are highly susceptible to pollutant pathways. Rising pressures, particularly from increasing drought risks, migration due to environmental and political stresses within and beyond the pan-European region, delayed implementation of more adapted and sustainable land-use practices and production standards, may result in unchanged or even increasing strains on ecosystems throughout the region.

Climate change-related situations such as drought events and heat spells with dust and sandstorms already result in more particle re-suspension and transport. At the same time, rising ambient temperatures drive higher plant emissions (volatile organic compounds) and increase photochemistry rates, leading to ozone formation. Current ozone concentrations have been estimated to reduce potential wood and crop production in Europe by up to 15 per cent (EEA 2015f).

Recovery of ecosystems from acidification is occurring in parts of Europe, but excess deposition of nitrogen is now a major cause of the loss of Red List species, where it also stimulates dominant species such as grasses, bushes, algae and nettle. Reducing emissions of ammonia and nitrogen oxides is thus considered more cost effective than additional nature management to protect threatened species.

Human health and economic costs

Air pollution strongly impacts human health. It has been known for many years that air pollution causes or exacerbates cardiovascular, cerebrovascular, respiratory and allergic diseases, as well as cancer (Dominici *et al.* 2006). It is related to the risk of stillborn, premature or low-weight births. Recent findings indicate that other widespread diseases such as diabetes are also associated with human exposure to airborne pollutants, such as particulate matter (Eze *et al.* 2014).

There are significant economic costs associated with air pollution arising from premature deaths, the costs of health care for the sick due to poor air quality, and the loss of productivity (Holland 2013). The WHO Regional Office for Europe and the OECD estimated that the costs caused by air pollution in the 53 Member States in the WHO European Region was about US$1.6 trillion in 2010. Therefore, in addition to health benefits, significant cost savings can be achieved through air pollution abatement (WHO 2015). In the EU, the health-related external costs from air pollution ranged between €330 billion and €940 billion in 2010, and are expected to be reduced under a business-as-usual scenario (baseline projection) to €210-730 billion in 2030 (considering € prices in 2005) (EC 2013d). The corresponding economic benefits of the proposed EU air policy package can be monetized, resulting in about €40-140 billion in savings, while the costs of pollution abatement to implement the package are estimated to reach €3.4 billion per year in 2030. The impact assessment states that the monetized benefits therefore will be about 12-40 times higher than the costs (EC 2013d).

Outdoor air

More than 500 000 premature deaths were caused in 2012 due to ambient air quality (EEA 2015f). Particles are potential carriers of health-affecting chemicals, including trace metals and metallo-organic fuel additives, and organic chemicals such as polycyclic aromatic hydrocarbons, persistent organic pollutants, pesticides and semi-volatile organic compounds. Effects on human health depend on the physico-chemical properties of the particles, although PM_{10} and $PM_{2.5}$ mass concentrations are the only metrics currently regulated by national and international laws. Recent findings underline the adverse health effects of smaller particles including submicron particles.

While annual mean concentrations of PM_{10} and $PM_{2.5}$ in outdoor air are decreasing in most EU countries, there are no clear trends for nitrogen oxide, black carbon and ultrafine particle concentrations (Birmili *et al.* 2015). These pollutants are closely related to urban traffic.

Ultrafine particles and soot-containing particles (black carbon) belong to these particle size classes. These air pollutants are emerging contaminants in both scientific knowledge and public awareness. A number of recent epidemiological studies

Many air pollutants are closely related to urban traffic
Credit: Shutterstock/Hung Chung Chih

found that short-term exposure to elevated concentrations of these small particles increases cardiovascular morbidity and mortality in particular. Monitoring of particle numbers and black carbon concentrations by national networks would help to improve the understanding of dose-effect relationships for such particles, and to develop a base for a specific legal framework.

Since both pollutants are related to transport, their concentrations in some urban environments may even increase. Recent studies found evidence that low emission zones can reduce urban ultrafine particle concentrations and soot even if particulate concentrations in terms of their mass are only slightly decreased (**More...39**). In contrast to other air pollutants, the vast majority of epidemiological studies on health effects of particulate exposure did not find a threshold concentration below which detrimental effects could be excluded: otherwise known as NOEL or "no observed effect level". All limit and target values for human exposure should therefore be adapted to the future development of ambient concentrations, further findings on health effects and advancing analytical and monitoring techniques including black carbon and particle number concentrations.

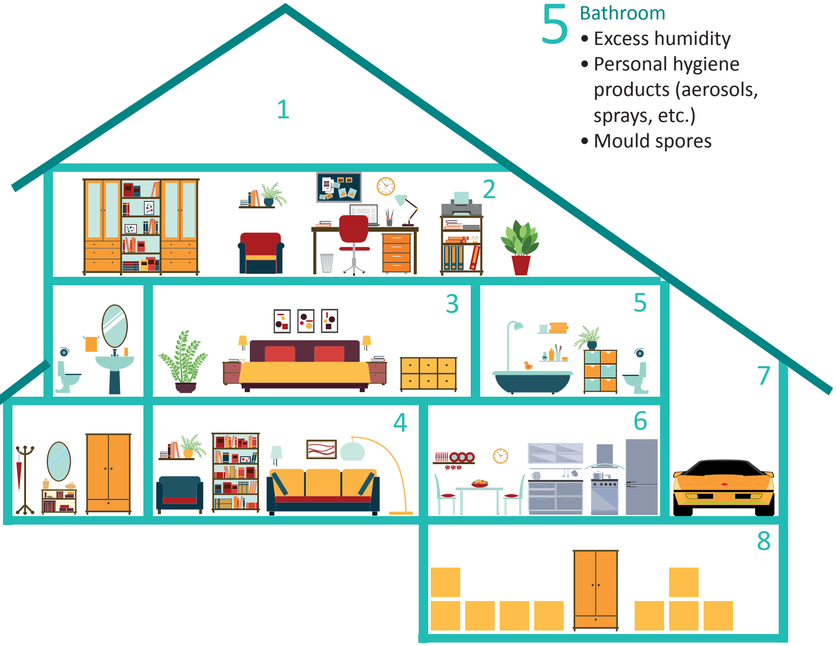
Current air quality standards are not necessarily health-based, and at concentrations of airborne pollutants below limit values health risks will not disappear. Even if there were no exceedances of concentration limits or target values, it would not mean that the problem of air pollution would be solved.

Indoor air

Depending on the climate zone, people in the pan-European region often spend more than 85 per cent of their time indoors. Indoor air exposure therefore often dominates the total dose received by people. As up to 30 per cent of the total burden of disease from particulate exposure is due to indoor-generated particles (Figure 2.3.4), indoor environments are likely to be a dominant environmental parameter affecting human health (Morawska *et al.* 2013). Organic and inorganic gases and radon are often found indoors in concentrations of concern for health. As well as gases and particles in general, microbial and mycological indoor air pollutants can impact health (Oliveira *et al.* 2009). Despite their general health impact, concentrations of indoor air pollutants vary strongly depending on housing conditions, climate zone and individual behaviour and lifestyle. This variability impedes generalized statements about public health of the kind that can be made, for example, about the impacts of outdoor air quality. Outdoor air pollution contributes to indoor exposure, but the latter is typically dominated by indoor sources, at least during cold seasons and in the northern parts of the pan-European region.

Intelligent ventilation, air conditioning and air filtration strategies can help to improve indoor air quality in classrooms, offices, factories and other public indoor spaces (Rosbach *et al.* 2015). Policies can directly address outdoor air quality and occupational indoor air quality, but not indoor air quality in private homes. Smoking bans in public rooms, for example, can have a positive influence on people's health (Konstantopoulou *et al.* 2014). Similarly, indoor air quality in homes could also be positively influenced by bans, and the associated detrimental health effects of this exposure may be lowered. Especially in less developed countries, the improvement of heating and cooking standards has a high potential to reduce concentrations of indoor air pollutants (Quansah *et al.* 2015; Bruce *et al.* 2000).

Figure 2.3.4: Primary sources of indoor air pollution



1 Attic
- Asbestos
- Insulation
- Fibreglass
- Dust and dust mites

2 Office
- Printers, photocopiers: ozone, volatile organic compounds (VOC)
- Melanine furniture (harmful vapors, VOC, formaldehyde)

3 Bedroom
- Allergens
- Dust and dust mites
- Pet hair and dander
- Carbon dioxide (CO2)
- Carpet

4 Living Room
- Fireplace
- Dust and dust mites
- Allergens
- Second-hand smoke
- Humidifiers
- Pet hair and dander
- Carpet

5 Bathroom
- Excess humidity
- Personal hygiene products (aerosols, sprays, etc.)
- Mould spores

6 Kitchen
- Lingering odours
- Bacteria
- Cooking pollutants

7 Garage
- Carbon monoxide (CO)
- Gas
- Solvents
- Pesticides and herbicides
- Dust
- Paint and chemicals
- Cleaning agents

8 Basement
- High humidity levels
- Unpleasant odours
- Mould
- Carbon monoxide (CO)
- Fireplace/smoke
- Firewood
- Radon
- Solvents
- Woodstove
- Dust and dust mites
- Combustion systems
- Paint and chemicals
- Household cleaners

Source: *http://www.standardheating.com/indoor-air-quality/*

In all countries, information campaigns can help improve common knowledge about indoor sources of air pollutants and can change aspects of lifestyle that are related to indoor air quality. This includes the use of cleaning agents, environmentally-friendly paints and other consumer products that might emit volatile organic compounds. In northern countries, energy saving, construction errors and limited air exchange can result in increased exposure to mould spores and microbial volatile organic compounds. This problem can often be easily managed if people are informed about how to handle it. In many, but not all countries, people are informed about the risks associated with indoor second-hand smoke, especially for children and people with pre-existing conditions. Nevertheless, educational advertising is still an important issue, at least in countries with a high percentage of smokers.

2.3.6 Policy responses

Air quality has improved in the pan-European region in recent decades, but progress has been uneven across different areas of the region. Particularly pronounced improvements can be observed in EU Member States (EEA 2015f), with the UNECE Convention on Long-range Transboundary Air Pollution (**More...40**) and WHO air quality guidelines being instrumental in crafting new and more ambitious air quality policies (WHO 2006a; UNECE 1979).

The UNECE Convention on Long-range Transboundary Air Pollution has been particularly successful in connecting scientific evidence with policy options. It started with a protocol setting limits on sulphur dioxide emissions, but over the years, the number of substances covered by the

Convention and its protocols has been gradually extended. Since 1999, its Gothenburg Protocol applies an integrated multi-pollutant multi-effect approach to identifying the most cost-effective air pollution policies (UNECE 2005). At the EU level, commitments under the UNECE Convention on Long-range Transboundary Air Pollution are transposed into the National Emission Ceilings (NEC) Directive that sets limits for several pollutants for each EU Member State (European Parliament and European Council 2001b), and defined national emission limits for sulphur dioxide, nitrogen oxides, non-methane volatile organic compounds and ammonia in order to abate acidification, eutrophication and ground-level ozone. The revised Gothenburg Protocol also includes ceilings for $PM_{2.5}$ emissions, and the proposed revision of the NEC Directive includes emission ceilings for $PM_{2.5}$ and methane. Means of implementation are further specified in various EU directives targeting vehicles, and sectoral directives including the Integrated Pollution Prevention Control Directive and the EU Large Combustion Plants Directive (**More...41**). EU vehicle emission standards (European Council 1991) have been establishing tighter limits for all new vehicles sold in the EU since 1992, although recent controversies over vehicle emission standards (Thompson *et al.* 2014; Weiss *et al.* 2013; Weiss *et al.* 2011) are likely to mean that policy effectiveness will be reevaluated. (**More...42**)

However, current policy responses do not sufficiently address air quality issues in the entire pan-European region, while joint international agreements, particularly in non-EU countries, have not been implemented in national environmental policies. As with transboundary air pollution, trade in consumer products can distribute risks and air quality issues across borders and continents, through direct emissions at the production site which cause ambient air pollution, and often by indoor air pollution from product use, for example through product degassing. There should be stricter testing of consumer products to assess their environmental impacts as well as health risks. Such policies could drastically reduce waste amounts and contribute substantially to improving both indoor and ambient air quality.

The EU's Directive on Ambient Air Quality and Cleaner Air for Europe obliges non-compliant jurisdictions to develop air quality action plans (European Parliament and European Council 2008a). This puts EU city and sub-national authorities at the forefront of air quality management. However, at certain times, a significant share of air pollution contributing to poor local air quality may originate from beyond the boundaries of the respective local authority, state or even continent, as climatic and geographical factors can also exacerbate the geographic dispersion of air pollution.

Air quality standards established by WHO function as non-binding environmental targets with the aim of preventing acute and chronic effects on human health. The current EU air quality standards, the strictest in the pan-European region, are less ambitious than the WHO standards. According to the latter, the majority of Europeans living in urban areas are exposed to air pollution concentrations that may give rise to negative human health consequences (Guerreiro *et al.* 2014).

Newer findings emphasize the particularly adverse role of ultrafine particles and black carbon on human health, for which no targets or limit values exist. Efforts to develop targets and (later) limit values for ambient black carbon and ultrafine particle concentrations, or for the range of particles, should therefore be enhanced by science and policy to ensure improved protection of public health.

Local authorities have a wide range of options for tackling local emission sources, most of which are related to the transport sector, including congestion and parking charges, speed limits, development of public transport, development of walking and cycling infrastructure, public cycle-sharing systems, promotion of eco-driving and the optimization of freight transport. The introduction of binding emission standards for heavy and passenger vehicles, as well as of low emissions zones and better bicycle infrastructure in all pan-European cities (**More...43**), would improve urban air quality and contribute to much-improved ambient air quality in the region.

Expanding and ameliorating bicycle infrastructure in pan-European cities can help to improve urban air quality
Credit: Shutterstock/ RAYBON

Other promising policies include fuel switching in domestic heating, promotion of district heating, bans on the sale of bituminous coal, compliance with low-sulphur fuel standards, reduction of dust in ports and promotion of industrial retrofitting (EEA 2013b). A combination of several policy measures can help achieve significant air pollution reductions, particularly in metropolitan areas – air quality management in Milan is one example. The ancillary benefits of such policies include avoided carbon dioxide emissions, fuel and financial savings, congestion reduction, noise reduction, better health due to increased physical activity and reduction in traffic accidents. However, societal awareness and support is crucial for the successful implementation of such air quality action plans (Beria 2015; Eliasson *et al.* 2009).

Integration of air quality and climate change policy in the pan-European region could produce synergistic benefits. Despite the separation of the two policy fields, to a large extent both have the same target: reducing fossil fuel combustion. For example air quality policies that lead to a reduction in black carbon and methane will also support the objectives of climate policy. Climate change mitigation policies that aim at energy efficiency, energy conservation and expansion of renewable energy could produce many benefits in the form of air quality improvement, human health improvement, energy poverty eradication, resource efficiency and economic growth (IEA 2014c).

"Velib" public bicycle rental system in Paris, France
Credit: Shutterstock/Pack-Shot

Importantly, the Batumi Action for Cleaner Air (2016-2021) presents a number of actions for improving air quality in the region. The overarching objective is to encourage and support Governments and other actors in their work to improve air quality during the period 2016–2021, and more specifically includes the following five objectives:

- to provide Governments and other stakeholders with a list of possible concrete actions to address local, national and regional air pollution problems for their consideration;

Public transport in Milan
Credit: Shutterstock/Leonid Andronov; Alexandre Rotenberg

- to inspire action on air pollution issues that are not currently being addressed;
- to aid the further implementation of the commitments under the ECE Convention on Long-range Transboundary Air Pollution and its protocols;
- to invite stakeholders (international organizations, donors and non-governmental organizations to support actions that improve air quality, in particular capacity-building and technical assistance actions; and
- to invite Governments to voluntarily commit to implementing specific actions and to share their successes and further challenges at future meetings of the ECE Committee on Environmental Policy.

Relevant data and indicators: *Centre on Emission Inventories and Projections (CEIP)* for comprehensive and up-to-date information about national emission inventories of air pollutants for Europe (including South and Eastern Europe); *UNEP Live* information on air quality and health; *EEA* on air pollution.

2.4 Biodiversity and ecosystems

Main messages: Biodiversity and ecosystems

- While the region contains five globally recognized biodiversity hotspots it also contains some of the most human-dominated environments, which have dramatically altered the natural environment, and reduced the size of natural and semi-natural habitats. In three of the five hotspots the extent of the remaining primary habitat has shrunk below 20 per cent of its original size, and in the Mediterranean Basin only 5 per cent of the natural habitat remains, with many of its endemic species threatened with extinction.
- Biodiversity loss and ecosystem degradation is continuing in the region. Ongoing biodiversity decline and loss is particularly high in Eastern and Western Europe, with lower rates in Central Europe, the Russian Federation and Central Asian countries.
- The main regional pressures and drivers of biodiversity loss are associated with increased land-use change, particularly agricultural intensification, urbanization and habitat fragmentation. Other pressures include unsustainable direct exploitation of biological resources, and invasive species. These pressures also affect ecosystems in the region some of which are particularly vulnerable, such as wetlands.
- An important challenge that needs urgent attention is improving open access to comprehensive and integrated biodiversity data to support assessments and analysis, as well as planning and implementation of conservation efforts.
- Some positive developments and individual success stories offer lessons worth learning. In a limited number of cases, positive trends can be observed in biodiversity health and habitat quality, both for species and ecosystems. For example, there are some positive developments in mammals in the Russian Federation.
- The Natura 2000 network is the most extensive network of protected areas in the world; it comprises more than 27 000 sites and covering 18 per cent of the terrestrial area of the EU Member States and 4 per cent of EU marine waters. Based on the same principles as Natura 2000, the pan-European Emerald Network and the pan-European Ecological Network would further enhance conservation efforts.

2.4.1 Biodiversity in the pan-European region - patterns and data

The biosphere provides the core components of the human life-support system on this planet. However, the profound importance of biodiversity for current and future human well-being and a well-functioning natural environment has still not been fully appreciated nor accounted for, neither globally nor regionally, although there is a high public awareness of biodiversity and its vulnerability. Over three-quarters of people in an EU-28 survey very much agree that it is important to halt species loss, seeing it as a moral obligation (EC 2013e) (**More...44**). The tremendous complexity of the biosphere and its hugely cross-cutting nature, with links to and affecting all sectors of the environment, also pose considerable challenges for scientific assessment and analysis, communication, and adequate societal and political response. For biodiversity alone, this has resulted in a huge diversity of political initiatives, mechanisms and agreements, all concerned with different aspects of biodiversity for the pan-European region alone. The region contains some of the most human-dominated environments in the world, and includes many ecosystems and habitats that have been shaped by human activities for centuries, if not for thousands of years. The transformation of landscapes, in the past mostly by agriculture and forest use and in more recent times by urbanization and industrialization, dramatically altered the natural environment, and reduced the size of natural and semi-natural habitats in the region. The connections between humans and the natural world have resulted in strongly developed, highly complex interactions between the cultural and natural diversity of the region.

Although the pan-European region is not known for high overall species richness (EEA 2010a), five globally recognized biodiversity hotspots are nevertheless found there (Conservation International 2010; UNEP 2007; Mittermeier *et al.* 2005; Myers *et al.* 2000) (**More...45**). These are the Mediterranean Basin, the Caucasian Mountains, the Carpathians, the mountains of Central Asia and the Irano-Anatolian highlands. While these hotspots have a high species richness and harbour many endemic species, in three of them the extent of the remaining primary habitat has decreased to less than 20 per cent of its original size, and in the Mediterranean Basin only 5 per cent of the natural habitat remains, with many of its endemic species threatened with extinction. For the oceans, the absence of any significant areas untouched by fishing leaves neither baselines nor reference sites by which to assess truly natural conditions.

Only five percent of the Mediterranean basin's natural habitat remains. The basin is one of the five globally recognized biodiversity hotspots in the pan-European region
Credit: Shutterstock/vololibero

While for many areas of the pan-European region, there are detailed and long-term biodiversity data available to support assessments and analysis, along with the planning and implementation of conservation efforts, significant data gaps persist geographically, taxonomically and thematically (Ficetola *et al.* 2013). With a long-standing tradition of biodiversity inventories, surveys and monitoring, as well as nature conservation, the challenge remains for the region to continue to lead the way in preserving its unique biota, as well as providing new and more sustainable solutions to the use and management of biological resources and ecosystem services, both within the region and beyond.

2.4.2 Ongoing biodiversity loss and ecosystem decline

Biodiversity continues to decline in the pan-European region (OECD 2012; Butchart *et al.* 2010), which directly affects the efficiency, productivity and stability of ecosystems (Cardinale *et al.* 2012). A considerable share of biodiversity has already been lost and mean species abundance has decreased significantly. In Western and Central Europe, only 38.4 per cent of the original species abundance remains, while 77 per cent remains in the Russian Federation (OECD 2012; Alkemade 2009).

Ongoing biodiversity decline and loss is particularly high in Eastern and Western Europe, with lower rates in Central Asian countries. There is a relatively low ongoing loss in Central Europe, with less than half the weighted (negative) annual change compared to other European sub-regions (for mammals, amphibians and birds). For Western Europe, loss rates are highest in amphibians and lowest in mammals (Table 2.4.1), whereas in Eastern Europe birds show the highest annual loss.

Apart from past and ongoing changes in species richness, there are some general patterns of species richness in mammals, amphibians and birds. Overall, the species richness of the three vertebrate classes is lower in more northern latitudes and increases to the south (Figure 2.4.1). Generally, this pattern is particularly pronounced for endemic species diversity (measured by the mean range sizes of the species, Figure 2.4.2).


77 per cent of the original species abundance remains in the Russian Federation
Credit: Shutterstock/YURY TARANIK; Gregory A. Pozhvanov

Table 2.4.1: Relative annual weighted change of the global IUCN Red List Index for mammals, birds and amphibians across the pan-European region and sub-regions

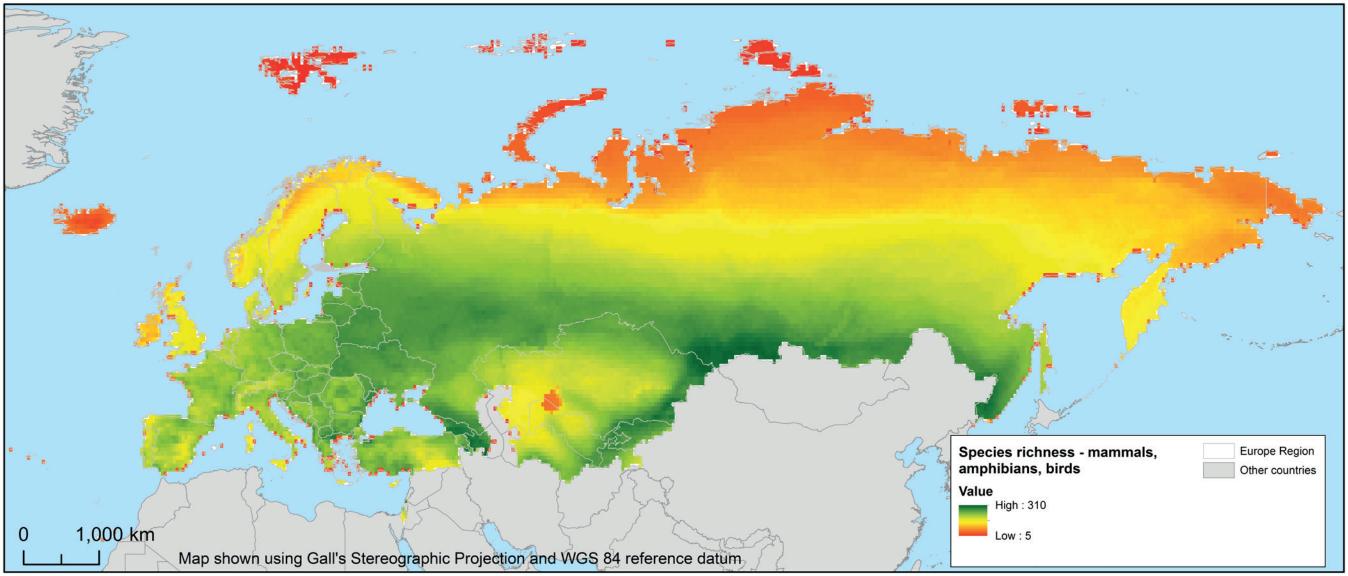
Region	Sub-region	Weighted annual change in Red List			
		Mammals	Birds	Amphibians	All species
Europe		-0.45	-0.82	-0.42	-1.68
	Central Asia	-0.30	-0.12	0.00	-0.43
	Central Europe	0.04	-0.07	-0.18	-0.21
	Eastern Europe	-0.12	-0.43	-0.01	-0.56
	Western Europe	-0.06	-0.20	-0.22	-0.48

Source: Brooks *et al.* 2016

There are quite significant differences in the percentage of threatened species in a group and also between sub-regions. An overview of IUCN's data for the region shows that of the 2 482 assessed species, around 13 per cent are threatened, with the highest proportion in Central and Western Europe. Freshwater fishes are among the vertebrate groups with the highest percentage under threat, 40 per cent, while nearly a quarter of amphibian species, 23 per cent, face the threat of extinction (IUCN 2015a). Some groups are generally more stable, for example, only 2 per cent of medicinal plant species are considered threatened (IUCN 2015a). A recent EU assessment shows that 23 per cent of vertebrates, invertebrates and plant species were found to be in a favourable condition over the 2007-2012 time period (Habitats Directive Article 17), whereas one fifth are in unfavourable/declining condition, particularly many marine and grasslands species (EEA 2015b) (**More...46**).

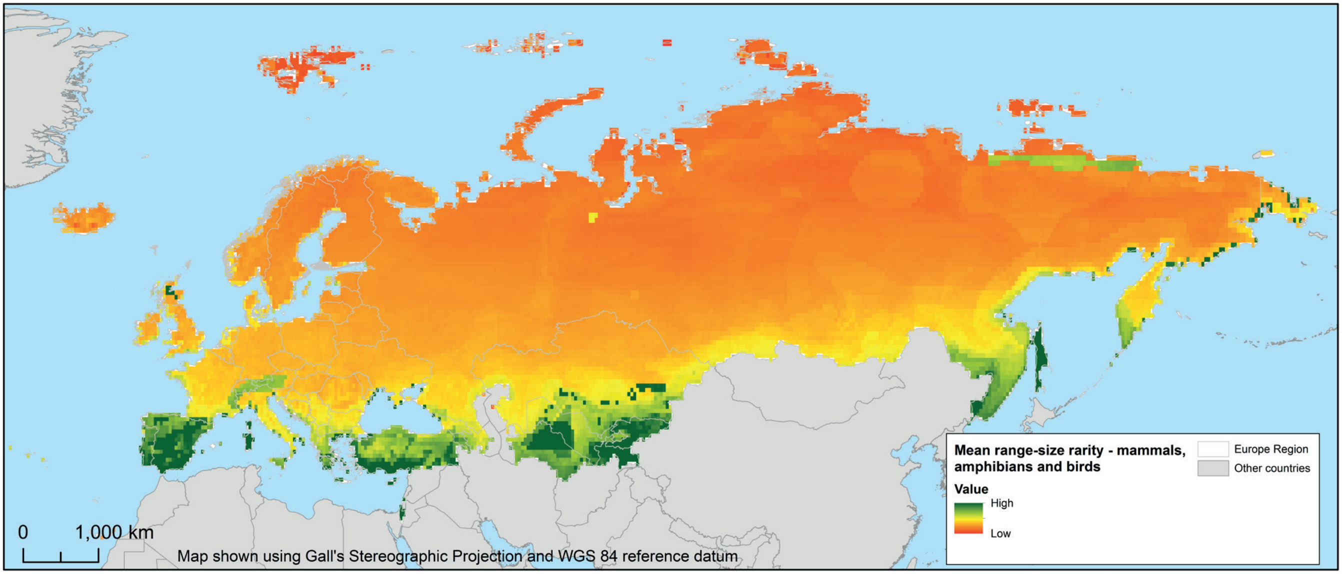
Population trends are one of the common indicators of species viability, and rather mixed trends can be observed. Although many species have continued declining, there are some positive developments, for example, in mammals in the Russian Federation, including the European bison (*Bison bonasus*) and the brown bear (*Ursus arctos*).

Figure 2.4.1: Current measure of species richness for mammals, amphibians, and birds in the pan-European region



Source: Map developed by UNEP-WCMC based on IUCN (2014b) data

Figure 2.4.2: Current endemic species of mammals, amphibians and birds



Endemic species are measured by the mean range size rarity found within a 0.5 degree grid cell (approximately a 50 km x 50 km area)

Source: Map developed by UNEP-WCMC based on IUCN (2014b) data

Table 2.4.2: Total numbers of species and of threatened species occurring in the pan-European region

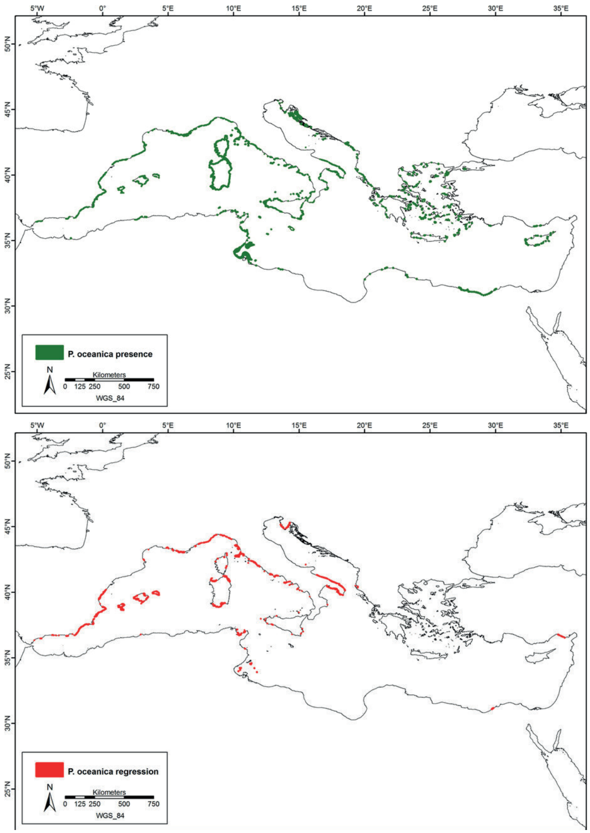
Region	Subregion	Threatened species	Total assessed	Proportion of threatened species		
				Lower-bound	Mid-point	Upper-bound
Europe		301	2482	0.12	0.13	0.19
	Central Asia	50	722	0.07	0.07	0.09
	Central Europe	107	920	0.12	0.12	0.15
	Eastern Europe	113	1224	0.09	0.10	0.13
	Western Europe	206	1777	0.12	0.12	0.18

Source: IUCN 2015b

However, other species are of conservation concern, such as the Saiga antelope (*Saiga tatarica)*, whose populations have decreased considerably (WWF-Russia 2014). The farmland bird index, one of the best indicators of the health of European farmland ecosystems and wildlife, showed that common farmland birds including the corn bunting (*Emberiza calandra*), goldfinch (*Carduelis carduelis*), northern lapwing (*Vanellus vanellus*) and the Eurasian skylark (*Alauda arvensis*) have declined by almost 50 per cent in the past 30 years (PECBMS 2013).

Goldfinch populations have declined by almost 50 percent in the pan-European region over the past 30 years
Credit: Shutterstock/Oral Zirek

Figure 2.4.3: Seagrass regression across the Mediterranean Sea



Coastline with a) current distribution (green areas) and b) regression of Posidonia oceanica meadows (red areas) over the last 50 years
Source: Telesca *et al.* 2015

Declines could also be observed in marine species, for example, *Posidonia oceanica* meadows – a seagrass species endemic to the Mediterranean – have regressed by 33.6 per cent on average in the last 50 years (in areas for which historical data are available) (Telesca *et al.* 2015) (Figure 2.4.3) (**More...47**). Other indicators expose similar declines. The EEA, for example, recorded an almost 50 per cent decline among European grassland butterfly populations between 1990 and 2011 (EEA 2013c) (**More...48**).

Few data sets exist to show trends in the genetic resources of pan-European biodiversity. However, current data show homogenization of domestic animals, with local breeds/landraces replaced by a small number of highly productive, globally distributed commercial breeds for the sake of intensification of production systems and improved resource efficiency (Leadley *et al.* 2014). The pan-European region has the second highest percentage of threatened domestic animal breeds globally, with 34 per cent of mammalian and 51 per cent of avian breeds at risk (FAO 2013a) (**More...49**).

2.4.3 Main regional pressures and drivers of biodiversity loss

Globally and in all regions, biodiversity loss and natural habitat decline continue beyond planetary boundaries (Steffen *et al.* 2015; Rockström *et al.* 2009), and biodiversity loss directly threatens critical ecosystem services. The main drivers and pressures identified at the global level, and which are highly relevant in the pan-European region (Leadley *et al.* 2014; CBD 2014), are the direct and/or indirect consequences of life styles, consumption and production patterns and economic development, leading to increased land use and land-use change, all constantly reducing natural and semi-natural habitats (**More...50**). Highly relevant is the non-sustainable use of natural resources due to agriculture, forestry or fisheries and the reduction of natural habitats, for example, by conversion into agricultural areas. The resulting anthropogenic pressures on biodiversity and natural ecosystems are exacerbated by the effects of climate and environmental change.

Overall, the greatest pressure on biodiversity in the pan-European region – degradation and loss of natural habitat – is primarily driven by agricultural intensification and urbanization, including land conversion and land-use change due to industrial, infrastructural and other forms of economic development (Potts *et al.* 2015) (**More...51**). Transforming agricultural or forested lands into highly intensified croplands or plantations poses a particular threat for fauna and flora in the region (**More...52**), since a large number of highly valued wildlife species and semi-natural habitat types in Europe are dependent on extensively managed agricultural land, of which considerable losses have been documented (**More...53**). Therefore, besides agricultural intensification, land abandonment in the context of agricultural land-use change can constitute a threat to local biodiversity, as has been shown for butterflies and bees (Nieto *et al.* 2014; EEA 2013c).

Natural habitat conversion is increasingly driven by urbanization. Despite the absence of mega-cities, Western and Central Europe are among the most urbanized regions on the globe, resulting in large demands on land area, even without further human population growth in the region (**More...54**).

Agricultural intensification and urbanization are the main drivers of habitat loss in the pan-European region
Credit: Shutterstock/riekephotos

Overharvesting and overexploitation of biological resources have traditionally been among the main drivers of biodiversity loss in the pan-European region (**More...55**). Over-fishing continues to threaten many stocks and habitats, both for freshwater and marine biota. For the EU, 58 per cent of assessed commercial fish stocks do not have a good environmental status, but 40 per cent of catches remain unassessed (**More...56**). Emissions of chemicals into the air and water and contamination by pollutants present a constant threat for many species and most ecosystems in the region. Although some improvement in air and water quality in the EU has recently been achieved, emissions remain problematic for biodiversity (EEA 2015g; EC 2013e).

Invasive alien species are considered the second greatest threat to biodiversity globally (MA 2005a), causing the extinction of many native species (Clavero and Garcia-Berthou 2005), with the most profound effects felt on islands (Leadley *et al.* 2014). Invasive species also severely affect critical ecosystem services (Vilá *et al.* 2010), which has far-reaching economic consequences for the pan-European region. For EU Member States alone, overall losses have been estimated at more than €12 billion per year (Kettunen *et al.* 2008) (**More...57**). Climate change is also one of the key pressures on biodiversity, and research suggests that it will be increasingly relevant by the end of the 21st century by impacting species behaviour and ecology, for example, causing species range shifts and changes in phenology (Leadley *et al.* 2014; MA 2005a) (**More...58**).

For habitats and ecosystem types, significant negative trends in terms of coverage and quality have been observed in recent years, with the largest losses in the EU in wetlands, heathland and natural grasslands (EEA 2015h). Conversely, urban habitats, forests and, due to land abandonment, transitional land areas have increased (EEA 2015h). Mires, bogs and fens cover around 1.84 per cent of the extent of EU countries (EEA 2015g). Wetland area decreased considerably during the 20th century, and further loss of wetlands is expected. Marshes and bogs in the EU show the largest decrease of all land cover types in recent years, with a reduction of 1 267 square kilometres, equal to a 4.8 per cent loss (EEA 2015i). Between 1990 and 2006, large areas of European wetlands were lost, mainly due to afforestation and conversion to agricultural land. In addition, wetlands are under threat from eutrophication, contamination with heavy metals, other pollutants and climate change (Appleton *et al.* 2012), particularly in the permafrost regions of the Russian Federation and forested steppes of Bulgaria, Moldova, Romania, Turkey and Ukraine. Among wetland birds, around one third are threatened, near-threatened or declining, with 32 per cent of bird populations showing decreasing trends (EEA 2015h).

Pan-European wetlands are under threat from eutrophication, heavy metal pollution, and climate change
Credit: Shutterstock/aabeele

Over the period 1990-2010, the growing stock in all European forest regions increased by 0.39 per cent per year on average, which is a positive sign (UNECE and FAO 2011). However, this may hide a more precarious situation for biodiversity hotspots in the Caucasus, the Iranian-Anatolian zone and the Mountains of Central Asia, where forests have been threatened. Large diameter and over-mature stands are not favoured in managed forests, and old-growth forests are lacking. Of pan-European forests excluding the Russian Federation, only 18 per cent are above 80 years old, and 27 per cent are uneven-aged or non-categorized. Areas of old and uneven-aged forests have shown a slight increase. In addition, despite some recent progress (Valentik 2014), illegal logging has been a problem in the Russian Federation, particularly in the east of the country, largely caused by strong demand from China and Japan (Smirnov 2013).

2.4.4 Availability of comprehensive and integrated biodiversity data

The availability of comprehensive, sound, robust and up-to-date biodiversity data, information and knowledge remains a challenge even for the pan-European region. Important efforts have been under way for mobilizing, assembling and sharing biodiversity and ecosystem data globally and regionally. Some prominent examples include the Global Biodiversity Information Facility (GBIF), Genbank and the Catalogue of Life (CoL), as well as the IUCN Red Lists and the UNEP-WCMC World Database on Protected Areas/Protected Planet. There also exist thematic or geographically-focused information systems such as FishBase, VertNet or BISE and the *European Bird Portal*. The Group on Earth Observations/ Global Earth Observation System of Systems (GEO/GEOSS), an international collaboration based in Geneva, Switzerland, is helping to integrate remote sensing and *in situ* data sets and layers, also for biodiversity and ecosystems.

Open and free access to digital biodiversity data and information has been and remains limited, however, in many cases, and relevant data sources are either not accessible online and/or are offered only with restricted access (Geijzendorffer *et al.* 2015). Furthermore, the biodiversity knowledge base is still highly fragmented across different initiatives, processes and ultimately databases and information systems themselves. There is thus an increasing need to continue promoting open access to primary data sources even from public institutions, and for new and higher levels of effective data integration, especially between different data types and layers, such as genetic, species occurrence and remotely-sensed data.

There are also significant gaps in terms of spatial, taxonomic and temporal coverage of the pan-European region. Data gaps overall lead to increased uncertainties in assessments and evaluations. In Europe, only 7.5 per cent of marine fish species are considered to be threatened. However, due to the high number of data-deficient (DD) species, the actual percentage of threatened species in Europe could range between 6 per cent if not all DD species are threatened and 26.6 per cent if they are (Nieto *et al.* 2015) (**More...59**). Furthermore, there are severe limitations on the side of data recording: currently there is no agreed and standardized monitoring scheme for all aspects of biodiversity and ecosystems for the pan-European region, and not even for the EU. Extensive monitoring schemes are being conducted in some countries; however, a unified pan-European biodiversity monitoring scheme and strategy still need to be developed. The multitude of diverse measurements and indicators proposed and in use to assess state and changes in biodiversity indicate a growing need for new unifying concepts for data interpretation, such as essential biodiversity variables (Pereira *et al.* 2013), which could also help to improve policy reporting and decision-making process (Geijzendorffer *et al.* 2015).

Data gaps need to be closed through a dedicated pan-European monitoring strategy. Furthermore, focused efforts should aim to establish and link local and regional monitoring and recording schemes and networks that use internationally accepted open data standards and exchange formats. There is a range of opportunities for the region, from technology including automated biota recording and high-resolution new-generation satellite imagery, to a multitude of citizen-science approaches and community-based activities to record and assess biodiversity and ecosystems locally. Initiatives like GEO BON or, on a European level, the European Biodiversity Observation Network (EU BON) aim to further integrate data and to close existing gaps in biodiversity data for research as well as policy reporting (Wetzel *et al.* 2015).

2.4.5 Positive developments, individual success stories and lessons learnt

Although biodiversity remains largely at risk in the region and there is generally an ongoing overall decrease in wild plant and animal populations, assessments show that there are also some positive signs in both the state and trends of species. For example, among mammals and birds, without the conservation measures of recent years the decline would have been more severe, with an 18 per cent additional decline in the Red List Index (RLI) globally (Hoffmann *et al.* 2010). Also, national and international policies increasingly pay attention to issues related to the conservation of biodiversity, which has already resulted in positive developments in regard to protection efforts.

In European countries, there are also positive developments concerning some species, for example, for large herbivores and carnivores (**More...60**). The recovery of Eurasian elk (*Alces alces*) populations, particularly in Scandinavia, originates from a range of conservation measures including habitat protection and/or restoration, successful wildlife management and effective legal protection (Deinet *et al.* 2013). Also, the status for some insect species in the Netherlands and the UK has improved. There have been, for example, increases of 7-10 per cent in some wild bee species detected over the past 20 years (Potts *et al.* 2015).

Conservation measures such as habitat protection and restoration, wildlife management and effective legal protection have been imperative in the recovery of the Eurasian elk populations
Credit: Shutterstock/robert cicchetti

Positive examples can also be highlighted among many bird species, for example, the population increase of the peregrine falcon (*Falco peregrinus*). Severe population declines in this raptor species in the 1960s-1970s were driven by eggshell breakage and mortality of adults and embryos from the hydrocarbon contamination associated with pesticides at that time (BirdLife International 2015a). However, due to changed agricultural policies, re-introduction programmes and improved protection, the European population is estimated at 14,900-28,800 pairs, which equates to 29,700-57,600 mature individuals (BirdLife International 2015b).

For wild medicinal plants, even though the conservation status is known for around 3 per cent of species, some positive developments can be found as well. In many Central and South Eastern European countries, the degree of collection of wild plants has fallen, leading to a decrease in the pressure that negatively affects many of these. Only a small number of European medicinal plants show increasing population trends (IUCN 2014a). Nevertheless, only a small percentage (2 per cent) are classified as threatened (IUCN 2014a).

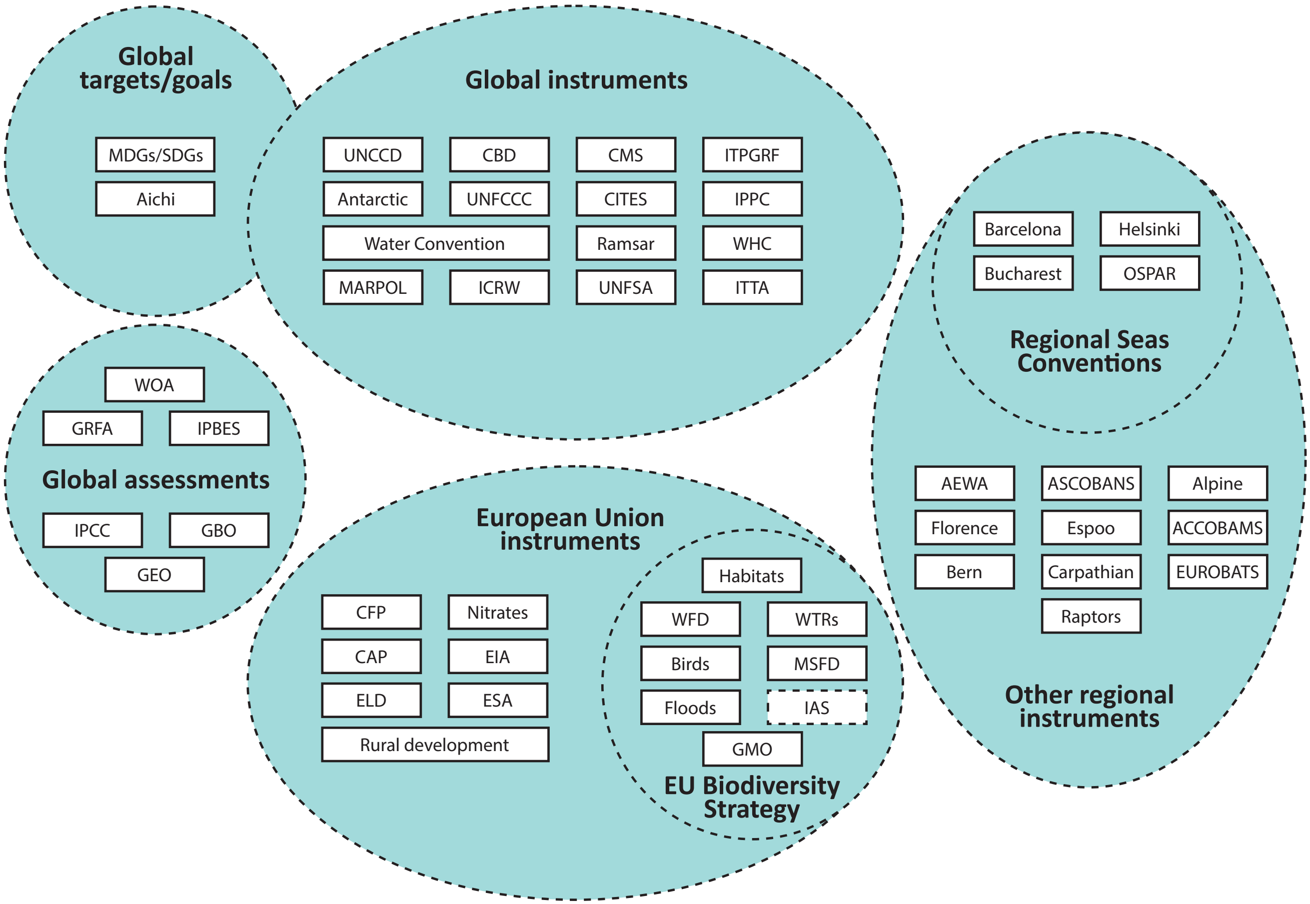
2.4.6 Policy responses

The huge complexity and highly cross-cutting nature of the biosphere make it a particularly challenging environmental realm to tackle politically. Biodiversity affects many aspects of society and many different sectors, and is highly relevant in spiritual, religious and cultural contexts. In addition to this cross-cutting importance, political or administrative boundaries are mostly meaningless for biodiversity and ecosystems, at least within the usual continental settings, which implies that effective political measures need to have at least a transboundary, regional and/or continental dimension. With biodiversity loss continuing and the increasingly recognized economic consequences (EC 2013f), the issue has remained high on political agendas, both for MEAs at a global level, and in EU and regional policy settings.

In response to these complex challenges, an overwhelmingly diverse landscape of international and regional conventions and policy instruments exists to deal with biodiversity for countries in the pan-European region, both in the context of MEAs, and especially for the EU (Figure 2.4.4). For the MEAs, the CBD has been important for setting overall targets, and most recently the Aichi Biodiversity Targets for 2020. Overall, however, the CBD has become increasingly difficult for many countries to fully implement or even follow, due to dilution related to the vast range of topics and issues it deals with. These include, *inter alia*, ecological tourism, trade, intellectual property rights and local and traditional knowledge, as well as conservation, sustainable use and biosafety. Several other biodiversity-related conventions at the global level have remained separate and more focused, such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) which came into force in 1973 (*n.b.* well before the 1992 United Nations Conference on Environment and Development), the International Plant Protection Convention (IPPC) and the Convention on Migratory Species (CMS), as well as the Ramsar Convention on wetlands. However, in many cases conventions are also struggling as well for sufficient support and effective implementation in certain countries of the region.

In terms of the region as a whole, strongly developed political instruments exist for the EU, sometimes including and

Figure 2.4.4: Some selected key institutions, instruments, and frameworks for European Biodiversity Policy



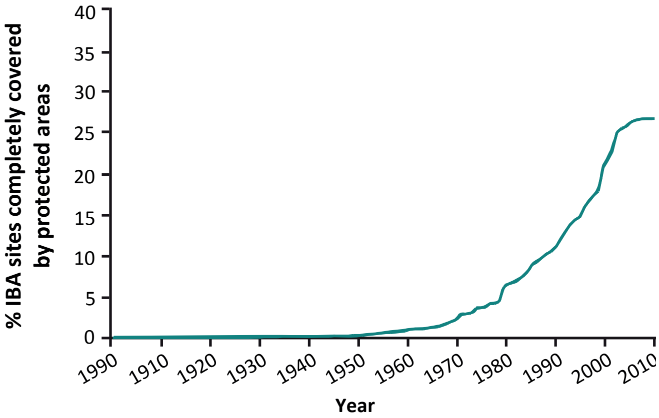
Source: Wetzel *et al.* 2015

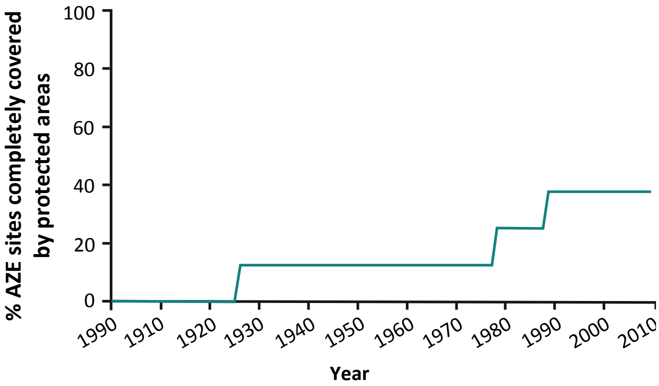
reaching out to the entire pan-European region. For the EU, a dedicated Biodiversity Strategy for 2020 has been put in place linked to the Aichi Biodiversity Targets (CBD 2014), but a larger number of environmental and conservation policies have been in place for some time to sustain biodiversity including habitats directly. A central role here has been played by the Habitats and Bird Directives (Gantioler *et al.* 2010; Gaston *et al.* 2008; Donald *et al.* 2007), now supplemented by the Marine Strategy Framework Directive, as well as a Directive on genetically modified organisms (GMOs) and the Regulation on Invasive Alien Species (IAS). Similarly, regional conventions have also shown significant, mainly positive impacts, such as the Bern Convention on the Conservation of European Wildlife and Natural Habitats, the European Landscape Convention, the Alpine Convention, the Framework Convention on the Protection and Sustainable Development of the Carpathians and the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR). For the Arctic regions of Europe, important efforts take place under the auspices of the Arctic Council, in particular with regard to its biodiversity program "*Conservation of Arctic Flora and Fauna*" (CAFF). Other conservation concerns are addressed by EU policy, for example, the illegal trade of wildlife products by the so-called EU Wildlife Trade Regulations, as illegal trade still severely affects biodiversity, particularly in the Asia-Pacific and African regions.

Establishment of protected areas and their networks is one of the essential policy responses to habitat loss and fragmentation and a key means of reducing biodiversity decline and loss (Juffe-Bignoli *et al.* 2014; CBD 2014; EEA 2012b). By number of sites, the Natura 2000 network is the most extensive network of protected areas in the world (EEA 2012b) (**More...61**). For an improved European approach towards protected areas, implementation of the Natura 2000 network can be counted as an overall success, now comprising more than 27 000 sites and covering 18 per cent of the terrestrial area of the EU Member States and 4 per cent of EU marine waters. Benefits from Natura 2000 beyond biodiversity conservation include a wide range of ecosystem services provided by the network, such as water quality, flood control, cultural services and increased values for tourism and recreation (Gantioler *et al.* 2010; EC 2013e, 2015b).

Also across the entire pan-European region, there is a relatively steep increase in the area that is protected according to international and national agreements and legislation. As shown in Figure 2.4.5, at the pan-European scale high percentages of Important Bird Areas (IBA) and Alliance for Zero Extinction (AZE) sites are currently protected. A relatively steep increase started in the 1980s,

Figure 2.4.5: Important Bird Areas (IBA) and Alliance for Zero Extinction (AZE) sites fully covered by protected areas in the pan-European region, 1900-2010





Source: Brooks *et al.* 2016

with a continuous rise in recent years. However, there are significant sub-regional differences, with a high proportion of sites covered by protected areas in Western and Central Europe and a relatively low number in Central Asia and Eastern Europe for IBAs. For AZEs, a high percentage of sites are protected in Eastern Europe and a medium proportion of sites in Western Europe, whereas none of the sites are protected in Central Europe.

Candidate Emerald site in Serbia: Djerdap national park
Credit: Shutterstock/Banet

The Bern Convention initiated the establishment of the Emerald Network launched by the Council of Europe in 1999, made up of areas of special conservation interest. This network is based on the same principles as Natura 2000 and represents its extension to non-EU countries.

It targets 180 habitat types and over 630 plant and animal species (EEA 2012b). A joint programme with the EU aimed to identify, by the end of 2011, all potential sites for the Emerald Network in Armenia, Azerbaijan, Georgia and Moldova, 80 per cent of the potential sites in Ukraine and 50 per cent of those in the Russian Federation and Belarus (EEA 2012b). The current list of Emerald sites includes 37 areas in Switzerland that have successfully passed the bio-geographical assessment for their sufficiency (CoE 2015). More countries are expected to have sites approved in the coming years.

Candidate Emerald site in Georgia: Svaneti
Credit: Shutterstock/Creative Travel Projects

The Pan-European Ecological Network (PEEN) was launched in the framework of the Pan-European Biological and Landscape Diversity Strategy (PEBLDS) and aims to conserve a full range of ecosystems, habitats, species and landscapes of pan-European importance (Jones-Walters 2007). It is also based on the Natura 2000 network and the Emerald Network, and in addition to those, the PEEN intends to link core areas physically through the restoration and preservation of corridors (Jongman *et al.* 2011). As a result of PEEN implementation to date, indicative maps have been prepared for Central, Eastern, South Eastern and Western Europe (Jongman *et al.* 2011). Other achievements include implementation of national ecological network programmes in more than 20 countries, as well as regional transboundary initiatives such as the European Green Belt and Ecoregional Conservation Plan for the Caucasus (MNPRA 2014; CBD 2010).

Finally, at both the global and regional level, there is a clear need to strengthen the synergies between the biodiversity-related conventions. There are opportunities for newly-established bodies such as the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) to also play an important role in the integration of relevant political processes and instruments.

2.5 Chemicals and waste

Main messages: Chemicals and waste

- Risks to human health and ecosystems persist across the region, with continued exposure to hazardous chemicals from a range of different sources.
- Significant differences exist amongst sub-regions in their chemicals and waste management capacities and in the resulting risks to human health and the environment. Some countries in Eastern Europe, the Caucasus and Central Asia face a legacy of environmental problems such as the presence of old stockpiles of chemicals and heavily contaminated sites, which constitute a serious source of pollution to the surrounding environment.
- Chemicals contained in products constitute a remaining challenge in terms of establishing and implementing an adequate policy response. The health impacts from product use can be significant, particularly on small children. The consequences of introducing these products into the waste stream at the end of their life are also not fully known and current legislation is not sufficient to handle the associated risks.
- Reducing food wastage is a key challenge in order to reduce pressure on limited resources. In the past five years, the loss of food has been given high priority on policy agendas. The high levels of wastage across the region, however, warrant continued and complex efforts and integrated food system approaches.
- Moving towards sound management of chemicals and waste, and reducing current risks, will require increased efforts. For example, the globally harmonised system of classification and labelling of chemicals (GHS) has not yet been fully implemented. There is also the need for full and coherent implementation of the three global conventions on chemicals – the Basel, Rotterdam, and Stockholm Conventions.
- Recent developments towards a more circular economy offer the opportunity to increase resource efficiency and improve plastics management. Recent improvements in waste prevention prioritization also look promising. These include innovative business models, repair and reuse programmes, preventing planned obsolescence, and encouraging new cultural practices with sustainable material flows such as up-cycling, do-it-yourself, and sharing.

2.5.1 Risks to human health and ecosystems persist across the region

Introduction

Inadequate management of chemicals and wastes causes negative impacts on human health and ecosystems, and jeopardizes current and future wealth. Occurrence of waste signifies that resources have not been used in an optimal way. Organic wastes degrading in dumps emit greenhouse gases, while making use of waste can contribute to net savings in greenhouse gas emissions. Inadequate waste management is a main cause of marine litter and contaminated sites (**More...62**), and hazardous waste represents a high potential risk for health and the environment.

There are more than 140 000 chemical substances on the market, and the volume of chemicals produced and used globally is growing, especially in the developing and transitional economies, due to chemical intensification and shifts in global demand and production. Global sales of chemicals are expected to rise by 3 per cent per year for the years 2013–2021, but 4–6 per cent per year in the Russian Federation and the emerging economies of Eastern Europe and the Caucasus (UNEP 2013b). As a result of the current production and use, a wide diversity and significant amounts of chemicals are released into air, water and soil in pan-European environments.

Ecological effects of chemical emissions

Chemical pollution can alter development, reproduction, behaviour and mortality in individual species, thereby negatively affecting species' diversity and the ecosystem as a whole (Walker *et al.* 2012). These effects can influence the ecosystem services available for human societies. Pesticides are of particular concern since these are applied in the field and are designed to be biologically active (Schäfer *et al.* 2007). Other types of chemicals that are of concern when they enter the environment are endocrine disruptors, pharmaceuticals, veterinary medicines, heavy metals and persistent organic pollutants (POPs). Among these types of chemicals, some have properties that significantly increase the risk of harm. These are chemicals that are persistent, bio-accumulating and toxic (PBT) or very persistent and very bio-accumulating (vPvB).

Pharmaceuticals can pose an environmental threat when improperly discarded
Credit: Shutterstock/Kaesler Media

Human exposure

Humans are exposed to chemicals (**More...63**) through air, drinking water, food, dust and direct contact with contaminated material or products containing chemicals. Exposure to toxic chemicals (**More...64**) can cause or contribute to a broad range of health outcomes (Section 1.2), such as damage to reproductive, immune and endocrine systems; developmental disorders; genetic effects and chronic diseases such as cancer, asthma, metabolic disorders and diabetes (Pruss-Ustun *et al.* 2011). Exposure to chemical pollution has been estimated to be the cause of up to 19 per cent of cancer cases globally (WHO 2011).

Monitoring of chemical pollutants

Monitoring the regional environment shows mixed trends for different substances and for different countries, depending on the pattern of use and emissions (**More...65**). Some chemicals, such as certain legacy persistent organic pollutants (POPs), show decreasing trends in the environment in many countries as a consequence of bans and restrictions. However, other groups of chemicals, for instance, fluorinated substances such as perfluorooctane sulphonic acid (PFOS) that are also persistent, show increasing trends in the environment (Sections 2.3 and 2.7). Highly fluorinated chemicals such as PFOS are of particular concern since they are extremely persistent, which means that once emitted, they stay in the environment for thousands of years.

Endocrine disruptors

Some chemicals interact with the endocrine system of humans and other organisms, leading to adverse effects in organisms and their offspring. These endocrine disruptors (EDs), of which some are POPs, appear in many different groups of products including pesticides, pharmaceuticals, additives or contaminants in food, and personal care products (EFSA 2013). They are of particular concern since they cause effects at very low exposure levels, and because effects may only become apparent after many years or in subsequent generations (WHO and UNEP 2012). The exposure to EDs in the EU is likely contributing to disease and dysfunction at high economic cost to society (Trasande *et al.* 2016; 2015; Bellanger *et al.* 2015; Hauser *et al.* 2015; Legler *et al.* 2015).

Mixtures of chemicals

Chemical pollution results in mixtures of chemicals being present in the environment and in the human body. There is growing scientific evidence of adverse effects of such mixtures of chemicals; meaning that even if the concentration of each chemical is close to or below a no-effect concentration, the mixture of chemicals present in the environment or human body can cause a toxic effect (Kortenkamp *et al.* 2009). For instance, a recent study suggests that mixtures of individual chemicals, which alone do not have carcinogenic effects, may act in combination to induce cancer at environmentally relevant low-dose exposure (Goodson *et al.* 2015).

2.5.2 ...and there are significant sub-regional differences

Introduction

While common driving forces such as lifestyle aspirations and growing consumption affect the creation of waste and use of chemicals across the region, the sub-regions also demonstrate significant differences both in terms of problems encountered and management capacity. Some countries in Eastern Europe, the Caucasus and Central Asia face a legacy of environmental problems, as well as continued reliance on heavy and highly resource-intensive industries and chemical-intensive agriculture, while the establishment of basic public utility services such as waste management is an ongoing challenge. Emissions from random dumping and the uncontrolled burning of waste present particular health hazards and environmental risks (UNEP 2013c). The uncontrolled dumping of wastes, with little or no sense of precaution and often in unknown mixtures that include hazardous components, creates health and environmental risks today and in future. At the same time, the EU is driving processes to establish advanced resource management schemes. The region also aspires to be a front-runner in the sound management of chemicals and waste, and in a transition to an inclusive green economy.

Municipal solid waste generation

Municipal solid waste (MSW) generated by a society is linked in both quantity and composition to consumption patterns, and therefore reflects pressures caused by human activities. Statistical data are available for the majority of countries in the pan-European region (Figure 2.5.1), but comparability is not necessarily achieved. Further progress in harmonization of waste definitions, data processing and reporting is necessary throughout the region (**More...66**).

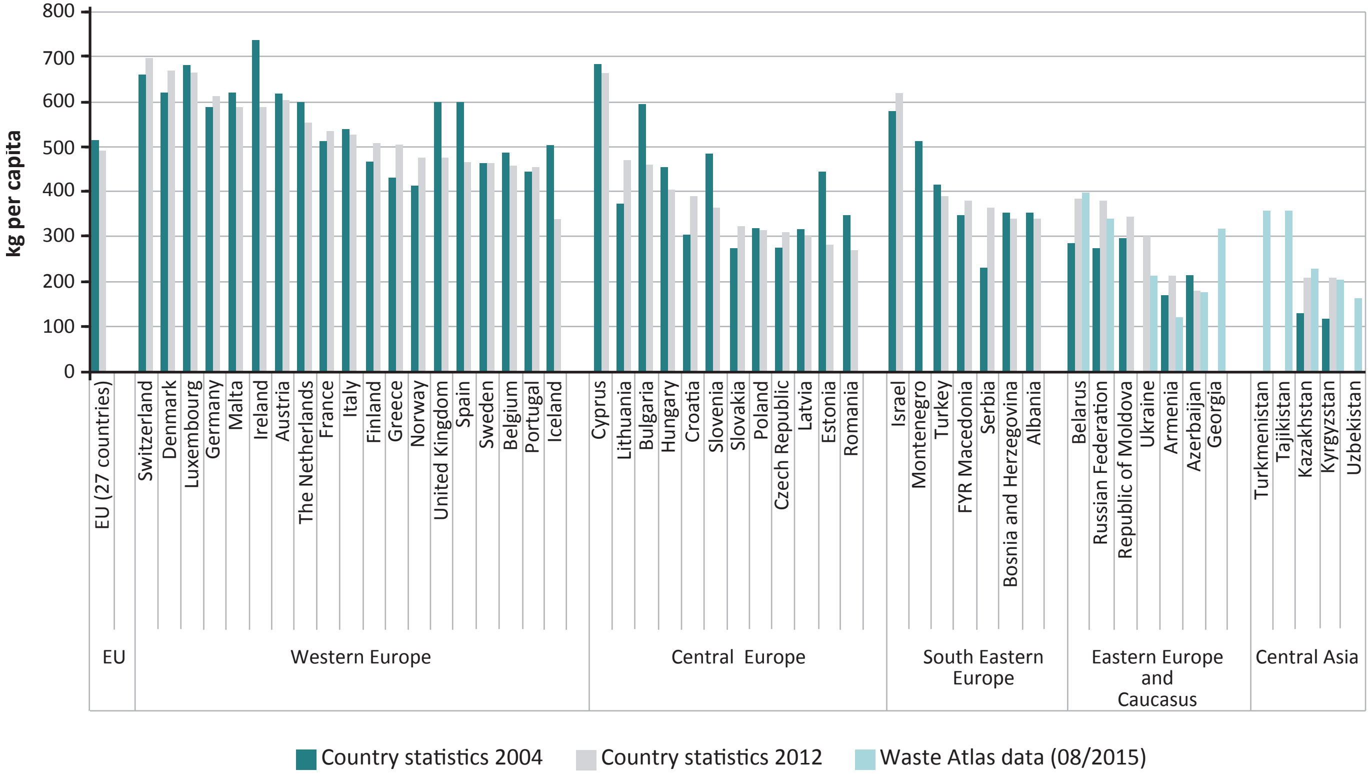
Basic waste management

Basic waste management infrastructure, including state-of-the-art landfilling of MSW, remains an issue of public health concern throughout Eastern Europe, the Caucasus and Central Asia (**More...67**). Valorisation of waste flows receives less attention there, although it is a prerequisite for transition to a resource-efficient society. Recycling is a common practice mainly throughout Western Europe, but with significant variations between countries (**More...68**).

Toxic emissions to air due to uncontrolled burning of waste can occur due to self-ignition of waste at sites with insufficient standards or due to deliberately set fires
Credit: Shutterstock/WitthayaP; Posonskyi Andrey

Establishing reliable municipal solid waste collection schemes and serving all the population is a public health priority
Credit: Shutterstock/Dmitry Kalinovsky

Figure 2.5.1: Municipal solid waste generated per person, or household waste collected per person, the pan-European region, 2004 and 2012



Sources: A) National statistics for Western, Central and South Eastern Europe: Eurostat data as compiled in *The European environment – state and outlook 2015* (EEA 2015a) (MSW generation or household waste collection); for other countries: national data published by country statistical entities (Armenia, Belarus, Israel, Kazakhstan, Kyrgyzstan: MSW, the Russian Federation, Ukraine; Azerbaijan: household waste; Moldova: household waste from urban population only); instead of 2004 data, 2005 data are shown for Belarus, Kazakhstan and Poland; 2006 data for Kyrgyzstan and Serbia; 2007 data for the Russian Federation; 2008 data for Bosnia and Herzegovina, the Former Yugoslav Republic of Macedonia and Moldova; instead of 2012 data, 2011 data are shown for Kyrgyzstan; 2013 data for the Russian Federation; conversion factor volume to mass (0.2) applied to Moldova, the Russian Federation; all data retrieved July–August 2015; B) Waste Atlas data amended for Eastern Europe, the Caucasus and Central Asia: latest available data (MSW) (WasteAtlas 2015).

On average, countries in Western, Central and South Eastern Europe recycled 29 per cent of MSW in 2012, up from 22 per cent in 2004 (EEA 2015a) (figures include Turkey but not Israel). EU legislation can be identified as a key driver of sound and resource-oriented waste management, constituting a specific motivation for the modernization of public utility services in countries joining or considering joining the EU.

Stockpiles of hazardous chemicals

Another problem with pronounced sub-regional differences is the presence of old stockpiles of chemicals and heavily contaminated sites, which constitute a source of pollution to the surrounding environment. In Eastern Europe, the Caucasus and Central Asia, this is a major concern for public health and ecosystem integrity. One category of contaminated sites of particular concern is the stockpiles of obsolete pesticides, most of which are highly toxic and

Recycling keeps resources in the value chain
Credit: Shutterstock/Evan Lorne; Ana del Castillo

persistent, with resulting contamination that will thus remain for decades. There have been efforts to clean up the disposal sites of obsolete pesticides, and achievements in reducing stockpiles have been seen in, for example, the Republic of Moldova (**More...69**) (UNECE 2014b). However, comparing estimates of stockpiles of pesticides from 2006 with those from 2013 shows that in Central Asian countries, not much progress has been made in reducing these (Table 2.5.1), and in Tajikistan, the estimated stockpiles are around four times larger in 2013 than were reported in 2006 (UNEP 2013c; FAO 2006).

Table 2.5.1: Obsolete pesticide stockpiles

Pesticide stocks (metric tonnes)			
Country	**2006**	**2013**	
		Minimum estimate	Maximum estimate
Uzbekistan	12 000	10 000	18 000
Kazakhstan	10 000	1 500	10 000
Tajikistan	3 300	10 000	15 000
Kyrgyzstan	2 000	1 500	3 000
Turkmenistan	1 671	1 500	1 500

Sources: UNEP 2013c; FAO 2006

Hazardous waste generation

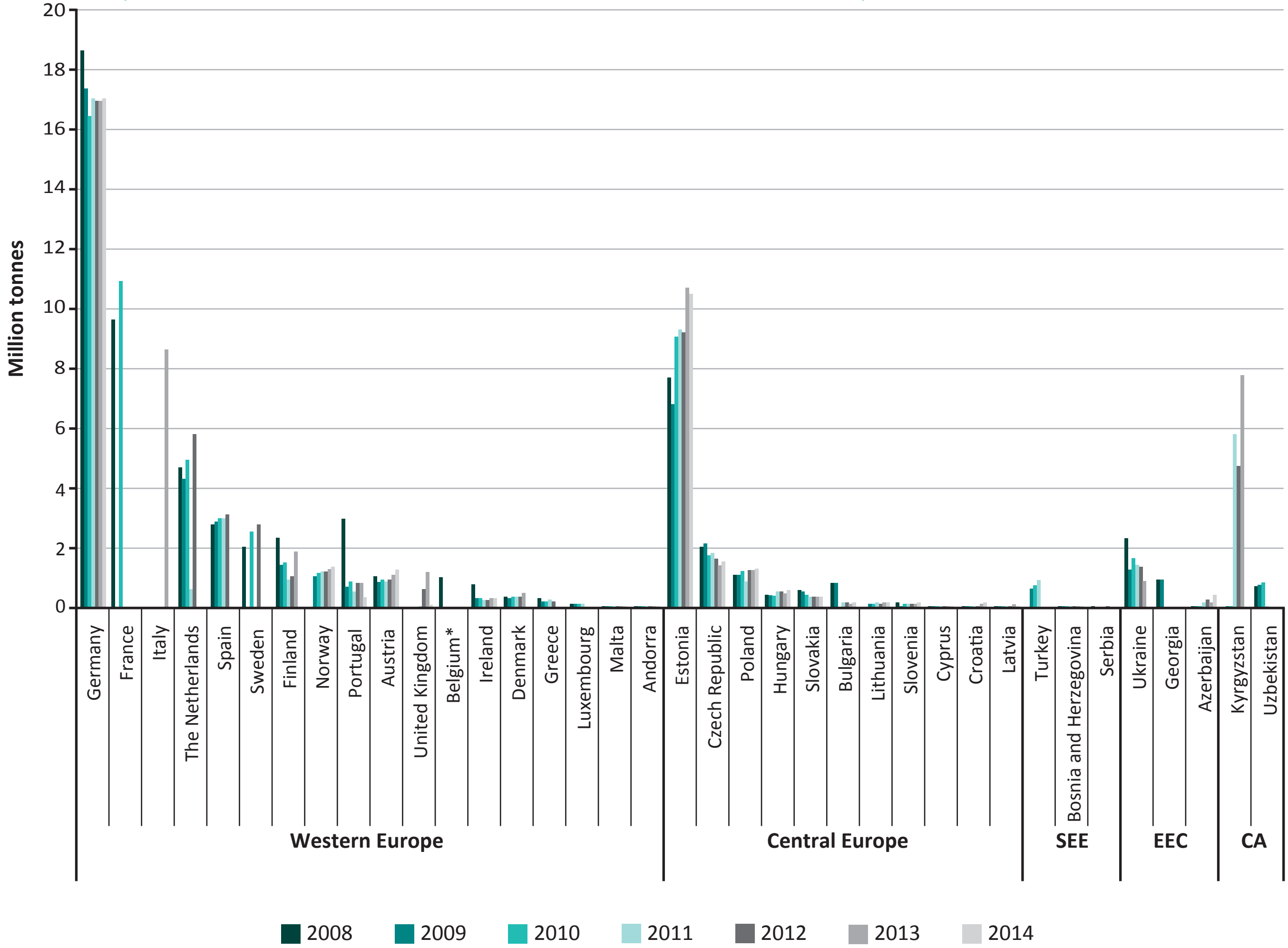
Data in the national reporting under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal suggest that the generation of hazardous waste in the region has fallen (Figure 2.5.2) but, as noted already in GEO-5 (UNEP 2012b), the number of national reports submitted to the Convention secretariat has declined, and data can be sparse and difficult to interpret, making a proper assessment difficult. More reliable and complete data sets, however, do exist for the EU (Eurostat), where the annual volume of hazardous waste generated per person remained fairly stable overall between 2006 and 2012 (low increase), but with large variations between countries. Estonia, at about 7 000 kilograms per person in 2012, and Bulgaria, at about 2 000 kilograms per person, generated the largest amounts per person in the EU, due to large shale-oil extraction and mining activities (Eurostat 2015a) (**More...70**). In Central Asia, mining activities in Kyrgyzstan also result in high amounts of hazardous waste.

2.5.3 Waste electrical and electronic equipment: a growing concern

Waste electrical and electronic equipment (WEEE) is a major challenge due both to its hazardous and precious components, as well as its rapidly increasing quantity (UNEP 2012b).

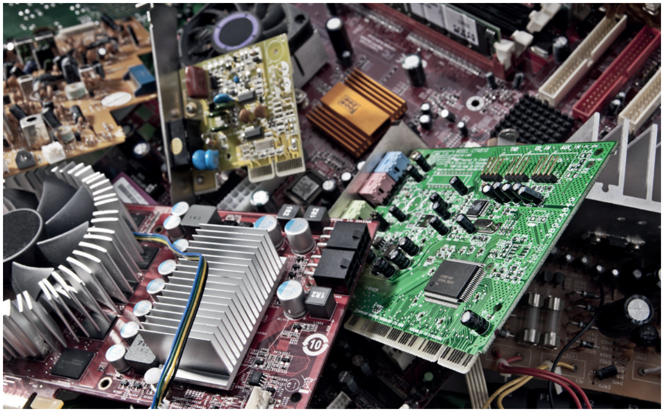
WEEE is one the fastest-growing waste streams worldwide and in Europe. Up from 9 million tonnes in 2005, it is expected that by 2020 more than 12 million tonnes per year of WEEE will be generated in the EU (EC 2016b). Domestic WEEE generation throughout the region reveals a close correlation with GDP (Figure 2.5.3), indicating that WEEE will be a companion of future economic growth. In Western Europe, generation per person of 21 kilograms is about twice the average in Central Europe, nearly three times that in South Eastern Europe, Eastern Europe and the Caucasus and nearly seven times higher than in Central Asia. Amounts generated in the EU are subject to EU-level regulations, while in other countries, including the Russian Federation that generates a large amount of WEEE, no specific regulations on management are in place.

Figure 2.5.2: Hazardous waste generation for countries in the pan-European region, as reported in the Basel Convention National Reports, 37 countries (others not available) (Basel Convention National Reports 2014; 2013; 2012).



Data refer to the categories under Art. 1(1)a (Annex I: Y1-Y45) of the Basel Convention; Finland, Hungary, Poland, Portugal (Art. 1(1)b); and Ireland, Ukraine (Total Art. 1(1)a + Art. 1(1)b).
Data are ordered by quantity and by sub-region (SEE: South Eastern Europe with Turkey; EEC: Eastern Europe and Caucasus; CA: Central Asia).
* Belgium: 2006 data (last available)

A significant share of WEEE does not enter official collection schemes even when schemes are in place, as in the EU (**More...71**). Instead, WEEE is often subject to informal waste schemes which, while less common in Western Europe, are common within the pan-European region. In Serbia alone, for example, there are approximately 5 000 informal WEEE collectors (ILO 2014). Impacts caused by activities in the region are not limited to the region, which is



WEEE contains both hazardous substances and precious components such as gold and rare earths.
Credit: Shutterstock/gopixa

Chemicals found in some toys include lead and cadmium in metal clasps and paint, phthalates as softeners, brominated flame retardants, azo dyes and bisphenols
Credit: Shutterstock/Africa Studio

demonstrated by detrimental effects caused by WEEE flows to other regions (**More...72**). WEEE and other waste material flows can be the result of legal or illegal movements. The Basel Convention has established a framework to manage transboundary waste flows, but illegal flows still occur all the same (Rucevska *et al.* 2015). Legitimate trade includes reusable and repairable equipment. Export for recycling, even of hazardous WEEE, can be legal if the Basel Convention control system for transboundary movements of wastes is in place.

2.5.4 Chemicals in products: a remaining challenge

Products used in everyday life may contain toxic compounds that contribute to exposure and negative environmental and health impacts throughout the product's life-cycle (**More...73**). There is a lack of information of the chemicals that different products contain and of the actual exposure that using the products will cause. In addition, the consequences of introducing these products into the waste stream at the end of their life are also not fully known.

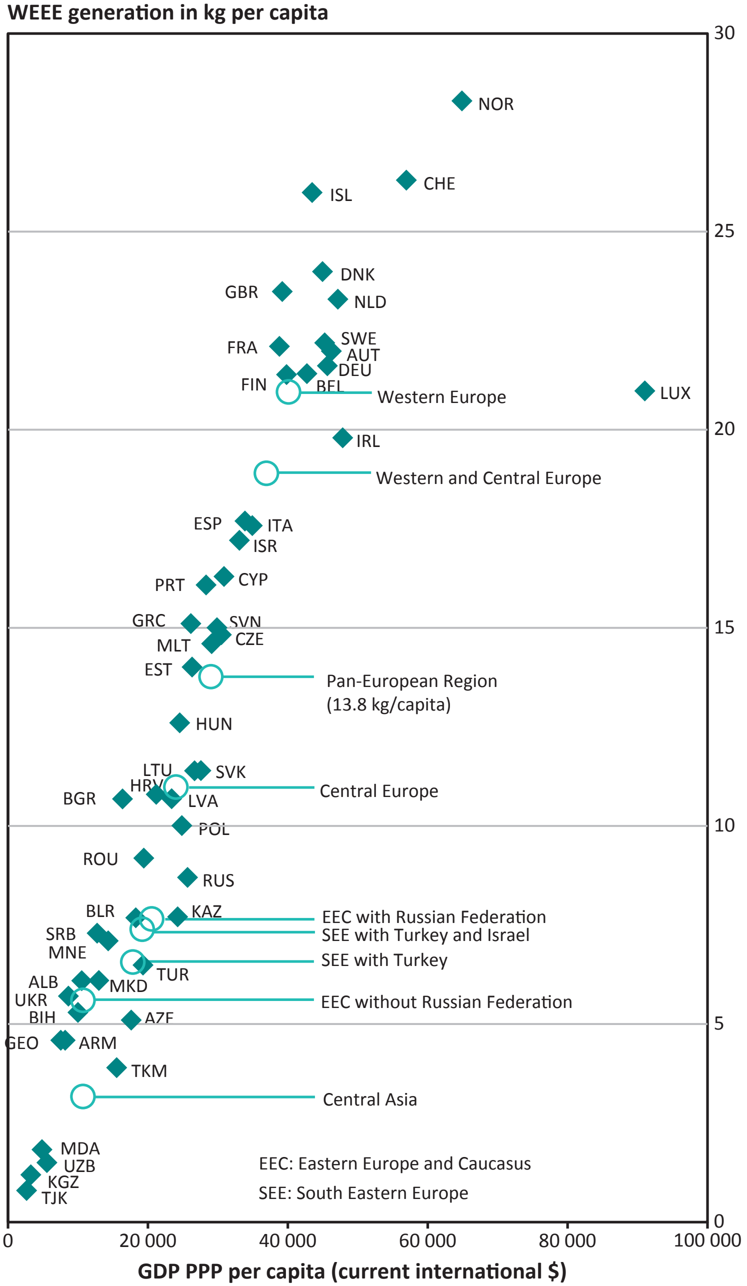
As the current legislation is not sufficient to handle the associated risks, *chemicals in products* have been identified as an emerging policy area under the Strategic Approach to International Chemicals Management (*SAICM*) (UNEP 2012b).

A product category of particular concern is toys. Chemicals found in toys include lead and cadmium in metal clasps and paint, phthalates as softeners, brominated flame retardants, azo dyes and bisphenols (Becker *et al.* 2010). Children are more susceptible and at higher risk to chemicals than adults, as they tend to put toys in their mouths, which drastically increases the exposure. Children are also more vulnerable to negative health outcomes of the exposure. As a result, toys have been made subject to special regulations in EU Member States[8] (**More...74**). Outside the EU, toy production and import are less well regulated and the corresponding measures to ensure toy safety are often missing (IPEN and GRID-Arendal 2013). Every year, more than 500 tonnes of toys enter Kyrgyzstan, the main port of entry to the Central Asian region, and concerns have been expressed over the lack of control of their chemical content (UNEP 2013c). A recent study found a toy with a lead concentration that exceeded the Russian Federation regulatory limit by 580 times (IPEN and GRID-Arendal 2013) (**More...75**).

The problem of hazardous chemicals in products requires a range of responses. Improved overall chemicals' management structures and capacity are necessary, but may not be enough

8 In the EU legislation, the word *articles* is used for what here is referred to as *products*.

Figure 2.5.3: Domestic WEEE generation (calculated from EEE trade data) in 50 countries of the pan-European region, 2014



		total per country in 1 000 tonnes
Western Europe	Germany (DEU)	1 769
	The United Kingdom (GBR)	1 511
	France (FRA)	1 419
	Italy (ITA)	1 077
	Spain (ESP)	817
	The Netherlands (NLD)	394
	Belgium (BEL)	242
	Sweden (SWE)	215
	Switzerland (CHE)	213
	Austria (AUT)	188
	Portugal (PRT)	171
	Greece (GRC)	171
	Norway (NOR)	146
	Denmark (DNK)	135
	Finland (FIN)	118
	Ireland (IRL)	92
	Luxembourg (LUX)	12
	Iceland (ISL)	9
	Malta (MLT)	6
Central Europe	Poland (POL)	397
	Romania (ROU)	197
	Czech Republic CZE)	157
	Hungary (HUN)	125
	Bulgaria (BGR)	77
	Slovakia (SVK)	62
	Croatia (HRV)	48
	Lithuania (LTU)	34
	Slovenia (SVN)	31
	Latvia (LVA)	22
	Estonia (EST)	19
	Cyprus (CYP)	14
South Eastern Europe with TUR and ISR	Turkey (TUR)	503
	Israel (ISR)	138
	Serbia (SRB)	56
	Bosnia and Herzegovina (BIH)	21
	Albania (ALB)	20
	FYR Macedonia (MKD)	13
	Montenegro (MNE)	4
Eastern Europe and Caucasus with RUS	Russian Federation (RUS)	1 231
	Ukraine (UKR)	258
	Belarus (BLR)	72
	Azerbaijan (AZE)	48
	Georgia (GEO)	21
	Armenia (ARM)	16
	Republic of Moldova (MDA)	6
Central Asia	Kazakhstan (KAZ)	131
	Uzbekistan (UZB)	45
	Turkmenistan (TKM)	22
	Tajikistan (TJK)	7
	Kyrgyzstan (KGZ)	7

Source: WEEE data from *The Global E-waste Monitor – 2014* (Baldé *et al.* 2015); GDP data from World Bank (2015) (instead of 2014 GDP data, 2013 GDP data for Luxembourg, Malta and Switzerland) in the short term when it comes to the need to reduce immediate risks posed by highly hazardous substances in specific product categories, such as heavy metals in toys. In the EU, the comprehensive European Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) does not adequately address the challenge of chemicals in products (Molander and Rudén 2012), and therefore complementary regulations, for example through the Restriction of the Use of Certain Hazardous Substances (*RoHS*) and *Toy Safety Directives* have been introduced. The aim of this legislation is to reduce hazardous substances in certain categories of products, but further harmonization between different pieces of legislation within the EU is needed. The private sector also has an important part to play in meeting the challenge posed by chemicals in products; there is also a clear business case for doing so (IOMC 2014) (**More...76**).

Food waste
Credit: Shutterstock/Dziewul

2.5.5 Food wastage in the pan-European region: a global burden

Food that is not eaten increases pressures on natural resources and competing land-use interests. Globally, annual food losses are equivalent to the production from around 30 per cent of the world's agricultural land and account for 3.3 gigatonnes of CO_2-equivalent emissions, more than the greenhouse gas emissions of the Russian Federation (FAO 2013b; FAO 2013c). Average pan-European food wastage per person is higher than the global average (HLPE 2014), and the region may account for up to 20 per cent of the global total.

Looking at different commodities, loss and waste along supply chains in the region differ notably and can be linked to a country's economic development (Themen 2014). In Western and Central Europe, distribution and consumption stages generally show particularly high rates of waste, while for some commodities, particularly fruit and vegetables, it can be assumed that market conditions divert produce to other uses such as animal feed at earlier stages of the supply chain. In South Eastern and Eastern Europe, the Caucasus and Central Asia, significant losses occur at the production and post-harvest stage. Some explanations are outdated facilities, lack of mechanization, insanitary conditions, absence of chilled transport, inappropriate storage (for example, potatoes in non-refrigerated rural household cellars) and power outages during processing (Themen 2014; Koester *et al.* 2013). But not all loss is avoidable: adverse weather conditions, losses during food processing and meal preparation set a baseline of unavoidable losses, although these are currently not well-quantified.

In the past five years, the loss of food has been given high priority on policy agendas, and is integrated in the 2030 Agenda for *Sustainable Development Goal 12*. The high levels of wastage across the region, however, warrant continued and complex efforts and integrated food system approaches (**More...77**).

2.5.6 Moving towards sound management of chemicals and waste

Chemicals and waste are part of modern society, and cannot be handled in isolation from the broader agenda of sustainable consumption and production (SCP). This is why achievement of environmentally sound management of chemicals and wastes is a specific target under SDG 12 on ensuring SCP patterns. Several targets in different SDGs address chemicals and waste. A significant number of countries in the pan-European region need to improve their basic waste management schemes and overall chemicals management systems.

Building waste management infrastructure in Bulgaria
Credit: Shutterstock/Cylonphoto

Countries in Eastern Europe, the Caucasus and Central Asia still lack basic waste management infrastructure and capacity. However, despite many remaining challenges, improvements can be observed in a number of countries, including Kazakhstan and Georgia (UNECE 2015a; UNEP 2013c) (**More...78**).

To achieve improved sustainability in consumption and production, there is increasing awareness that life-cycle thinking and eco-innovation along the whole chain of value creation need to replace traditional sectoral approaches (**More...79**), and chemicals and waste are seen as integrative elements in establishing a more circular economy (**More...80**). The waste hierarchy (**More...81**) is widely accepted as a guiding principle to increase economic value from resources and to reduce pressures on the environment. Increased recycling accentuates the importance of controlling and reducing hazardous chemicals in products and material flows, and highlights a crucial connection between the areas of chemicals and waste. Monitoring progress towards a circular economy remains a challenge (EEA 2016).

Enabling strategies within a circular economy framework, and the transition to a more resource-efficient society, need to rely on full use of the potential of private sector engagement. Positive initiatives include efficient production processes, product life-cycle extension under re-use and refurbishment schemes, remanufacturing, industrial symbiosis (**More...82**) and other forms of cooperation between various market actors, take-back schemes, service and sharing models and ecodesign (**More...83**). In the field of chemicals management, industry initiatives such as Responsible Care (**More...84**) aim to associate voluntary steps with reduced chemical risks from production. Awareness is also increasing regarding the opportunities in reducing risks through chemical substitution to safer alternatives (OECD 2013; EC 2012b).

2.5.7 Policy responses

Chemicals

Introduction

At the global level SAICM (**More...85**) has been agreed upon, with the aim to support the development of an overall, preventive chemicals management system in every country. Such a system has been achieved by EU Member States through the REACH legislation (**More...86**). For the non-EU countries in the region, the situation is more mixed, with significant gaps in basic chemical control.

For example, a cornerstone of basic chemicals management at the national level is the Globally Harmonized System for the Classification and Labelling of Chemicals (GHS) (UN 2015a), which aims to ensure that all countries use the same classification of chemicals and the same system for labelling when informing about chemical hazards. This should increase chemical safety and facilitate trade in chemicals, but although countries agreed to introduce the GHS by 2008, it has not yet been fully implemented across the region (**More...87**).

Overall and given the current pace of progress, it is unlikely that the entire region will reach the goal of sound chemicals management by 2020, as agreed at the World Summit on Sustainable Development in Johannesburg in 2002 (UNEP 2015b; UN 2002a). Indeed, *The European Environment - State and Outlook* (EEA 2015a) notes that for chemicals, the 5–10 year prospect is one of deteriorating trends because of knowledge gaps and emerging chemicals of concern (**More...88**). Failure to manage chemicals properly comes at high costs to society, including in economic terms (UNEP 2013a), and could even result in negative effects at the planetary scale (Diamond *et al.* 2015; MacLeod *et al.* 2014). On the other hand, improved chemicals management can serve as a driver of development (KEMI 2005). Connecting management of chemicals to the transition to a circular economy and resource efficiency can offer new opportunities in terms of innovation, for example in the field of sustainable and *green chemistry* (Schulte *et al.* 2013; Jenck *et al.* 2004).

Response at the national level

Chemicals are addressed at the national level in various environmental policy domains and regulatory frameworks, such as freshwater/marine water management, air quality policies and in respect to soils. Increasingly, challenges posed by some chemicals are also addressed in other sectoral policies; for example, in safety regulations for consumer products, workplace safety, plant protection in agriculture, food safety, forests and fisheries. Overall, however, policy responses at national levels are still fragmented and in many cases inadequate for complying with international commitments and making substantial progress towards the relevant SDGs.

A significant number of countries in the region urgently need to improve their overall chemicals management systems. EU Member States, which are subject to the most stringent governance system for chemicals in the region, have continuously improved their overall, preventive chemicals management system through the REACH legislation and other EU regulations and policy frameworks. But even for these countries, the 20-year outlook of *The European Environment - State and Outlook* (EEA 2015a) notes that the long-lasting and cumulative impacts of some chemicals still call for additional, concerted policy responses in conjunction with a more coherent global framework of action.

The proper and safe handling of chemicals in the context of an increasingly integrated global economy calls for a multi-dimensional capacity-building effort, for which some states in the pan-European region do not have adequate resources. To strengthen capacities in the pan-European region, safety of chemicals has to become a concern of transnational capacity-building programmes, both within the region, for example, within the EU Neighbourhood/Accession policy, and at the global level, for example, the Global Environment Facility (GEF), the Stockholm Convention and SAICM.

Sustainable chemistry, as a complementary approach to chemical safety, is an emerging policy field in the region that aims at creating capacities and innovation as part of the region's green economy agenda and the *EU's circular economy strategy*. A more sustainable chemistry already at the design stage of new substances, products and applications results in prevention of chemical risks. Currently, policy approaches and supportive means of implementation to increase the rate of substitution of hazardous chemicals in production systems and products are still at an early stage, but have some potential to be further activated by better enabling frameworks for innovation in product design and value-chain management through best available technology (BAT) and Integrated Environmental Management schemes, both within the region and globally.

Multilateral environmental agreements on sound management of chemicals

The widely recognized need for regulating the use and disposal of chemicals and prevention of harmful effects on people and the environment have resulted in a relatively coherent and well-developed global governance system for chemical safety in the past three decades. The building blocks of this system include the *Stockholm Convention* on Persistent Organic Pollutants (POPs), the *Rotterdam Convention* on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, the *Basel Convention* on the Control of Transboundary Movements of Hazardous Wastes and their Disposal and the *Minamata Convention* on Mercury, as well as the SAICM framework. A growing number of countries in the pan-European region are parties to these conventions and frameworks, which have contributed to strengthening national capacities for better management of chemicals and their lifecycles. The SAICM policy framework in particular provides an important and coherent vision for a preventive overarching chemicals management system for countries (Persson *et al.* 2014).

Enhanced synergies between the Basel, Rotterdam and Stockholm Conventions, together with an early entry into force of the Minamata Convention (29 countries of the 50 needed have ratified the Convention) and continued implementation

There is a need to continue strengthening national capacities for better management of chemicals and wastes
Credit: Shutterstock/Cary Kalscheuer; Vladimir Melnik

of the SAICM policy framework will contribute to achieving sound management of chemicals and relevant global goals and targets, such as SDG 12.4 on ensuring sustainable consumption and production patterns. In this regard, the Fourth Session of the International Conference on Chemicals Management (ICCM4), the governing body of SAICM, agreed on 11 basic elements that are regarded as cornerstones of sound management of chemicals at the national level and that will require priority action from countries in the coming years. In addition, the ICCM4 identified six priority policy issues requiring urgent action to protect human health and lives: lead in paint; endocrine-disrupting chemicals; chemicals in products; nanotechnology; hazardous substances in the lifecycle of electronic and electrical products; and environmentally persistent pharmaceutical pollutants. It is expected that progress in these areas, as enabled by SAICM, will contribute to the implementation of SDG Target 3.9 on reducing the number of deaths and illnesses from hazardous chemicals; SDG Target 6.3 on minimizing impacts of hazardous chemicals on water quality; and SDG Target 12.4 on the environmentally-sound management of chemicals and reduction of their release to air, water and soil to minimize their adverse impacts on human health and the environment. Implementing the agreements of ICCM4 in the pan-European region will enable countries to be better equipped for reducing chemical risks and for creating opportunities for successful implementation of SDG targets and the 2030 Agenda for Sustainable Development.

Waste

Introduction

Existing global, regional and national governance mechanisms provide a fairly robust basis for tracking and managing flows of hazardous and other wastes, and mitigating the human health and environmental effects of disposal. However, further improvement in strengthening the framework is necessary. Furthermore, in pursuit of the transition to a circular economy, implementation of resource-oriented waste management is of particular relevance. Expertise, availability of infrastructures and supporting regulatory frameworks are basic prerequisites. Establishing a circular economy is not limited to improving collection and recycling rates of wastes, but recovery of precious materials, especially critical technology elements that have very low recycling rates (UNEP 2011), and that end up being lost as resources, is one key priority.

Regional and national regulations

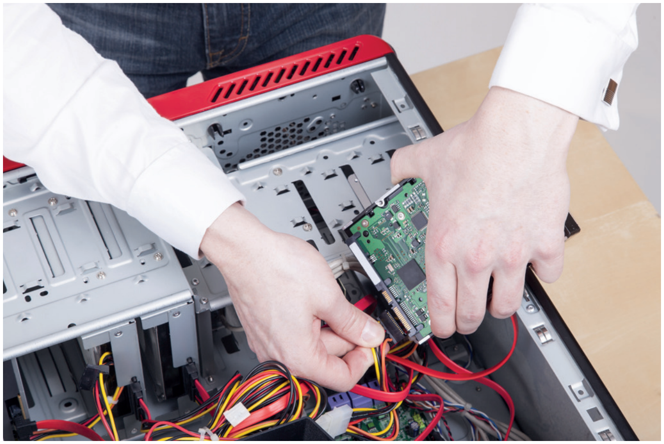
The Basel, Rotterdam and Stockholm Conventions constitute a framework of regional and national actions to track and manage the flows of hazardous and other wastes. A majority of countries in the pan-European region are parties to these treaties. The Basel Convention, as the main global institution that regulates the transboundary movement and disposal of hazardous and other wastes, is influential throughout the region and, through one of its provisions, obliges the parties to cooperate in cases where illegally shipped waste has to be repatriated. In line with Articles 3.1 and 4.1 of the Basel Convention most if not all countries in the region have national legislation in place to prevent and manage hazardous and other wastes. However, insufficient legal clarity of some rights and obligations, less-than-adequate enforcement capacity and other problems have led to implementation problems in various parts of the pan-European region (**More...89**).

The considerable potential for illegal trafficking is of particular concern (Rucevska *et al.* 2015), notably with regard to WEEE flows to other regions, where the often rudimentary methods used for informal processing pose serious environmental and health risks. Thus, building further capacities for the safe handling and management of various waste streams, including transboundary movements, needs strong legislative, economic and organizational capacities and additional enforcement power. There thus remains a need to strengthen the framework for capacity building within the Basel, Rotterdam and Stockholm Conventions.

From waste to resources management

Remanufacturing, product life-cycle extension schemes such as reuse and refurbishment, and recycling are economically viable if a market exists. Such schemes have the potential to achieve significant energy and material savings, while offering high product value at lower costs to consumers. Challenges posed by increased product complexity can be addressed by product-centred approaches supported by design for disassembly and recycling, and the use of best available technology (Reuter *et al.* 2013). Constraints to reverse logistics operations and to movements of end-of-life products to refurbishment and remanufacturing facilities posed by regulatory and market barriers can hinder circularity options in the pan-European region. Improving criteria and measures to distinguish end-of-life products exported for legitimate testing, repair, refurbishment, remanufacturing and reuse from waste destined for recycling or final disposal is essential to enable the full potential of the circular economy in the pan-European region to be realized.

Policy approaches and public-private partnership initiatives should aim at aligning global goals to create more green jobs, and promote resource efficiency and the sustainable use of resources (as captured in SDG Target 12.2: "by 2030 achieve sustainable management and efficient use of natural resources"). If undertaken jointly with industrial and business actors, such policy approaches and partnerships will have a high potential for moving economies towards improved material circularity in the pan-European region. The creation of *Rotterdam's circularity centre* is an example of a private sector-led initiative aimed at exploring the benefits of moving towards a circular economy. Where institutions with relevant expertise already exist, such as cleaner production centres, their extension should be given priority.



Challenges posed by increased product complexity can be addressed by product-centred approaches supported by design for disassembly and recycling, and the use of best available technology
Credit: Shutterstock/grafvision; Dirk Ott

The circular economy package adopted in December 2015 by the EC (**More...90**) comprises a revision of EU legislation on waste and an action plan focusing on measures such as a strategy for plastics management that, among other ideas, fosters reduction of marine litter (EC 2016a). Quality standards for secondary raw materials and the promotion of economic instruments for application of the waste hierarchy are included. A specific focus on critical raw materials reflects their strategic importance (**More...91**).

One example of government policies that show promising advances in the region is the prioritization of waste prevention that is increasingly being translated into concrete mechanisms and initiatives (**More...92**). Nevertheless, waste prevention remains particularly challenging (EEA 2015j). Moving up the waste hierarchy implies moving the consumer to the centre and aiming for increased consumer involvement and sustainability competence of individuals. Social innovation or new social consumption practices are

Plastic litter continues to pile up on European beaches
Credit: Shutterstock/Sascha Corti

pro-active responses for engagement of citizens. Hacker spaces and repair cafes (**More...93**), where people with an interest in computing or technology can gather to work on projects while sharing ideas, equipment and knowledge, are examples of citizen initiatives aiming to turn waste into a resource and to instil respect for repairing useful objects.

Further investment in research and development, and technology and innovation for putting circular economy concepts into practice throughout the pan-European region would pave the way for significant reductions in volumes of waste generated and disposed of in the region, while building capacities and contributing to the creation of much-needed jobs. Coupled with fostering consumer engagement, improved collection schemes and removal of regulatory and market barriers to product reuse, refurbishment and remanufacturing, the creation of technology centres for a circular economy could help foster significant energy and material savings.

At the same time, this would help in reducing illegal waste flows and exports of hazardous substances to other regions, as is the case of WEEE flows currently being diverted from legitimate recycling and refurbishing schemes within the region. There is also a need, and an opportunity, to more precisely estimate the current and potential contributions of remanufacturing, refurbishment, repair and direct reuse in the pan-European region under the scope of the circular economy. Further research should be encouraged to determine the full potential of these schemes, including in terms of material and energy savings, economic value and job creation in the region.

Waste recycling plant in Lithuania
Credit: Shutterstock/Rokas Tenys

Netted bins full of discarded electronics waste waiting to be transported to a recycling plant for further processing
Credit: Shutterstock/Imfoto

2.6 Freshwater

Main messages: Freshwater

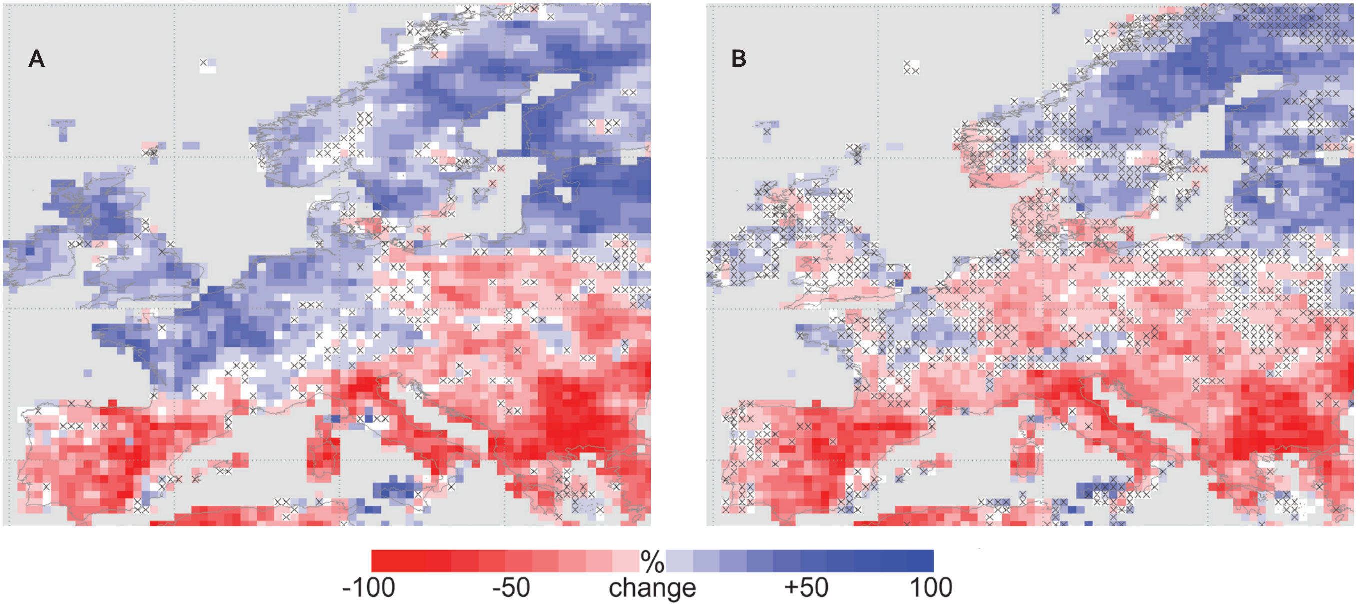
- Water availability is sensitive to climate change, and adapting to climate change requires re-evaluation of the risks of extreme events (floods and droughts) and water management as a basis of the implementation of adaptation measures. Decrease in river discharge of more than 50 per cent could be expected in Southern Europe, Israel, and large parts of Turkey while South Eastern Europe and Eastern Europe and Caucasus sub-region regions could experience a decrease of up to 30 per cent.
- The chemical status of water in the European Union is generally improving; pollutant loads from point sources are decreasing particularly as a result of the Urban Waste Water Treatment Directive, but progress is slow for diffuse pollution. Many of the classified river and lake water bodies of the EU-27 have poor ecological status as a result of pollution loads from intensive agricultural practices and population agglomeration.
- Large differences in levels of sanitation and access to drinking water persist across the pan-European region and differ by sub-region. On average, almost 100 per cent of the urban population and 85 per cent of the rural population have access to and use improved drinking water sources in the pan-European region overall, whereas access is lower in rural areas in Central Europe (38 per cent) and Central Asia (77 per cent).
- The Central Asian sub-region is considered to be facing water scarcity resulting from excessive water consumption in agriculture, with average water withdrawals for irrigation at 12 294 cubic metres per hectare per year for the sub-region, compared to a global annual average of 7 700 cubic metres per hectare. Consequences of intensive irrigation persist in Central Asia, mainly from the increase in freshwater abstraction associated with highly polluted return flows.
- Water management policies and measures will be a key contribution to meet future water challenges. The UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes and the EU Water Framework Directive are the most important instruments alongside bi and multilateral conventions on transboundary river, lake and groundwater basins, such as the Danube.
- Improving coherence between energy, agriculture, environmental and water policies would help to safeguard freshwater, or at least minimise the effects of sectoral activities on the water environment.

2.6.1 Regional variations and the fragile balance of water availability

The key drivers of water availability are climate and variations in the hydrological cycle. Recent studies suggest that the evolution of river flow rates in the recent past (last 40 years) and those forecast for the next century exhibit a widening contrast between the northern and southern regions of Western and Central Europe (EEA 2015a; van Vliet *et al.* 2013; Stahl *et al.* 2012, 2010). The spatial distribution of the mean trend in temporal runoff for the period 1963-2000 is shown in Figure 2.6.1

Glacial meltwaters are relevant to the hydrological regime and particularly during the summer period. When air temperature is high and precipitation is low, river discharge can be increased or balanced, depending on the degree of glacierization of the river basin (Dahlke *et al.* 2012; Huss 2011). In the Aral Sea region, meltwater resources are of high importance and summer flow depends greatly on the storage capacity of snow and glaciers (Kaser *et al.* 2010). Glacier retreat in the European Alps has accelerated in the last two decades (Huss 2012); the hot and dry summer of 2003 alone caused a record mean mass loss (Haeberli *et al.* 2007). Glaciers in Central Asia experienced

Figure 2.6.1: Spatial distribution of annual runoff trends a) Annual mean flow, and b) Summer low flow



Source: Stahl *et al.* 2012

substantial losses in glacier mass (27 per cent) and area (18 per cent) during the last 50 years (Farinotti *et al.* 2015). Future warming will further reduce the extent and area of pan-European glaciers, which in turn will result in major changes in the timing and magnitude of the runoff regime.

Water scarcity – when the exploitation of water resources is approaching or has exceeded sustainable limits – can be defined by the water exploitation index (WEI+), characterized by the withdrawals-to-water availability ratio. If more than 20 per cent of the renewable freshwater resources are used for agricultural, industrial and domestic purposes (WEI+ > 20 per cent), a *water resource* is under stress, while WEI+ > 40 per cent indicates severe stress and clearly unsustainable resource use (Raskin *et al.* 1997). In the southern EU-28, Turkey and southern Central Asia, high water demands related to agriculture and human populations are exacerbated by the limited natural availability of water, along with climate variability. Climate change is expected to intensify problems of water scarcity and irrigation shortfall in the Mediterranean region (Jiménez Cisneros *et al.* 2014).

Cracks in river bottom in a water basin in Spain. Climate change will lead to an increased frequency of droughts
Credit: Shutterstock/Geir Stene-Larsen

Climate change will lead to an increased frequency of drought and extended low flow conditions, lowering the dilution capacity of rivers (Whitehead *et al.* 2009; Reder *et al.* 2013). Increased water temperatures during heat waves will decrease the oxygen capacity of rivers (Cox and Whitehead 2009), and more frequent heavy rainfall events could increase the runoff of pollutants from urban and agricultural areas (Bloomfield *et al.* 2006; Boorman 2003). Weather extremes combined with seasonally changed precipitation patterns could increase losses of soil and nutrients, and complicate progress towards the achievement of good ecological status for all water bodies in Europe as required by the Water Framework Directive (WFD). Further consequences of these changes could be higher exposure of humans and aquatic life to toxic chemicals (Boxall *et al.* 2009), increasing frequency of harmful algae and cyanobacteria (Paerl and Paul 2012; Johnson *et al.* 2009) and increased river transport of nutrients and other compounds to Europe's regional seas including dead zones (Billen *et al.* 2011; Störmer 2011).

2.6.2 Limitations on water use

Schewe *et al.* (2014) analysed trends and uncertainties in future river discharge with 2°C global warming, and showed a decrease in river discharge of more than 50 per cent could be expected in Southern Europe, Israel and large parts of Turkey, while South Eastern Europe, Eastern Europe and the Caucasus sub-regions could experience a decrease of up to 30 per cent. Discharge is also projected to decrease in southern parts of the Central Asian sub-region. In addition, model simulations show that stream flow droughts will become more severe and persistent, with a decreasing trend in low-flow discharge in many European regions (Forzieri *et al.* 2014). Hence high water demands for agricultural, industrial and domestic purposes will be exacerbated by global warming and socio-economic development.

Countries may compensate for their scarcity of renewable freshwater by exploiting groundwater resources. In Europe (including the Russian Federation), 15 per cent of total water abstraction is pumped from groundwater aquifers (van der Gun 2012). The largest share is allocated to drinking water purposes, that is, about 75 per cent of EU inhabitants depend

Countries may compensate for their scarcity of renewable freshwater by exploiting groundwater resources for inefficient irrigation methods
Credit: Shutterstock/alexmisu

on groundwater for their water supply (EC 2015c). Aquifers characterized by groundwater depletion are mostly located in arid and semi-arid areas of the pan-European region, and can be attributed to agricultural withdrawals (Siebert *et al.* 2010; van der Gun and Lipponen 2010). Siebert *et al.* (2010) used a modelling approach to estimate groundwater use for irrigation requirements based on national and sub-national statistics on irrigated areas. Their results show for example that 50 per cent of the water used for irrigation was abstracted from groundwater in Turkey and Israel, and on average 40 per cent in Western and Central Europe, contrasted with 5 per cent in Central Asia. Furthermore, the general warming trend is causing an overall warming of rivers and reduction of flows, which are also likely to affect the electricity production sector (van Vliet *et al.* 2012), with concomitant effects on electricity prices (van Vliet *et al.* 2013).

Competition for water increases the risk of a conflict of interests between water-related sectors (Flörke *et al.* 2012) and can affect the economy. The 2006-2007 survey from the Environment Directorate-General of the European Commission (DG Environment) estimated the economic impacts of droughts over the past 30 years at €100 billion across the EU, with annual costs at more than €6.2 billion, which was about 0.05 per cent of gross domestic product (GDP) in 2006 (Strosser *et al.* 2012). A recent study by Brown *et al.* (2013) has found that a 1 per cent increase in the area affected by drought can slow a country's annual GDP growth rate by as much as 2.7 per cent.

Good practices in adaptation to climate change in water management range from improved water use efficiency to adaptation strategies coordinated between the riparian countries (UNECE and INBO 2015). As cautious water allocation cannot itself improve total water availability, climate change adaptation in regions affected by water shortages requires demand management in one or more sectors (Wimmer *et al.* 2015), and/or measures to increase the supply, such as desalination. Demand-side measures, however, should have higher priority than supply-side measures (Kossida *et al.* 2012), as there is still a large potential for water saving through the application of economic incentives and promoting behavioural changes. (**More...94**) Water efficiency gains are already being made across the pan-European region, though rebound effects sometimes lead to an offset, as higher efficiency does not necessarily lead to decreasing water use, especially in the absence of adequate water allocation mechanisms (Scott *et al.* 2014). Furthermore, efficiency improvements in Mediterranean agriculture are only partly a question of technology, (**More...95**) and need to be accompanied by appropriate policies reflecting socioeconomic needs, for example, commercialization of improved cultivars and marketing Tuberosa *et al.* 2007).

Another way to save water is to reuse treated wastewater, an approach used in the Mediterranean rim countries, mainly for agricultural purposes. In Western Europe, Spain accounts for the largest amount of reused wastewater (347 million cubic metres per year) followed by Italy (233 million), with agriculture receiving most of it. Israel is another large user of treated wastewater: 280 million cubic metres per year, or about 83 per cent of the country's total treated wastewater. The water reuse rate is high in Cyprus at 100 per cent, and Malta at approximately 60 per cent, whereas in Greece, Italy and Spain treated wastewater reuse represents only 5–12 per cent of all effluents (MED-EUWI 2007). Nevertheless, there is significant potential for increasing the volume of wastewater reused in the EU, but a wider uptake of water reuse solutions is hampered by several barriers such as inadequate water pricing or insufficient control over freshwater abstraction (BIO by Deloitte 2015). Although the water reuse industry benefits from technological innovations, water reuse solutions face new challenges, such as for example risks to human and environmental health impacts, energy footprint, as well as social and economic considerations (Alcalde-Sanz and Gawlik 2014). It needs to be borne in mind that safe wastewater reuse requires stringent control of water quality and related health risks (WHO 2006b).

The Central Asian sub-region is considered to be facing water scarcity resulting from excessive water consumption in agriculture, with average water withdrawals for irrigation at 12 294 cubic metres per hectare per year for the sub-region (FAO 2013d), compared to a global annual average of 7 700 cubic metres per hectare (FAO 2011a). The difference is partly due to the region's large area of saline soils (Murray-Rust *et al.* 2003), which need to be flushed at a rate of 3 000 - 3 500 cubic metres of water per hectare after harvest, sometimes two or even four times for the most saline soils. As a result, this sub-region's water use efficiency is one of the lowest worldwide (Europe Aid 2010).

Water availability is the major limiting factor for crop cultivation in the pan-European region (Murray-Rust *et al.* 2003). Although the overall regional trend indicates a slight reduction in precipitation over Central Asia (IPCC 2014b; Lioubimtseva and Henebry 2009), the opposite has been observed in the vicinity of major oases due to an increase in the area under irrigation (Pielke *et al.* 2007). A moderate increase in precipitation of 10 per cent (Kirilenko *et al.* 2009; 2009; Micklin 2007) or a slight decrease is projected for the region. Higher temperatures are likely to affect the melt rates of glaciers in the Tien Shan Mountains and the Pamirs, increasing the flow of the Syr Darya and Amu Darya rivers, with the potential to compensate for the growing irrigation demands caused by higher temperatures (Micklin 2007). However, the flow will rapidly decrease during the dry

Box 2.6.1: The Aral Sea

The drying of the Aral Sea has come to symbolize the environmental problems of Central Asia. In the 1960s the Amu Darya (72 cubic kilometres annual inflow to the Aral Sea) and Syr Darya (37 cubic kilometres annual inflow to the Aral Sea) rivers accounted for 80 per cent of the hydrological inputs to the Aral Sea, with average annual water discharge of 56 cubic kilometres. Extraction to meet the irrigation needs of large-scale cotton production, however, reduced flow to such an extent that the Syr Darya discharged no water at all to the Aral Sea between 1974 and 1986, and the Amu Darya discharged very little or none during 1982-1983, 1985-1986 and 1989 (Izrayel and Anokhin 1991). In 1986, the Aral Sea divided into two separate water reservoirs, the Large and the Small Aral Sea. Kazakhstan supported by the World Bank and scientists built a dam (Kok-Aral dike) in 2005 which prevented the water of the Syr Darya from flowing into the Large Aral Sea (i.e. Southern Aral), and together with irrigation efficiency improvements the discharge into the Small Aral Sea (i.e. Northern Aral) could be increased. Consequently, the Northern Aral recovered and the surface and water level significantly rose, while salinity dropped, allowing freshwater fish such as pike, perch and carp to return to the sea (Walters 2010). However, there is no hope that the entire Aral Sea can be revitalized (Sehring and Diebold 2012).

season once the glaciers exceed their replenishment rates (Micklin 2007; Stern 2007). Reductions in flow due to climate change have been estimated at 7-15 per cent for the Amu Darya and 5 per cent for the Syr Darya by 2050 (Sehring and Diebold 2012).

2.6.3 Multiple water challenges, particularly in transboundary river basins

Climate change will further increase the complexity of transboundary water management, as any change in the use and natural conditions at one point in a river and groundwater basin will affect the availability and quality of water resources for other uses in the river basin. Water use by sectors - influenced by climate change, socio-economic developments and other policies - is likely to have a greater influence on the state of water resources and the volumes of discharges than climate change, even though climate change is expected to exacerbate those tendencies. While hydropower generation potentially affects the timing of discharges in a major way, it is still non-consumptive. (*UNEP-DHI* and *UNEP 2016*). The water energy nexus is one aspect of this (**More...96**).

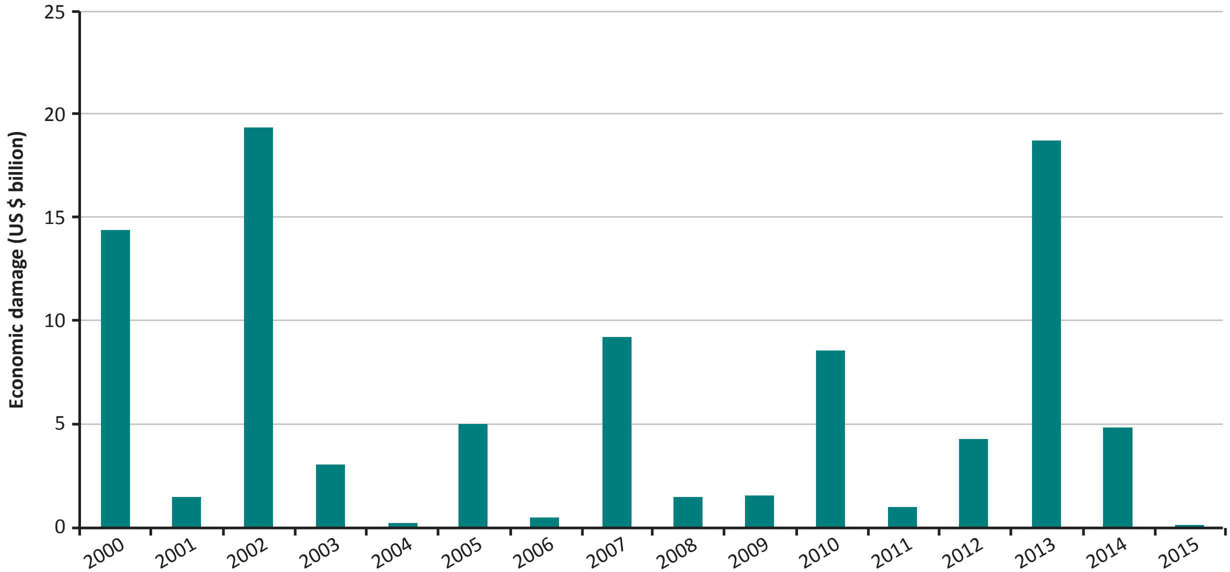
Analysis of the history of conflicts and cooperation over water in transboundary basins suggests that some political, socio-economic and physical circumstances may act as exacerbating factors and increase the risk of hydro-political tensions due to basin development in the absence of institutional capacity (Wolf *et al.* 2003). Transboundary cooperation frameworks are crucial, and water management requires coordination over different political, legal and institutional settings as well as over different information management approaches and financial arrangements (Petersen-Perlman and Wolf 2015). Key principles are equitable and reasonable utilization; not causing significant harm; environmental protection and conservation of ecosystems; cooperation, including information exchange, notification of planned measures and consultation; and peaceful settlement of disputes. These principles are accepted globally as principles of international water law and are incorporated in modern international conventions, agreements and treaties, including the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (*UNECE Water Convention*), the United Nations Convention on the Law of Non-Navigational Uses of International Watercourses (*UN Water Courses Convention)* and the *Ramsar Convention on Wetlands*. The UNECE Water Convention, now open for global accession, and the UN Watercourses Convention incorporate all the above-mentioned principles.

2.6.4 Changing frequency and intensity of extreme events

The impacts of floods and droughts can widely affect human health and safety (EEA 2012c). Climate change is projected to increase the risk of flooding and droughts in the pan-European region. According to data collected in the EM-DAT International Disaster Database (Guha-Sapir *et al.* 2016) (Figure 2.6.2) there were 337 riverine, flash or coastal floods in the region between 2000 and 2014. These floods caused the death of more than 1 500 people, affected more than 7 million people and caused more than US$88 billion in damages. The largest number of fatalities (172 deaths) was reported for a flash flood event that affected 31 410 inhabitants in the Russian Federation in 2012. The largest number of flood-affected inhabitants (1.6 million) was reported in Serbia in May of 2014. The recent largest financial damage for a single flood event, around US$14.73 billion, was reported by Austria, Germany and the Czech Republic, for a flood lasting from the end of May until mid-June 2013. According to EM-DAT, this flood caused the loss of 23 lives and affected about 1.3 million inhabitants. The EU Floods Directive requires the assessment of risks/hazards of flooding and flood management planning, through the mapping of areas that are prone to significant floods and humans at risk in these areas, and the drawing up of flood-risk management plans based on close cooperation between the EU countries.

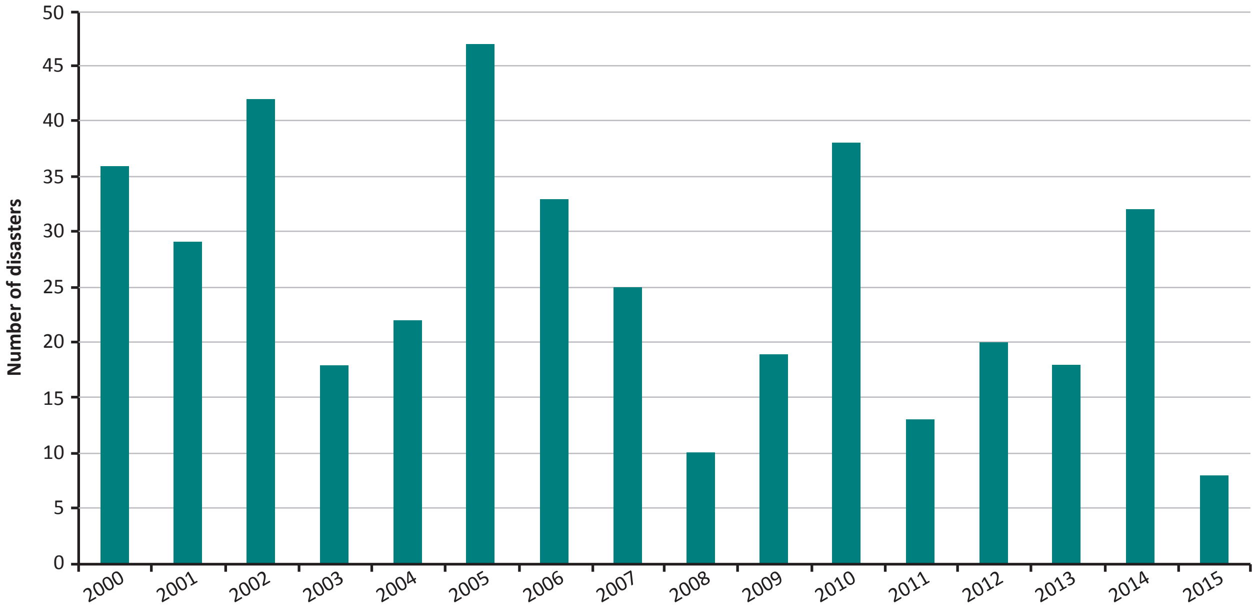
2013 flood in the Old Town of Heidelberg, Germany
Credit: Shutterstock/EQRoy

Figure 2.6.2: Impacts of floods in the pan-European region a) economic damage, b) number of disasters, and c) number of affected persons



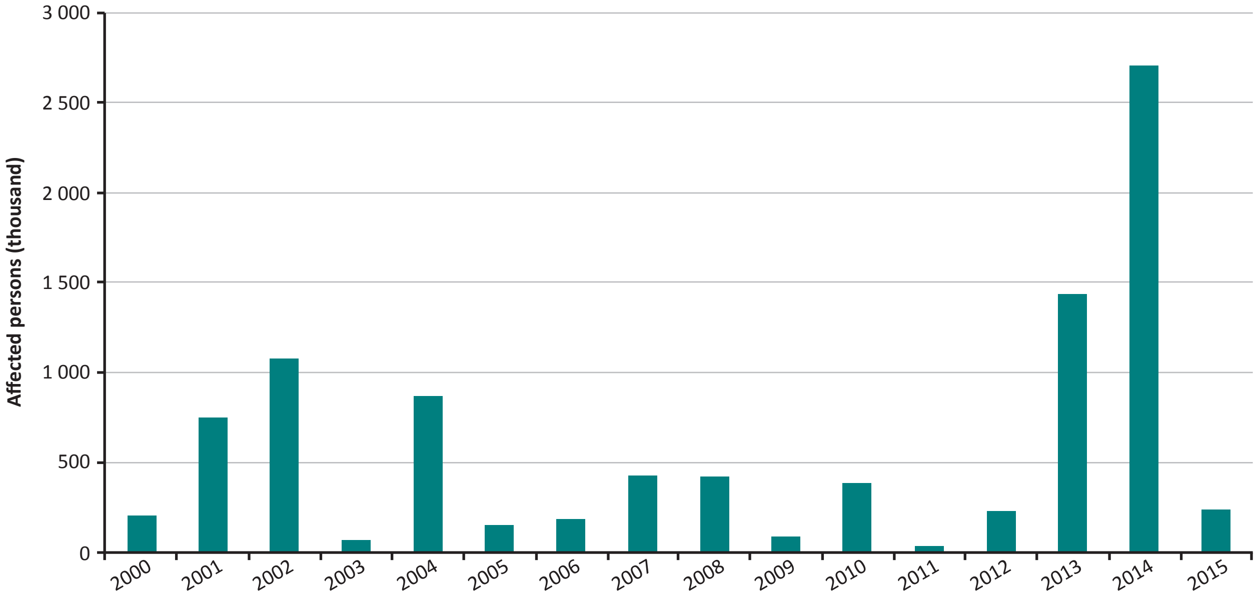
Source: Guha-Sapir *et al.* 2016

(b)



Source: Guha-Sapir *et al.* 2016

(c)



Source: Guha-Sapir *et al.* 2016

While floods can develop over short timescales such as a couple of days, droughts usually develop as a result of low precipitation over several months or years. This can make it difficult to find good data on long-term drought trends (EEA 2012d). Spinoni *et al.* (2015) have compiled data on major European drought events (meteorological and hydrological droughts) between 1950 and 2012. According to their analysis, the highest drought frequency and severity could be observed in Western and Southern Europe between 1991 and 2010; the Mediterranean area in particular was affected. Further, the authors found a small but continuous increase of European area prone to drought since the 1980s. The EM-DAT database reports 25 drought occurrences within the pan-European region for the time period 2000 to 2015, which affected 8.67 million people and caused total damages of more than US$9 billion (Guha-Sapir *et al.* 2016; Below *et al.* 2007). A small longitudinal study, carried out in 1998 in the UK, reported that the physical effects of flood events were observed in about 60 per cent of survey respondents and that they lasted an average of about 12 months, whereas mental health impacts were observed in 75 per cent of respondents and lasted more than twice as long (Jakubicka *et al.* 2010).

2.6.5 Ambient water quality: regional variations and needs

Wastewater is a major contributor to water quality degradation and therefore poses a risk to human and ecosystem health. About 50 000 million cubic metres of wastewater was generated in Western and Central Europe in 2010, a reduction of 11 per cent since 2000 (Flörke *et al.* 2013). In comparison, quantities of wastewater increased by 18-48 per cent in the other pan-European sub-regions. Changes in wastewater generation are a result of changes in freshwater use and connection rate. Leaks in sewerage systems can result in either infiltration or exfiltration, depending on local groundwater tables. Exfiltration of wastewater may result in contamination of groundwater, and thereby compromise groundwater resources where they are required for human consumption, particularly in cities. Infiltration contributes to diluting wastewater and leads to roughly proportional increases in pollution loads released into the environment. In the EECCA region, the tendency seems to be towards

December 2015 flood of the river Ouse in York, UK
Credit: Shutterstock/Phil MacD Photography

increasing generation of wastewater and thus water pollution as urban populations grow, material consumption increases and untreated wastewater volumes multiply. This is also due to insufficient and aging wastewater treatment plants.

On average, almost 100 per cent of the urban population and 85 per cent of the rural population have access to and use improved drinking water sources in the pan-European region overall, whereas access is lower in rural areas in Central Europe (38 per cent) and Central Asia (77 per cent). The situation is

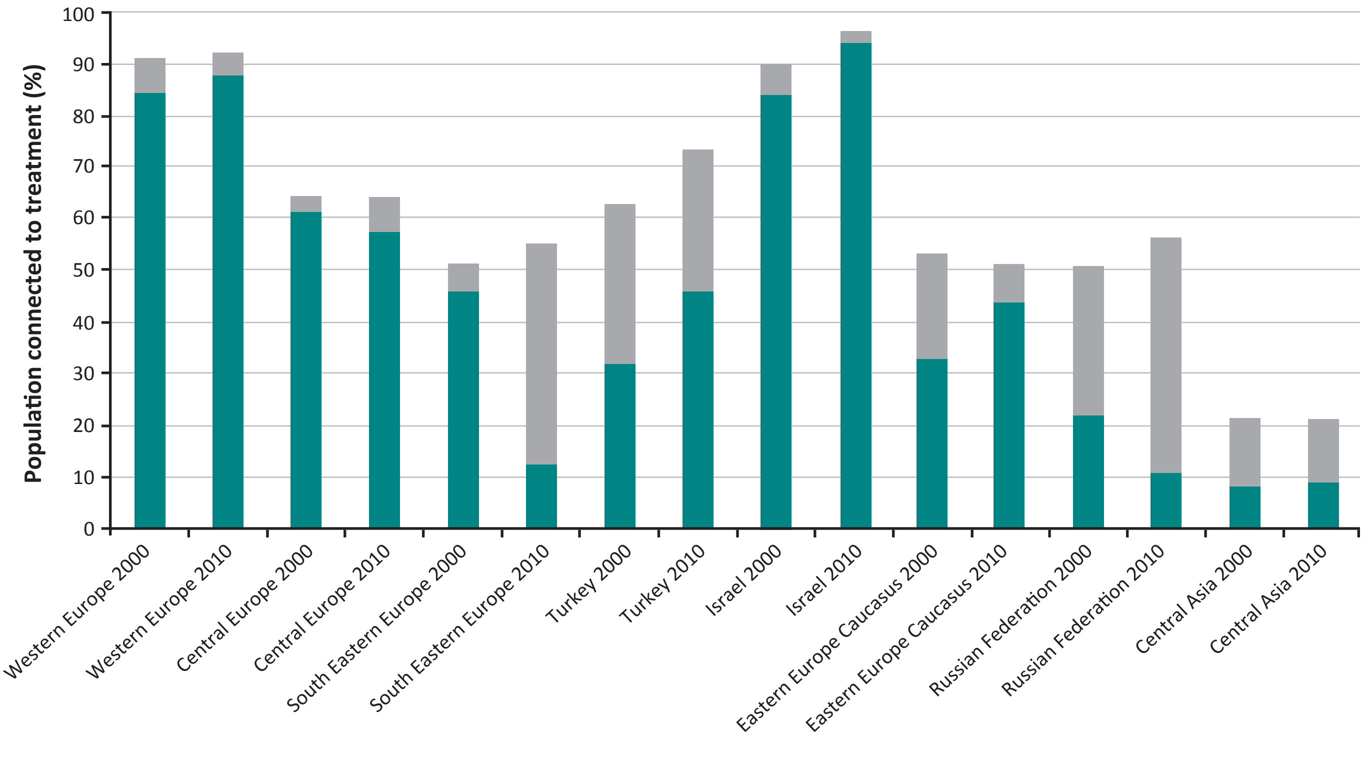
Aerial view of public sewage treatment plant for 165, 000 inhabitants of Pilsen city in Czech Republic, Europe
Credit: Shutterstock/Kletr

more diverse across the entire pan-European region in the case of the collection and treatment of wastewater. More than 90 per cent of the population in Western Europe and Israel was connected to a sewer system with wastewater treatment in 2010, an improvement on 2000 when about 85 per cent per cent of the population was connected (Figure 2.6.3) Only about 1-2 per cent of collected household wastewater remained untreated and was released into the environment without any treatment.

In contrast, the proportion of the population connected to sewer systems with wastewater treatment was lowest in Central Asia and South Eastern Europe, with 9 per cent and 13 per cent respectively in 2010. Although the number connected to sewer system and treatment facilities increased in South Eastern Europe over the previous decade, still 43 per cent of the wastewater collected from households was being discharged into surface waters without treatment. In Eastern Europe and Caucasus sub-region, only 7 per cent of the collected wastewater was left untreated in 2010, an improvement on the 2000 figure of 32 per cent.

A decreasing trend in wastewater collection and treatment can be seen in the Russian Federation due to a lack of infrastructure. Here only 12 per cent of the population was connected to a sewer system with wastewater treatment in 2010, while the highest proportion of the population was connected to a sewer system without treatment. Overall, although more wastewater was collected, less of the population was connected to treatment.

Figure 2.6.3: Percentage of the population connected to sewage system and wastewater treatment in pan-European regions for the years 2000 and 2010



Source: WHO and UNICEF 2014

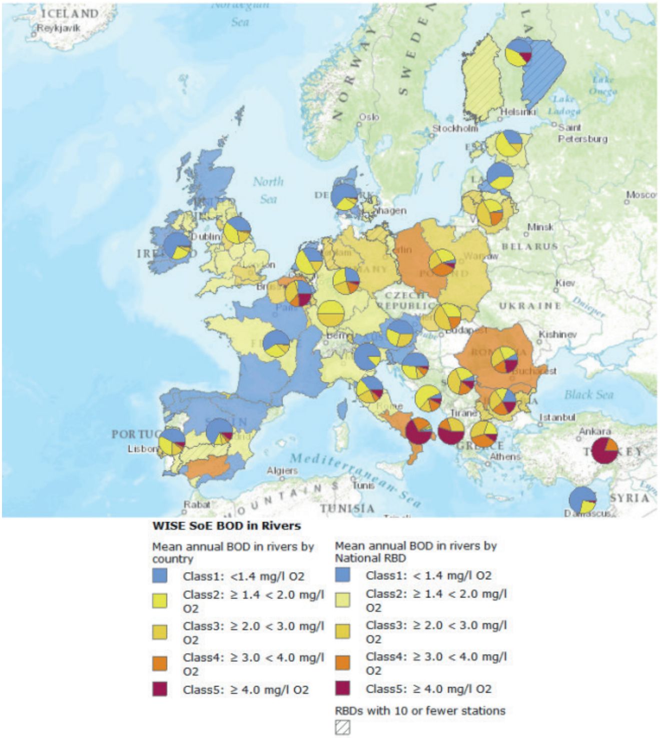
There are many different causes of organic pollution. The main source of organic materials in rivers is domestic and industrial wastewater, as well as livestock wastes discharged to freshwaters without proper treatment. In this context, the collection of wastewater and its treatment are key elements in reducing organic pollution, and hence for protecting ambient water quality.

Biochemical oxygen demand (BOD) concentrations are a measure of the potential of organic matter to deplete the critical oxygen resources of waters and a key indicator of organic pollution (EEA 2015a). It has been decreasing in European rivers throughout the period 1992 to 2012, reflecting improvements in wastewater treatment. In 2010, the highest BOD concentrations occurred in the Central European and South Eastern European sub-regions where wastewater treatment is not well-advanced (Figure 2.6.4). Large quantities of organic matter pose a potential risk to aquatic ecosystems and human health. Nevertheless, improvements have been made in these sub-regions too, and river concentrations are at their lowest level to date.

The frequency of months each year in which severe BOD pollution levels occur in large Central Asian rivers from 2008 to 2010 is shown in Figure 2.6.5. Severe BOD levels occur in downstream reaches of the major cities, mainly caused by discharges of domestic and industrial wastewater, which typically contain large quantities of biodegradable substances. An increase of BOD concentrations in main rivers and tributaries has been observed as a result of low operating efficiency of wastewater treatment plants (UNECE 2010).

Water temperature is also an important water quality parameter that influences chemical and biological processes, as well as the physical properties of rivers and lakes. Water temperature plays a key role in influencing aquatic animal health through a temperature-driven effect on the epidemiology of diseases (Karvonen *et al.* 2010), but also in fostering, for example, cyanobacteria blooms and lower oxygen concentrations in combination with nutrient concentrations (EEA 2010c). According to data records, water temperatures in major European rivers have increased

Figure 2.6.4: Mean annual concentrations of BOD (milligrams per litre) for the year 2010, as measured at the EIONET-Water River monitoring stations for the time period from 1993



Source: WISE 2015

by 1-3°C over the last century (EEA 2012a), with several data time series indicating a general trend of increasing water temperature in European rivers and lakes in the range of 0.05 to 0.8 °C per decade (Dabrowski *et al.* 2004; George & Hurley *et al.* 2004). (**More...97**). Global warming is likely to cause a shift in temperature of freshwater systems, and although increased water temperature could lead to an increase in certain vector-borne diseases, the predictions for future development of human health related disease vectors are still highly uncertain (EEA 2010c; Hunter 2003).

Figure 2.6.5: Frequency in which severe pollution levels of biochemical oxygen demand occur in different river stretches in Central Asia over the period 2008-2010.

Severe pollution level has been defined as concentrations exceeding 8 milligrams per litre shown in number of months per year.
Source: UNEP 2016

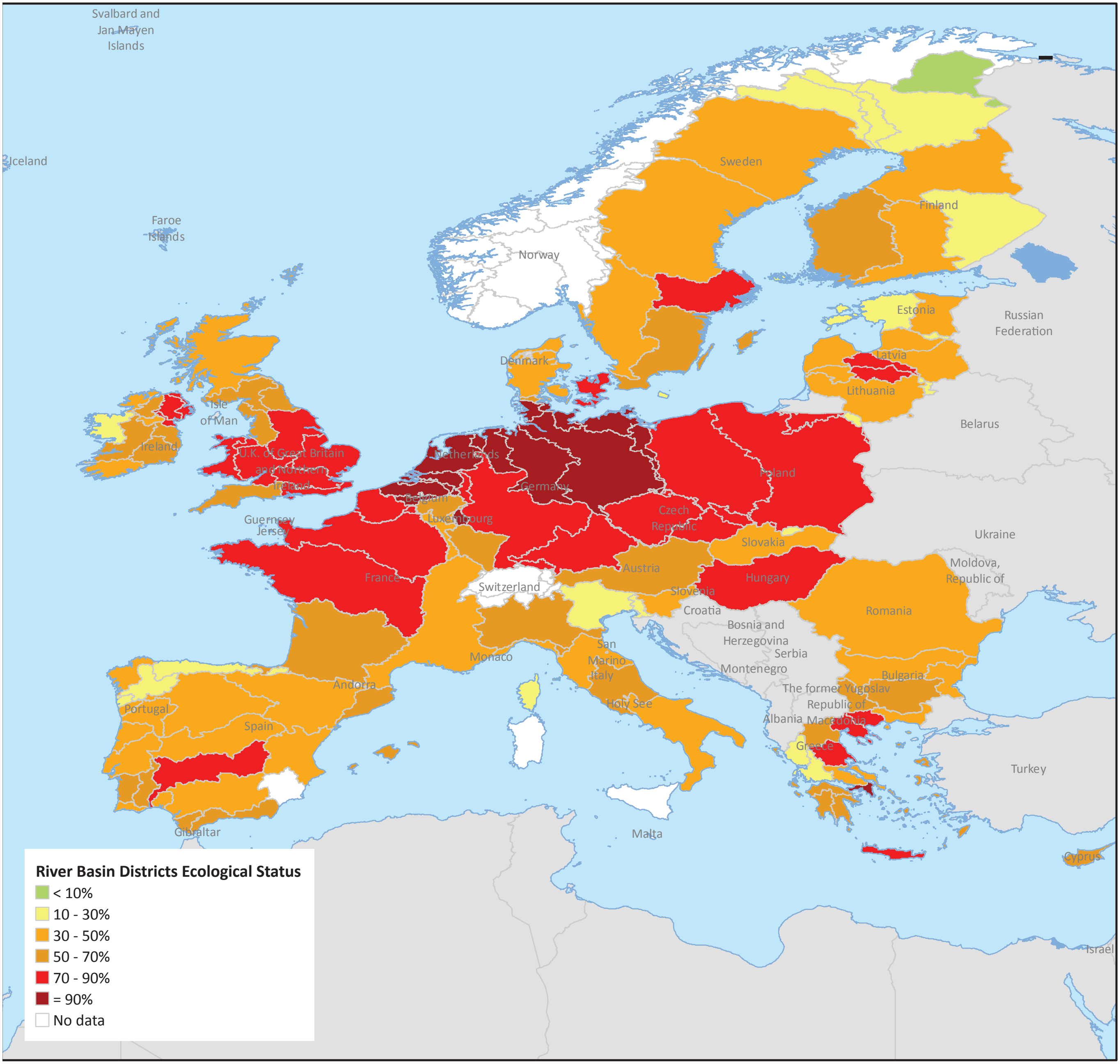
2.6.6 Rivers, lakes and reservoirs: routes for fertilizers and chemical pollution

The waters of the EU are cleaner than they were 25 years ago, with 53 per cent of surface waters having a good ecological status in 2015. However 48 per cent of European waters are exposed to morphological pressures that have significant negative impacts (EC 2015c). Overall, average levels of phosphate and nitrate in rivers declined by 57 per cent and 20 per cent respectively between 1992 and 2011 (EEA 2014d). This mostly reflects improvements in wastewater treatment achieved by the EU Urban Wastewater Treatment Directive and reductions in the levels of phosphorus in detergents, rather than measures to reduce agricultural inputs of nitrate at European and national levels, which are reflected in the Nitrate Directive.

The effect of actual measures on water quality is sometimes not evident because of time lags due to specific transport mechanisms and soil-aquifer characteristics (Jackson *et al.* 2008). In contrast to diffuse sources, where the storage of nitrate in soils and aquifers plays a role, emissions from point sources are directly released into surface waters. Thus effects of emission reductions related to point sources are immediately measurable compared to diffuse sources. Overall, river nitrate concentrations are below the threshold of 50 milligrams per litre, (**More...98**) but current concentrations are still often sufficient to promote eutrophication in coastal waters. However, many of the classified river and lake water bodies of the EU-27 have poor ecological status and currently fail the environmental objectives of the WFD, as a result of pollution loads from intensive agricultural practices and population agglomeration (Figure 2.6.6)

In 2009, only 43 per cent showed a good/high ecological status; the expected 10 percentage point increase for 2015 (to 53 per cent) constitutes only a modest improvement in

Figure 2.6.6: Proportion of classified river and lake water bodies in different EU-27 River Basin Districts holding less than good ecological status or potential



Source: EEA 2015p

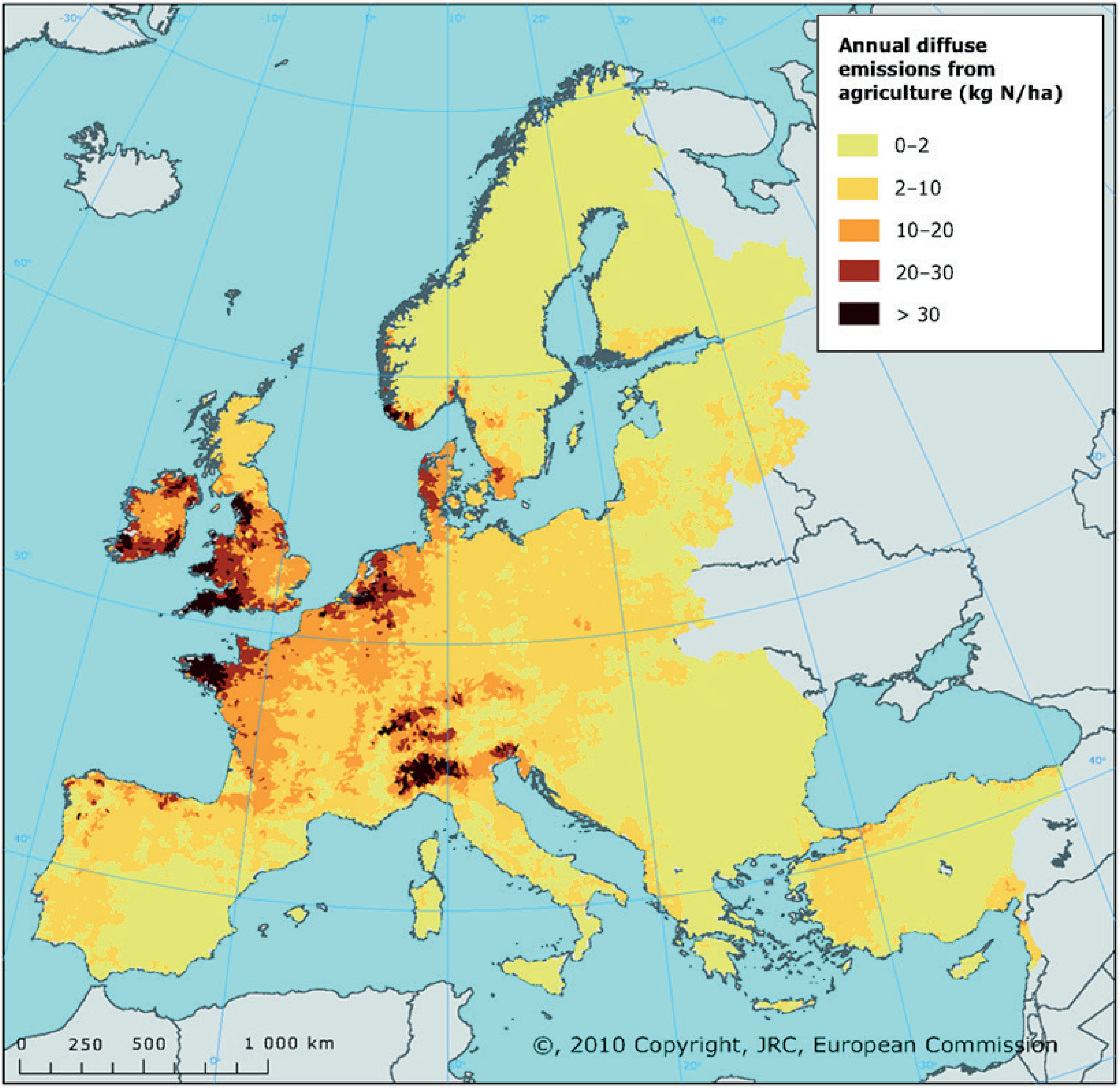
The chemical status of water in the European Union is generally improving; pollutant loads from point sources are decreasing particularly as a result of the Urban Waste Water Treatment Directive, but progress is slow for diffuse pollution.
Credit: Shutterstock/Photodiem

aquatic ecosystem health. Although agricultural nitrogen balances are declining, they are still high in some countries, particularly in lowland Western Europe (Figure 2.6.7). The EEA has noted the large percentage of water bodies where diffuse pollution is a significant pressure, and EU Member States have reported that agricultural pollution is a major issue in 90 per cent of River Basin Management Plans (Farmer *et al.* 2012).

Phosphorus is an important nutrient for aquatic life, but because it is a limiting factor, emissions from human sources increase the level of phosphorus concentrations in surface waters and cause eutrophication. Actually, total phosphorus (TP) loads transported to the large lakes and reservoirs in Europe range between 2-10 kg TP per square kilometre of catchment area per year (Figure 2.6.8). The share of anthropogenic phosphorus dominates the intakes, and high loadings from human sources have been estimated for the Kuybyshevskoye Reservoir (83 per cent) and Lake Peipsi (60 per cent). In this regard, major human sources are domestic wastewater, industrial fertilizer and livestock wastes (manure). The fraction of domestic phosphorus loads is especially high at Lake Onega; at other lakes, fertilizer (industrial and manure) contributes with more than 50 per cent to the total loads. But this situation is not consistent through time. Phosphorus loads to large lakes in Eastern Europe and Central Asia declined significantly after the break up of the former Soviet Union (UNEP 2016) (Box 2.6.1 The Aral Sea), due to a massive reduction of fertilizer application. On the other hand, phosphorus loadings to Western European lakes declined due to improvements in wastewater treatment and reduction of phosphates in domestic wastewater under the EU Urban Wastewater Treatment Directive.

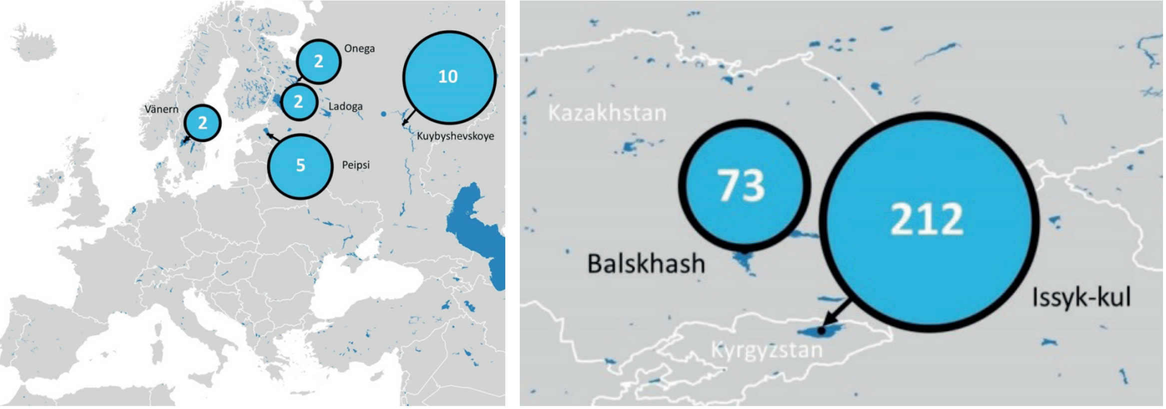
Significant improvements in regard to the chemical status of water bodies have been achieved in the last 30 years, however, the situation in regard to the priority substances introduced by the WFD is not clear (EEA 2012e). There is a large proportion (about 40 per cent) of water bodies with unknown status because of the lack of monitoring, but about 10 per cent of Europe's surface water bodies have a poor chemical status. A challenge for river basin management is new and emerging contaminants such as many novel organohalogenated substances, including perfluorinated compounds, brominated flame retardants, certain veterinary and human pharmaceuticals, alternative anti-fouling biocides, components from personal care products, plastics and plasticizers that have been found in all pan-European seas. This is an important issue of concern that requires special attention, as for example in the case of endocrine disrupting compounds (EDCs). It has been observed that river concentrations of EDCs in storm water

Figure 2.6.7: Annual diffuse agricultural emissions of nitrogen (in kilograms per hectare) to freshwater in 2009



Source: Bouraoui *et al.* 2011

Figure 2.6.8: Average total phosphorus loads per unit catchment area (kilograms per square kilometer per year) into large lakes and reservoirs in Europe (left) and Central Asia (right)



Source: UNEP 2016

Box 2.6.2: Nutrient pollution in the Danube River Basin

The Danube River Basin Management Plan (DRBM) was updated in 2015 in order to provide a revised assessment on
(i) the main pressures impacting the river basins,
(ii) information on the water status and progress achieved, and
(iii) further actions agreed by the Danube countries (ICPDR 2015).

In terms of nutrient pollution entering the Danube River system, diffuse pathways clearly dominate the total emissions by 84 per cent (total nitrogen, TN) and 67 per cent (total phosphorus, TP), originating mainly from agriculture (TN: 42 per cent, TP: 28 per cent) and urban water management (TN: 25 per cent, TP: 51 per cent). Groundwater (base flow and interflow) is the most important diffuse pathway for TN emissions with a proportion of 54 per cent. In case of TP, soil erosion (32 per cent) and urban runoff (18 per cent) generate the highest emissions. Nevertheless, it should be emphasised that total point source emissions are significantly influenced by untreated wastewater discharges and emissions of medium-size and large agglomerations without nutrient removal.

increase during heavy precipitation events (Jonkers *et al.* 2009; Boyd *et al.* 2003) because of overflowing wastewater treatment facilities, and possible re-suspension of EDCs from river sediments. Higher concentrations of EDCs may also occur in rivers because of decreased dilution during low flows (Cladière *et al.* 2014; Johnson 2010). Both factors might have an impact on the future provision of clean drinking water in many places. Concentration limits for a list of priority (hazardous) substances are defined by the Environmental Quality Standards Directive (EQSD), which is meant to improve the protection of the aquatic environment and reduce the risks to human health. (**More...99**)

In the EU, the main problem caused by nitrates occurs when they leach into groundwater (due to their high solubility). The associated health risks are primarily related to potential exposure through uptake in infants. About 25 per cent of the groundwater bodies in Europe were characterized by a poor chemical status due to the excessive concentration of nitrate in 2009 (EEA 2012e). For more than 50 per cent of these groundwater bodies, excessive nitrate concentration was the main cause, with a significant portion of nitrates coming from agricultural land in densely populated catchment areas (Colombo *et al.* 2015; Grizzetti at al. 2015), followed by Groundwater Directive's Annex II pollutants (other common groundwater pollutants) (34 per cent) and pesticides (20 per cent) (EEA 2012e).

In Central Asia, the major problem is salinization of surface water and groundwater, due to intensive development of irrigated farming and effluents from municipal and industrial sewers. At the end of the 1960s, water salinity did not exceed 1 gram per litre (g/l), even in the lower reaches of rivers (Sokolov 2009). The level of mineralization in the waters of the Syr Darya ranges from 0.45-0.6 g/l in the upper flow to 1.1–1.4 g/l in the middle flow (excluding the Fergana valley) (Valentini 2004), to 3 g/l in the lower reaches (SIC ICWC 2011). Owing to the state of disrepair of the drainage system, the groundwater table has risen everywhere and become contaminated with high levels of salts and other minerals (Mukhamedzhanov and Nerozin 2008; Mukhamedzhanov 2007; Baknell 2003). Total dissolved salts in the groundwater range from 0.5 g/l to 6 g/l. In some areas, total dissolved salts in drinking water are found at 3.5 g/l, with the salt limit set by the Uzbek government at 1 g/l (Small *et al.* 2001). About 65 per cent of drinking water samples taken in Karakalpakstan proved not to correspond to standards (Small *et al.* 2001). Besides a decline in crop productivity, waterlogging leads to bacterial and chemical (pesticide) pollution of underground sources of drinking water, resulting in a high risk of hepatitis and typhus fever outbreak (Baknell 2003). Nevertheless, the amount of pollutants discharged into freshwater bodies stabilized over the last decade and even dropped in some countries, but water quality continues to deteriorate due to unsustainable water use and restoration of production capacity (UNECE 2012).

2.6.7 Policy responses

A wide range of governance systems for sustainable freshwater management exists at national and international levels. They guide policy-making in the pan-European region. But implementation challenges remain and vary strongly across countries, basins and in regard to particular freshwater problems. While acute pollution problems are concentrated in some hot spots only, virtually all areas of the pan-European region still experience serious problems with respect to ecological status and nutrient loads. These problems can only be resolved through better coordination between policies that target biodiversity, land use, agriculture, energy and freshwater systems, as well as chemicals and waste. Acute challenges associated with water allocation, for example in Central Asia and southern Europe, must be resolved mainly through intensified cooperation among the riparian countries of the respective catchments. This is challenging in catchments where the EU's Water Framework Directive and other governance systems provide little political leverage, and global MEAs currently provide only general guidance, for example, water allocation is a topic in the UNECE's Water Convention work programme.

The policy and governance system for freshwater in the pan-European region consists of three layers and is rather complex in structure, not least because the pan-European region includes around 120 international freshwater catchments. (**More...100**)

Firstly, most of the international legal frameworks that exist are bilateral or multilateral, covering individual international river, lake or groundwater basins. The most advanced and comprehensive of these frameworks cover the rivers Danube and Rhine. Because of clearly manifested transboundary challenges associated with navigation, water scarcity, flooding and pollution, some of these individual river basin regimes have emerged over many decades, notably in Western Europe, while others have formed more recently, for example in Central Asia.

Secondly, the EU has established a complex international freshwater governance system of its own, consisting of the WFD, which guides and organizes EU policy-making in the water sector, and several more specific directives. These include, for example, the 1991 Urban Waste Water Treatment and Nitrates Directives, the 1998 Drinking Water Directive, the

The transboundary Rhine River crosses Belgium, France, Germany, the Netherlands, and Switzerland
Credit: Shutterstock/Yurchyks

1996 Integrated Pollution and Prevention Control Directive addressing pollution from large industrial installations, and the 2007 Floods Directive. The Water Framework Directive places great emphasis on the concept of integrated water resources management at the catchment scale, and thus promotes stronger institutionalization of environmental management efforts similar to what has emerged in the Rhine River basin since the 1970s. In addition to UNESCO's World Water Assessment Programme, the Water Framework Directive and the European Environment Information and Observation Network (EEA's EIONET) in particular provide the most elaborate and coherent framework for monitoring freshwater systems at a transboundary scale.

Thirdly, several MEAs at the global level and the WFD define basic principles for international freshwater management. One example of a global MEA is the UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes. These global MEAs essentially codify practices that have existed in Western European river basins for the past few decades, such as setting up monitoring systems at the river basin scale and exchanging data in a transparent and reliable manner. These practices have helped considerably in resolving transboundary water allocation and pollution issues. They also provide useful points of reference, particularly for parts of the pan-European region where international freshwater catchment institutions have only emerged recently and where such efforts remain challenging, for example in Central Asia and South Eastern Europe. Combined with greater access of civil society to policy-making and implementation processes, better monitoring and data exchange systems are also crucial for improving local-to-national level water policies, and improving coordination among policy-making at different levels, from the local to the pan-European.

In areas of the pan-European region where basin-scale governance systems are weak, for example in Central Asia, global-level MEAs provide elements for resolving transboundary water allocation and pollution problems. Cases such as the Syr Darya and Amu Darya or the Euphrates and Tigris basins also show, however, that these global principles provide only limited leverage when political conflicts over water among riparian countries emerge. In most cases, riparian countries need to resolve such problems on their own, sometimes with technical and financial support from other countries and international institutions, for example, the UNECE Water Convention, the OECD, the OSCE, the World Bank or the EU.

Better data and greater transparency are also essential prerequisites for meaningful use of market instruments and for enhancing domestic and transboundary liability schemes. They are also important first steps in trying to resolve transboundary water allocation and pollution challenges associated with consumptive and non-consumptive water uses, as well as pollution from industry, agriculture and mining. Continuing development of the pan-European water governance framework and monitoring system, using the UNECE Water Convention and its Protocol on Water and Health, the EU's Water Framework Directive, the EEA's EIONET and UNEP's GEMS-Water could help to reduce the differences in basin management in the region.

Going forward, Rio+20 placed water at the core of sustainable development and highlighted the need to reduce water pollution, improve water quality and reduce water loss. The 2030 Agenda for Sustainable Development has a specific water-related goal encompassing water management, water supply and sanitation as well as water quality (UN 2015b) (**More...101**).

2.7 Coastal, marine and oceans

Main messages: Coastal, marine and oceans

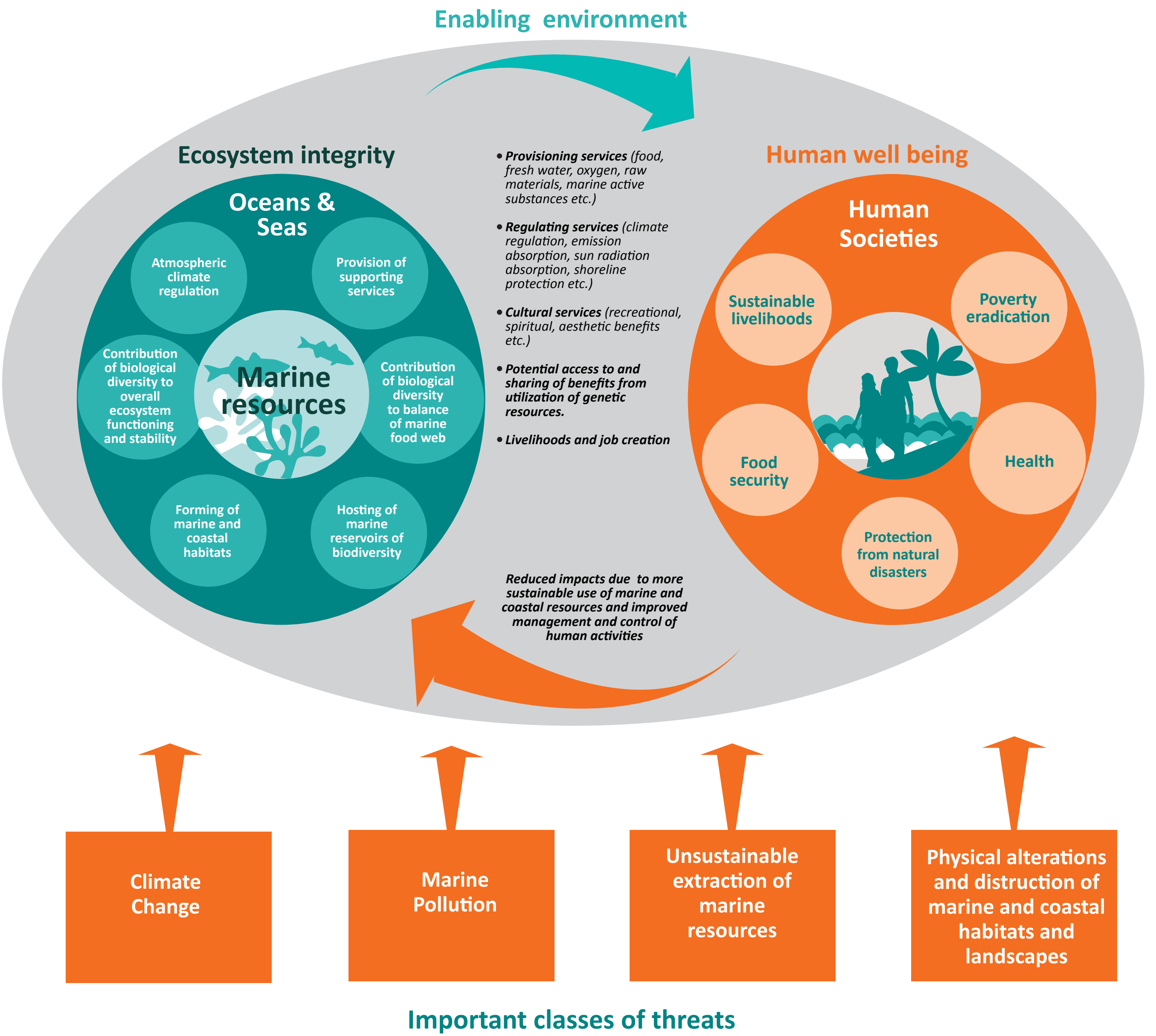
- Many of Europe's marine ecosystems are environmentally, economically and socially vulnerable and they risk being irreversibly damaged by human activities and global climate change and are exposed to unsustainable uses. Further policy-making efforts are needed, so that national and international commitments can help reduce impacts and ensure ecological and economical sustainability of the region's oceans and seas.
- Overfishing has been reduced in European Atlantic waters, the North Sea and the Baltic Sea during the last decades, showing that effective policy implementation and related improvements can lead to positive outcomes. The new Common Fisheries Policy, together with existing management and regulatory instruments, should now ensure that fishing activities in European oceans and seas are environmentally less destructive and sustainable in the long-run and governed consistently to achieve economic and social benefits.
- Climate change is impacting on marine ecosystems, in particular; on coastal fringes and low-lying areas, through submergence, flooding and erosion due to more frequent storms and sea level rise; redistribution of marine species and invasion of alien species; expansion of reduced oxygen zones and anoxic 'dead zones'; ocean acidification in more sensitive regions, such as polar and coral reef ecosystems; and these impacts needs to be further addressed in international climate agreements.
- Across all of Europe's regional seas, marine biodiversity is in poor condition: only seven per cent of marine species assessments indicate 'favourable conservation status'. The establishment and expansion of marine protected areas (MPAs) and their well-connected networks can act as a key conservation measure to safeguard marine biodiversity and ecosystems at regional and global scales.
- The chemical status of pan-European oceans and seas has generally improved, but recent assessments also show that harmful substances continue to degrade coastal areas and open oceans, nutrients loads remain high and the impacts of new pollutants, including plastic wastes forming marine litter are growing. A wide range of marine species are now known to encounter plastic debris and some of these species are considered threatened or near-threatened in terms of their status. Ongoing policy efforts are needed to reduce chemical and fertilizer contamination of Europe's seas, including new challenges of marine litter reduction. The environmental targets should be continuously revised and assessments conducted through the Regional Sea Conventions, European directives and pan-European agreements.

2.7.1 Vulnerable status of pan-European seas and oceans

Oceans and seas are a major and vital part of global ecosystems and the world's stocks of natural resources, which include all the living and non-living elements of the seas (UN 2015c, d, and e). Regional seas cover more than 11 million square kilometres, of which about 50 per cent is under EU jurisdiction (**More...102**), and provide essential services such as contributing to the food supply, livelihoods and well-being of millions of people (EEA 2015k). In the EU alone, the marine environment provides 6.1 million jobs and €467 billion in gross value added (EEA 2015k).

Oceans and seas thus provide a wide range of ecosystems goods and services which are life-sustaining. These services may be defined as supporting, provisioning, regulating or cultural services that humans benefit from (UN 2015c; MA 2005b). Together they include primary production, oxygen

Figure 2.7.1: Humans and marine ecosystems



Source: UN 2015d

formation, and nutrient cycling; provisioning of food, freshwater and renewable energy; regulation of water quality and mitigation of climate change; and recreational and aesthetic benefits (MA 2005b). The ecosystem services approach thus emphasizes not only the substantial economic value of natural capital of oceans and seas (**More...103**), but also encompasses all intangible life-sustaining benefits, highlighting therefore human well-being as a normative goal (UN 2015c; Spash 2011; TEEB 2010).

These include the recognition of the vulnerability and intrinsic importance of the healthy functioning of the seas, and of possibly irreversible changes in the marine ecosystems, as well as of the cultural and recreational services that seas and oceans provide (EEA 2015a). A better appreciation is needed in order to establish safe ecological limits for seas and oceans because their social, economic and ecological sustainability is interdependent (EEA 2015a; Steffen *et al.* 2015). A range of modern marine activities (such as industrial fisheries, shipping, sub-marine communications cables, oil, gas and minerals extractions, energy supply, coastal urbanization, tourism, recreation) collectively impose a certain level of anthropogenic pressures on the seas and their services. These activities, if not managed properly, may lead to significant degradation of marine ecosystems and threaten their integrity, structures and functioning (Rockström *et al.* 2009; Jackson *et al.* 2001a). They may thus compromise the marine ecosystem's potential to deliver essential services on which human communities depend.

The exploitation of the seas continues and is only expected to increase in the future (EEA 2015k). Oceans and seas present growing opportunities for further developing human well-being, if conducted within safe ecological limits. Recognition of this fact has led to the emergence of various blue-economy sectors, such as, for instance, the European Blue Growth Strategy. Although seas and oceans moderate anthropogenic climate change, thus providing an essential ecological service, this comes at the cost of fundamental and mostly irreversible changes to marine systems, with impacts of global concern on ecosystems and people (Gattuso *et al.* 2015; UN 2015c and d). The climate change impacts are already detectable in the pan-European seas and oceans (IPCC 2014c; Gattuso *et al.* 2015). The recent assessment of the state of Europe's seas and oceans (EEA 2015k) shows strong sub-regional differences, and also that many areas of European seas cannot be considered healthy or clean. However, Europe's seas and oceans encompass a wide range of biogeochemical characteristics from the open ocean to semi- and enclosed sea areas which also differ strongly in terms of anthropogenic pressures. The latter leads to contrasting states of their ecosystems, including some healthy and productive sub-regions. Nonetheless, it can be argued that current and future exploitation of global marine natural capital is unsustainable in the long term (EEA 2015k) (**More...104**).

A further demanding task is the assessment of cumulative impacts of human activities on marine and coastal ecosystems, including deep-sea ecosystems (**More...105**). This also involves identifying the main sustainability challenges affecting our seas and oceans, and how adequate policy and management implementation will mitigate negative effects and improve the state of the seas, along with a need for greater systemic understanding of the linkages between the ecosystem and human pressures and activities driving change. Furthermore, innovative tools to assess cumulative pressures and impacts of human activities are at hand (Micheli *et al.* 2013; Korpinen *et al.* 2013; Korpinen *et al.* 2012; Halpern *et al.* 2009; Halpern *et al.* 2007). These tools hold promise for supporting ecosystem-based management of human activities affecting Europe's seas (EEA 2015k).

2.7.2 Endangered fish stocks and long-lasting challenges of fisheries management

The pan-European seas encompass diverse, ecologically distinct marine ecosystems, with different histories of fishery practices and their management. However, despite a decline of about 37 per cent in fish catches by the EU-28 (from a 7.6 million tonnes peak in 1995 to 4.8 million tonnes in 2013), all pan-European sub-regions share a record of long-time global overfishing (**More...106**); that is, catching more fish than seas and ocean can produce (Eurostat 2015b). Although the EU fishing fleet operates worldwide, almost

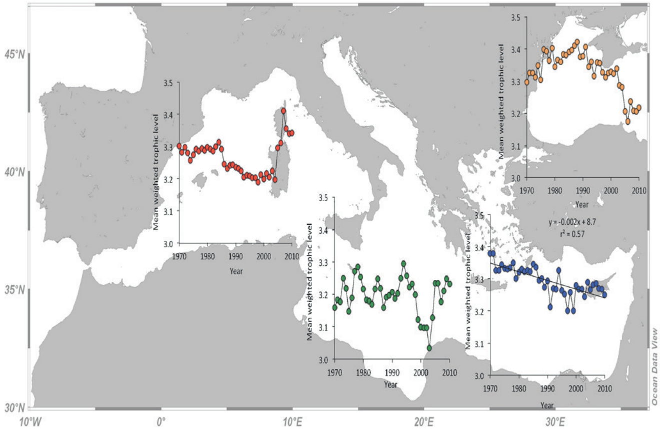
75 per cent of the EU's catches in 2013 were made in the Northeast Atlantic, with another 8.8 per cent coming from the Mediterranean and Black Seas, and 7.9 per cent from the Eastern Central Atlantic (Eurostat 2015b). In the Northeast Atlantic Ocean and the Baltic Sea 41 per cent of assessed fish stocks were overfished in 2012 (EC 2014b). This, however, indicates a significantly improving trend, because overfishing has decreased from 94 per cent of stocks in 2003 to 63 per cent in 2009 and 41 per cent in 2012 (EC 2014b).

Overfishing In the Northeast Atlantic Ocean and the Baltic Sea has decreased from 94 per cent of stocks in 2003 to 63 per cent in 2009 and 41 per cent in 2012
Credit: Shutterstock/Yurchyks; Alan Smillie

However, current knowledge on the state of fish stocks in European seas should also be appraised on a sub-regional scale, because catches of commercially exploited species reveal strong sub-regional differences. For instance, most stocks of herring in the North Sea west of Scotland, and the Irish and Celtic Seas, are fished at or within maximum sustainable yield (MSY). The situation has deteriorated for some other stocks: western horse mackerel and herring northwest of Ireland are overfished. For mackerel, an agreement has been reached between the EU, the Faroe Islands and Norway for sustainable management.

In total, 91 per cent of assessed stocks in 2012 were overfished in the Mediterranean and 71 per cent in the Black Sea, although only seven commercially-exploited fish were assessed (EC 2014b). Similarly, a recent study confirmed that the number of over-exploited and collapsed fish stocks in the Mediterranean and Black Seas had increased between 1970 and 2010 (Tsikliras *et al.* 2015; Tsikliras *et al.* 2013). The pattern of exploitation and the state of stocks differed among the sub-regions, with the Eastern Mediterranean and Black Sea fisheries being in the worst affected. In these sub-regions, mean trophic level of commercial fish landings has significantly decreased, indicating that fish catches are increasingly dominated by those from lower levels of the food chain (Figure 2.7.2). This trophic downgrading (**More...107**) of ecosystems is recognized as a phenomenon occurring world-wide (Estes *et al.* 2011; MA 2005b; Pauly *et al.* 1998).

Figure 2.7.2: The mean trophic level of the catch per year for the western (red), central (green) and eastern (blue) Mediterranean; and the Black Sea (orange), 1970–2010



Source: Tsikliras *et al.* 2015

At the pan-European scale, many commercial fish stocks are not assessed, and there is concern also about fisheries in large areas of the Arctic and far eastern part of the region. Illegal, unreported and unregulated industrial fishing is also of concern, and needs to be tackled as part of any pan-European fisheries assessment efforts. This is also the case for other regions. *GEO-6 Regional Assessment for Asia and the Pacific; GEO-6 Regional Assessment for Africa*.

Existing legal frameworks for the conservation and management of straddling and highly migratory stocks, as well as for the living resources on the high seas, include the 1982 UN Convention on the Law of the Sea (UNCLOS) and the 1995 UN Fish Stock Agreement, as well as the relevant regional fisheries management bodies such as the General Fisheries Commission for the Mediterranean (GFCM), the North East Atlantic Fisheries Commission (NEAFC) and the International Commission for the Conservation of Atlantic Tunas (ICCAT).

2.7.3 Climate change and biodiversity: key challenges for oceans

Climate change and biodiversity losses are the most serious drivers of change in pan-European marine biomes (EEA 2015k, 2014d); they introduce major physical, geochemical and biological upheaval in our seas and oceans (Gattuso *et al.* 2015). About 30 per cent of anthropogenic carbon dioxide emissions are captured by the oceans and seas, leading to seawater acidification (IPCC 2014c). Ocean acidification poses substantial risks to marine ecosystems, (**More...108**) especially in more sensitive polar regions and coral reef ecosystems (for example, by decreasing the rate of calcification, stimulating dissolution of calcium carbonate and affecting primary production of some phytoplankton, possibly leading to more frequent harmful algal blooms) (EEA 2015a, 2015k, 2014e; IPCC 2014c). Warming of seawater has multiple consequences for European seas, including oxygen depletion that is further enhanced in semi-enclosed regional seas (EEA 2015k; Carstensen *et al.* 2014). Warming is also affecting food webs and phenological timing, along with the introduction and spread of invasive species in the European seas. The Northern Atlantic receives melt waters from Arctic ice sheets and glaciers, which contribute to sea level rise (Gattuso *et al.* 2015; IPCC 2014c) (Figure 2.7.3). Changing weather conditions and more frequent and intense storm surges, combined with sea level rise, may also profoundly impact coastal fringes in the European seas, leading to losses of dune systems due to erosion and overall "coastal squeeze" (IPCC 2014c).

Thinner ice cover in the Arctic Ocean leads to new and unexpected plankton outbreaks and climate change feedback

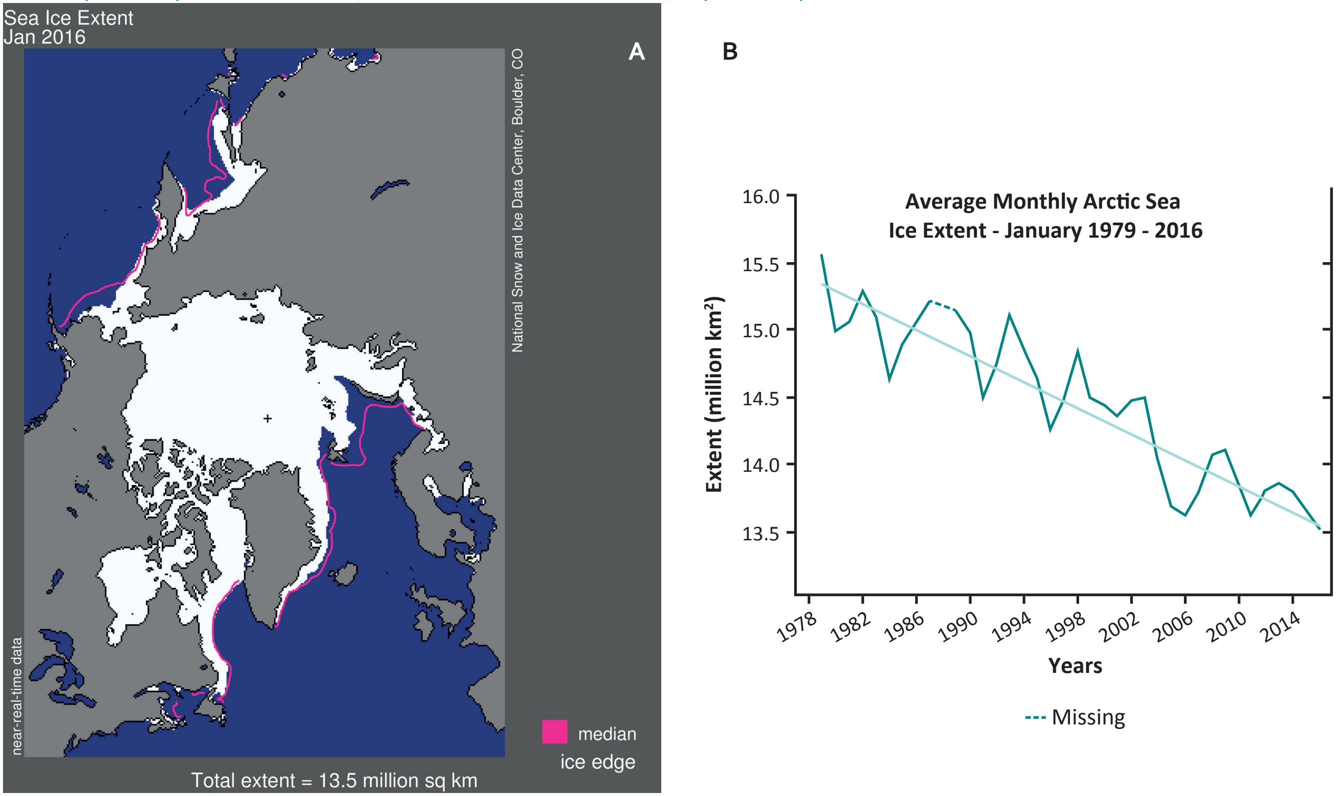
Arctic sea ice cover is shrinking
Credit: Shutterstock/lev radin

in the area (Park *et al.* 2015). Examples of species' northward movement, such as mackerel and sole being found further north in the Northeast Atlantic, and changes in life traits, including earlier spawning, have been reported in several pan-European seas. These changes profoundly affect ecosystem integrity and alter the distribution of commercially-important fish species at higher latitudes, thus reducing harvesting potential in their native areas (EEA 2015k; Gattuso *et al.* 2015; IPCC 2014c). Northward distribution shifts have resulted in increased species richness in mid- to high-latitude regions (Hiddink and ter Hofstede 2008) and changing community structure (Simpson *et al.* 2011). Increases in warm-water components of communities concurrent with regional warming have been observed in mid- to high-latitude ocean regions including the Bering Sea, Barents Sea, Nordic Sea and North Sea (Poloczanska *et al.* 2014).

A wide range of sensitivities to temperature increases exists within and across organisms. Phyto- and zooplankton communities have extended their ranges at remarkable rates, for example in the Northeast Atlantic, with implications for marine food webs (Poloczanska *et al.* 2014). Seawater warming may also lead to mass mortality of coral reefs through bleaching as well as through biotic diseases (Gattuso *et al.* 2014). The consensus is that observed and forecasted responses of marine species biogeography, abundance and phenology to warming provide robust evidence with a high confidence level (Poloczanska *et al.* 2014).

The rapid decline of Arctic sea ice has had dramatic effects on marine mammals. For polar bears, numbers are expected

Figure 2.7.3: a) Arctic sea ice extent for January 2016 was 13.53 million square kilometers (5.2 million square miles). The magenta line shows the 1981-2010 median extent for that month. The black cross indicates the geographic North Pole; b) Monthly January ice extent for 1979-2016 shows a decline of 3.2 per cent per decade.



The magenta line shows the 1981-2010 median extent for that month. The black cross indicates the geographic North Pole; b) Monthly January ice extent for 1979-2016 shows a decline of 3.2 per cent per decade.
Source: NSIDC 2016

to decline by 30-70 per cent in the next half-century (Kovacs *et al.* 2011). This rapid loss of sea ice also affects microbial communities that live within the ice and diverse species of bacteria: *Achaea* and *Eukarya* are now facing extinction (Vincent 2010). A new study calls for further research on methane release from thawing subsea permafrost in the Arctic. These methane emissions could potentially contribute to climate change (Shakova *et al.* 2010).

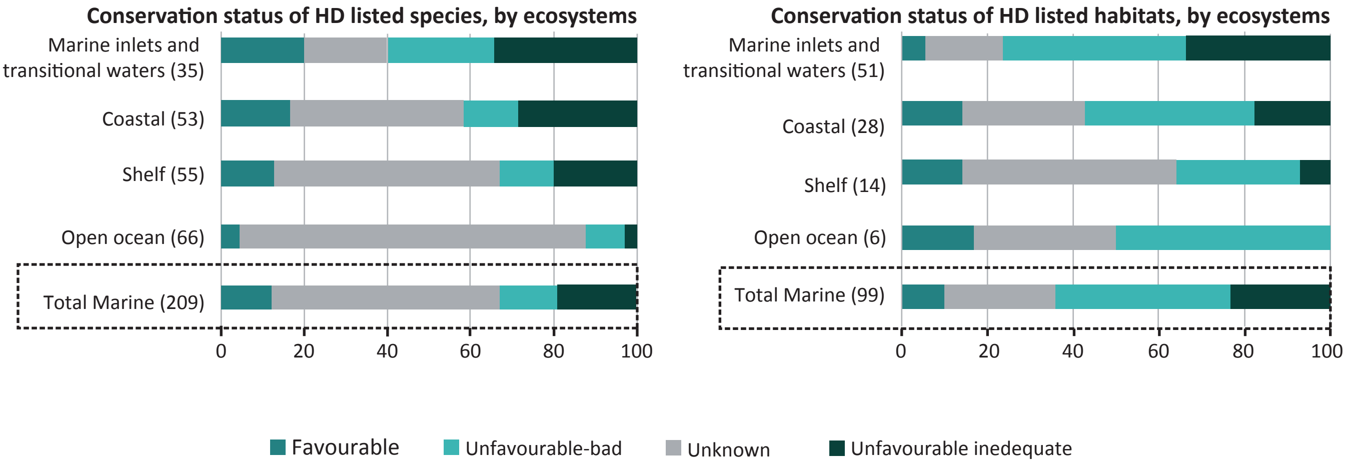
Changes in ice cover of the Arctic seas of the Eurasian shelf directly influence the marine ecosystems and economic activity of the area (Forbes 2011). In recent years, navigation conditions (**More...109**) at the end of the warm season (August - September) improved at high latitudes along the Northern Sea Route (NSR) (Forbes 2011; Roshydromet 2008). However, a new analysis by the Arctic Institute analysing the 2013 NSR shipping season shows that the NSR will remain a limited trade route compared with the traditional shipping routes of the Suez and Panama Canals, and be mostly used for export of natural resources (Humpert 2014). The increased occurrence of icebergs has also been reported, which enhances risks for marine transport and fishing. The changes in climate have also negatively affected the coasts of the Arctic seas by intensifying erosion. The areas impacted are spatially extensive, extending beyond European regions, with the highest mean erosion rates now found in Alaska, the Yukon and the Northwest Territories, to large parts of the Siberian coast in the East Siberian and Laptev Seas (Forbes 2011). Adaptation to the changing climate in these northern seas concerns all sectors of the economy including fisheries, maritime transport and coastal infrastructure (Roshydromet 2008).

Conducting assessments of marine biodiversity remains a challenging task (**More...110**) as biodiversity losses are related to cumulative effects from multiple human pressures (Andersen *et al.* 2015). The pan-European seas are home to more than 26 000 marine species, excluding bacteria and viruses (Narayanaswamy *et al.* 2013; Vandepitte *et al.* 2011), and many more than 30 000 if the latter are included (Costello and Wilson, 2010).

Only 12 per cent of marine species and 10 per cent of marine habitats in the EU with conservation targets assessed under the Habitats Directive (Directive 92/43/EEC) from 2007 to 2012 were considered to have a favourable status, whilst 33 per cent of marine species and 64 per cent of habitats had unfavourable status (Figure 2.7.4). The previous assessment, covering 2001–2006, showed that compared with land and freshwater habitats, there is still a high proportion of marine species and habitats with unknown conservation statuses. This proportion increases from coastal to offshore species assessed, reaching more than 83 per cent for open ocean species. The number of habitat types assessed is also decreasing from coastal to open ocean ones. Marine protected areas (MPAs) can act as a key conservation measure to safeguard marine ecosystems and biodiversity (**More...111**).

The main biodiversity losses associated with fisheries are caused by intensive fishing activities, such as trawling. However, the level of impact varies according to the scale of fishing and the local biological characteristics of the sea (EEA 2015k). Beyond the direct effect on population size, fishing may also change the age profile of the target species, as larger specimens are often targeted, which in turn can contribute to the introduction of invasive alien species. This may cause changes in the genetic structure of the population and impact food-web dynamics, possibly resulting in poorer ecosystem resilience (Pauly *et al.* 2013; Pereira *et al.* 2010;

Figure 2.7.4: EU conservation status of listed marine species and habitats, by ecosystem type (number of assessments in brackets), 2007-2012



N.B.: Habitat Directive listed species and habitats are a very small part of total European marine biodiversity.

Source: Habitat Directive Article 17 reporting 2007–2012 in EEA 2015k

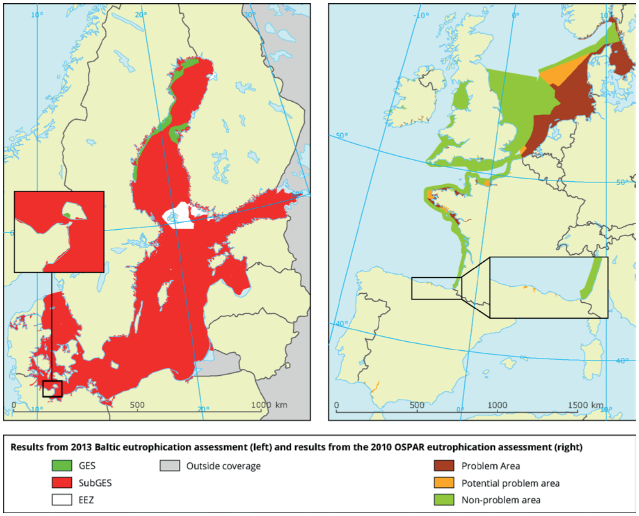
Worm *et al.* 2006), inducing cascading effects through entire food webs (Möllmann *et al.* 2011). In this regard, there are several well-documented examples of regime shifts (**More...112**) in the Baltic, North, Black and Caspian Seas.

Other direct effects of concern related to industrial fisheries are significant physical damage that bottom trawling can cause to seafloor habitats. In fact, the majority of fishing gear disturbs the seafloor and damages the benthic flora and fauna in exploited areas (EEA 2015l). Estimates published by Tillin *et al.* (2006) noted that bottom-trawling activities in the North Sea in 2006 resulted in a 56 per cent reduction in biomass and a 21 per cent reduction in production of benthic invertebrates in the southern North Sea. Marine biodiversity may be further affected by significant by-catch of non-target species (including fish, mammals, sea-turtles and seabirds) and discards from industrial fisheries; that is, the harvesting of non-target species which are usually dead when thrown back into the sea. New EU legislation (CFP 2014 modifications) bans the discard of unwanted catches through the introduction of a landing obligation, to be introduced gradually between 2015 and 2019 for all commercial fisheries. This policy change further enhances selectivity, and should provide more reliable data for discard assessments.

2.7.4 Can eutrophication be halted in European seas? - the need for decadal policy efforts

The recent assessments show that eutrophication related to nitrogen and phosphorus fertilizer inputs continues to be a major environmental problem in the pan-European seas (Carstensen *et al.* 2014; EEA 2012e; Billen *et al.* 2011; Grizzetti *et al.* 2012; Bouraoui *et al.* 2011; HELCOM 2010; OSPAR 2009). This is of particularly serious concern in semi-enclosed marine regions such as the Baltic and Black Seas,

Box 2.7.1: Regional eutrophication assessments



Source: HELCOM 2014 and OSPAR 2010

Eutrophication in the Baltic and North Seas:
HELCOM assessments (2009 and 2014) show that not only the coastal area, but the entire open Baltic Sea is severely stressed by eutrophication, despite a reduction in total inputs of phosphorus and nitrogen. The assessments also indicate that further reductions beyond agreed targets are needed, and that there is a significant time lag between effective reductions in nutrient inputs and a decline in eutrophication. In the North East Atlantic regions (OSPAR 2010), certain coastal areas are affected by eutrophication, including large areas along the east coast of the North Sea, and more localized zones in France, Norway and Sweden, as well as in a number of European estuaries.

plus the closed Caspian Sea, that are particularly sensitive to eutrophication. But the North East Atlantic and North Seas also have specific areas affected by eutrophication (EEA 2015k; OSPAR 2010). The evidence is also growing that eutrophication (**More...113**), in combination with other human and environmental stressors, may lead to profound modifications of the structure of marine ecosystems.

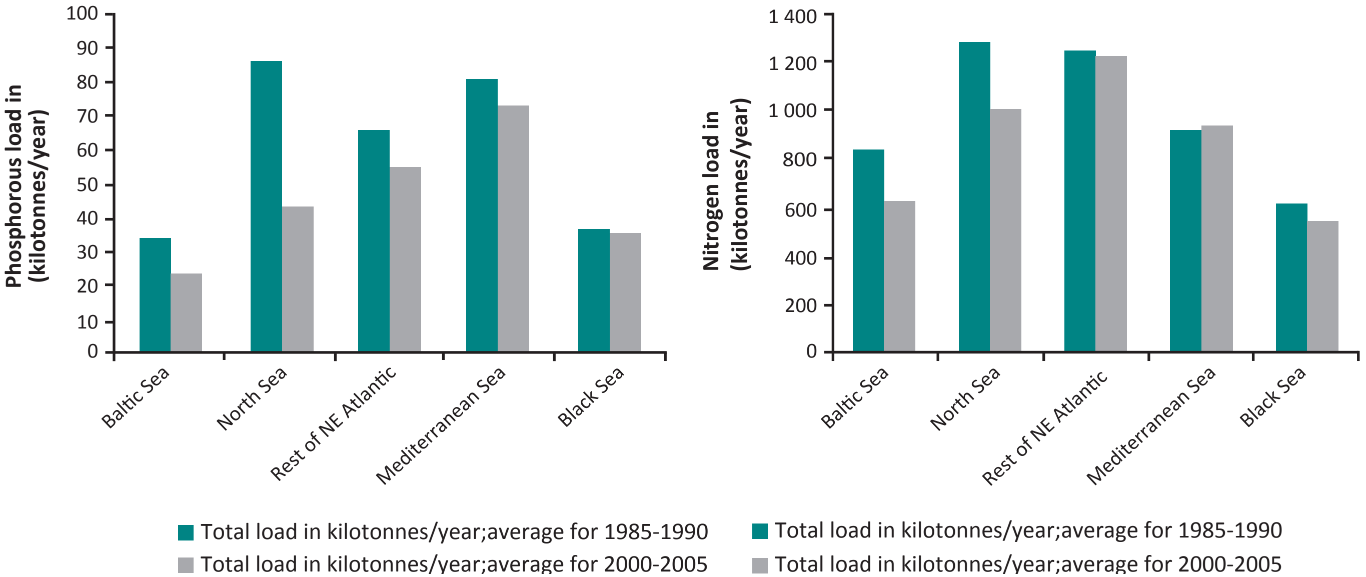
At the continental scale over the past 20 years, total nitrogen inputs into European marine waters have decreased by 9 per cent and total phosphorus loads have fallen by around 15 per cent (HELCOM 2014; EEA 2012e, Mee *et al.* 2000) (Box 2.7.1). Significant regional differences remain, however, and the reduction is generally greater from phosphorous point sources than from diffuse sources of nitrogen, including atmospheric deposition (EEA 2015k; Grizzetti *et al.* 2012; Bouraoui *et al.* 2011) (Figure 2.7.5). It appears also that the long-term policy to reduce nitrogen and phosphorous (**More...114**) emissions provides a mixed picture of improvements, showing difficulties in preventing eutrophication.

2.7.5 Coastal seas and open oceans: recipient environments for harmful chemicals and marine litter

The chemical status of pan-European seas has generally improved, but recent assessments also show that harmful substances continue to degrade coastal areas and open oceans. The impacts of new pollutants, including plastic wastes forming marine litter, are growing and not well known in the pan-European region (EEA 2015a; EEA 2015k; EEA 2011; OSPAR 2010).

The semi-enclosed Baltic, Black and Caspian Seas are the most vulnerable to the effects of harmful substances because of a long history of local industrialization, the high density of coastal populations and also because of their natural characteristics: large watersheds, high continental loads of freshwater and sediments, and long water residence times (EEA 2015k; HELCOM 2010). The chemicals of concern are persistent organic pollutants (POPs) (**More...115**) and heavy metals including mercury, cadmium and lead. Most areas of the Baltic Sea, for instance, were classified as disturbed by

Figure 2.7.5: European Seas, phosphorus and nitrogen loads, 1985–1990 and 2000–2005, kilotonnes per year



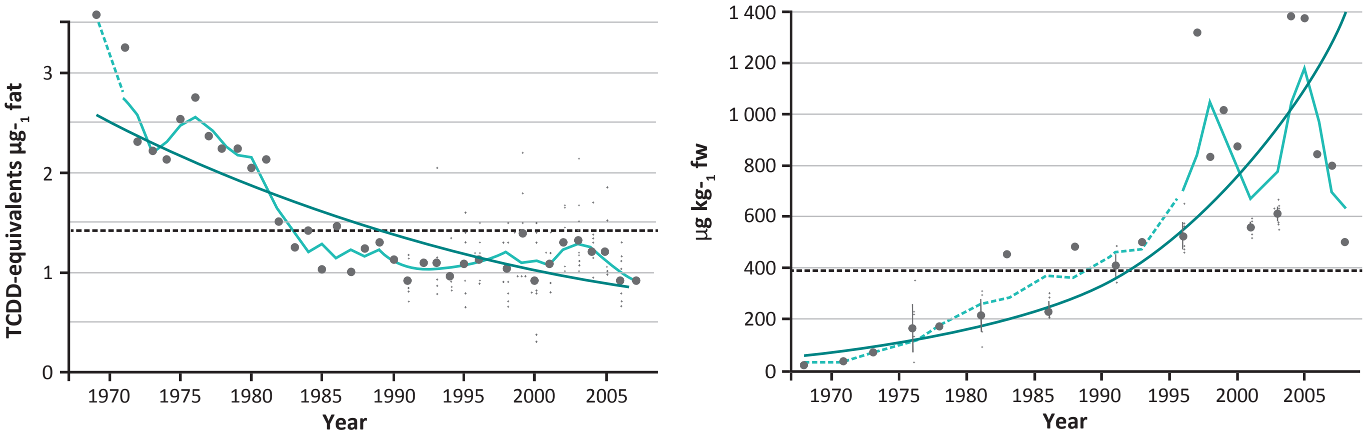
Source: Bouraoui *et al.* 2011 and Grizzetti *et al.* 2012 hazardous substances with polychlorinated biphenyls (PCBs), lead, mercury, cesium-137, dichlorodiphenyltrichloroethane (DDT) dichlorodiphenyldichloroethylene (DDE), tributyltin (TBT), benz(*a*)anthracene and cadmium being the substances in highest concentrations relative to ecological target levels (EEA 2015k; HELCOM 2010). In the specific hot spots areas in the Northeast Atlantic, Mediterranean and Black Seas, recent assessments show a few examples of similar outcomes (EEA 2015k, 2011; Carubelli *et al.* 2007; Martí-Cid *et al.* 2007; Bordajandi *et al.* 2006). The continuous inputs of persistent organic pollutants (POPs) and trace elements into the marine environment are mainly related to land watershed riverine loads mostly impacting coastal areas, and from atmospheric depositions affecting more remote offshore areas of the seas and oceans (Durrieu de Madron *et al.* 2011).

However, the last decades show downward trends in most sub-regions for many historically hazardous contaminants including certain POPs (PCBs, dioxins, organochlorine pesticides), polycyclic aromatic hydrocarbons (PAHs) and mercury (EEA 2015k; Azoury *et al.* 2013; HELCOM 2010). In contrast, upward trends are reported for certain emerging chemicals, the concentrations of which have increased significantly over the last two decades (HELCOM 2010) (Figure 2.7.6).

Emerging contaminants, such as many novel organohalogenated compounds including perfluorinated compounds, brominated flame retardants, some veterinary and human pharmaceuticals, alternative anti-fouling biocides, personal care products and plasticizers are now found in all pan-European seas (EEA 2011; EEA 2010d; Helcom 2010; Schwarzenbach *et al.* 2006; Kolpin *et al.* 2002; Singer *et al.* 2002; Giesy and Kannan 2001; Halling-Sørensen *et al.* 1998). The list of emerging contaminants also includes relatively new classes of pollutants such as microplastics and nanomaterials. Generally these novel contaminants, even if detectable, are known to occur at very low levels in the marine environment, not necessarily sufficient to lead to detrimental impacts in the ecosystems. However, a broad range of health and environmental outcomes from various hazardous pollutants were also reported (EEA 2015a, 2015k, 2012f; WHO and UNEP 2012; Kortenkamp *et al.* 2011; Pruss-Ustun *et al.* 2011) (**More...116**).

Figure 2.7.6: Left panel: temporal trends of tetrachlorodibenzodioxin (TCDD) equivalents (micrograms per kilogram of fat). Right panel: perfluorooctane sulfonate (PFOS) concentrations (micrograms per kilogram of formula weight) in common guillemot (*Uria aalge*) eggs from Stora Karlsö in the Western Gotland Basin.

The horizontal lines represent the geometric means, the dark green lines are the trends and the light green lines the running means smoother of the time series



Source: HELCOM 2010

Marine litter in pan-European seas has been a concern since the 1970s. In their study Jambeck *et al.* (2015) estimated that European countries were responsible for the release of 1 173 tonnes of plastic into the sea each day, while the Seine, Po and Danube rivers deposit two to six tons of microplastics into the sea every day (Galgani 2015). Substantial quantities of microplastics have also been reported in deep sea sediment (Woodall *et al.* 2014) and in Arctic Sea ice (Obbard *et al.* 2014). Plastic has become ubiquitous and may comprise up to 95 per cent of the debris accumulated on shorelines and the sea floor; on the sea surface, this figure could be as high as 100 per cent. The Mediterranean Sea is one of the areas most affected by marine litter in the world and has the highest density of marine litter on the sea floor (Barnes *et al.* 2009). Sea surface microplastics were found in mean concentrations of up to 115 000-1 050 000 particles per square kilometre in the northwestern Mediterranean Sea, with a maximum 4 860 000 particles per square kilometer and an estimated weight of more than 1 000 tonnes for the entire basin (Galgani 2015). The highest microplastic concentrations in sediments, however, were found on beaches and in harbours of the southern North Sea, with concentrations of up to 391 microplastic beads per kilogram of dry sediment (Claessens *et al.* 2011). Microplastics are shown to be transferred in the marine food web from zooplankton to higher trophic levels of marine organisms (Setälä *et al.* 2013). Marine litter may also have socio-economic and ecological impacts (**More...117**) on local-to-global scales, leading to often costly revenue losses for fisheries, tourism and the shipping industry, and impacting the health and well-being of people, while degrading inland, coastal and open-sea ecosystems (Watkins *et al.* 2015). These concerns are also shared by other regions.

2.7.6 Policy responses

The well-being of people in many parts of the pan-European region depends on healthy coastal and marine environments. Due to the multitude of socio-economic-ecological links and threats, and cumulative negative effects of human activity on coastal and marine ecosystems, there is a need for a more integrated approach to national, supranational, inter-regional and global policy responses as well as trans-national cooperation (EEA 2014d; UNEP 2014a).

Example of intertidal marine litter
Credit: Shutterstock/Rich Carey

To limit and where possible reverse degradation of coastal and marine environments, and to build a stronger baseline for safeguarding their many ecosystem functions, a multifaceted set of policy responses has emerged in the pan-European region. These include a number of regional seas conventions and action plans, supra-national policy frameworks and integrative programmes, towards which countries are increasingly orientating their national policy responses. These endeavours are supported by a global environmental governance system covering the protection of coastal and marine environments on the basis of various MEAs. However, an integrated global policy framework for the protection of oceans is not yet in place.

The 1982 UN Convention on the Law of the Sea (UNCLOS) constitutes the main global legal framework of reference for other governance frameworks. Over the years, it has been complemented by several Regional Seas Conventions, as well as various programmes, action plans and EU policies. To be able to more effectively slow down and eventually halt the degradation of coastal and marine environments, these efforts at different levels require more integration, based on well-coordinated target setting, monitoring systems and capacity building at local to national levels. The 2008 EU Marine Strategy Framework Directive and the 2014 Maritime Spatial Planning Directive are steps in the right direction.

The UN Convention on the Law of the Sea is the main global legal framework for governance of marine environments
Credit: Shutterstock/Andrey_Kuzmin

The EU Marine Policy and related regional MEAs provide a framework for a coherent approach to the sustainable protection, use and management of marine and coastal resources. However, this requires that instruments for the implementation of EU framework directives need to be created by the Member States (Boyes and Elliott 2014; SwAM 2013; Apitz *et al.* 2006).

Existing EU marine policies are the result of the long-term, continuously improving and ongoing development. The process is enhanced by cross-border cooperation with other non-EU country authorities in meeting obligations under international law, and other local and global agreements (UNCLOS, Regional Sea Conventions). In this context, the integrated assessment and management approaches within the framework of the Regional Sea Conventions (RSC) such as HELCOM, OSPAR, Barcelona and Bucharest Conventions, and the Tehran Framework Convention for the Protection of the Marine Environment of the Caspian Sea (**More...118**), all bring notable contributions.

The EU's current approach is to Integrate Marine Policies with the adoption of an ecosystem-based management (EBM) framework for human activities in the marine environment: the 2008 Marine Strategy Framework Directive, the 2014 Marine Spatial Planning Directive and the Common Fisheries Policy (last modified in 2014), are three of the main EU marine policies that adopt EBM (EEA 2015k; Jennings and Rice 2011). Marine EBM allows the shaping of governance structures in a new way, by recognizing the need for spatial planning of marine activities (MSPD), assessing cumulative impacts (MSFD) and acknowledging connections between policies. These three directives are combined with others, including the Biodiversity Strategy to 2020 and the Habitats and Birds Directives (Directives 92/43/EEC and 2009/147/EC), in ways capable of handling multiple objectives. It is generally accepted that the new governance structures should be more flexible and adaptive, more collaborative and inclusive, and more integrated than traditional administrative structures (EEA 2014d). Finally, as the environmental marine policies are knowledge- and information-based, scientific evidence and data collection through monitoring networks must continue to play a central role in marine environmental policy structures. The effective solutions to pan-European environmental problems depend on the availability of sound and unbiased scientific information.

Implementing effective coastal and marine management policies remains a key environmental policy challenge linked to biodiversity, eutrophication, climate change, chemicals and other threats from socioeconomic activities; for example urbanization, agriculture, fisheries, transport, industrial development and energy production. Traditionally, different sectors and different aspects of marine ecosystems have been considered separately. One step toward better integration could come from current developments at the science-policy interface, for instance the Policy-oriented *Marine Environmental Research in the Southern European Seas*.

2.8 Land

Main messages: Land

- Soils are under threat from a range of drivers including: climate change; erosion; local and diffuse contamination; loss of organic matter; loss of biodiversity; compaction and other physical soil deterioration; salinization; floods; landslides; and sealing.
- Competing interests for land resources are widespread across the region. Every day the countries of the EU28 lose 275 hectares of agricultural land to soil sealing and land take. New forms of land take include installation of solar panels, which in many cases replace cultivated crops. In Eastern Europe and Central Asia, land abandonment has been caused by social, demographic and economic constraints.
- Land use change is leading to the deterioration of the physical and chemical properties of soils, causing land degradation, water and air pollution, followed by losses of biodiversity. Forty per cent of Mediterranean coastal land has already been sealed.
- EU28 is a net food importer, as 40 per cent of the food needs and derived food products are imported. This externalization of European land requirement is leading to a significant and, particularly for other regions, detrimental footprint.
- A shortage of green areas reduces air quality and living conditions for city dwellers. The loss of green areas in cities with up to 100 000 inhabitants is accompanied by an average temperature increase of 5°C, compared with their surrounding rural areas. Increasing green areas inside cities including green roofs, "living walls" and wider use of permeable materials in parking areas are some of the potential solutions.
- Trade-offs between ecosystem functions and services and the need for strategic land-use planning require establishing a long-term balance between economic development priorities and environmental protection. Sustainable land management including practices such as organic farming, conservation agriculture, agro-ecology and integrated soil fertility management has the capacity to harmonize sustained crop production systems with environmental protection.

2.8.1 Land and soils are finite resources

Land and soils are not the same. Land is well recognized for the multi-functionality of its services, providing vital environmental as well as cultural and societal services that support the well-being of humans and the biota. As soils constitute the foundation for agricultural development, essential ecosystem functions and food security, they are thus key to sustaining life on Earth (EEA 2015m) (**More...119**).

There are many ecosystem functions and services provided by the land, ranging from water purification and storage, to biodiversity hosting and carbon sequestration, as well as landscape beauty, nature conservation, ecotourism, housing, transport and preservation of cultural heritage.

Fertile soil is a finite resource
Credit: Shutterstock/Johan Larson

Nevertheless, its major role is the production of biomass – agriculture, forestry and overall land cover – as 95 per cent of human food needs are sustained by soils (FAO 2015). Soil is an important component of the land ecosystem, but it is typically the reduction of supporting ecosystem services that ultimately leads to a persistent decrease in the ability of soils to provide provisioning, regulatory and cultural services (Sparks 2014; Dominati *et al.* 2010; Haygarth and Ritz 2009). (**More...120**)

Video on sustainable soil management: "A major step in achieving Sustainable Development"

http://www.fao.org/news/audio-video/detail-video/en/?uid=11496

Land resources in the pan-European region show the interaction between development trends, globalization, landscape fragmentation, urbanization, coastal over-development and a set of drivers and pressures leading to land degradation processes and changes in land use. Cross-cutting issues affecting land dynamics include land-use change, migration and cultural/social dynamics, with all of these influencing human well-being and biodiversity status. Fertile soil is a finite resource and how it is used constitutes one of the principal reasons for environmental change, with significant impacts on the quality of life and ecosystems, as well as on the management of infrastructure (EEA 2015n) (Figure 2.8.1).

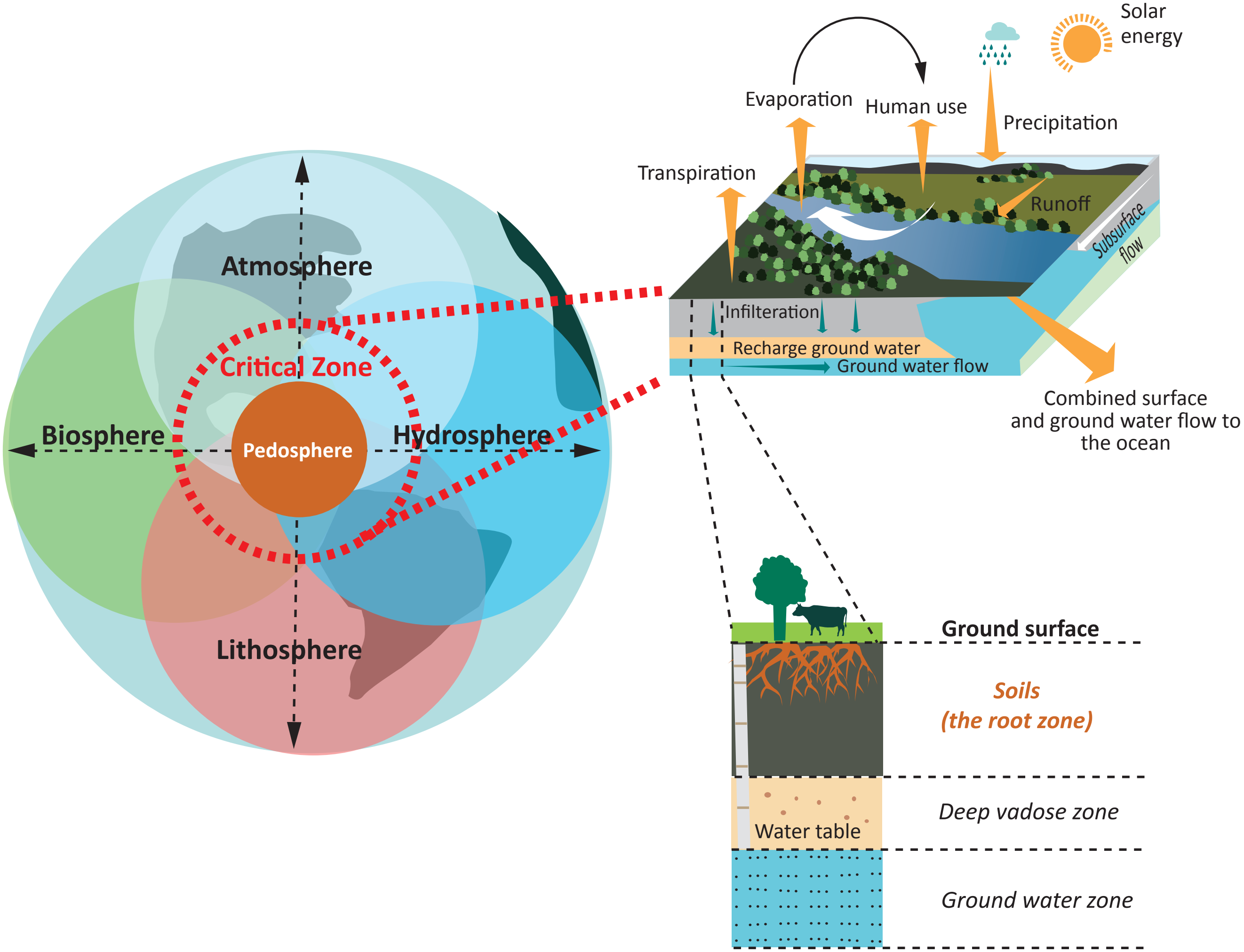
2.8.2 Soils under threat

There are eight main soil threats affecting pan-European soils (Figure 2.8.2). They include erosion, local and diffuse contamination, loss of organic matter, loss of biodiversity, compaction and other physical soil deterioration, salinization, floods, landslides and sealing (EC 2006a). Soil sealing is considered the major threat in Western Europe (Montanarella *et al.* 2015). Climate change could accelerate the intensity of these threats that are already endangering soil quality and causing billions of Euros in damage. They remain an ongoing source of concern for the provision of fundamental ecosystem functions and services provided by soils.

Construction zone for a new housing development – soil sealing is a major threat in Western Europe
Credit: Shutterstock/ThomBal

Evaluations conducted at the European scale consider soil erosion as a major threat to soil degradation in Europe, followed by the loss of organic carbon in the topsoil (Eurostat 2015c; Montanarella 2007). (**More...121**). Recent reports indicate that soil water erosion affects more than 25 per cent of Europe, especially the Mediterranean and the Alpine regions (Panagos *et al.* 2015a). To a lesser extent, wind erosion (Borelli *et al.* 2014a) is also a problem (**More...122**).

Figure 2.8.1: Soils are at the centre of the critical zone interactions between atmosphere, biosphere, hydrosphere, lithosphere and anthroposphere

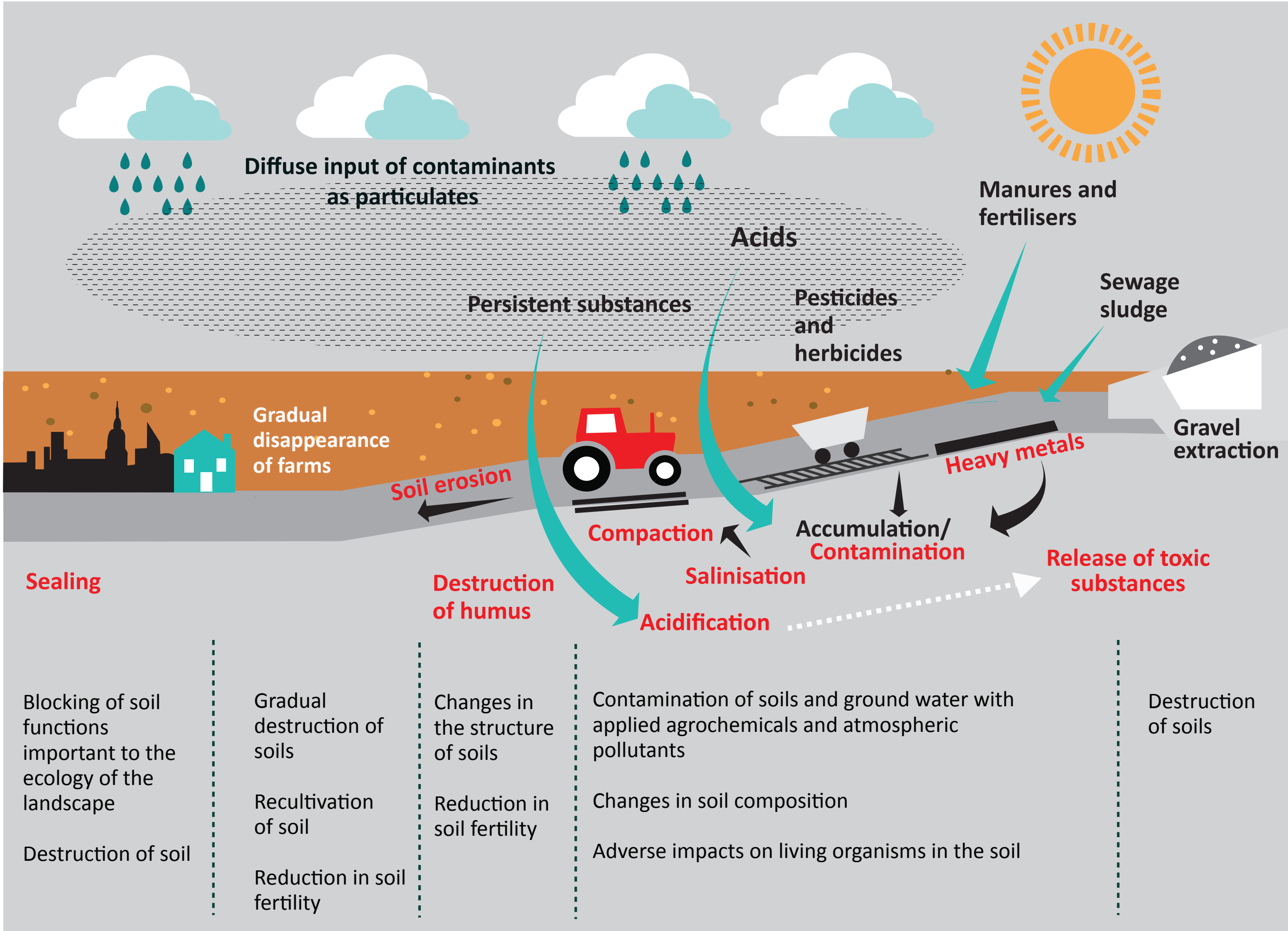


The pedosphere represents a geo-membrane across which water and solutes, as well as energy, gases, solids and organisms are actively exchanged with the atmosphere, biosphere, hydrosphere and lithosphere to create a life-sustaining environment. Soil-water interactions create the fundamental interface between the biotic and abiotic environments and serve as a critical determinant of the state of the Earth system

Source: Wilding and Lin 2006

Given the extent of pan-European land affected by soil erosion, this process has a significant economic impact, estimated in the EU to range between €6–118 per hectare (2015 Euro rates) (Montanarella 2007). Soil erosion rates are mainly controlled by land use, and its intensity in the next decades will mainly depend on the farming practices and land-use policies implemented in Europe (Vanmaercke *et al.* 2015).

Figure 2.8.2: Degradative threats affecting European soils



Source: Tóth *et al.* 2008

Soil contamination remains an issue of major concern in the pan-European region, and the vast majority of the EU-28 Member States lack comprehensive inventories (Brombal *et al.* 2016). Local soil contamination in 2011 was estimated at 2.5 million potentially contaminated sites in the EEA-39, of which about 45 per cent have been identified to date. About one-third of an estimated total of 342 000 contaminated sites in the EEA-39 have already been identified and about 15 per cent of these sites have been remediated (EEA 2014f). Total costs for remediation amount to several billion Euros (EC 2012c) (**More…123**).

Extensive areas of European soils are affected by natural and man-made salinity, with Spain topping the list with 3.4 million hectares of saline and sodic soils (Zdruli 2014). An extreme form of land degradation is desertification, that results in serious impairment of all soil functions and currently affects about 33 per cent of the territory of the Mediterranean semi-arid drylands. However, the most critical threat to European soils is sealing, as described in Section 2.8.3.

In Central Asia, (**More...124**) the main human-induced pressures are increasing population, lack of investment and land abandonment. Agriculture is predominantly small-scale but intensive, and large-scale farming schemes are also emerging. Nonetheless, there is an increasing tendency of using conservation agriculture principles, for instance in Kazakhstan and Tajikistan. Wherever degradation processes were occurring and land was subsequently abandoned, often also due to socio-economic and political reasons, natural recovery is expected, except where ecological or natural changes such as desertification were severe.

From 1953 to 1963 on 45.2 Mha of steppe lands converted to cropland across the Russian Federation and Kazakhstan, there have been Soil Organic Carbon (SOC) losses of 852±36 Mt C (42.6±1.8 Mt C yr^{-1}), with over 70 per cent (611±47 Mt C) of total SOC losses occurring in the Russian part and 241±11 Mt C in Kazakhstan (Kurganova *et al.* 2015).

Another critical problem for the sub-region is human-induced salinity that has expanded to millions of hectares, mostly due to unsustainable irrigation systems and poor quality of irrigation water. The most dramatic example of this trend was the overuse of water of the Amu Darya River, one of the main reasons for the drying of the Aral Sea. The dramatic reduction of this water body is recognized as a major ecological crisis of global impact: its volume is less than one-thirteenth of its original size, and its area less than one-seventh of its original extent, with the shoreline having moved hundreds of kilometers. This territory has become a new desert called the Aral Kum that covers 5 million hectares. The expanding Aral Kum desert has already absorbed 2 million hectares of arable lands and led to the degradation of pastures, riparian forests and other vegetation cover.

Overall, the total area affected by water erosion in Central Asia is more than 30 million hectares, and by wind erosion, about 67 million hectares. In Uzbekistan, up to 80 per cent of agricultural land is affected by water erosion (Kuziev *et al.* 2009) while in Tajikistan, a very mountainous country, 60–97 per cent of agricultural land is also affected by water erosion (CACILM 2006).

The main challenges to soil productivity are degradation processes such as soil salinization, water and wind erosion, nutrient depletion and improper management. On the positive side, the World Overview of Conservation Approaches and Technologies (WOCAT) has identified a number of good examples of sustainable land management throughout the region (Schwilch 2011; WOCAT 2007).

Video: "Good land management to reduce disasters in Tajikistan"

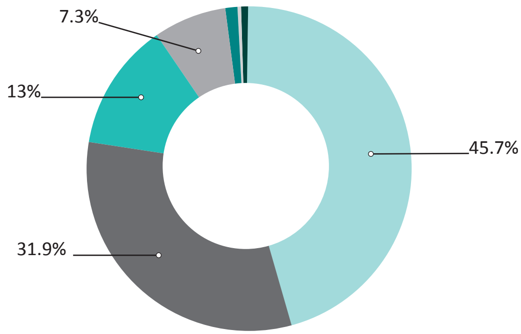
https://vimeo.com/129765829

2.8.3 Competing interests for land resources

Significant pressures on land throughout the pan-European region include demographic and socio-cultural changes, populations shifting from rural to urban areas (and in some cases vice-versa), the creation of urban-rural "fringe" areas, rising demand for housing, and competing economic demands for industry, agriculture, energy sources (solar, wind, fracking, gas) and their related infrastructure, and expanding transport infrastructure, along with space allocated for recreation, especially inside urban areas. In Western Europe, urban sprawl and building on "green belt" land designated for conservation, under political pressure for housing, is consuming rural landscapes and agricultural potential. The rural areas are also desirable for environmental reasons; the arrival of urbanites is distorting housing prices, the local social structure and depressing rural economies. Re-ruralisation will be an important component of the Green Economy (Lacour and Puissant 2007).

The EU-28 countries continue to lose substantial areas of agricultural land to infrastructural development and urban sprawl (Figure 2.8.3). Across the EU, 20 per cent of Natura 2000 protected areas, 32 per cent of wetlands and 45 per cent of agricultural lands had already been lost to soil sealing by 2006, and this trend was not expected to change in a more recent assessment (EEA 2015m). Every day, 275 hectares of the EU's arable land are lost to soil sealing or land take. It means that every three minutes, an area equal in size to a football field changes to another use. Almost 1 000 square kilometers of agricultural or natural land disappear every

Figure 2.8.3: Land take from urban development in the EU at the expense other land use categories, 2000-2006



Source: EEA 2013d

year in the EU, as they are converted into artificial areas (EC 2012d). Already 40 per cent of the European Mediterranean coastal areas are sealed (**More...125**); by 2050 the figure will reach 50 per cent if present trends continue (Zdruli 2014).

The European Commission estimated in 2012 that implementation of the Integrated Coastal Zone Management (ICZM) programme was only about 50 per cent completed across the EU as a whole. It identified two shortcomings that are especially important. The first is a lack of clear administrative responsibility for the implementation of the ICZM programme, and the second is an absence of commonly agreed objectives and timeframes in which these objectives should be achieved (EEA 2013e).

Video: "Better save soil"

https://vimeo.com/125438160 or

Increasingly, the EU's environmental legislation is attempting to counter these trends, but current indicators suggest that in general, policy changes and regulations are ineffective except in some specific cases. Given the rate of land consumption, the sustainability of the EU's environment and ecosystems has to be considered questionable and, without significant progress in policy implementation, dependency on external land resources may become permanent. It is for these reasons that the EU has endorsed the no-net-land-take-by-2050 policy (EC 2011b).

Video: "Soil sealing: destroying Earth's living skin"

http://www.tvlink.org/mediadetails.php?key=64640b2a69a635e84c10&title=Soil+sealing+-+Destroying+earth per cent 27s+living+skin&titleleft=Environment

The Thematic Strategy for Soil Protection never materialized as an EU Directive. In 2015, the European Commission noted that the proposal for a Soil Framework Directive had been pending for eight years, during which time no effective action had been taken. As a result, it decided to withdraw the proposal, which was a major setback. Nevertheless, the 7th Environment Action Programme restates the EU's commitment to *"reduce soil erosion, increase soil organic matter, limit the effects of man-made pressures on soil, manage land in a sustainable fashion, and remedy sites with contaminated soils"* (EU 2013).

In 2015, the EC expressed its intention to work towards the development of a Land Communication. The related targets are:

1. no net land take by 2050;
2. by 2020, the area of land in the EU that is subject to soil erosion of more than 10 tons per hectare per year should be reduced by at least 25 per cent compared to 2000; and
3. by 2020, soil organic matter levels should not be decreasing overall and should increase for soils with currently less than 3.5 per cent organic matter.

The Communication will also aim to highlight the need for the EU to have a coherent and sustainable approach to land management.

The new Common Agricultural Policy (CAP) covering the period 2013–2020 pays particular attention to the green economy, provides compensation for farmers who implement environmental farming services (Dedeurwaerdere *et al.* 2015) and supports aspects of soil protection that have been an integral part of Good Agricultural and Environmental Conditions (GAEC) policies since their introduction as part of a cross-compliance requirement in 2003. (**More...126**)

Responses to soil sealing in Eastern Europe remain sporadic and strongly influenced by economic development trends in which agriculture is at a relative disadvantage. Due to the vast extent of land in Central Asia, soil sealing and land take are not yet issues there, but that may change in the future.

2.8.4 Land-use changes and the need for strategic land-use planning

Land use changes are greatly influenced by political and economic decisions, especially in periods of economical crises. Eighty percent of European continental territory has been transformed by humans, either for settlement, production systems including agriculture, agro-forestry or managed forests and infrastructure. Conflicting land-use demands often arise, requiring decisions involving difficult trade-offs. There are several important drivers for this land-use change: the increasing demand for living space per person and increased mobility and growth of transport infrastructure.

The Roadmap to a Resource Efficient Europe has proposed halting net land take by 2050. Nevertheless, the net-land-take concept is ambiguous and could be interpreted either as being based on the surface area of change of non-artificial areas into artificial ones, or on the basis of more ecological criteria, depending on the balance between the land functions lost and restored (BIO by Deloitte 2014).

Studies show that reaching the no-net-land-take target by 2050 would require a reduction of land take in the EU-28 of about 17 per cent by 2020 (Lavalle *et al.* 2013). This intermediate target seems unlikely to be achieved, since most countries recognize that land take cannot be halted without the implementation of stringent policy instruments, which, despite several attempts, have been unsuccessful. In order to optimize the efforts of Member States, the EU target must be allocated to countries following their specificities in terms of land use, demographics and economic development. But because of the substantial discrepancies in the monitoring of artificial areas between the EU and certain national data sets, as well as the high political sensitivities related to land stewardship, it seems more relevant for Member States to propose their own national targets to the Commission rather than for the EU to set national targets (BIO by Deloitte 2014).

Central Asia is characterized by an arid climate, saline parent material and complex rugged relief. Consequently, contrasting land-use scenarios can be observed: on the one hand, land abandonment and some recovery of natural steppe grassland can be observed, and on the other, the expansion of large-scale farming (**More...127**). Furthermore, there is increasing pressure on natural resources from mineral and fossil-fuel extraction, which is driving economic growth and urbanization, and exposing new land-use patterns.

Another trend is farmland abandonment and the factors causing it are common across the entire of pan-European region (Terres *et al.* 2013). Abandonment mostly occurs in marginal areas with limited natural productivity (Figure 2.8.4), and occasionally also in productive ones due to migration and socio-economic factors.

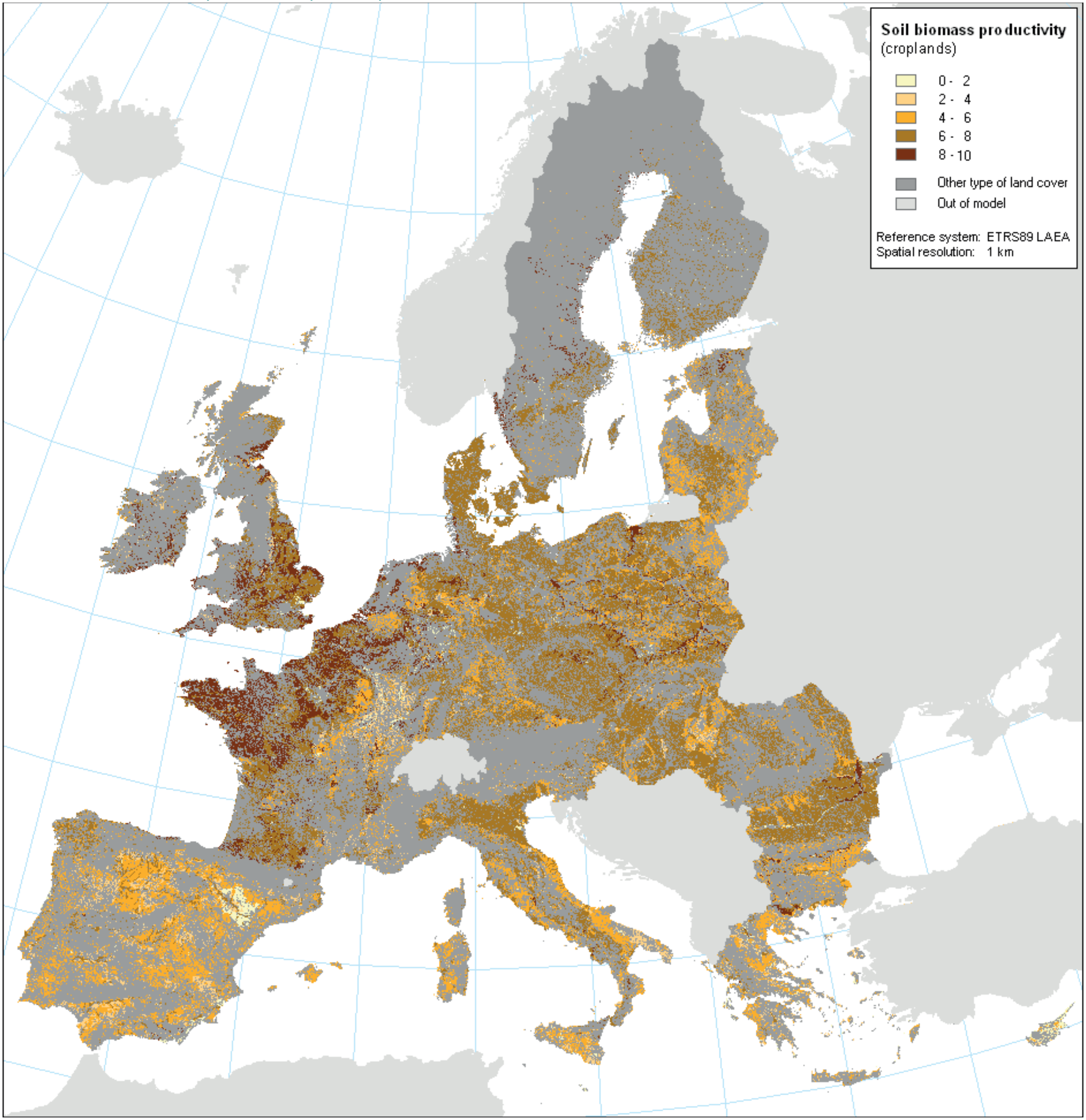
According to Alcantara *et al.* (2013), by 2005 in Central and Eastern Europe and the Balkans, 52.5 million hectares were abandoned, including 32 million hectares in the Russian Federation. According to the Food and Agriculture Organization of the United Nations (FAO), the combined use of arable lands in the Russian Federation, Ukraine and Kazakhstan dropped from 200 million hectares in 1991 to 177 million in 2003 (FAO 2013e), but these numbers may be underestimated. Furthermore, the Russian Federation statistics for cultivated areas and remote sensing data suggest that up to 40 million hectares of the cropland area were abandoned in the Russian Federation alone (Prishchepov *et al.* 2013; Shierhorn *et al.* 2012), significantly more than FAO's land-resources statistics report. Other factors influencing land abandonment relate to changes in the political system and the economy in the Russian Federation and the Central Asia countries. The loss of pasturelands occurred at an even larger scale in Eastern Europe and Central Asia (**More...128**).

Land-use planning and land management are functional and complementary when they reconcile land use with environmental concerns (Foley *at al.* 2005). These are crucial challenges that involve various policy levels and different sectors. Monitoring and mediating the negative environmental consequences of land use while sustaining the production of essential resources is a major priority for policy-makers worldwide (EEA 2015a). Finally, it should be emphasized that land take not only reduces the crop production capacity of agriculture, but has severe consequences also in terms of biodiversity loss and landscape diversity.

2.8.5 Globalization, economic development and Europe's land needs

As 40 per cent of the food and related food products consumed in the EU-28 are imported, the region is a net food importer. This could have consequences for food security globally, possibly affecting populations already facing food-related poverty (**More...129**). About half of the land-take for urban development and infrastructure in the EU comes at the expense of arable farmland (EEA 2013e). The existing rates of sealing are equivalent to losses of agricultural production capacity of 6.1 million tons of wheat per year, with large regional variations. This is a very significant figure, since for every hectare of fertile arable land lost in the pan-European region, it would be necessary to bring a much larger area into production elsewhere (Gardi *et al.* 2015). This could also accelerate the process of large-scale land acquisition beyond the region, for example mostly, but not exclusively, in Africa.

Figure 2.8.4: Soil biomass productivity of croplands in the EU-27 in 2006



Source: Eurostat 2012a

Understanding the pan-European region's economic relationships between human activities and anthropogenic landscapes requires not only an appreciation of processes that occur within its borders, but also a consideration of the indirect links between populations and lands that lie on either sides of regional boundaries (Wiedmann 2009). The EU-28, and especially its more western part, occupies a role as one of the strongest net importers of the benefits of land use beyond its borders through global trade (Weinzettel *et al.* 2013). Yu *et al.* (2013) calculate that in 2007, the EU-27 as a whole was associated with 27 per cent of the global total displacement of agricultural-land use through trade. As such, while only 14 per cent of agricultural land use – the combination of croplands, timberlands and pasturelands – located within Western Europe was associated with exports to satisfy final demand (including consumption) in other world regions, 58 per cent of the land required for final demand in Western Europe was located outside of the region (Bergmann and Holmberg 2016).

Europe as a region is highly integrated within and dependent on global flows of land use embodied in trade. In 2007, Western Europe had only 0.7 hectares of agricultural land use per person, but a final demand of 1.4 hectares per person. The Russian Federation and Eastern Europe, on the other hand, were net exporters of embodied agricultural land use, having 2.0 hectares available per person but a final demand of only 1.6 hectares worth of products per person (Bergmann and Holmberg 2016). It is also important to consider that global land use is indirectly required to produce manufactured goods and services used in Europe.

A report by the International Resource Panel (UNEP 2014b) calculated the global cropland requirements of the EU, finding that 0.31 hectares per person were required in 2007. This is one-fourth more than what is available domestically in the EU; one-third more than the cropland globally available per person in 2007; and it is well over the "safe operating space" concept orientation value of 0.20 hectares for 2030 (UNEP 2014b).

In this sense, Africa is a major "donor" of land use to the pan-European region through trade, and finds itself reaping the benefits of only 0.6 hectares of land per person (the effective area that goes to food and income of the African individual), while using 1.3 hectares per person, much of the benefit actually accrues to others. This imbalance will continue as long as structural differences in industrial production capacity of developing economies remain weak.

The migration crisis affecting Europe, with over a million migrants and asylum seekers, is primarily due to political and civil conflicts, as well as economic factors such as poverty and the economic attractiveness of potential host countries. However, the causal links between soil fertility decline, human hardships and the decision to emigrate are beginning to emerge (Cunfer and Krausmann 2009).

2.8.6 Urban sprawl and green infrastructure

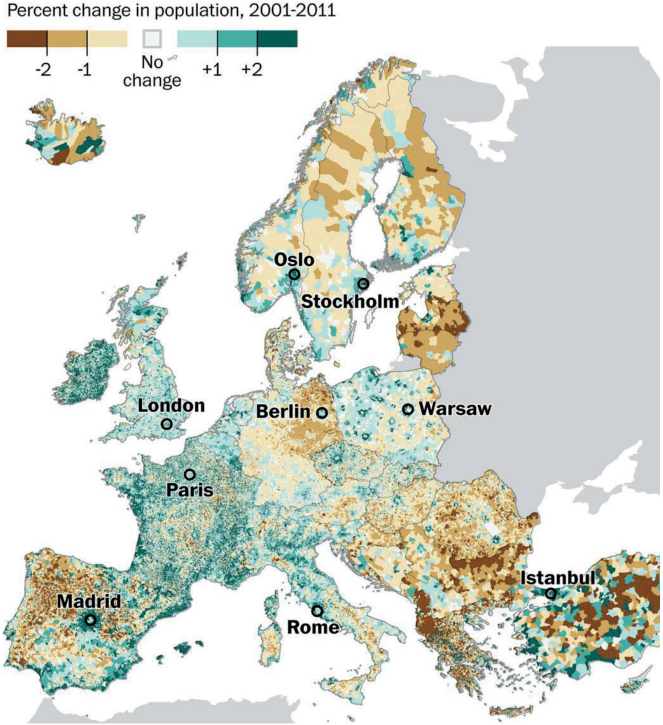
Urbanization, particularly the spatial extension of cities, is a well-known cause of land-use change, reflected mostly by the loss of arable land (Panagos *et al.* 2015b), natural habitats and biodiversity. Urban sprawl is driven by population growth, increased incomes, demand for housing and transport connectivity, while it is constrained by the cost of commuting, agricultural land values, rent and the amenity values of agricultural land and green space. Analysis of the EU Urban Audit Database showed an overall 18 per cent average increase in urbanized areas and a 9.43 per cent decrease in the density of a sample of European cities between 1990 and 2006 (Oueslati *et al.* 2015). Both of these trends were highest in Southern European cities. Northern European cities showed the lowest average increase in urbanized areas, while Western European cities had the lowest reduction in population density.

Different trends are emerging throughout Europe regarding population growth and dynamics. For instance, compared to neighboring England, Scotland and Wales, both the Republic of Ireland and Northern Ireland experienced more significant population growth between 2001 and 2011. Ireland's fertility rate currently stands at 2.1, which is the highest in the EU. Interestingly, there is a drastic difference between Germany and Poland along their border, with the latter showing higher population growth rates (Figure 2.8.5). Due to advantageous economic opportunities, coastal areas show higher population growth rates, while in Eastern Europe and the Baltic States populations shrunk dramatically between 2001 and 2011.

High density urban developments could decrease urban sprawl, leaving more land for nature or agriculture
Credit: Shutterstock/Dutourdumonde Photography

A key challenge for urban as well as agricultural policy is the balance between land sharing and land sparing (Lin and Fuller 2013). High-density urban development can prevent urban sprawl, sparing land for nature and agriculture, but may reduce space for biodiversity within cities, sharing land with nature and agriculture (Fuller and Gaston 2009). Analysis of land cover and urban audit data sets for European cities between 2000 and 2006 showed an overall increase of 0.54 per cent of urban green space area per year (Kabisch and Haase 2013), although 23 per cent of cities showed a net loss of urban green space during this period, mostly in Eastern Europe. In cities with shrinking populations, green areas decreased by 0.8 per cent per year, indicating that household size, planning policy and other drivers of urban land use are more significant than population size.

Figure 2.8.5: Percentage of change in European population for the period 2001-2011



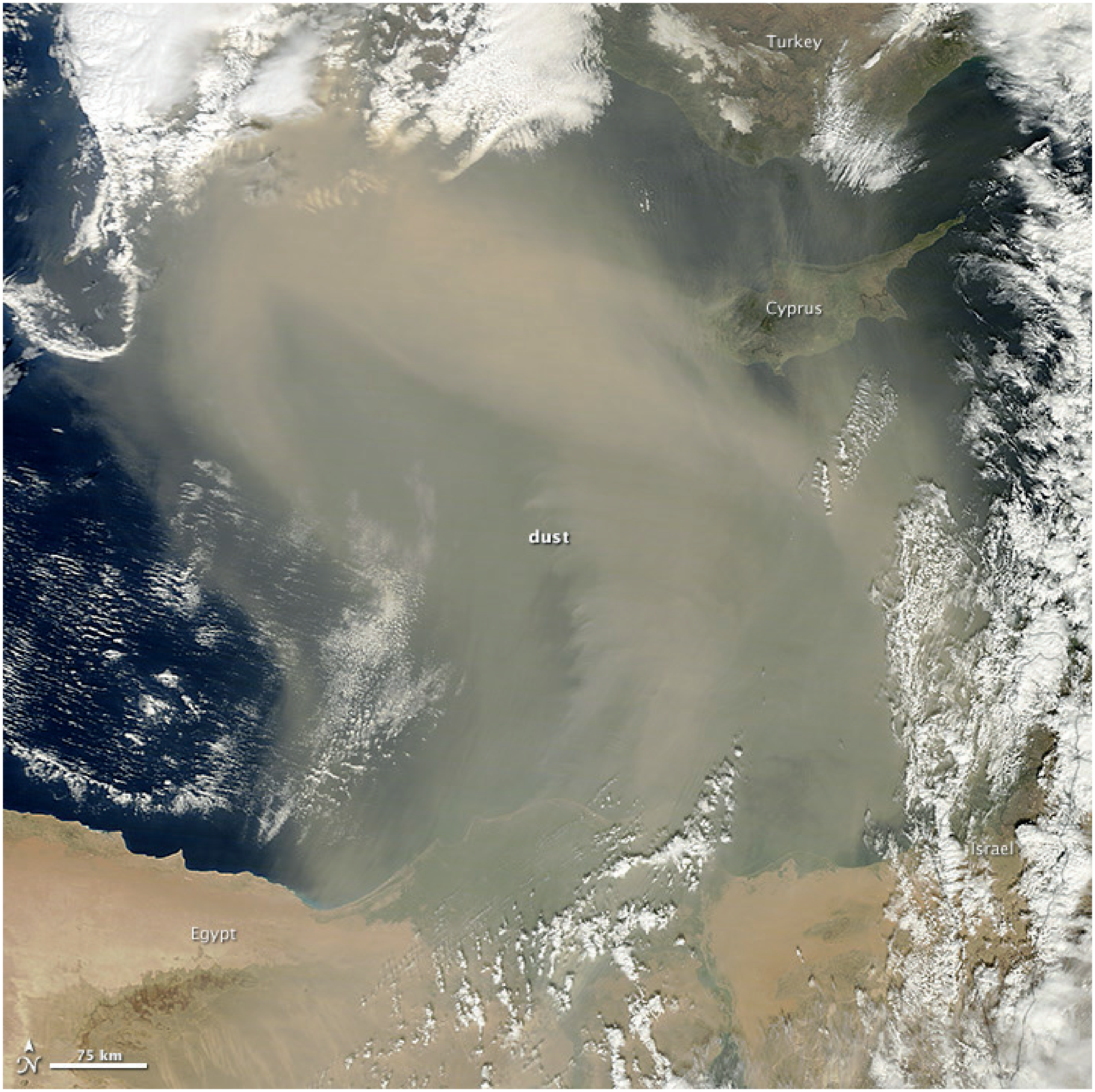
Source: German Federal Office for Building and Regional Planning 2015

2.8.7 Healthy lands sustain healthy people

The pan-European region is by no means isolated from neighbouring regions, and thus its environment is not only influenced by land use and climate change but also by air pollution. Saharan dust storms, for example, could have critical impacts on air quality and subsequently on public health (Figure 2.8.6).

Land quality impacts human health in various ways (Pepper 2013), through direct benefits from food and nutrition, living and recreational space for optimal lifestyles, physical exercise and even mental health. The mineral content of soil has strong effects on human nutrition and health, as many minerals such as iron, zinc and selenium entering the food system come from soils. If a child has suffered micronutrient

Figure 2.8.6: Sahara dust storms affecting Southern Europe and Turkey Dust storm event of 15 January 2014 over Cyprus and Turkey



Source: NASA 2014

deficiency in utero or during the first couple years of life, they may never attain their full cognitive and physical potential (Barret *et al.* 2015).

Land can be a source of direct exposure to harmful and toxic substances through waste, accumulation of chemicals and toxins, and as a reservoir of pathogens. In Europe, waste disposal systems are relatively advanced and infectious diseases sourced from pathogen-contaminated land are relatively rare (Traill *et al.* 2013; de Sa and Lock 2008).

Forests are an important component of land use with direct impacts on health benefits from the recirculation and cleansing of water through transpiration, cloud formation and rain, and contribute to the production of river systems and wetlands. These play a key role in filtering water and reducing the need for chemicalisation for health purposes. Because of their vertical dimension, mountain regions are characterized by climatic diversity that varies significantly with altitude. This verticality is also the origin of the land cover diversity, habitats and species within limited horizontal distances. Mountain areas also have different socio-economic profiles (tourism, logging, use of ecosystem resources) that have undergone profound changes over the last century with the development of modern societies (Schroter *et al.* 2005). Therefore, they need to be well-protected due to their fragility and vulnerability to anthropogenic pressures and climate change.

Central Asia, on the other hand, still suffers from periodic environmentally-derived pathogens such as anthrax and certain other parasites, whilst soil-derived tetanus is ubiquitous but rare. Land use is influencing certain health challenges in the region; for example, subsistence or industrial livestock systems being a source of pathogens through food

Forests provide many ecosystem services
Credit: Shutterstock/Andreas Zerndl

or from direct contact with infected animals. Nevertheless, the most dramatic event whose 'legacy' still continues was the Chernobyl disaster, which contaminated a total of 784 320 hectares of agricultural land in Ukraine, Belarus and the Russian Federation, and where timber harvesting was halted for a total of 694 200 hectares of forest. Since 1986, radiation levels in the affected environments have declined several hundred-fold due to natural processes and counter-measures. Therefore, the majority of the 'contaminated' territories are now safe for re-settlement and economic activity. However, in the Chernobyl Exclusion Zone and in certain limited areas, some restrictions on land use will need to be retained for decades to come (IAEA 2006).

Public health in the pan-European region is also influenced by current land use practices such as deforestation, agricultural consolidation, large field systems, intensification and mono-cropping, which also lead to loss of soil fertility and overall biodiversity. This in turn results in the loss of pollinators and natural pest control species, and a reduction in the viability of fruit trees and shrubs, further compounded by intensive crop agriculture that tends to favor commodity crops of low diversity, many of which were originally imported. The end result for humans is a poor diet, low in fresh fruits and vegetables, and high in carbohydrates and animal products (Holloway *et al.* 2011). The latter are derived from the increase in cheap grains that have underpinned the expansion of livestock globally. There is an overall loss of dietary diversity (Crops for the Future 2015 *The Declaration on Agricultural Diversification*, Paris, December 2015). and an increase in consumption of processed foods. There are various options to overcome this problem, which do not necessarily increase land use for agriculture, including recovery of abandoned land in Eastern Europe and reduced food consumption in Western Europe, including the introduction of other food systems such as insect breeding and production for protein.

The demand for cheap food and agricultural consolidation is also driving a loss of diversity in food supply and diet, further complicated by the rise in demand for meat which has a much higher impact on land needs (Machovina *et al.* 2015). There is thus a need to improve food systems and land stewardship. As farming practices and technologies continue to be refined, more food can be produced per unit of land, meaning that less area is needed for agriculture and more land can be spared for natural habitats that benefit wildlife and store greenhouse gases, but only if the proper policies are put in place (Phalan *et al.* 2016) and well-implemented.

A good example of optimal healthy living and eating is the so-called "Mediterranean diet", due to the provision of locally-produced nutritious food and care for the land embedded in social behavior recognized by UNESCO as human cultural heritage. Indeed, the "Slow Food movement" is another good example also originating in Italy.

The pan-European region is also one of endless examples of people living in harmony with the surrounding environment. Some of these are the millenary grape-producing terraces of Cinque Terre of the Ligurian coast in Italy; thousands of concave hollow-shaped zocos of Lanzarote in the Canary Islands in Spain, producing high quality vines in volcanic soils without any form of irrigation; and the renowned karstic terraces of Primošten in Croatia dating back to the 8th Century B.C. There are many more examples such as these across the continent, including in Central Asia that were showcased as part of the International Year of Soils in 2015.

The expansion of green infrastructure in cities delivers benefits to human well-being, biodiversity, urban cooling and adaptation to climate change, as shown by a growing number of case studies around Europe (Kazmierczak and Carter 2010). (**More...130**) Green infrastructure includes urban design features such as gardens, green roofs, green walls, rain gardens and ponds, as well as improving connectivity between green spaces, rivers, wetlands and woodlands within and between villages, towns and cities (**More...131**).

2.8.8 Policy responses

Existing goverenance frameworks covering land and soils at the global as well as pan-European and EU level are highly fragmented and widely regarded as inadequate for effectively protecting land and soil against problems of erosion,

Animal agriculture has a great impact on land use, and the situation is further aggravated by the growing demand for meat.
Credit: Shutterstock/Sergey Bogdanov; visivastudio

contamination, sealing, salinization and compaction. There is no international consensus yet on what is implied by a "land degradation neutral world" (LDNW) and the "target of zero net land degradation" (ZNLD), although current efforts under the World Soil Charter and the 2030 Agenda for Sustainable Development (Goal 15) suggest that some progress might be made within coming years. Efforts should focus on strengthening monitoring and data integration, ideally within the FAO's Global Soil Partnership, establishing internationally agreed reference targets, legal codification of soil protection in national, supranational and international law, and integrating soil management in environmental and urban planning as well as in sectoral policies.

However, compared to other environmental domains, land and soils are not well covered by international, EU and national environmental laws. The often-declared common concern for humankind and the pivotal role of land and soils for safeguarding ecosystem functionalities as a backbone for human development have not yet been backed by a coherent governance framework, but have been considered in part through various MEAs, principles and protocols. Some examples are the UN Convention to Combat Desertification (UNCCD), the UN Framework Convention for Climate Change (UNFCCC), the Convention on Biological Diversity (CBD), the

Tivoli City Park Ljubljana, (Slovenia)
Credit: Shutterstock/Matic Stojs

Ramsar Convention, the World Heritage Convention, the UN Forest Principles, various marine conventions and the Protocol to the Alpine Convention, (**More...132**) among others. In comparison to international governance frameworks established in related areas, such as the UNCCD's Land Degradation Neutrality (LDN) and Land Degradation Neutral World frameworks (LDNW), there is no well-developed and coherent international governance system for the protection of land and soils in the pan-European region. However, in June 2015, at the 39th FAO conference, coinciding with the 2015 International Year of Soils, all FAO Member States endorsed the new World Soil Charter, which is a non-legally binding instrument that seeks to promote and institutionalize sustainable soil management at all levels of society.

Within the pan-European region, the EU has sought to establish the most coherent and ambitious governance system for land and soils. In 2006 it launched the EU Thematic Strategy for Soil Protection. But this effort failed to result in a new Directive, and in 2015 the EU Commission withdrew the proposal for a Soil Framework Directive. Currently, a legally binding legislative framework for land and soils is missing at the EU level. Legislation is also widely considered to be inadequate within and among EU Member States and throughout the pan-European region. Such legislation is needed to address land degradation threats via prevention, remediation/off-setting and/or other policy measures. The EU environmental legislation attempts to address these threats, but the available evidence on land and soil degradation suggests that existing policies are still mostly ineffective, except in some very specific cases (EEA 2015m). In the meantime, there is a growing community of organisations who are committed to strengthen soil protection as a common good (**More...133**).

See references to Chapter 2

See links to Chapter 2

CHAPTER 3

Strengthening Environmental Governance

Main messages

- A stable pan-European environmental governance system has emerged over the past three decades, which has contributed to ecological improvements in the 54 countries of the region. Nonetheless, important differences between countries of the region, as well as gaps and unexploited opportunities for synergies between policies - within and across priority areas - remain.
- To support the transition to sustainable development and to an inclusive green economy, further efforts should focus on creating the required enabling conditions and improving the means of implementation; these include:
  - achieving greater integration of, and synergies between, existing policies with an emphasis on pluralistic multi-level governance that also involves strong elements of trans-national cooperation;
  - addressing gaps in coverage of existing policies with the aim of internalizing external environmental costs, reducing environmentally harmful subidies and encouraging sustainable lifestyles;
  - connecting existing and forthcoming policies with the SDG process;
  - pursuing open data policies throughout the region;
  - investing in research and development (R&D), as well as socio-technological innovations through public-private partnerships;
  - re-calibrating the fiscal system and creating innovative financial instruments; and
  - enhancing the involvement of business, civil society actors and citizens in environmental policy-making.

3.1 Introduction

This chapter discusses opportunities for improving the pan-European environmental governance system. It builds on the more specific assessment of policy responses and options discussed in Chapter 2. It places particular emphasis on enabling factors and means of implementation that can support the transition towards an inclusive green economy.

The region's environmental governance system is embedded in a rapidly changing geopolitical setting as well as transition processes in societies, markets and political systems. Anticipating structural changes and strengthening adaptive capacities will be key to improving the effectiveness of the region's environmental governance system, notable when pressures on the environment, risks to people and social and political stability are increasing (EEA 2011; UNEP 2010).

In highly complex modern societies, translating the many normative aspirations and demands for environmental protection and sustainable development into operational policies is a multi-dimensional process. This process is often accompanied by conflicts, structural shortcomings and counter-productive actions, which the environmental governance system, with its institutional settings,

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United Nations Office of Geneva
Credit: Shutterstock/Martin Good

operational approaches and implementation mechanisms, needs to accommodate.

Improving the environmental governance system is essentially a learning and capacity building process. It is a strategic endeavour aimed at creating social organizations to manage the many inter-relations among society, people and the natural environment. Designing environmental governance systems in a changing world requires large amounts of evidence, knowledge and capacity in order to adequately respond to upcoming threats and risks to social and economic development (EEA 2011; UNEP 2010).

3.2 The challenge ahead

The challenge ahead for the region's environmental governance system is two-fold. First, the assessment of state and trends and policy responses in the thematic areas indicates the need to strengthen the implementation of existing policies. This requires full exploitation of current commitments in order to reach agreed environmental goals and targets and pro-active learning from the wide spectrum of good-practice examples in the region.

In critical areas such as climate change and the atmosphere, aquatic environments, land and soils, biodiversity, and chemicals and hazardous waste, additional commitments and efforts are needed to improve on the current situation. The current trajectory will not achieve the ambitions of the SDGs and enable an inclusive green economy. Moreover, problems with political and social stability, as well as economic crises in parts of the region, may lead to further environmental degradation and an erosion of existing environmental policies.

Second, progress towards the SDGs and an inclusive green economy will require re-calibrating policies and re-designing institutional settings to better integrate environmental policy into policies across different sectors, horizontally and vertically, as well as stimulating innovation in markets and society. There should be a strong emphasis on sustainable consumption and production, with the aim of achieving a circular economy, and bringing resource consumption levels and greenhouse gas emissions in line with the principles of common but differentiated responsibility.

To this end, the means of implementation needs to be strengthened towards more pluralistic governance in the region, including greater public participation in decision-making, trans-national cooperation and cooperative financing. This approach will leverage the positive effects coming from interactions with business, civil society and citizens to place the region on the trajectory towards sustainability, working for the planet, people and prosperity within a global partnership of sustainable development.

3.3 The pan-European environmental governance system

Since the early 1970s, a multitude of bilateral, regional and global environmental treaties and other policy instruments, such as supranational laws and regulations, action programmes, joint declarations and resolutions, and decisions by international organizations and governing bodies of *MEAs* have emerged (**More...134**).

However, the pan-European environmental governance system remains fragmented, both in terms of substantive coverage of priority areas by existing MEAs, and due to the participation of the region's 54 countries. Participation by all countries in all MEAs levels off at an average of around 50 per cent, indicating that this remains a challenge.

Despite these limitations, existing MEAs and other policy instruments have helped embed environmental policy within national and trans-national political systems and supported national environmental protection efforts. These efforts have contributed towards improving the environment as well as generating indirect benefits (EEA 2015; UNEP 2012a). Further efforts should focus on developing an overall strategy for re-aligning existing MEAs, establishing new MEAs to fill gaps, and achieving full participation and implementation by all countries in the region.

The SDGs and the 2030 Agenda for Sustainable Development provide opportunities for increasing cross-fertilization between MEAs and building momentum to better integrate the fragmented policy landscape at the pan-European level. Overcoming this institutional fragmentation could help the region and its countries achieve the various SDGs, and also build capacity for social and economic improvements more generally. From this perspective, strengthening the environmental governance system can be seen as a strong enabler for building more sustainable, just and inclusive societies.

3.4 Enabling conditions and means of implementation

Strengthening enabling conditions, the means of implementation and capacities for better environmental management have been integral to global environmental governance since the United Nations Conference on Environment and Development (UNCED). Countries in the pan-European region have improved living conditions and environmental quality, but still face significant challenges, in particular regarding inequalities.

The concept of an inclusive green economy creates opportunities for establishing a common framework for action involving governments, business, civil society and citizens. It could help motivate and incentivize public and private institutions, business and citizens to invest and act in line with the principles of sustainability.

A common strategic framework for the transition towards an inclusive green economy should be established in the region. The Batumi strategic framework for action could facilitate such an endeavour and enhance commitments to further invest in the means of implementation, and help build the knowledge base to improve governance (UNECE 2016). The strategic framework is flexible and can be tailored to different national circumstances. It also comprises an operational agenda that supports countries in their efforts to achieve the Rio+20 objectives and the SDGs. At the upcoming eighth Environment for Europe (EfE) Ministerial Conference, the Batumi Initiative on Green Economy (BIG-E), which contains ECE's Member States' voluntary commitments for green economy actions, will be announced.

Efforts to improve environmental governance in the region, through mainstreaming the strategic approach of an inclusive green economy, could focus on the following seven elements:

3.4.1 Pluralistic governance

Multi-level and pluralistic environmental governance systems tend to be more effective (UNEP 2010). Thus, mobilizing business, civil society actors, municipalities and citizens alongside central governments and regulatory authorities is important.

Multi-level and pluralistic governance systems not only strengthen the regulative framework by command-and-control mechanisms, but also increase the level of active involvement of business, civil society and citizens. In some areas, such as climate change, broader cross-cutting coalitions of governments, public institutions, business associations, civil society organizations, municipalities and local citizens' networks have emerged and become very active (UNEP 2015). In other priority areas, such as freshwater, marine and coastal management, soils, bio-diversity, chemicals and waste, there are also signs of increased commitment by business and non-state actors (**More...135**).

Another promising area of joint action in the region concerns sustainable consumption and production (UNEP 2012b). Notably, many countries in the region have been actively engaged in the process of establishing a global ten-year framework (*10YFP*) for sustainable consumption and production. Other multi-stakeholder partnership initiatives aim at promoting a circular economy, green growth and an inclusive green economy, and are also emerging at national levels (**More...136**).

3.4.2 Integration and coherence

The pan-European environmental governance system has become more integrated and coherent in recent years, mostly within the environmental policy domain, but also partly in relation to other policy areas. Key mechanisms supporting this trend have been the EfE process and the EU's Environmental Action Programmes, now in their seventh cycle 2014–2020. At the multi-lateral and supra-national level institutions are in place to facilitate better integration and coherence. In addition, a scarcity of resources of governments and non-governmental actors and the need to better allocate the available resources (especially in view of the financial crisis) (OECD 2009) have also been important drivers. Despite this progress, there is still room for improvement in strategic policy formulation and integrative environmental planning, particularly in lower-capacity countries of the region, and within as well as across different environmental priority areas.

Greater integration of the pan-European environmental governance system is also in part the result of the growing complexity of many, if not all, environmental domains (Underdal 2010; Persson 2004). Overall, the level of policy integration and coherence varies significantly in the region (EEA 2005). Environmental policy has become more integrated between various environmental domains in a growing number of countries. However, in some countries the integration of environmental requirements and considerations in other policy areas has reached a stage where environmental objectives remain secondary and/or have become part of a multi-sectoral or institutional arrangement, relating for example to urban development, climate mitigation, biodiversity or resource management. Similar to horizontal integration of policies, vertical integration of policies is often plagued by inadequate coordination mechanisms or capacities for implementation, especially at the local level (Mullally and Dunphy 2015). In view of the need to overcome counter-productive effects of different, competing or conflicting public policy objectives (Hildingsson and Johansson 2016; Lafferty and Hovden 2003; Nilsson and Persson 2003), integration can be seen as a means for mobilizing additional social and economic capital from non-state actors.

A bottleneck in trying to achieve better integration and more coherence with other policy areas is the difficulty of adapting or re-designing existing regulatory frameworks and reducing harmful subsidies *(Global Subsidies Initiative of IISD)*.

3.4.3 Technology and innovation

While research on and development of environmental technologies takes place both in the private and public sector, governments can and should play an important role in incentivizing such activities. Environmental Technologies (ET), feed-in tariffs, tax breaks, removal of environmentally damaging subsidies, funding for basic research and other measures are already showing significant positive effects.

Some countries in the region are overall leaders in eco-efficient technology. The EU eco-industries, which employ more than 2 million people, account for about one-third of the global market and are growing by around 5 per cent a year (EC 2013). However, there are substantial barriers

Strong business growth in renewables
Credit: Shutterstock/Marco Prati

to full exploitation of these opportunities. These barriers include environmentally damaging subsidies and insufficient financial incentives to eco-innovate (EEA 2014). There are opportunities in the region to make better use of the latest technologies in energy, transportation and material use. Companies in the region are particularly strong in renewable power generation, and waste management and recycling, with global market shares of 40 and 50 per cent respectively.

The EU and its Member States, as well as a growing number of non-EU countries, have set up enabling policy frameworks, implementation programs, networks and technology roadmaps to facilitate eco-innovation and development of greener technology. These include for example, the EU *Eco-Innovation Action Plan*.

Considering the more systemic risks associated with climate change, resource depletion and other ecological dysfunctionalities, and to overcome the often claimed structural "lock-in", neither the market creation and commodification of ET in itself, nor its incremental institutionalization, is a solution to create a widespread applicable framework for an inclusive green economy that drives profound changes in dominant economic structures and thinking, ensuring ecosystem, economical and societal resilience (EEA 2014). Nearly all countries in the region are, to varying degrees, creating enabling frameworks and programs for R&D and market penetration of ET. Investment and public support measures are often driven by the fact that increasing capacities for technological development are associated with environmental, economic and social benefits, and may move existing markets towards an inclusive green economy (UNEP 2014; UNEP 2011).

3.4.4 Financial mechanisms

In addition to the European Neighbourhood Policy (ENP), a core framework for streamlining funds between the EU and neighbourhood countries, the EU and its Member States have set up a range of other frameworks and financial instruments to support implementation in all policy areas of common interest, including the environment. For example, the LIFE Programme supports nature conservation and climate change projects throughout the EU. Since 1992, *LIFE* has co-financed some 4 200 projects, contributing approximately €3.4 billion to the protection of the environment and climate.

In the majority of countries in the region, financial instruments have been set up to foster innovation and better implementation of environmental policy, especially in areas of the highest concern, such as climate mitigation and adaption, protection of biodiversity and conversion of habitats and protected areas, waste management and recycling, chemical safety, water management and wastewater treatment. Financial mechanisms and instruments are directed mainly to businesses to facilitate innovation in environmental technologies and infrastructure (EEA 2014). However, in a growing number of cases they also support civil society actors, including funding to enhance the engagement of citizens in environmental matters, such as energy efficiency. These measures are complemented by increased efforts to re-design taxation systems in order to support environmental protection, and by other economic measures such as the *European Emissions Trading System* (ETS) and related environmental funding programmes (see a national example from *Germany on National Climate Initiative*).

The financial sector has also engaged in joint initiatives to facilitate investments and capital flows aimed at promoting a low-carbon, resilient and sustainable global economy (**More...137**). Re-calibrating the fiscal system so as to treat economic, social and environmental performance objectives equally will be crucial to achieving environmental objectives (EEA 2014).

3.4.5 Trans-national cooperation

In view of capacity problems in many countries of the region, notably in Eastern Europe, the Caucasus and Central Asia, trans-national cooperation plays an important role in moving countries towards better environmental performance and compliance with MEA commitments (**More...138**).

While cooperation between EU Member States is strongly institutionalized, cooperation between EU and non-EU

Signature by the Ministers and High-Level Representatives of the 'Ashgabat Protocol' at COP5 in Ashgabat Turkmenistan in May 2014.
Source: ICSD 2016

countries is being addressed in many policy domains, including the environment. The *EU's European Neighbourhood Policy* and the *EU's Enlargement Policy* have had particularly strong positive effects in this regard (**More...139**).

The Greening Economies in the Eastern Neighbourhood (EaP-Green) programme is an example of a collaborative initiative between the EU and the six Eastern Neighbourhood Partnership countries: Armenia, Azerbaijan, Belarus, Georgia, the Republic of Moldova and Ukraine. It aims at moving towards a green economy by decoupling economic growth from environmental degradation and resource depletion (**More...140**).

In addition, trans-national cooperation in the pan-European region is fostered by a broad spectrum of global and regional programmes and networks of collaboration managed by UNECE and other UN agencies, funds and programmes; for example the Global Environment Facility (GEF), as well as non-UN organizations such as the Council of Europe. Cooperation at the bilateral and multilateral level between governments is increasingly complemented by trans-national cooperation among business sectors and civil society, with the aim of improving governance structures, implementation, and capacity building (Rohrschneider and Dalton 2002).

Various forms of cooperation, institutional settings and instruments in the region have created a robust bottom-line for environmental improvements in many domains. However, the challenge ahead for trans-national cooperation in the region is to better align cross-border, inter-regional and trans-national capacity building with risks associated with transboundary environmental problems in the region, and with increasing regional impacts on the global environment (EEA 2014). Strengthening the mechanisms and means of trans-national cooperation should take place within existing global and regional environmental institutions (Dauvergne 2012). Such efforts can build on joint capacity-building for cross-sectoral and sectoral inclusive green economy approaches, including enabling frameworks, and co-operative action for sustainable consumption and lifestyle changes in the areas of housing, food, mobility, leisure and tourism, together with public institutions, business, civil society and citizens.

3.4.6 Public participation

Increasing the formal and informal level of citizens' involvement in all environmental matters is key to good performance of environmental policies (Bernauer and Betzhold 2012; Rask *et al.* 2012; OECD 2001), but also to inclusiveness and overall justice. There is evidence that the level of citizens' participation in the region is positively correlated with the level of environmental policy performance. That is, the degree of the general openness of the political system to creating democratic "deliberative" (Gutmann and Thompson 2004; Carpini *et al.* 2004) or "interactive" mechanisms (Leggewie 2004) that serves as a baseline for a political culture of participation needed for ecological modernization (Jänicke and Jacob 2006; Jänicke 2005). Improved environmental performance in this regard could result from a higher degree of social acceptance and political legitimacy of environmental policy measures (Lucke 1995). Improved performance could also result from mobilizing the additional social and cultural capacities of citizens that are needed for them to become more involved in environmental policy decision-making and implementation (Newig and Koontz 2014). Besides more experimentation with formal and informal citizen's participation within the countries of the region, there are also promising signs with regard to increased involvement of citizens in global environmental matters. One example includes the deliberative process focusing on world citizens' views on climate and energy leading up to the UNFCCC COP-21 conference, in which 10 000 people in 76 countries participated (Danish Board of Technology Foundation 2015).

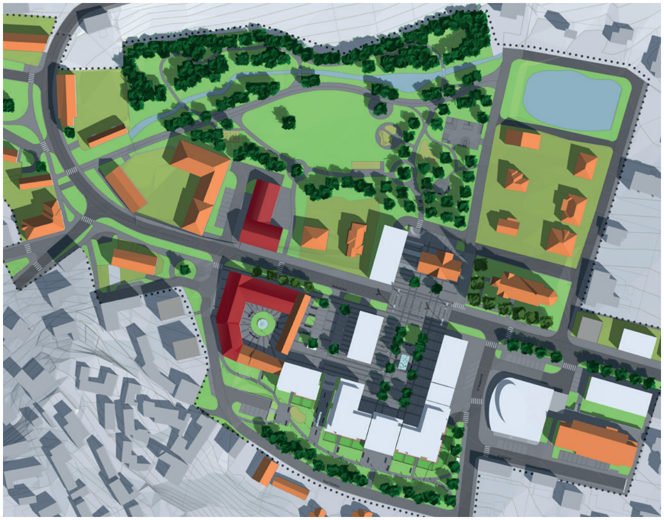
The 1998 Aarhus Convention (**More...141**) provides a solid starting point for increased public participation. Its focus links government accountability, transparency and responsiveness to environmental protection. The 2003 Kyiv Protocol on Pollutant Release and Transfer Registers (PRTR) has helped strengthen this governance system with respect to access to information on pollutants. To promote the implementation of the Aarhus Convention, *Aarhus Centres* have been established with the support of the *Organization for Security and Cooperation in Europe* (OSCE). As of December 2014, 57 OSCE-supported centres are in operation. The Aarhus Centres aim at strengthening environmental governance at the national level by facilitating policy dialogue between the government and the public, as well as other stakeholders, offering guidance to the public, performing awareness-raising activities for various target groups, assisting the public to participate in environmental decision-making and facilitating access to justice.

However, implementation of the Convention and its Protocol remains uneven across the region, and the extent to which they have mitigated negative distributional consequences and environmental justice problems remains open. The challenge ahead is to systematically incorporate various dimensions of justice into environmental policy; for example, intra- and inter-generational justice, procedural justice and distributional justice. This would help make environmental policy a stronger force for social inclusion, fairness and overall justice in societies of the region.

The EU, which is a party to this Convention since 2005, has developed a series of secondary laws to strengthen the Aarhus Convention and its implementation by Member States, in specific environmental areas such as the Water Framework Directive (**More...142**). The EC also provides relevant information in relation to the *three pillars* of the Aarhus Convention and has launched several training sessions for judges and magistrates, including an *E-Justice portal.* Strengthening public participation in environmental impact assessment and strategic environmental assessments is also key to better governance and policy implementation (**More...143**).

Reports to the Compliance Committee of the Aarhus Convention indicate that many Parties in the pan-European region are, despite significant progress, still facing difficulties in complying with all relevant aspects of the Convention. Besides problems with creating and institutionalizing "procedural justice" through formal legislation and procedures for public participation, reducing negative distributional effects of environmental policies and achieving intragenerational and intergenerational justice remain very challenging (Hermann *et al.* 2015; Fitzpatrick 2014; OECD 2006). In particular, when considering low-income and highly environmentally vulnerable households, environmental policies are in many cases not designed to ascertain proportional equality in relation to the polluter-pays principle and/or the precautionary principle, or to increase environmental, social and economic benefits to people in need.

Public opinion surveys over the past decade indicate rising dissatisfaction with a widening "justice gap" within environmental policies (OECD 2013; OECD 2011), and increasing concern about being excluded from benefits from environmental policies due to social, economic, cultural or physical constraints and barriers (German Environment Agency 2015, 2013). As a result, the social implications of environmental policies are receiving greater attention from policy-makers in most countries in the region. Remedies aim



Good urban master planning requires community participation
Credit: Shutterstock/Petr84

at including vulnerable people in policy-design efforts and policy implementation; for example, in the area of urban development planning.

3.4.7 Science, data, indicators and monitoring

The pan-European region is in a leading position to support the follow-up to and review of the 2030 Sustainable Development Agenda within the region and globally. Various organized processes and mechanisms already exist, including the Shared Environmental Information Systems (SEIS) supported by the UNECE Committee on Environmental Policy and the EEA as well as UNEP through its *UNEP Live* knowledge management platform. The UNECE Environmental Performance Reviews conducted in the pan-European region by OECD and UNECE (**More...144**) since early 1990s make the region a pioneer in using peer review mechanisms for the evaluation of progress in improving environmental and sustainable development policies. The region also benefits from many academic institutions, scientific academies and research centers. Large amounts of information are currently available through various means, such as national websites, MEA secretariats, the EEA's Central Data Repository (part of their ReportNet architecture) and UNEP Live.

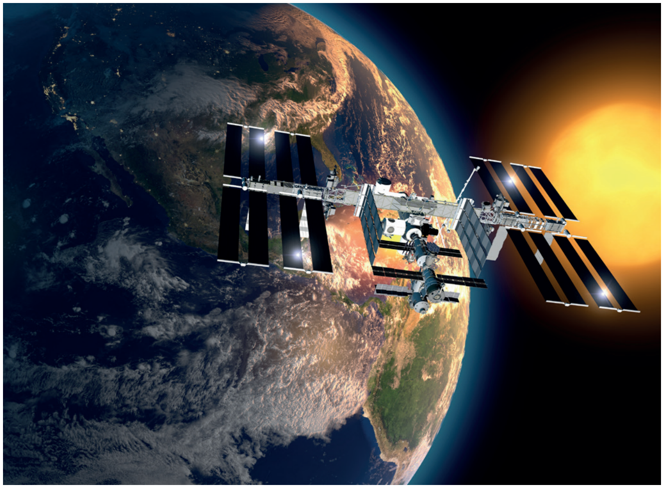
Supported by EEA and UNECE processes, countries have agreed on indicators to be used for state of environment reporting. One key issue remains whether these indicators are aligned to support the monitoring of the 2030 Sustainable Development Agenda. While a global indicator framework has been adopted and is being fine-tuned for the UN System to monitor global progress, the processes and standards for national, sub-regional or regional reporting are yet to be determined.

There are also other ways in which the pan-European region can contribute to monitoring progress. These range from high-tech to low-tech, and may involve scientists and/or citizens. The *Copernicus* Earth observation programme is a system in which data and information from multiple satellites are fed into thematic information services that inform decision-makers. The European Space Agency launched Sentinel 2 on 23 June 2015, and Sentinel 3A on 16 February 2016, greatly enhancing earth observation capacities in the region and globally. Once the remaining Sentinels are launched, the Sentinel family will collect a wide range of data covering land, oceans and atmosphere. The earth observation services will provide a wealth of data and information to support environmental management, and track progress to policy goals such as those identified in MEAs and SDGs.

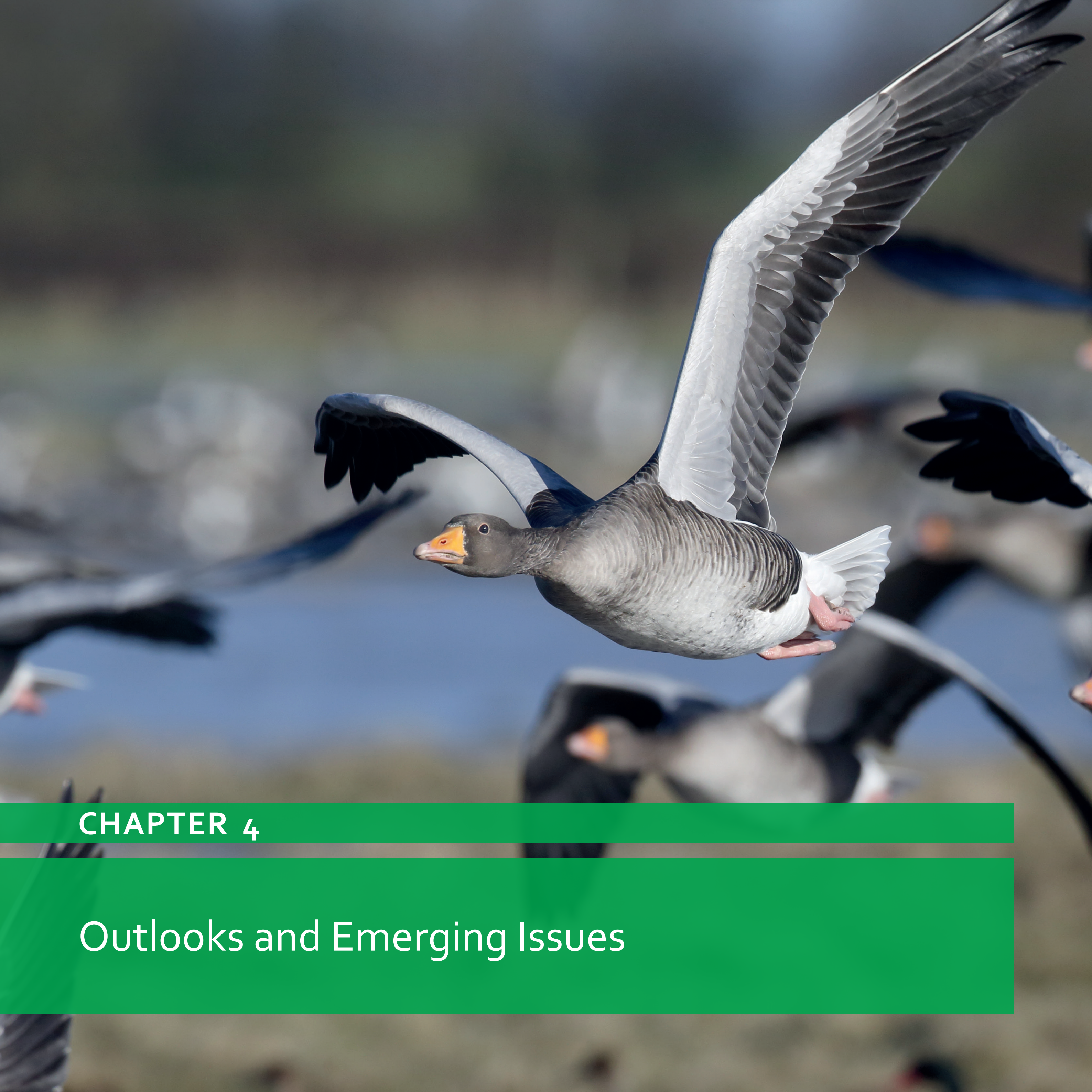
Engaging the public in environmental decision-making can happen in a variety of ways, not least by making the public part of observing and monitoring the environment. In this regard, the region and in particular some EU countries are well advanced. The *European Citizen Science Association* is a growing network that includes NGOs, museums, universities, research institutions and other local and national citizen science groups that organize the collaboration of scientists and citizens with a view to increasing the scope, scale and depth of environmental monitoring.

See references to Chapter 3

See links to Chapter 3



Transmission of environmental monitoring observations to decision-makers using state of the art technologies
Credit: Shutterstock/Naeblys



CHAPTER 4

Outlooks and Emerging Issues

Main messages

- The pan-European region is in the initial stages of greening its economy, pioneering transformative system solutions where economic performance, environmental quality, and human well-being are enhanced through reduced use of natural resources. The development of closed-loop, circular-economies with substantially reduced environmental footprints are starting to gain momentum. Bio-solutions that link the production and use of renewable biological resources and waste streams to food, feed, clothing, other bio-based products and bioenergy, are of increasing interest to businesses. Yet achieving a healthy planet and healthy people requires more urgent transformation of the current systems of production and consumption that most contribute to environmental degradation and societal inequalities, such as food, energy and mobility.
- Several global megatrends are expected to most affect the longer-term environmental outlook of the pan-European region: demographic change, increasing urbanization, global competition for resources, climate change and the implications of an increasingly multipolar world. Some of these trends offer opportunities for new innovations, others increase the risks of resource scarcities and conflicts. The complexity of ecosystems can mean considerable time lags between reduced pressures and restored functions. The crossing of planetary boundaries are adding new elements of risk for which both the developed and the transitional countries of the region are largely unprepared.
- Pan-European outlooks suggest in particular the need to halve material resource use in Western Europe and stabilize it elsewhere in the region. Other outlooks point to: increasing pressure on water resources across the whole region and water stress in Southern Europe and Central Asia; continued biodiversity loss and degradation of ecosystems and the services they provide, increased burden of disease and significant levels of premature deaths due to ambient air pollution; and acute climate change impacts. Increasing policy coherence and integrated interventions across these areas could improve the longer-term outlook overall.
- The challenges faced by the region are increasingly systemic, complex, interdependent and uncertain. Achieving progress under greater uncertainty needs coalitions between government institutions, businesses and civil society, to agree on pathways for tackling different societal risks. Vertical coordination between national and local policy levels will be instrumental in accelerating the needed systems transitions. These transitions should be focused on creating meaningful employment and eliminating poverty, while rebuilding the environmental resources and services on which future pan-European sustainability will depend.
- The SDGs provide a strategic framework within which environmental policy in the region can contribute to transition processes as well as provide a mechanism for strengthening regional adaptive capacities and resilience. Operationalizing the SDGs will require ambitious quantitative targets and indicators so that progress towards sustainability can be tracked properly to ensure convergence towards a shared regional vision and ambition within planetary boundaries.

4.1 Setting the scene

4.1.1 Ecosystem health and human well-being as key policy objectives

The pan-European outlook examines two projections to 2030 through the lens of the regional environmental priorities including natural resource consumption and waste, water, biodiversity and ecosystems, air quality and climate change, in relation to ecosystem health and human well-being. One is a business-as-usual (BAU) projection based on current policies and the other an alternative development projection that envisages achieving the outcomes of the Multilateral

◄ Credit: Shutterstock/ Erni

Environmental Agreements (MEAs) and Sustainable Development Goals (SDGs) and the transformative changes needed to meet them. As the pan-European region's possibilities are also embedded in a dynamically changing and increasingly challenging regional and global context, global megatrends are also taken into account: demographic change, increasing urbanization, global competition for resources, climate change, and the implications of an increasingly multipolar world.

Much of the pan-European region is considered well-off by comparison to other regions of the world, even though inequalities in income, opportunity and health exist across the region. This comparatively high standard of living and health in the region, is however, fragile, as demonstrated by the 2008–2009 financial crisis (Eurofund 2013), and not immune to significant political uncertainties vis-à-vis the recent migration crisis and conflicts, or to the effects of environmental stress and vulnerability on people and ecosystems. New challenges may also emerge, including the effects of increased extreme weather events which can contribute to the loss of livelihoods particularly in marginal lands, and to people abandoning traditional areas (Ebi and Bowen 2015). In a BAU world, without the ability to interpret subtle signals and other warnings (EEA 2013, 2001) and develop competencies to differentiate between the root causes and symptoms of problems, and without sufficient capacity to think and act within a common value frame and a longer-term perspective, the pan-European region could become increasingly vulnerable.

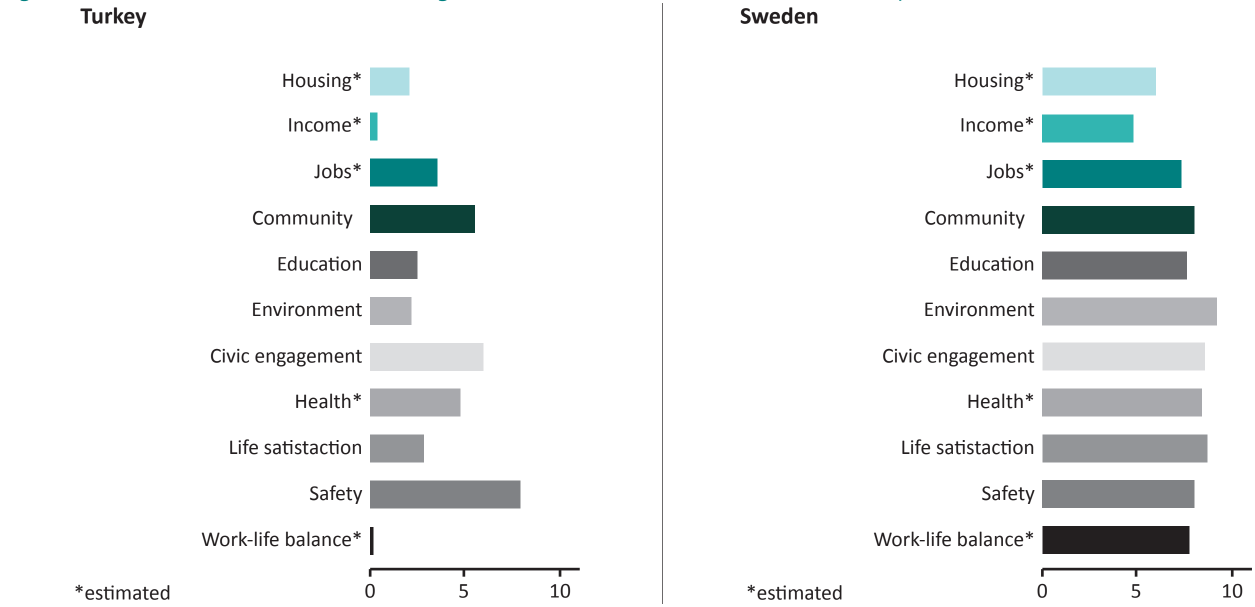
The level of uncertainty regarding the future impacts of climate change on the standard of living and health in the region, is also an increasingly important factor in decision-making (IPCC 2014). The shrinking of the Aral Sea and its segmentation into two separate reservoirs following a failure in lake management provides a stark example. The collective failure in relation to lake management led not only to declining water levels and loss of biodiversity, but also to the loss of thousands of fishing related jobs and the collapse of former shore towns, as well as significant health problems due to Sand and Dust Storms (SDS) generated from the dry lake bed (Micklin and Aladin 2008; Whish-Wilson 2002). The health impacts however helped to catalyse *national and international political action on health monitoring*. The WHO now has an Operational Framework for building Climate Resilient Health Systems that includes policies and programmes on climate-informed health, integrated risk monitoring and early warning, emergency preparedness, and vulnerability assessments to support member countries in the development of their National Adaptation Plans under the UN Framework Convention on Climate Change (UNFCCC) (WHO 2015). As for the Aral Sea itself, the Northern Aral has recovered as a result of irrigation efficiency improvements and preventing outflow to the Large Aral Sea, but revitalization of the entire Aral Sea is not expected (Sehring and Diebold 2012).

Cow grazing in a dry harbour on the Aral Sea
Credit: Shutterstock/Tracing Tea

In response to recent political calls for action on SDS, UNEP together with WMO and UNCCD have produced a rapid global assessment on SDS. The assessment synthesizes the latest knowledge on the science and policy of SDS and applies this knowledge to identify elements of a comprehensive framework for preventing and managing SDS at the local, regional and global levels (UNEP 2016).

As stated in Section 1.2, environmental health and human well-being are recognized as inherently integrated and interdependent within the 2030 Agenda for Sustainable

Figure 4.1.1: Factors of human well-being in the OECD's Better Life Index for Turkey and Sweden



Source: OECD 2015

Development (UN 2015). Human health is directly affected by environmental factors (WHO 2015), and while there is no standard, universally applicable definition of well-being, it is commonly considered as a sum total of objective and subjective factors that determine how well people live and how well-off they think they are. The Organization for Economic Co-operation and Development's (OECD) Better Life Index (OECD 2015) building on the work of Stiglitz *et al.* (2009) and Hall *et al.* (2010) includes material living conditions, quality of life and sustainability. Comparisons of the Better Life Index for the pan-European OECD countries shows that large differences in the factors of well-being exist (Figure 4.1.1).

At the policy level, the development of closed-loop, circular economies with substantially reduced environmental footprints, and bio-economies linking the production and use of renewable biological resources and waste streams to food, feed and bio-based products and bioenergy, are also starting to gain momentum in public policy and with businesses (Philippidis *et al.* 2016; EC 2015). In addition, some countries are beginning to confirm their commitment to redirect investment and trade to support a green and inclusive economy (UNECE 2015).

There are also promising signs of a shift in thinking at the individual level in some countries, as illustrated in value surveys that show public recognition of the post-material dimensions of well-being (Delhey 2010). Nevertheless, to achieve a true transition to sustainability, the region will need to effect fundamental shifts in societal value systems, lifestyles and mindsets (van Vuuren *et al.* 2015; Özkaynak *et al.* 2012), and secure absolute decoupling through burden sharing between the public and private sectors and by actively reducing the delocalization of resource use and pollution to other regions of the world.

4.1.2 Megatrends and the pan-European region

In building the pan-European outlook, five major megatrends, which broadly define the region's operating conditions, have been considered: demographic change, increasing urbanization, global competition for resources, climate change, and the implications of an increasingly multipolar world. (EEA 2015; EY 2015; KPMG 2013).

Demographic change: by 2030 Western and Central Europe's population is expected to fall by about 0.5 per cent, not taking the recent upsurge in migration flow into account, while in the Caucasus and Central Asia, it will grow by almost 13 per cent (UNDESA 2015). Population size in the Russian Federation is projected to fall by 7.7 per cent without taking migration from Central Asia and the Caucasus into account and by 2.8 per cent taking migration into account (Zayonchovskaya 2013). Considering all sub-regional trends, in net terms the population of the pan-European region appears stable, although this may need to be revised if Europe attracts a steadily increasing flow of immigration. On an annual basis, 2.4 million immigrants are expected to arrive in Western Europe between 2013 and 2050 (EEA 2015) and there is no doubt, that intraregional differences in population demographics and trends will make the coordination of policies across the pan-European region very challenging.

Structural changes, particularly the increase in one-person households in Western and Central Europe, could outweigh the effects of stabilizing or falling population numbers and subsequently result in growing resource use (EEA 2014; OECD 2011). This trend is reflected in the significant increase in demand for land for housing in some countries in Europe, and the associated soil sealing rates.

Trends in life expectancy, long used as an indicator of improving health of human populations, show that by 2030, the median age in Western European will be 45 years or more (ESPAS 2015). Historically, increasing age is generally accompanied by chronic disease and increasing physical and mental suffering, however the significant inward migration from developing countries may alter the balance between these conditions.

Increasing urbanization: it is foreseen that Western Europe's already high levels of urbanization will continue to increase, so that by 2050 around 80 per cent of the population will live in towns and cities (UNDESA 2014). In Central Asia and the Caucasus, the urban population ratio is lower, but it is projected to increase to around 55 per cent in 2030 and 63 per cent in 2050 (UNDESA 2015). The increasing age and immobility of populations living in urban settings, is also likely to lead to greater demands across the region for accessible services including green public spaces,

Climate change: over the coming decades, the impacts of climate change will put further pressure on the region's natural resources, especially on freshwater and particularly in Central Asia (Dunford *et al.* 2015; IPCC 2013). In Central and Western Europe, projected impacts include more intensive floods, droughts and forest fires, as well as extreme weather events and colonization by invasive alien plant species (EEA 2015). Increased temperatures will have inevitable ecological consequences such as destabilized ecosystems, the spread of malaria, and other vector-borne viral and parasitic diseases, and bacterial proliferation rates, threatening human and animal health at a time when antimicrobials are becoming less effective.

Moscow is now classed as a megacity with over 10 million inhabitants
Credit: Shutterstock/OlegDoroshin

Global competition for resources: the latest projection of a world population of 8.5 billion by 2030 (UNDESA 2015), coupled with a growth in incomes, means that the demand for natural resources and the impacts associated with their use, will rise. Today Western and Central Europe's annual material consumption is around 20 tonnes per person, while in Eastern Europe, the Caucasus and Central Asia it is around 7.5 tonnes per person (Schandl *et al.* 2016). (**More...145**) Yet, the latest projections for food prices for the next decade anticipate a long-term secular decline (OECD and FAO 2015). With agricultural products being extended toward industrial processes and energy generation in the future, there will be a direct impact on the agrifood system and food security across the region in addition to the impacts of climate change over the coming decade (Brown *et al.* 2015; Maggio *et al.* 2015). The Agricultural Model Intercomparison and Improvement Project (AgMIP) results show how these considerations are crucial to determining the external (land productivity, technology and oil prices) and internal (policies influencing agrifood and bio-based sectors) drivers for scenarios of the bioeconomy in 2050 and beyond.

Current resource use in the region is unsustainable
Credit: Shutterstock/Marcin Perkowski

Increasingly multipolar world: as a result of the globalization of the economy through changing consumption and production processes, rapid technological development and demographic shifts, the world is becoming increasingly multipolar. Forces that point towards homogenization in terms of technology or consumption and production patterns coexist with forces that keep countries and regions apart on geopolitical, cultural or religious grounds. The growing interdependence of countries, which is particularly characteristic of the open economies of the pan-European region where it is expected to play a stabilizing role, is a mismatch with the current global system of governance, and hence unless addressed could become a factor of unsustainability and instability (ESPAS 2015).

These five megatrends do not exist in isolation: they can combine or interact, and strengthen or weaken each other. New megatrends may emerge and affect familiar patterns of change in unpredictable ways. Megatrends can have overwhelming momentum, pervasive and long-term effects that are positive or negative, and unintended consequences. Most of the megatrends that the pan-European region is exposed to originate from cultural and demographic patterns, technological change and economic and development policies that interact with and amplify worsening environmental conditions, such as climate change and air and water pollution. The crossing of planetary boundaries are adding new elements of risk for which both the developed and the transitional countries of the region are largely unprepared. At the extreme, history suggests that such convergence can stress the governance systems of countries beyond their point of resilience, and ultimately to a point of collapse (Diamond 2011). Clearly, a shortage of critical raw materials could jeopardise strategic development objectives. One example is rare metals as bottlenecks in the supply chain of low-carbon energy technologies (Moss *et al.* 2013).

4.2 Outlooks for 2030 and beyond

The set of international environmental agreements agreed in the pan-European region since the early 1970s, represent an expression of desired environmental conditions. These agreements vary with regard to the detail they include on environmental goals, targets, performance indicators and implementation mechanisms, but collectively they express the direction of environmental progress countries would like to follow.

In addition, the SDGs set out in the 2030 Agenda for Sustainable Development articulate a world in which societies recognize and successfully address the many linked environmental challenges coming from global megatrends and local drivers and pressures. The SDGs, with the UNFCCC Paris Agreement (UNFCCC 2015) and the Sendai Framework for Disaster Risk Reduction 2015-2030 (UNISDR 2015), together provide a long-term comprehensive package for dealing with sustainability challenges. Operationalizing the SDGs will require ambitious quantitative targets and indicators so that progress towards sustainability can be tracked properly to ensure convergence on a shared regional vision and ambition within planetary boundaries. The task of all countries of the region will be to turn the aspirations of this package into tangible implementation programmes. For this reason, countries will need to develop integrated policies and measures to tackle effectively a wide range of sectoral, national and regional challenges. The rest of this section provides insights to what is at stake through a series of illustrative examples that, for each, compare alternative pathways of development within a 2030 time horizon.

4.2.1 Natural resource consumption and waste

Since the start of the industrial revolution, Western Europe's transition from agrarian to industrial regimes has led to a growing use of resources, with average Domestic Material Consumption (DMC) increasing three- to five-fold, from 3–6 tonnes per person per year to 15–25, in the early 1970s (UNEP 2011). The EU has since stabilized its DMC and has improved the rate of resource efficient by 1–2 per cent per year (EC2011), due in part to structural changes in the economy, manifested in the increasing weight of the non-material intensive service sector and the more widespread use of material-efficient technologies (Giljum *et al.* 2008). However, when factoring in imported products, the EU's per person material footprint has continued to increase.

Today, the pan-European region shows considerable diversity in terms of the natural resources going into a unit of economic output, i.e. the material intensity, with 0.5 kilograms per US$ (kg/US$) in 2010 Western and Central Europe to around 2.6 kg/US$ in Eastern Europe, the Caucasus and Central Asia, compared to the global average of 1.4 kg/US$. Taking direct and indirect material content related to trade into account, Western and Central Europe's material intensity is closer to 0.8 kg/US$, while for Eastern Europe, Caucasus and Central Asia it is close to the global average at around 1.8 kg/US$ (Schandl *et al.* 2016).

The region faces a formidable challenge to decouple natural resource consumption from economic growth in absolute terms to levels that are both sufficient from a regional and global sustainability point of view without compromising economic performance or human well-being. Ultimately the region will need to approach absolute decoupling, by increasing the circularity of materials through product life-cycle extension approaches, advanced waste management schemes (such as urban mining of secondary resources), and through factoring in imports and burden shifting, reducing intra regional and global burden shifting to zero and eliminating sub-regional differences in natural resource-use efficiency. There will also need to be a significant commitment to the sound management of chemicals as a cornerstone of implementing policies on sustainable consumption and production.

Business-as-usual projection and associated risks

Without significant changes in baseline policy conditions, model results point to a stabilization of domestic resource extraction in Europe and an increasing portion of Europe's demand for natural resources derived through imports (Giljum *et al.* 2008).

Despite continuing to move in the right direction, the BAU projection perpetuates a rebound effect, whereby resource use efficiency gains would be outpaced by economic growth and related increases in consumption and production, resulting in no reduction in absolute impact (Ferguson 2015). Other calculations confirm that, fuelled by increasing reliance on imports and assuming no abatement measures, the overall material footprint of the EU would continue to grow (Schandl *et al.* 2015).

In the pan-European region, the marked difference in material footprint of consumption is likely to persist between EU Member States, at around 25 tonnes per person per year on average and close to levels in the United States of America (Wiedmann *et al.* 2015), and countries of non-EU Eastern Europe including the Caucasus. The latter have significant potential for improvement, but under a BAU projection are likely to make uneven progress in resource use efficiency and to experience some economic rebound while remaining well behind the EU average in resource efficiency (UNEP 2013).

Trends in waste disposal, waste for energy and recycling continue to improve for the next ten years up to 2025, under a range of scenarios for the EU and EEA countries, but beyond this there is a mixed picture (EEA 2015; Bartl 2014). Waste prevention could help to alleviate these trends, but waste management will need to change radically in order to phase out landfilling of recyclable or recoverable waste to meet the new EU 2030 circular economy waste targets.

Disposal of hazardous and toxic chemicals across the region remains a problem, although there are improvements foreseen over the next 5-10 years (EEA 2015). Beyond 2025 there is a mixed picture with a reduction in the overall chemical burden under the EU chemical policy, REACH (registration, evaluation, authorization and restriction of chemicals) (EU 2006). However, the regulation does not address the problem of simultaneous exposures to multiple chemicals.

Waste to energy plant in Lombardy, Italy
Credit: Shutterstock/ marcobir

Alternative projection to meet the relevant goals

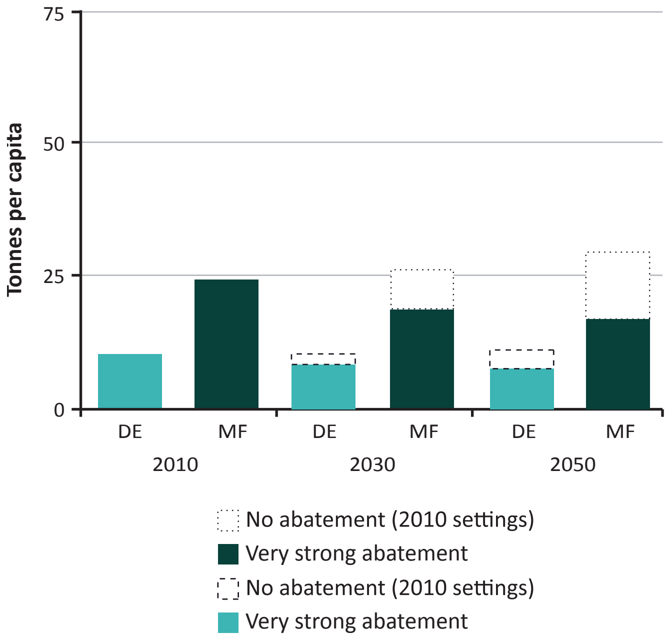
The UNEP International Resource Panel (UNEP 2011) has suggested a target of 6–8 tonnes per person per year at the global level by 2050, in order to move towards a sustainability transformation of material and resource use. Today per person resource extraction in the EU is around 16 tonnes per person per year, about 20 tonnes in Western Europe, and 7.5 tonnes in Eastern Europe, the Caucasus and Central Asia, compared to a global average of about 10 tonnes per person per year (Hak *et al.* 2013).

According to calculations of the Commonwealth Scientific and Industrial Research Organization (CSIRO), significant reductions relative to a baseline scenario in domestic material extraction (DE) and material footprint (MF) are possible in the EU while maintaining a high level of economic growth and employment. Figure 4.2.1 shows the scale of what is achievable for both of these leading indicators for 2030 and 2050, which essentially represent a reversal in baseline trends, with a possible turning point well before 2030. Lowering material consumption to 10.5 tonnes per person per year by 2030 and 10 tonnes per person per year by 2050 is ambitious and would be hard to achieve (Schandl *et al.* 2015; UNEP 2014).

Meeting these targets will require concerted action by all key players in society, as it has a direct effect not only on the economy but also on consumer behavior and lifestyles. For example, resource consumption is strongly linked to carbon emissions and land use. According to CSIRO's models, carbon pricing at US$50 per tonne, coupled with significant investment in resource efficiency and lifestyle change, would be needed to bring global resource consumption to 10 tonnes per person per year by 2050, illustrating that reaching integrated goals also requires integrated, cross-cutting strategies.

The scenarios also underline the importance of time lags and "lock-ins" given the long shadow of past technology choices, the endurance of cultural patterns of consumption and production, and the known long time lags between putting the necessary transformative measures in place and those measures having an effect.

Figure 4.2.1: Contrasting projections of domestic material extraction and material footprint in the EU with and without abatement measures



Source: Schandl *et al.* 2015

Under an alternative projection to meet the relevant goals, the aims of the Basel, Rotterdam and Stockholm Conventions and the Strategic Approach to International Chemicals Management (SAICM) policy framework to promote chemical safety around the world should be met by 2020.

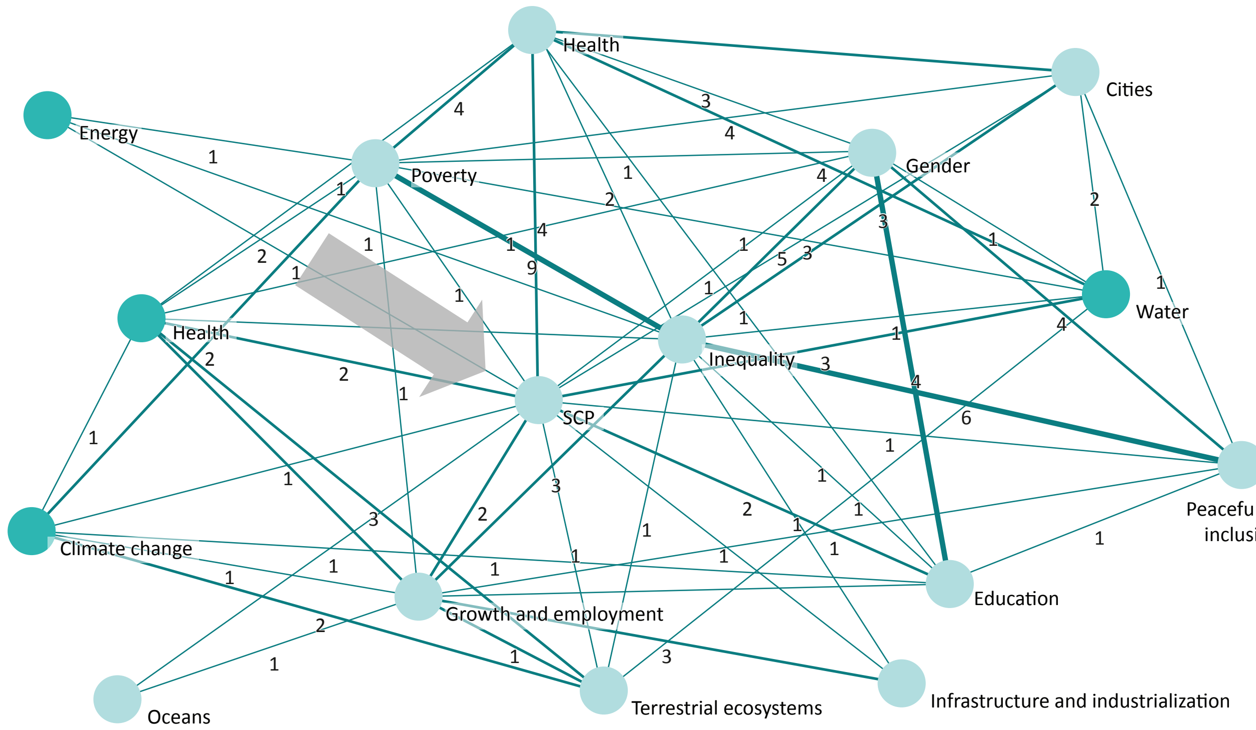
Links with other environmental priorities and emerging issues

At the global level, the increasing use of materials – biomass, fossil fuels, metal ores and non-metallic minerals – is the result of unsustainable consumption and production and a key element of the SDGs (Akenji and Bengtsson 2014). While different aspects of resources management appear across several SDGs, the core issues are addressed by the overarching nature of Goal 12 to "*ensure sustainable production and consumption patterns*"(LeBlanc 2015). Goal 12 is a mix of high-level, programmatic, composite targets related to overall outcomes and targets that refer to specific areas, actors or modalities.

In a broader context, many other SDGs rely on the sustainable use of natural resources as an enabler, including Goal 1 on ending poverty, Goal 2 on ending hunger or Goal 3 on ensuring healthy lives and human well-being. Goal 8 which includes resource efficiency and decoupling of economic growth from environmental degradation in accordance with the 10-year framework of programmes on sustainable consumption and production, and Goal 13 on taking climate action (Figure 4.2.2). All of these as well as Goal 12 have implications – both challenges and opportunities – for the pan-European region, as it relies on increasingly long and complex, and therefore risky, supply chains to meet its natural resource requirement. It is a divided region in terms of its sustainable consumption and production patterns. There is however, a potential for the pan-European region to build on its successes in technological innovation, social innovation and sustainable lifestyles, towards transformative change.

The connectedness of resource consumption to so many other areas of the 2030 Agenda for Sustainable Development represents both a challenge and an opportunity. The challenge is that resource consumption is not politically

Figure 4.2.2: Linking sustainable consumption and production to other global goals



Source: Le Blanc 2015

and institutionally anchored to one sector, but cuts across the widest spectrum of interest groups (Le Blanc 2015). At the same time, the richness of connections indicates the pervasive positive effect that changes in resource consumption can have on other sectors, from ecosystem health and well-being to economic performance. Achieving the 2030 Agenda for Sustainable Development can also help address emerging issues linked to the releases of mixtures of hazardous and toxic chemicals, especially those that are persistent and bio-accumulative into the environment and their impacts on ecosystem and human health.

Based on the analysis of resource consumption from an integrated perspective, recent reports have found that achieving progress on the SDGs as a whole, and resource consumption as a highly connected goal in particular, requires simultaneous progress on the entire set of issues. This is an argument against cherry picking specific sectors, which runs the risk of unfavourable trade-offs and achieving progress in one area at the cost of lagging behind in others (UNEP 2015; Pinter *et al.* 2013). Instead, SDGs should be managed as a coherent whole to maximize co-benefits and minimize adverse trade-offs.

4.2.2 Water

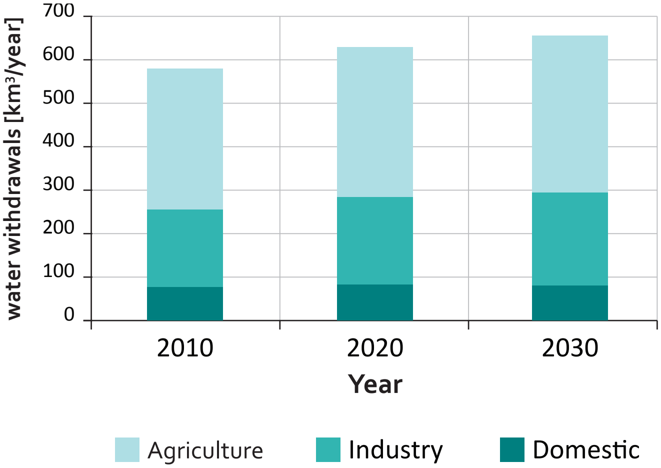
Water resources are under pressure across the pan-European region, with many areas experiencing water stress, over-abstraction, droughts and flooding and lack of access to clean water and sanitation (Section 2.6). The projections presented here underline the need for greater policy coherence to secure the future sustainability of water resources and ecosystem health.

Business-as-usual projection and associated risks

In the pan-European region, total water withdrawals are expected to increase by about 12 per cent between 2010 and 2030 (Figure 4.2.3); changes differ across the entire region with the highest increases in the Eastern Europe and Caucasus sub-region (30 per cent) and the lowest in Western and Central Europe (4 per cent). In 2030, the impact of climate change is expected to be small compared to socio-economic developments (mainly driving domestic and industrial water withdrawals), although agricultural water withdrawals are likely to rise due to climate change by about 15 per cent in Western and Central Europe and 11 per cent in Central Asia (Wada *et al.* 2016).

Changes in precipitation raise or lower the average volume of river runoff. Meanwhile, the expected increase in air temperature intensifies evapotranspiration nearly everywhere, and hence reduces runoff. These two effects interact differently at different locations and produce the net increase or decrease in water availability. Other effects are the management of reservoirs and dams as well as water abstractions for human activities and return flows. Discharge trends vary between Northern and Southern Europe (Section 2.6.1) and are expected to further increase due to the impact of climate change (Figure 4.2.4). Average annual river discharge is expected to decrease up to 40 per cent in Southern Europe while Northern Europe is likely to experience an increase of about 20 per cent in the 2040s. The same effect is apparent for low flow conditions (here expressed by the 10th percentile of daily distribution of river flow).

Figure 4.2.3: Sectoral water withdrawals as computed by the WaterGAP model for the pan-European region for current conditions (2010) and the future under the SSP2 scenario and RCP6.0 climate change conditions



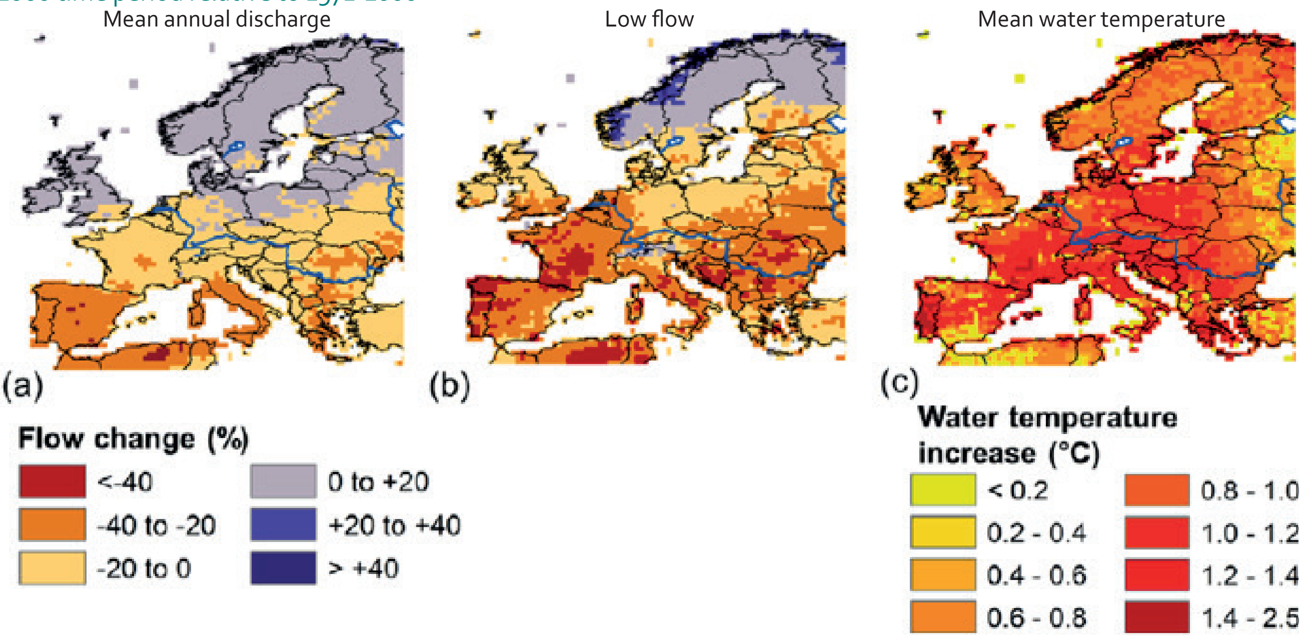
Source: Wada *et al.* 2016

A similar phenomenon is visible within the Central Asian region, with a reduction of average annual freshwater availability in the southern river basins (up to 40 per cent) compared to the north-east which may experience an increase in freshwater availability up to more than 50 per cent in the 2050s (Figure 4.2.5). Low flows are likely to further decrease in the southern Central Asia while increasing in the north.

Using the concept of water exploitation (WEI+, see Section 2.6.1) or water stress (Raskin *et al.* 1997, Alcamo *et al.* 2000) the average conditions of water resources can be easily compared (see Figure 4.2.6). A drainage basin is assumed to be under low water stress if water withdrawals-to-water availability ratio (wta) ≤ 0.2; under medium water stress if 0.2 < wta. ≤ 0.4 and under severe water stress if wta. > 0.4. Future "hotspots" of severe water stress are located in South and South Eastern Europe as well as in Central Asia. Mainly water scarce regions are affected which are likely to become drier in the future, but even regions where water availability is expected to increase may become water stressed as a result of increasing water abstractions in the future (Flörke *et al.* 2012a).

Climate Change does not only affect the quantity of freshwater resources but also the quality. Water temperatures, for example, are expected to increase on average by 0.8°C across Europe, whereas mean water temperature is largest (>1°C) in Central and South Eastern European regions (Figure 4.2.4c). This is likely to increase environmental restrictions on cooling water use with substantial reductions in power

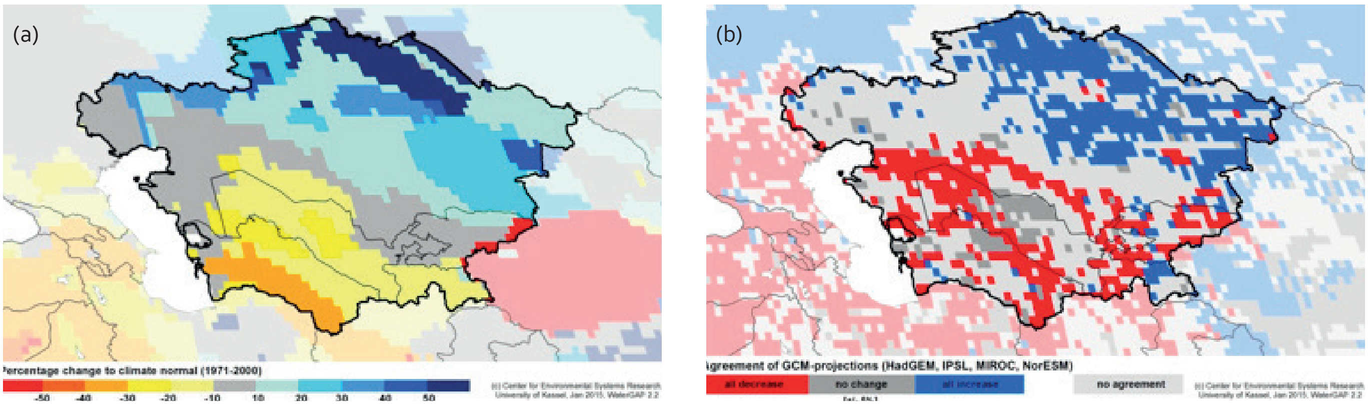
Figure 4.2.4: Climate change impacts on river flows and water temperatures in Europe. Projected changes in (a) mean annual discharge, (b) low flows (10th percentile of daily distribution of river flow), and (c) mean water temperatures for the 2031-2060 time period relative to 1971-2000



Changes are presented using the GCM ensemble for the SRES A2 scenario relative to the reference period

Source: van Vliet *et al.* 2013

Figure 4.2.5: Climate change impacts on (a) mean annual discharge, and (b) low flows in Central Asia for the time period 2041-2070 relative to 1971-2000

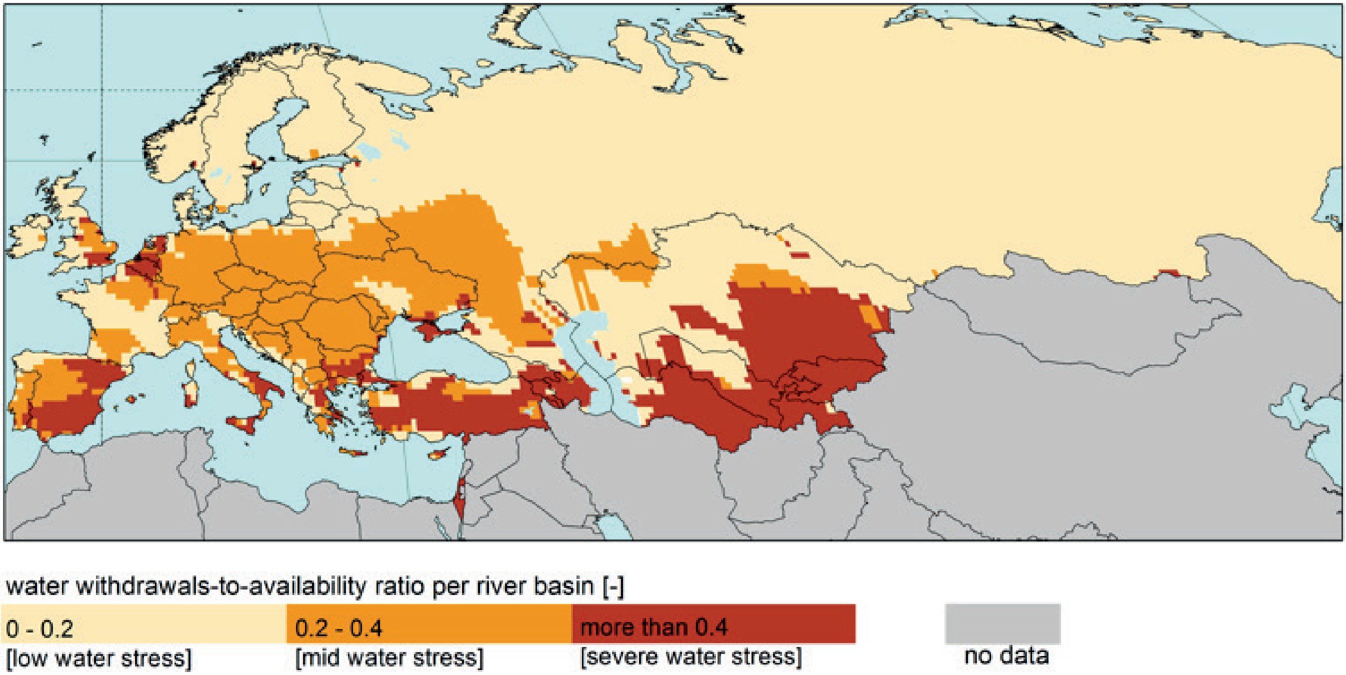


WaterGAP2.2 results prepared within the ISI-MIP initiative

Source: ISI-MIP n.d.

Chapter 4: Outlooks and Emerging Issues

Figure 4.2.6: Water stress defined as the water withdrawals-to-availability (wta) indicator in the pan-European region in the 2030s



WaterGAP2.2 results prepared within the ISI-MIP initiative

Source: ISI-MIP n.d.

plant capacities as water temperature increases (Flörke *et al.* 2012b, Van Vliet *et al.* 2013). However, temperature regimes influence the life history patterns of many stream and river animals (Mims and Olden 2013), and the timing of particular flow or inundation events is also important (Schneider *et al.* 2013, Laizé *et al.* 2014).

A study from Reder *et al.* (2013) concluded that future total nitrogen (TN) loadings, mainly originating from diffuse sources, may decrease in different regions in Europe, but are likely to remain the same in other parts. The main reasons are land-use change and improvements in land-use management on TN loadings up to 2050, but less influenced from climate change. Nevertheless, raising TN concentrations are a result from reduced river discharge (due to climate change). Future total phosphorus (TP) loadings are expected to increase primarily from the domestic and manufacturing sectors (point sources) all over Europe. Like TN concentrations, in-stream TP concentrations are likely to increase in some parts in Europe in the 2050s caused by a reduction in river discharge due to climate change. Land-use change shows little influence on future in-stream TP concentrations (Reder *et al.* 2013).

Alternative projection to meet relevant goals

Climate change, socio-economic developments, land-use change and freshwater are related in scientific terms, but at the EU policy level there has been an artificial separation between them. In the future, large areas of Europe, particularly in Southern and South Eastern Europe, are vulnerable to water scarcity and drought events. Water scarcity and droughts have severe consequences resulting in social, economic, and environmental losses. However, in approximately half of the vulnerable river basins an integrated multi-sectoral approach is required. Therefore, adaptation to climate change should not be discussed in isolation and the focus of any policy intervention should be on socio-economic drivers, such as land use and production patterns. Technical measures that mainly aim at maintaining the current state or are trying to reduce the impacts are not sufficient to save water and to reduce vulnerability to water scarcity in the future (Flörke *et al.* 2012c).

Under the assumptions of an alternative projection to meet the relevant goals, reductions in water withdrawals can be reached. Model simulations show that water abstractions may decrease in the thermal electricity production sector, which is mainly driven by the assumption of changing technologies, i.e. cooling systems, and a reduction in thermal electricity production (Flörke *et al.* 2012b). Reductions in the manufacturing sector are influenced by a slow economic development leading to a lower manufacturing output (Flörke *et al.* 2012c). Water withdrawals are expected to decrease for irrigation purposes due to a combination of changes in the extent of irrigated areas and improving irrigation efficiencies (Schaldach *et al.* 2012). In the domestic sector, the promotion of improved technologies as well as lifestyle changes helps to reduce water withdrawals.

Links with other environmental priorities and emerging issues

The future status of water in the region is likely to become highly critical in achieving Goal 6 to "ensure availability and sustainable management of water and sanitation for all" as well as for a number of other goals including Goal 2 (food security, improved nutrition and sustainable agriculture), Goal 3 (reducing mortality rates attributed to unsafe water); Goal 7 (shifting to sustainable energy systems), Goal 12 (adhering to the principles of sustainable consumption and production, Goal 13 (implementation of ambitious climate change policies) and Goal 15 (ensuring the conservation, restoration and sustainable use of inland freshwater ecosystems). Similarly, achievement of the various river basin agreements, such as for the Danube, and restoration of inland waters such as the Aral Sea are likely to require a multi-sectoral approach.

The sustainable management of inland waters provides co-benefits for human well-being and ecosystem health
Credit: Shutterstock/Banet

There are two major emerging issues that could also affect the future sustainability of water in the region. The first is that decreased groundwater levels, due to overuse and reduced recharge will lead to more severe and more frequent droughts, soil loss and the release of particulate matter, which can carry pesticides metabolites and trace elements. The second is the unregulated disposal of waste and chemicals leading to the spread of chemicals that are persistent, bio-accumulative and toxic, as well as pharmaceuticals, such as endocrine disrupters, entering into the groundwater supplies and the food chains of freshwater organisms.

4.2.3 Biodiversity and ecosystems

The pan-European region's ecosystems are already undergoing biodiversity decline (Section 2.4), including a decrease in IUCN Red List species (Brooks *et al.* 2016). Avoiding further degradation as suggested by available outlooks, will depend on investment in conservation and regeneration, establishment of sustainable use and management plans as well as greater emphasis on transdisciplinary research and knowledge developments. The long time lags between reduced pressures and the subsequent restoration of ecosystem functions and services have implications for future availability and security, especially food.

Business-as-usual projection and associated risks

According to most scenarios, the regional trends in biodiversity loss and the degradation of ecosystems and the services they provide will continue (Newbold *et al.* 2015; EEA 2015). In the EU, ecosystem services are expected to decrease by up to 5 per cent by 2020 and 10–15 per cent by 2050 relative to today (Maes *et al.* 2015).

Under the MESSAGE BAU scenario for 2030 (Newbold *et al.* 2015), where rapid human growth drives widespread expansion of agriculture, there are significant differences in the percentage change in species richness, with more northerly areas experiencing a likely net increase, and most parts of Western and Central Europe and Central Asia having a high likelihood of losses of more than 20 per cent with implications for ecosystem functioning (Figure 4.2.7) (Hooper *et al.* 2012).

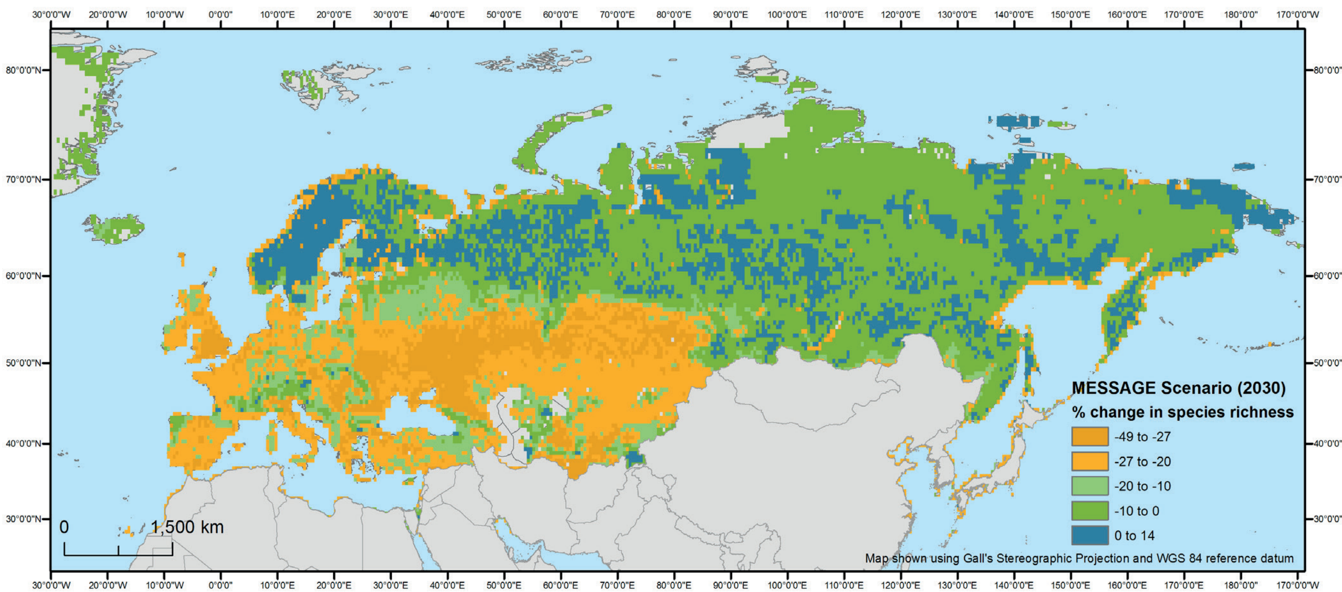
In another study, species abundance in the region is projected to decrease by 24 per cent between 2010 and 2050 (OECD 2012), again with more northerly latitudes seeing small losses or small gains in species richness, and other parts of pan-European region projected to experience significant losses. By 2050, due to the combined effects of climate change and land-use change, the breeding range of 71 per cent of birds is expected to decrease, especially in southern Europe (Barbet-Massin 2012).

Although overall current pan-European policies do have the capacity to slow biodiversity loss, they are insufficient to reverse these negative trends (Spangenberg *et al.* 2012).

Alternative projection to meet the relevant goals

An alternative development projection, that reaches the outcomes required by the SDGs and Aichi Targets in the pan-

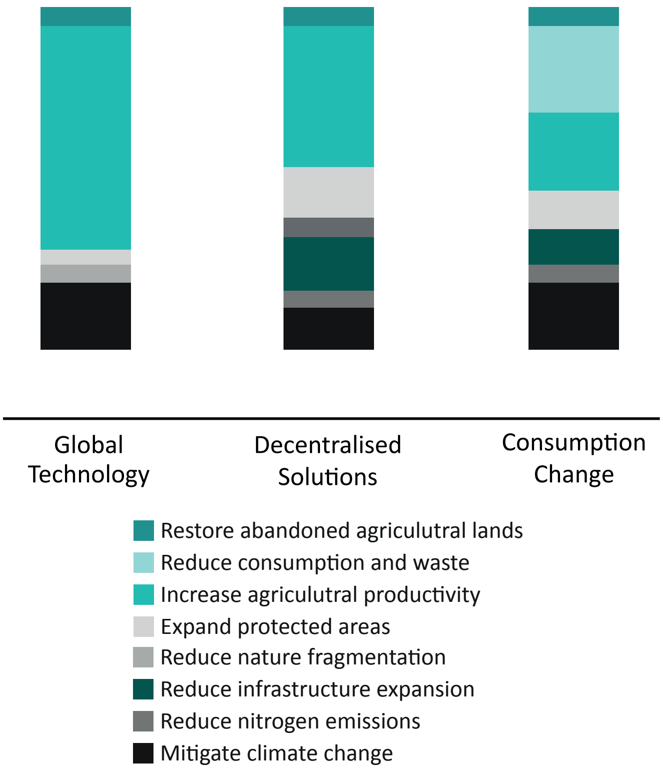
Figure 4.2.7: Pan-European region, projected net change in species richness under a BAU scenario, 2030



Areas shown in orange are expected to lose more than 20 per cent of species richness by 2030. Areas that are expected to lose species richness but not cross the 20 per cent threshold are shown in green. Blue areas are expected to experience a net increase in species richness. The map is based on a business as usual scenario where rapid human population growth drives widespread expansion of agriculture.
Source: Newbold *et al.* 2015

European region and enhances protection of biodiversity, will require a combination of global technological innovation, decentralized or localized solutions and changes in consumption patterns based on adequate policies in addition to more traditional conservation measures (Figure 4.2.8) (van Vuuren *et al.* 2015).

Figure 4.2.8: Contribution of options to prevent further biodiversity loss by 2050



The policy actions covered by this alternative projection for the region include: land sparing, natural restoration and regeneration of forests through farmland abandonment, rewilding combined with sustainable intensification, land sharing in mosaic landscapes, development of green and blue infrastructure, changes in patterns of food consumption, increasing agricultural productivity, and restoration of abandoned lands, leading to reduced nitrogen and greenhouse gas emissions, and to an increase in protected areas (Newbold *et al.* 2015; CBD 2014; Kuemmerle *et al.* 2011). These would not only contribute to the prevention of further biodiversity loss (van Vuuren *et al.* 2015), but also help to protect mental and physical health through the positive impacts of green and blue infrastructure (Triguero-Mas *et al.* 2015; Bernstein 2014; and Hanski *et al.* 2012). Improvement in the quality of urban green and blue ecosystems could also potentially offset some of the environmental pressures and provide cities with necessary resources such as food and freshwater (Rodríguez-Rodríguez 2015).

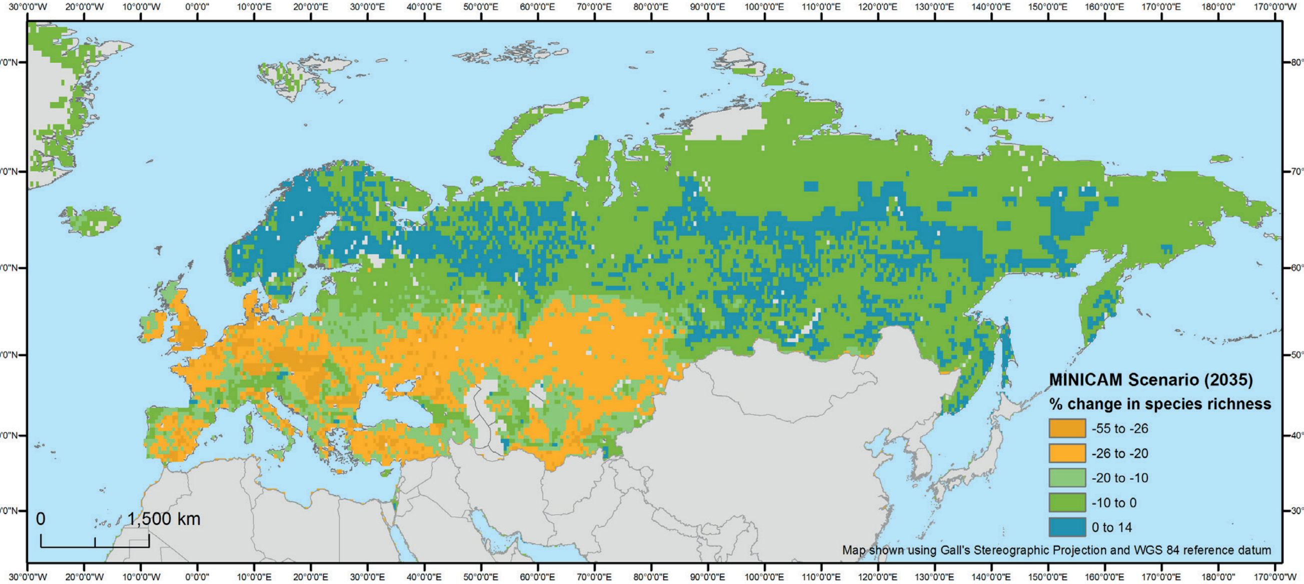
The MINICAM biodiversity scenarios of projections of 21st century changes (CBD 2010) show that as a result of ambitious and cross-cutting policy changes aimed at ecosystem and biodiversity conservation, areas with higher intactness of species richness could significantly increase in the pan-European region by 2035 (Figure 4.2.9) (Newbold *et al.* 2015). As the results show, significant regional differences would remain, with the region's densely settled and more intensively used southern areas still exhibiting lower species richness.

Links with other environmental priorities and emerging issues

Sustaining and restoring pan-European biodiversity and ecosystem services, through landscape management, species protection and urban planning, have the potential to improve the livelihoods of those that depend on the healthy functioning of ecosystems in sectors such as agriculture and forestry, contribute to healthier diets, protect water resources, help in climate change mitigation and adaptation (ICSU and ISSC 2015) and thus maintain human well-being.

Three emerging issues could affect these outcomes. One is the concentration of ownership and restrictive seed and animal breed policies, which could potentially threaten agricultural biodiversity, farmer knowledge systems and the socio-ecological networks built around this biodiversity. The next is the spread of viruses and microorganisms and

Figure 4.2.9: Pan-European region, projected species richness under an improved policy scenario, 2035



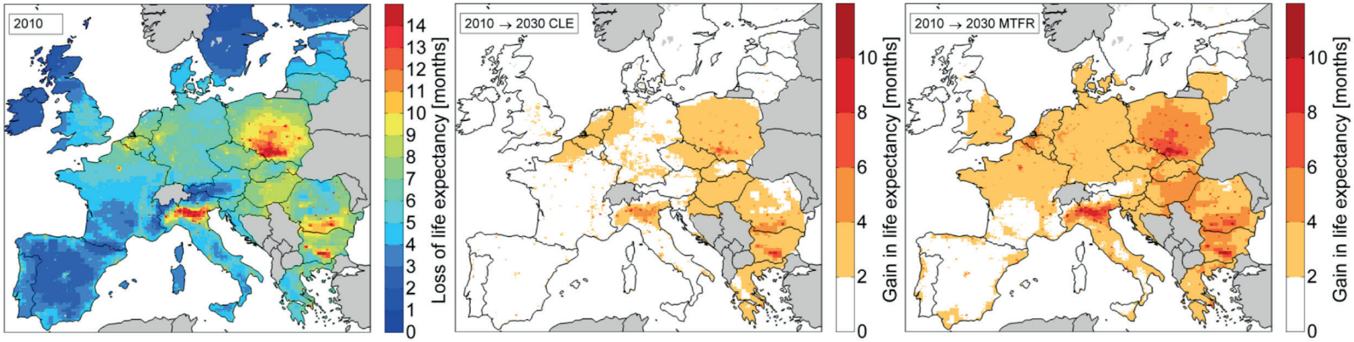
The light green areas are expected to experience greater losses in species richness intactness while the dark green areas are expected to undergo smaller losses or even small gains.
Source: Newbold *et al.* 2015

the emergence of novel pathogens via wildlife pools leading to epidemics and outbreaks of malaria, SARS, MERS, bird and swine flu, Ebola and Zika virus. The final relates to the environmental fate of banned chemicals, candidate chemicals and chemicals of concern under the Stockholm Convention, that are persistent, bio-accumulative and toxic, for example, persistent organic pollutants (POPs) and which can enter into the food chains of freshwater and terrestrial ecosystems with long-term consequences for morbidity and productivity.

In terms of the SDGs, the biodiversity and ecosystem conservation related Goals 14 and 15 focus on policies that encourage conservation and protection, but there are also strong synergies with the Goals 3 (through improvements in water quality and health), 6 (maintaining the extent of freshwater related ecosystems), 11 (through sustainable land management and maintenance of open, including green and blue, spaces in cities), 12 (through resource efficiency and reduction of food waste), and 13 (climate change impacts including ocean acidification). Because of the cross-cutting nature of biological diversity, trade-offs between the various SDGs also need to be considered. These trade-offs, however, may not necessarily be positive (UNEP 2015). For example, first-generation energy crops can contribute to the mitigation of greenhouse gas emissions under Goals 7 and 13, but can also increase land-use conflicts and land-use scarcity and in some cases undermine biodiversity protection efforts; accelerated nutrient loading of surface waters can cause eutrophication problems in coastal areas, especially in the Mediterranean and the Black Sea regions through the increased use of fertilizers (van Wijnen *et al.* 2015).

Overall, closing the gap between present trends in biodiversity and those needed to achieve the SDGs will require policy action in several sectors – those directly related to ecosystem management and also those indirectly connected such as tourism and spatial planning as well as

Figure 4.2.10: Current (2010) and projected (2030) effects of air pollution on life expectancy in the EU



Source: Kiesewetter *et al.* 2015

regulatory measures on illegal wildlife trade, market-based instruments and awareness raising related to the direct value of ecosystems for human well-being.

4.2.4 Air quality

Despite the region's significant improvements in air quality in the last few decades (Section 2.3.1), ambient air pollution is likely to continue to be the principal environmental factor contributing to the burden of disease and responsible for significant levels of premature deaths.

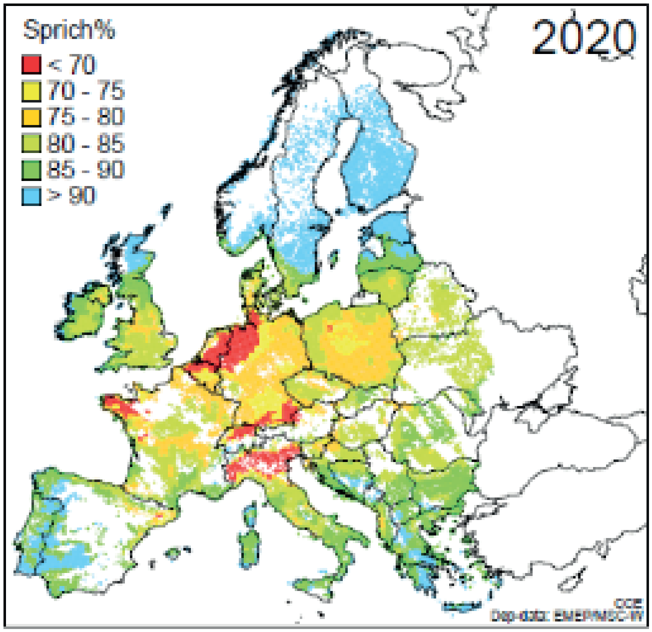
Business-as-usual projection and associated risks

According to recent modeling results, implementation of the current legislation will lead to a gain in life expectancy of 2.3 months on average in the EU, ranging from 0.7 in Ireland and Sweden to 4.5 in Bulgaria by 2030 compared to 2010 (Figure 4.2.10)[9]. However, air pollution exceedances above the WHO guideline values will continue occurring at 37 per cent of the EU's air quality monitoring stations (Kiesewetter *et al.* 2015). Air pollution exceedances for average annual $PM_{2.5}$ levels would continue to persist at 26 per cent of monitoring stations even under a maximum technically feasible scenario, which includes only technical measures applied to their full extent and excludes lifestyle and fuel changes (Kiesewetter *et al.* 2015).

9 Future air pollution projections for the whole pan-European region have not been identified. The Clean Air Policy Package applies only to the EU member states, whereas the impacts of this policy may result in reduced transboundary air pollution flows within and beyond the EU.

However, in the current context of economic uncertainty, there is a risk that implementation of air quality policies may

Figure 4.2.11: Estimated share of species in grasslands that may not be affected by European nitrogen deposition in 2020 with the Revised Gothenburg Protocol



Source: Adapted from Hettelingh *et al.* 2015

Red colours show areas where less than 70 per cent of the plant species in grassland will not be affected.

be undermined by economic recovery priorities. This risks to increase health inequities, as vulnerable populations often reside in areas particularly exposed to pollution, for example close to traffic and industries.

Under a BAU projection, relating to the Gothenburg Protocol, there will be continued effects on biodiversity, especially on vegetation, insects and birds, through the displacement of protected species by dominant species, such as grasses, due to excess deposition of ammonia (NH_3) and nitrogen oxides, and on the spread of diseases and algal blooms (Figure 4.2.11) (Hettelingh *et al.* 2015).

Alternative projection to meet relevant goals

An alternative projection is underpinned by the EU Climate and Energy policy package that by 2030 simultaneously and with equal consideration, seeks substantial reductions in greenhouse gas emissions, alongside increases in energy efficiency and in the use of renewable energy sources for meeting needs.

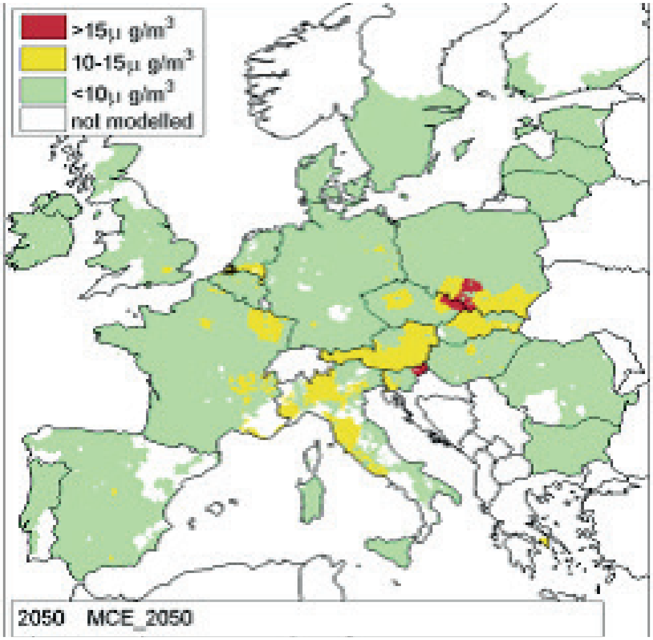
If the EU achieves these climate and energy goals, it would also help countries across the region to move closer to the WHO guidelines, further adding an average of 4.4 months to life expectancy by 2030 compared to 2005 (Amann *et al.* 2014a) (Figure 4.2.12).

However, an extension of climate change and air pollution policy regimes on a global level will be required to achieve further air quality improvements due to the hemispheric transport of pollutants, especially in relation to ground-level ozone (Schucht *et al.* 2015).

Links with other environmental priorities and emerging issues

Apart from human health, the negative effects of air pollution are also borne by ecosystems. A reduction in air pollution would translate into reduced acidification and eutrophication pressures on natural and agricultural ecosystems, improving the prospects of protected areas, biodiversity conservation, surface water quality and agricultural and forest productivity (Amann *et al.* 2014b).

Figure 4.2.12: $PM_{2.5}$ concentrations in 2050 after implementation of climate and energy policies in the EU needed to meet the 2 degrees target of the UNFCCC and a shift towards low-meat diets



Red and orange colors show regions where WHO guideline levels still will be exceeded in 2050 after implementation of climate and energy policies needed to meet the 2ºC target of the UNFCCC and a shift towards low-meat diets.
Source: Maas and Grennfelt eds. 2016

Policies to reduce air pollution would help achieve the Stockholm Convention objectives on dealing with banned and candidate chemicals, such as POPs, and the Minamata Convention objectives on mercury. An alternative projection would also help to address the emerging issue of toxic and hazardous chemicals entering into the air through extended usage and poor waste disposal, by avoiding "regrettable substitution" and leapfrogging manufacturing and production processes away from the use of chemicals of concern, especially those that are persistent, bio-accumulative and toxic (PBT) and very persistent and very bio-accumulative (vPvB), to safer alternatives where environmental fate is explicitly addressed.

In the context of the SDGs, reductions in air pollution will contribute not only to human health and well-being i.e. Goals 2 and 11 (through reduced premature deaths and illness due to poor air quality) but also to achieving Goal 12 (through significantly reducing the releases of chemicals to air), Goal 13 (on climate mitigation with reference to short-lived climate pollutants), Goal 14 (by reducing land-based emissions of air pollutants in coastal and marine areas), and Goal 15 (with regard to loss of biodiversity due to emissions of air pollutants). Conversely Goals 7, and 9 will support reductions in air pollution.

4.2.5 Climate change

The 2015 UNFCCC Paris Agreement means countries will put in place plans for mitigation and adaptation. The first global stock take is currently being designed, in parallel with the next assessment cycle of the Intergovernmental Panel on Climate Change. The projections used below relate to the projections elaborated by the IPCC and the assessments of progress towards reducing the annual emissions gap based on the Intended Nationally Determined Contributions (INDCs), submitted by countries to the UNFCCC (UNEP 2015).

Business-as-usual projection and associated risks

The latest IPCC assessment's Representative Concentration Pathways scenario RCP8.5 (representing the highest radiative forcing) is frequently adopted as a proxy for a BAU scenario (Riahi *et al.* 2011; van Vuuren *et al.* 2011). Based on this, emissions of greenhouse gases will continue to increase close to 30 GtC per annum until the end of the 21st century.

For the pan-European region, under the RCP8.5 scenario the largest warming is projected in the territory of the Russian Federation (+4.6ºC in the 2050s), followed by 3.3 – 3.9°C increase in the countries of Central Asia and 2.9 – 4.1ºC in Western and Central Europe. This temperature increase leads to projections of a 5- to 10-fold increase in heat waves as severe as the record 2010 heat wave in the eastern part of the region including the western part of the Russian Federation, Baltic countries, Ukraine, and Kazakhstan (Barriopedro 2011) with all the potential attendant impacts of unabated temperature increase across the region (Section 2.2.4).

The emissions gap report (UNEP 2015) based on a business as usual scenario, plus the Cancun pledges and estimates of reductions under the INDCs, concluded that without significant further efforts after 2030 there would be a temperature increase of 3.5°C by the end of the century, with a multiplicity of associated risks relating to ecosystem and human health and economic and social disruption.

Alternative projection to meet relevant goals

The Paris Agreement calls for limiting global warming at no more than 1.5°C above the pre-industrial levels (UNFCCC 2015). Among four RCP scenarios included into the 2013 IPCC report (Stocker *et al.* 2013), only with the RCP2.6 scenario is the global temperature likely to stay within the 1.5°C limits at the end of the 21st century (Moss *et al.* 2010). The RCP2.6 is an aggressive climate change mitigation scenario with CO_2 emissions falling to zero or below in the second part of the century (van Vuuren *et al.* 2011). However the feasibility, pathways, impacts, emission technologies or the implications of reaching the 1.5°C target have not yet been sufficiently researched so as to be able to provide certainty as to which technologies or policies will deliver such a significant shift (Hulme 2016).

Links with other environmental priorities and implications for human well-being

Climate change has profound and pervasive effects on life, and even advanced societies in the pan-European region with significant capacity to adapt are not immune to significant impacts. There are regional differences in how specific vulnerabilities unfold, depending on what economic sectors are dominant and their exposure to specific climate change stress factors. Recent studies that used linked physical and economic models to assess the impacts and costs of climate change in Europe found that these were the most significant in the areas of coastal systems, agriculture and flooding. One study found that if the projected climate of the 2080s were to occur today, it would reduce annual household welfare by 0.2-1 per cent. If the impacts were persistent, climate change would about halve Europe's annual welfare growth (Ciscar *et al.* 2011).

Within the context of the 2030 Agenda for Sustainable Development, countries have agreed within Goal 13 to "Take urgent action to combat climate change and its impacts" by integrating climate change measures into national policies, strategies and planning, to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters and to mobilize funding to address the needs of countries to implement the changes needed. This links directly to Goals 11 and 3 (reducing mortalities arising from climate related extreme events) and the 2015-30 Sendai Framework for Disaster Risk Reduction, which envisages the reduction of disaster risk as an expected outcome, focusing on preventing new risks, reducing existing risk and strengthening resilience, especially health resilience, through a set of guiding principles, including primary responsibility of states to prevent and reduce disaster risk, and society-wide engagement.

There are a range of other goals within the 2030 Agenda for Sustainable Development that are also linked directly to climate change and which will help to support many of the transformative processes within the regional priority areas described above that are underway, including Goal 2 (on climate smart agriculture, food security), Goal 7 (on delivering renewable energy) Goal 11 (on implementing climate adaptation plans in cities), Goal 12 (extending climate awareness and education), Goal 14 (monitoring ocean acidification), and Goal 15 (on combatting desertification). Given the extraordinary level of investment that will be needed to achieve the outcomes of the UNFCCC Paris Agreement and the 2030 Agenda for Sustainable Development, there are extensive efforts within the development policy arena to develop new forms of financial incentives and investments, such as the Green Climate Fund.

Beyond lifestyle changes and a shift away from carbon intensive energy systems, there are two technological pathways that could reduce greenhouse gas emissions rapidly so as to avoid dangerous climate change. The first covers negative emission technologies such as biomass plus carbon capture and storage (BioCCS or BECCS), which uses the energy produced from biomass, with the combustion gases being captured and stored underground or used in industrial processes as well as carbon capture and utilization. The second is geo-engineering, an umbrella term describing ideas that involve deliberate intervention into the climate system, for example, using aerosols to reflect solar radiation. Both are being looked into actively by many countries as providing solutions, but which as yet have had limited policy development.

4.3 Insights for knowledge, policy and governance towards sustainability

4.3.1 Inter-linkages between outlooks

Policy makers and scientists have historically treated thematic issues such as biota, energy, water and air separately, with governance and research in discipline-specific and isolated silos. There is increasing understanding of how all these elements are connected, and of how introducing solutions in one domain can have likely problematic consequences elsewhere. The nexus approach to dealing with multiple issues with common features and points of intersection is gaining traction as a way to deal with interconnected challenges (Hoff 2011). The pan-European region is, however, far away from putting in place governance mechanisms that are commensurate with the interconnected sustainability challenges the region faces.

Looking across the outlooks discussed in this section leads to a number of core insights:

- The connected nature of the areas and challenges requires pan-European policy-makers to go beyond isolated solutions and consider natural resource use reductions and decoupling in absolute terms. Because of trade, the impacts of pan-European material consumption reach beyond the region's borders, and are felt where resources are extracted and processed.

- Intervention in some areas, such as land-use, ecosystem conservation, and climate change, are crucial because such changes lead to cumulative effects in different areas.

- In order to activate synergies in the alternative projections, solutions beyond those that take place in some areas of the pan-European economy are needed.

- Some technological solutions, including some forms of renewable energy and high-performance instruments that might reduce natural resource use, may have undesired socio-environmental outcomes, as in the case of conflict minerals. At the same time, the pan-European region's reliance on external players in terms of energy and natural resource supply and the trade-offs involved may have implications for security of supply.

- Policies will need to prioritise lifestyle changes and efficiency measures, reductions in emissions at their source and emerging risks including newly identified health effects.

- In an alternative projection to meet relevant goals, there might be a reconfiguration of the idea of nature, both in rural and urban environments. This does not come free from tension, which may arise owing to transaction costs and the demands of the social innovation required to downscale natural resource use. Lifestyle changes will be needed in order to decrease resource use and resource extraction rates.

- Synergies operate hand-in-hand with institutional development and the reinforcement of deliberative decision- and policy-making processes. New institutions or better functioning ones are needed to take these synergies and tensions into account and design approaches to deal with them effectively.

How the countries of the region choose to address environmental issues at the global and at the national levels will have a significant effect on the sustainability and stability of the region as a whole. As historically demonstrated through its response to past challenges, such as acid rain or stratospheric ozone depletion, the countries in the pan-European region are capable of addressing common, complex environmental challenges and thereby steering away from much costlier and potentially catastrophic consequences.

4.3.2 Implementing the 2030 Agenda for Sustainable Development

Taken together, if well implemented, the SDGs with the UNFCCC Paris Agreement and the Sendai Framework offer a coherent package for sustainable development to 2030-

2050. The pan-European region can take the lead in designing an ecosystem-resilient, well-being-centred economy, by making full use of available skills and knowledge, adopting measures of genuine progress, enhancing transparency and accountability within governments, and steering developments that meet societal needs for natural resources rather than for excessive wants.

This would necessitate greater collaboration between governments, companies and citizens, as well as more iterative policy-making that integrates gaining experience with new forms of business models including social enterprises. A more inclusive and cooperative green economy could focus on creating meaningful employment and eliminating poverty, while rebuilding the environmental resources and services on which future pan-European sustainability will depend. The region can accelerate progress by adopting a nexus approach to resource use as a way to address interrelated challenges and to unlock the synergies created by the SDG framework.

Operationalizing the SDGs will require defining ambitious quantitative targets, indicators and pathways at the country level (Pinter *et al.* 2013) so that long-term impacts and progress towards sustainability can be tracked properly. Processes will be needed to recognize and represent links between goals and examine tensions and synergies, to identify rights and holders of power, and to formulate relevant legislation in a "common but differentiated governance" mode (Meuleman and Niestroy 2015).

One challenge ahead is that today's governance institutions in the region are not well-equipped for addressing the complex and connected challenges of a sustainability transition, with some actors involved also suffering from a lack of legitimacy and effectiveness.

In contrast to current environmental policy in the region, the core principles and functions of environmental policy in the overall governance system needed for the 2030 Agenda for Sustainable Development could be strengthened in a number of ways by:

- bringing the principles of environmental policy into all other policies to safeguard and enhance ecosystem stability, and reduce adverse economic and social impacts.
- strengthening the codification of the protection status of the region's ecosystems and their functions with regard to human development within international law and rights.
- improving strategic environmental planning, and strengthening ecosystem-based management capacities.
- implementing new mechanisms of transnational cooperation to strengthen institutional management capacities and ensure collective liability
- addressing the negative distributional effects of environmental policy through increasing the overall level of environmental and health justice.
- increasing the level of self-sufficiency within the region, through enabling frameworks that foster technological and social innovation to establish stronger cultures of resilience.

4.3.3 Building momentum to achieve the sustainability trajectory in Europe

Considering the megatrends, and BAU projections, the pan-European region could face additional social conflict and stress (UNECE 2015, 2012, 2011, 2010). The level of social complexity in the region would be further burdened by additional environmental stress caused by cumulative effects and a lack of sufficient time for an orderly societal transition to sustainability.

Building momentum to bring the region onto a more sustainable trajectory will be a multi-dimensional process, which will require strengthening the individual and structural institutional adaptive capacities at all levels of policy-making to cope with ongoing changes and crises. As described in Chapter 3 these will need to occur across the social and economic landscape.

In this future, clean air and water, functioning ecosystems and the hyper-efficient use of materials are not side effects, but key elements of the societal metabolism. As the various outlooks show, turning the normative aspiration of the SDGs into a social reality will happen if the fundamental bottom line of policy-making is centred around a culture of inclusiveness, environmental health and human well-being (Bauknecht *et al.* 2015; Jacob *et al.* 2015a; 2015b; WGBU 2011).

A key task and opportunity for the pan-European countries and institutions under the 2030 Agenda for Sustainable Development is the new demand for better dialogue and communication, participation and conflict-solving processes. There is a need to motivate institutions and for people to become part of the overall transformative agenda. At this point, knowledge of the various transformative pathways and their potential implications is still far from adequate. More policy-relevant research, experimentation, learning and innovation in all parts of the region will be needed.

The 2030 Agenda for Sustainable Development stresses the need for pushing the pan-European region further towards a knowledge society to tackle all of these challenges and conflicts in the course of transformation, and to empower institutions and people to build on the new knowledge for better governance and implementation. In this regard, the knowledge of connectivity and cumulative effects should play a central part in capacity building and future policy design.

Bearing these points in mind, countries in the pan-European region will need to experiment with different models of change, in effect turning SDG implementation into an institutionalized process of co-design between government, business and civil society. The changes will need to point towards the creation of cultures of sustainability, in which institutions and people invest to overcome the social dilemmas and implementation gaps, and to build the confidence that all actors – governments, institutions and citizens – need to commit themselves to a common future.

See references to Chapter 4

See links to Chapter 4

Supplementary Information

Additional information and to read **More…**:

The pan-European region and the 2030 Agenda for Sustainable Development

1: *External environmental footprint*

With globalized trade, a significant share of the environmental impacts linked to a country's consumption of goods and services takes place outside its borders (Wiedmann 2016). There is growing interest among policy-makers, in many countries, in finding ways to reduce such external environmental impacts of consumption; however, it is not always clear which instruments might offer the most effective ways of doing so.

The Stockholm Environment Institute was commissioned by the Swedish Environmental Protection Agency to examine what existing and possible policy instruments Sweden could use to tackle its external environmental footprint. A resulting brief outlined a three-step analytical approach, including mapping the national consumption profile, identifying relevant policy instruments, and classifying and systematically prioritizing them, through which around 60 applicable policy instruments were identified (Persson and Persson 2015).

The Swiss government commissioned UNEP/GRID-Geneva and the Institute of Environmental Sciences, University of Geneva to study the application of planetary boundaries to the national context of Switzerland (Dao *et al.* 2015). The production of indicators adapted to both global and national scales is the second attempt of this kind, after Sweden (Nykvist *et al.* 2013). Globally, limits have been crossed for four out of nine planetary boundaries due to human-induced changes: climate change, biosphere integrity, land-system change, and biogeochemical flows (nitrogen and phosphorus) (Steffen *et al.* 2015). The situation for Switzerland is very similar to the global situation for climate change, ocean acidification and rate of biodiversity loss but worse in the case of nitrogen losses as well as for land cover anthropisation, because of a rapidly evolving footprint. The situation for phosphorus losses is unknown due to a lack of footprint data. All in all, the proposed indicators, limits and footprints provide an indication of the ecological sustainability of the impacts induced by Swiss consumption in a long-term global perspective, assuming that past, current and future populations on Earth have, by definition, similar rights to resources.

2: *Energy transition*

An energy transition in the pan-European region will entail the removal of fossil fuel subsidies, decarbonizing the economy, addressing risks to hydroelectricity with changing rainfall and glacier melting, and the integration of regional electric transmission networks to balance electricity production from different renewable sources and regions. Many Western and Central European countries are particularly dependent on external energy supplies, such as gas from the Russian Federation and North Africa, leading to economic and political vulnerability that could be reduced by developing domestic sources of renewable energy. Much can also be done to change energy consumption patterns and encourage energy efficiency throughout the economy. The pan-European region has the potential to promote innovation in energy technologies and efficiency, and to resolve the challenge of energy storage. Since every technology has its drawbacks, research is needed on the environmental impacts of renewable energy sources, including bioenergy, and the associated risks of conflict with other environmental targets, whether in the region or beyond. An example is the risk of land use change or intensification of management practices triggered by biomass demand conflicting with nature conservation targets. Finally, an emerging environmental issue that particularly concerns the region is the largely underestimated cost of radioactive waste management and decommissioning existing nuclear power plants as they are retired, a cost that has not yet been incorporated in the present cost of electricity.

Healthy Planet, Healthy People

3: *The human species in a planetary context*

Human health and well-being are based on increasing supply and fulfilment of demands. Like any other species, our basic

◄ Credit: Shutterstock/Robert Schneider

needs, our survival, derives from accessing sufficient energy and basic elements for life. This must be achieved through adequate nutrition to satisfy maintenance of metabolic demands for normal activity and the extra needed for reproduction. Energy is also required to deal with variable stressors, such as the avoidance of predation and other threats to survival. Given conditions and environments, various adaptation strategies have been developed for securing energy supply among human beings and other animals.

Human stress: One physiological adaptation mechanism of humans is the acute stress response – the traditionally called fight-or-flight reaction (Cannon 1929) or, as later suggested, also including the tend-and-befriend reaction (Taylor 2006). These bodily adaptation responses are still evoked in humans faced with a perceived threat or stressors, inducing physiological reactions like release of stress hormones, increased pulse rate and redirection of oxygen supply from the vascular system to the muscles instead of the brain (McEwen 2007). Predation, however, is now extremely rare and in case of chronic stress, the physiological stress reactions accumulate and turn maladaptive, as the energy demanding fight-or-flight reactions do not occur and the bodily systems are in a constant alert mode, instead of equilibrium (McEwen 1998). The stress demand on the energy equation and the subsequent wear and tear on the body is therefore an important component of the interactions between health and environmental factors and an example of how originally adaptive mechanisms become harmful in a changed environment. Overcrowding in cities, for example, and lack of green spaces for physical activity and stress recovery, lead to an inability to cope and escape perceived threats, which can feed into the disease burden and the risk of stress related non-communicable diseases (NCDs) (Peen *et al.* 2010; McEwen and Stellar 1993). Basically, all, organisms require an environment that allows expression of evolutionary adaptation and natural behaviour to maintain health (Okin and Medzhitov 2012).

Overall, speed of change in the environment and biological community affects resilience, sometimes exceeding human adaptive capacity. The potential for adaptation is largely determined by scale. For example, microbial communities evolve in minutes or hours and can adapt to rapid environmental changes relatively easily, while maintaining energetic equilibrium. Higher vertebrates, including human beings, on the other hand, require millions of years for functional adaptation and are more likely to be affected by diseases and to decline, or become extinct in phases of very rapid environmental change.

Evidence exists for apparently increasing die-off in certain taxa (Fey *et al.* 2015) and, in the pan-European context, events reported in musk ox (Kutz *et al.* 2014) and saiga antelope (Kock 2015) have climate associations with *Pasteurella multocida* infections and mass mortalities. This is to be expected as these animals are living on the edge, adapted to the extremes of weather on the planet and therefore likely to be indicators of rapidly changing conditions. These anomalies are unlikely to remain the exception with the current speed of environmental change. This puts microorganism at a distinct advantage and may be part of the explanation for the emergence of novel pathogens, epidemics and pandemics, recent examples of which are HIV/AIDS, SARS, bird and swine flu and the Ebola virus.

Ecosystem stress: Although their evolutionary adaptation is slow, humans are a remarkably resilient species in the face of increasing emerging disease events, relying on their dominant access to natural resources, medical technologies and therapeutics to deflect or ameliorate risk – most other animal populations are not so fortunate. For example, a rise in mass die-off events has been reported (Fey *et al.* 2015; Munson *et al.* 2008), including of some highly adapted species, especially in the northern temperate latitudes but also in the tropics. These events are most probably a consequence of human induced climate change, causing fundamental ecological shifts, sudden rises in insect vectors and pathogens, in subtle ways stressing animals beyond their evolved adaptive capacities.

More than 220,000 saiga antelope (*Saiga tatarica tatarica*), 88 per cent of the world's population, died suddenly in May 2015, over a landscape of some 410 000 square kilometres in Kazakhstan. Saiga is a wild migrating antelope species that has occupied the vast central Asian steppe since before the time of the mammoths. This mass mortality, caused by bacterial infection, is linked to weather events – in this case, highly variable temperatures at the time of calving and with a background of a 10ºC overall decadal rise in spring temperatures.
Credit: A. Wolfs (Royal Veterinary College)

In essence, communicable diseases are increasingly occurring where human and domestic animal populations have exceeded the ecological capacity to support them. This scenario is exemplified in the pan-European region which is, perhaps unexpectedly, a hotspot of disease emergence (Jones *et al.* 2008). On the other hand, non-communicable, chronic diseases are also rapidly increasing as a result of other environmental and lifestyle changes.

The human brain, the most complex and advanced organ system found among species, has evolved over millions of years in an environment that has been developing at the same pace. As a result of slowly growing environmental and social pressure for more sophisticated cognitive abilities, the brain has played a key role in the evolution of information processing and communication (Hofman 2014).

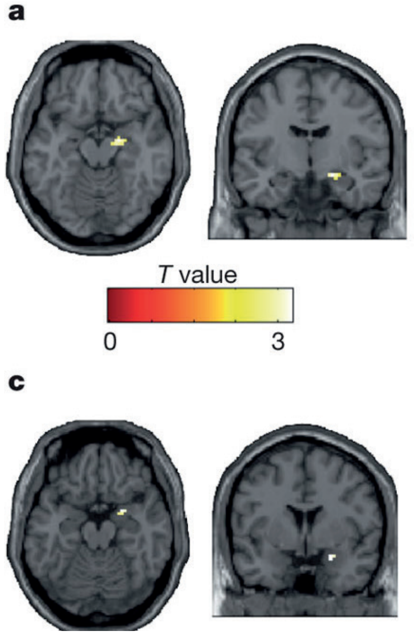
However, our evolution designed humans for a very different world from what exists today. From an evolutionary perspective, within an instant, humankind has transformed our environment and created a mismatch between the world we live in, our brains and our bodies (Gluckman *et al.* 2011). Over the last centuries, with the industrial and technological revolutions and the current information society, an overload has occurred on the capacity for the brain's adaptive development and we are challenged by the evolutionary and developmental constraints of our constitution (Replace with (Gluckman and Hanson 2006).

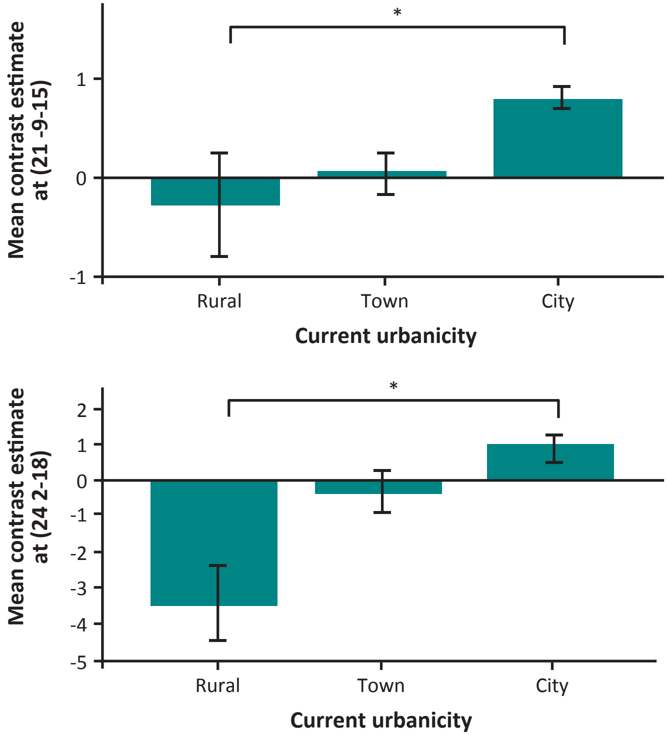
From a biological perspective, humans have changed very little over the last million years. In spite of the fact that the overwhelming majority of the world's population lives in a changed environment and context, our bodies continue to respond to physiological imperatives that are more appropriate to survival in a wild environment where energy sources are scarce. Our physiological propensity to store sugar and fat continues despite reductions in requirements for physical activity and a relative abundance of energy sources. This may contribute to the increase in obesity and other lifestyle-related disorders of today. Effectively, human biology seems to be out of step with many aspects of the environmental conditions in which most of us now live. The relatively recent change from rural to urban living has also resulted in a socio-biological mismatch (*Figure-L2 1: Results from functional magnetic resonance imaging, comparing groups living in urban or rural areas show a relationship between current urbanicity and activation of the amygdala, a brain structure regulating negative affect and stress-L2 1*), at least seemingly, with a failure of the brain to adapt to chronic stress. Urban upbringing as well as current urban living induce structural and functional changes in the brain, not seen in rural populations, increasing human vulnerability to social stress as well as the risk for development of mental disorders (Lederbogen *et al.* 2011) .

4: The developmental origins of health and disease

The relationship between health and disease development is further complicated by epigenetic influences and developmental plasticity in relation to the environment. This explains why environmental exposures in prenatal or infant life can affect genetic material and the later development of disease, as expressed in the concept of the developmental origins of health and disease (DOHaD).

Figure-L2 1: Results from functional magnetic resonance imaging, comparing groups living in urban or rural areas show a relationship between current urbanicity and activation of the amygdala, a brain structure regulating negative affect and stress





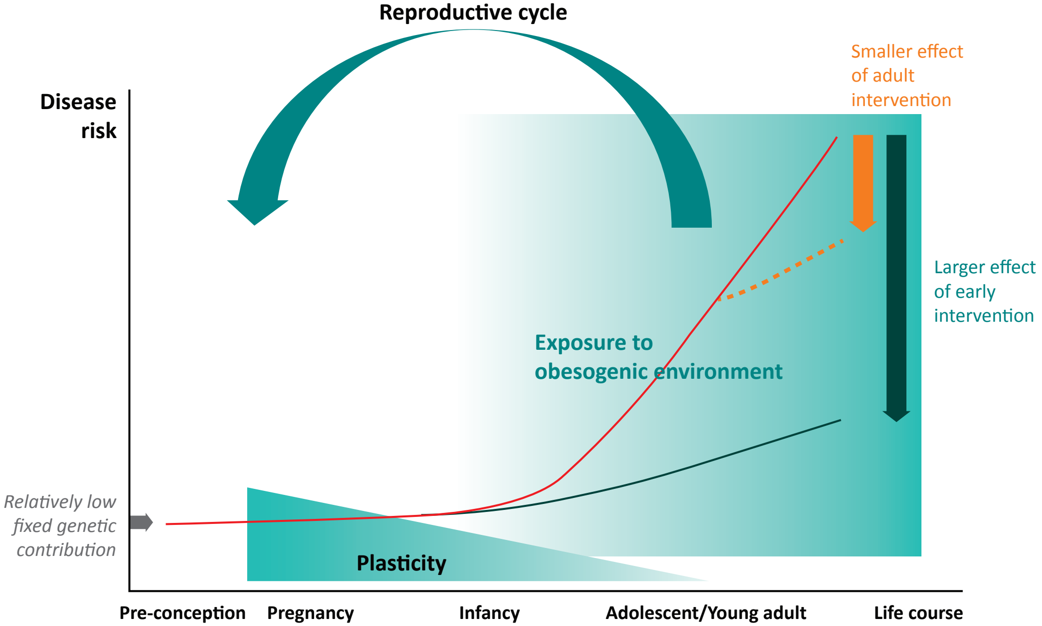
The increased activation of amygdala among city dwellers demonstrates a distinct neural mechanism for urbanism as well as an environmental risk factor for mental disorders.
Source: Lederbogen *et al.* 2011

The DOHaD paradigm has emerged from overwhelming epidemiological, clinical and experimental evidence (Gluckman and Hanson 2006; Bateson *et al.* 2004). A key underlying principle is that organisms are more plastic in early development, something that will affect vulnerability to developing non-communicable diseases (NCDs) later in life (Figure-L2 2: An individual's developmental experiences during the period of plasticity influence risk of obesity and related NCDs on later life exposure to an obesogenic environment-L2 2). Relatively minor changes or exposures in early life become magnified over a lifetime to have larger effects later. For example, obesogenic environments in deprived areas contribute to cementing socio-economic health inequalities. Health policies should therefore pay particular attention to the environmental context for improving public health and reducing health inequalities (Hanson *et al.* 2011), especially as primary interventions applied in early life have a greater effect on disease risk compared to secondary interventions in adulthood when levels of plasticity are relatively low (Balbus *et al.* 2013).

5: The burden of non-communicable diseases and environmental risk factors

Non-communicable diseases (NCDs) are chronic diseases and are not passed from person to person. The epidemic of NCDs is strongly related to a changing environment. NCDs disproportionally affect low- and middle-income countries, due to unequal distribution of healthy conditions

Figure-L2 2: An individual's developmental experiences during the period of plasticity influence risk of obesity and related NCDs on later life exposure to an obesogenic environment



The reproductive cycle highlights important intergenerational considerations whereby the health status of young adults of reproductive age can affect the next generation.

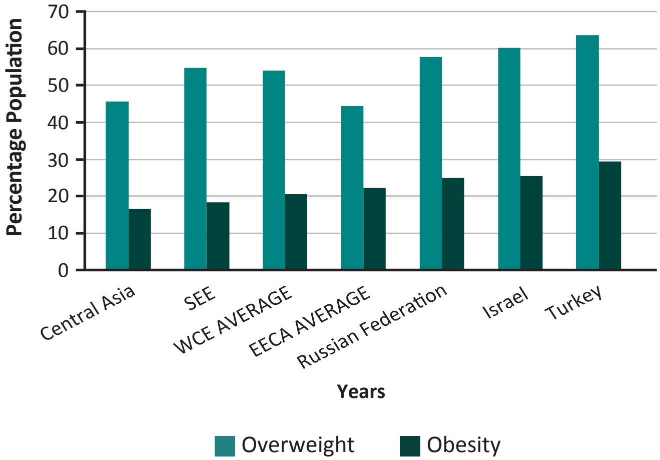
Source: Reproduced from Peter Gluckman, Mark Hanson, and Felicia M. Low, ‘Evolutionary medicine, development, and epigenetics: influences on public health,’ in Matilda van den Bosch and William Bird, (Eds.), Oxford Textbook of Nature and Public Health: The Role of Nature in Improving the Health of a Population, Oxford University Press, Oxford UK, [Forthcoming], Copyright ©OUP, with permission from Oxford University Press

and environments as well as health resources (Murray *et al.* 2012). In 2012, the age-standardized overall premature mortality rate per 100 000 for the most common NCDs – cardiovascular diseases, cancer, diabetes mellitus, chronic respiratory diseases, and mental disorders – was 404.3 in the pan-European region ranging from 667.2 in Ukraine to 200.4 in Sweden (data only available for 28 of the 54 pan-European countries: *http://www.euro.who.int/en/home*). Many of these morbidity and mortality rates can be substantially decreased along with related health inequalities, by adequate prevention measures at societal and environmental levels (Balbus *et al.* 2013).

Mental disorders constitute the second largest disease burden in the pan-European region, affecting more than a third of the population every year. In several countries the number one cause of death of adolescents is suicide. Unipolar depressive disorder alone is responsible for 13.7 per cent of the disability burden, making it the leading chronic condition in Europe (Murray *et al.* 2013). Investing in mental health is essential for the sustainability of health and social welfare in the region. Such investments must be all-inclusive, directing resources to vulnerable populations with the highest risk of developing poor mental health, especially in deprived urban areas where environmental risk factors are abundant.

The prevalence of obesity has increased by more than 40 per cent over the past 10 years in a number of countries, including the Czech Republic, Denmark, France, Norway and Sweden, and the trend continues (WHO 2015c). Country profiles are

Figure L2 3: Prevalence of overweight and obesity in the pan-European region



freely available from the *European Health Report Targets and beyond – reaching new frontiers in evidence* (WHO 2015a) (Figure L2 3). In particular, the numbers of overweight and obese children are now alarming and children who are obese are more likely to suffer from NCDs later in life.

Approximately 50 per cent of citizens in the region are overweight and in several countries – Azerbaijan, Bosnia and Herzegovina, Czech Republic, Hungary, Ireland, Israel, Kazakhstan, Lithuania, Malta, the Russian Federation, Spain and the UK – the prevalence of obesity is ≥24 per cent in the general population.

A study of nine countries in the region suggested that about 3–7 per cent of the annual burden of disease is associated with known, but narrowly defined, environmental risk factors (Hänninen *et al.* 2014). Airborne fine particulate matter (PM2.5) is the leading risk factor associated with the loss of 6 000–10 000 Disease Adjusted Life Years (DALYs) per year per million people (Hänninen *et al.* 2014). Second-hand smoke, traffic noise, including road, rail, and air traffic noise, and radon had overlapping ranges estimated at the loss of 600–1 200 DALYs per million people. If the NCDs derived from poor diets, overconsumption and lack of activity are considered environmentally derived through links to soils and land – agriculture and food systems, cities, biodiversity, and green and recreational spaces – the figure of annual burden of disease derived from the environment increases significantly (Nurse *et al.* 2010). In particular, if NCDs related to climate change, such as cardiovascular events due to heat waves or mental disease associated with natural disasters (McMichael *et al.* 2006, Noji 1996), are included, the figure increases further (Dora *et al.* 2015).

6: One health paradigm

During the early years of the 21st Century a new movement has emerged around concepts of One World, One Health. This arose from discussions amongst professionals, academics, NGOs and government sectors and resulted in the adoption of a set of One Health principles and a tripartite agreement by the main human and animal health and agricultural development agencies, OIE, FAO and WHO.

There is now a significant body of academia and public agencies adopting this approach. There is a focus on links between human-animal infections and emerging diseases and also a strong emphasis on the environment and how social, economic and environmental factors and/or changes can drive or trigger disease emergence and evolution (Wallace *et al.* 2014a). Examples of the One Health context include:

i) Nipah virus emergence in Malaysia where livestock and fruit development strongly interfaced with Pteropid bat habitat and led to the spill over and emergence of a serious disease in pigs and people with significant human mortality and high economic costs;

ii) SARS coronavirus was driven by wild and domestic animal markets in China, which provided a conduit for viral emergence and evolution; and

iii) Ebola virus in West Africa is suggested to be driven by changing landscape and forest disturbance (Wallace *et al.* 2014b).

Urbanisation and fundamental restructuring of the environment has also provided new niches and disease reservoirs as seen with Dengue Fever and possibly Zika virus, where there has been colonisation of these new expanding environments by mosquito vectors.

7: Ragweed – an aggressive and invasive allergenic species

A striking example of a climate change induced allergy issue is the rapid spread of the highly invasive and potent allergen Common Ragweed (*Ambrosia artemisiifolia*) across the region, which could increase by a factor of four by 2050 (Reznik 2009; Ziska and Caulfield 2000). Ragweed pollen concentrations are projected to increase substantially in north-central Europe, northern France, and the southern UK, where levels are at the moment negligible. In areas where pollen levels are already high, concentrations are projected to increase by up to a factor of two (Hamaoui-Laguel *et al.* 2015). A 2013 report from the EU estimated the combined economic losses of Common Ragweed invasion from agriculture, work productivity, and health costs to be €4.5 billion (NERC 2013).

8: Other mosquito-borne diseases

The Asian Tiger mosquito (*Aedes Albopictus)*, which can carry and transmit dengue fever, for example, has significantly expanded its geographical range since its establishment in the pan-European region in the 1990s. Due to climate change, large areas in the region will become climatically suitable for this vector in the near future (ECDC 2012).

Increasing cases of the tropical disease of Chikungunya (also carried by *Aedes Albopictus* or *Aedes Aegypti)* have also begun to be seen in France and Italy. This mosquito-borne virus has gone from being a rare tropical disease to an international threat. The elderly or those with underlying chronic medical problems are most likely to suffer severe complications from this infectious fever disease (Mavalankar *et al.* 2008).

Another disease transmitted by an *Aedes* mosquito is the Zika virus. Since May 2015, it has spread in the Americas and the Caribbean. The arrival of the virus has been associated with steep increases in babies born with microcephaly, though a causal relationship between Zika virus infection and birth defects with neurological syndromes has not been established; however, it is strongly suspected. Imported cases of Zika have been reported in Europe and the risk of Zika-infected travellers is increasing. During the winter, the risk of Zika virus transmission in Europe is extremely low, but with the onset of spring and summer, the risk of Zika virus transmission in Europe will increase. Countries where *Aedes* mosquitoes are present should prepare to address the risk of Zika spreading when the temperature increases. European countries should use their experience with dengue and chikungunya to control the risks associated with these mosquitoes. WHO advises countries in the pan-European region to strengthen vector control surveillance and laboratory detection of Zika virus disease and neurological complications, as well as communication to those at particular risk. This will help to decrease the presence of *Aedes* mosquitoes and in turn the risk of Zika spreading in Europe.

Box 1: Selected examples of national health-specific assessments related to climate change

In Albania a vulnerability assessment of the potential health impacts of climate change for the Albanian population was conducted in 2011. It took place within the framework of the seven-country of the WHO regional Office for Europe (2015d)

In Austria several health assessments have been conducted as part of the national adaptation strategy, including of heat risks, vectors spread potential and allergenic pollens.

In Denmark the 2008 national adaptation strategy includes a section on various health assessments. Regions and municipalities also conduct assessments of vulnerability to different kinds of risk as part of local emergency planning.

In Germany an assessment of the health and vulnerability effects of climate change was carried out in 2010.Several research projects are looking at outcome-specific climate influences, including vector-borne diseases and allergic pollens.

In Kyrgyzstan an assessment of vulnerability to climate change of the population residing in Bishkek was conducted in 2008 and a report published within the framework of the seven-country initiative of the WHO Regional office for Europe (2015d)

In Lithuania national vulnerability and adaptation to climate change were evaluated as part of the analysis in preparation of a draft national strategy for climate change management for 2013-2050.In particular, heat and pollen allergies were taken into account.

In Norway an official Norwegian report of 2010 includes a section on health vulnerability evaluation, featuring qualitative and quantitative estimates of prospective impacts of climate change on climate-sensitive diseases.

In Spain the national climate change adaptation plan of 2006 includes a section on health and vulnerability assessment conducted by research institutions and universities.

In the Former Yugoslav Republic of Macedonia the second national communication to the UNFCCC of 2006 includes a health sector vulnerability and adaptation assessment, and in 2011 several health assessments were conducted within the framework of the seven-country initiative of the WHO Regional Office for Europe (2015d). These focused on heat waves and morbidity, temperature and salmonella infection, the presence of the dengue vector in the country, and climate and airborne allergenic pollen.

10: Health co-benefits of climate change mitigation and adaptation in various sectors

The health co-benefits of climate change mitigation and adaptation were analysed by *WHO Health in the Green Economy*. The following tables (Table 1: Housing sector1, Table 2 and Table 3) present the co-benefits by sector; namely housing, transport and health care.

Table 1: Housing sector

Mitigation Strategy	Likely health co-benefits	Impact of health co-benefit	Health risks to be avoided	Impact of health risk
Improved thermal performance of building envelope (IPCC 6.4.2)	**Environmental exposure** Thermal comfort Noise exposure reduction	 ++ +	Risk of inadequate ventilation: a) Reduced indoor air quality leading to potentially increased concentrations of indoor air pollutants (e.g. radon, mould and moisture) as a cause of asthma, bronchial obstruction and other illnesses b) Increased air borne infections transmissions (e.g. TB); risk of exposure to health damaging insulation materials and fibers that cause cancer and other illnesses	 -- --
	Disease risk reduction Reduced cardiovascular diseases, bronchial obstruction, asthma and other respiratory conditions Reduced vector-borne disease due to infestations and pests Better mental health through thermal comfort	 ++ ++ +		
	Equity Impacts Depends on access of poor to improvements	 +		
Low-carbon emissions heating systems and passive solar design (IPCC 6.4.3, 6.4.6-7)	**Environmental Exposure** Thermal comfort Hygiene	 ++ +	Field studies have found that more cost- and energy-efficient heating do not always reduce net household energy use (and thus energy-related greenhouse gases and air pollutants) by an equivalent amount. This is because some households may allocate a portion of their cost savings to increase their energy (electricity or heat) consumption, a phenomenon described as the "take-back effect"	o
	Disease risk reduction Reduced asthma and respiratory symptoms related to cold exposure, damp and mould Reduced pneumonia and COPD (in case of reduced biomass use) Better mental health due to better thermal comfort	 ++ ++ +		
	Equity impacts Depends on access of poor to improvements	 +		

Strongly positive health impact ++; Positive health impact +; strongly negative health impact:--; Negative health impact: -

Mitigation Strategy	Likely health co-benefits	Impact of health co-benefit	Health risks to be avoided	Impact of health risk
Reduced cooling loads of buildings through design features and improved natural ventilation (IPCC 6.4.4)	**Environmental exposure** Thermal comfort	 ++	May not work when night temperatures remain high; need to be adapted to regional humidity Design must take account of winter as well as summer risks Natural ventilation without house screening may increase vulnerability to vector-borne diseases May increase exposure to high outdoor air pollution concentrations, causing respiratory symptoms, unless filters are used Avoid use of lead in paint (e.g. white paint for albedo effect)	o o -- -- -
	Disease risk reduction Reduced asthma/respiratory illness from particulates, radon, mould, etc. Reduced TB and other air borne infection risk Less airborne disease transmission via air-conditioning systems	 ++ ++ +		
	Equity Impacts High equity co-benefit from broader access to effective cooling and ventilation, particularly when design measures are adopted in low-income settings	 +		
More energy-efficiency and better-maintained heating, ventilation and air conditioning systems (HVAC) **Greater reliance on building design and natural ventilation (IPCC 6.4.4-5)**	**Environmental exposure** Thermal comfort Reduced noise exposure	 ++ +	Great risk of airborne infectious diseases (e.g. tuberculosis) and upper and lower respiratory symptoms in AC rooms/spaces lacking sufficient fresh air exchanges Increased urban dependence on AC stimulates vicious cycle of exacerbated urban heat island effect More noise and pollution exposure for those not using air conditioning Bacteria proliferation/legionellosis in very large HVAC tanks/cooling towers Delayed climate-related health impacts from added greenhouse gas emissions of air conditioners	-- - - -- -
	Disease risk reduction In settings with significant outdoor air pollution, reduced respiratory symptoms and asthma Less risk of cardiovascular disease due to heat exposure Less risk of vector-borne disease due to closed windows	 ++ ++ +		
	Equity Impacts Those least able to afford AC suffer the most from its noise and heat island impacts	-		
Strongly positive health impact ++; Positive health impact +; strongly negative health impact:--; Negative health impact: -				

Mitigation Strategy	Likely health co-benefits	Impact of health co-benefit	Health risks to be avoided	Impact of health risk
Passive solar hot water and photovoltaic solar electricity (IPCC 6.4.7-8)	**Environmental exposure** Hygiene and sanitation	+ 	Greater initial cost outlays pose barriers for poor families if not offset by subsidies New technology risks require more assessment, including of occupational and environmental risks of production and exposure to waste byproducts, e.g. respiratory irritations and impacts of exposure to toxics or heavy metals	- o
	Disease risk reduction Less asthma and respiratory disease due to decreased use of kerosene lighting in developing countries Fewer burns from kerosene appliances	+ +		
	Equity impacts More access to electricity among poor and rural populations Lower long-term electricity cost once initial investment is made	++ +		
Lighting and day lighting: window positioning to reduce heat/ cold impacts; highly energy-efficient indoor lighting (IPCC 6.4.9-10)	**Environmental exposure** Thermal comfort	++	Household injury from inadequate indoor/ proximity lighting	-
	Disease risk reduction Less asthma and respiratory disease due to natural ventilation through windows Fewer home injuries (falls) Positive effect of light on metabolic function and mental health	+ ++ +		
Strongly positive health impact ++; Positive health impact +; strongly negative health impact:--; Negative health impact: -				

Mitigation Strategy	Likely health co-benefits	Impact of health co-benefit	Health risks to be avoided	Impact of health risk
Household appliances and electronics: more low-energy and direct-current appliances, including improved biomass cookstoves (IPCC 6.4.11; 6.6.2)	**Environmental exposure** Reduced indoor air pollution Improved food security, kitchen hygiene	 ++ +	Equity gains dependent on increased access of poor to new low-energy cookstove technologies and other appliances In developed countries, more efficient appliances may not decrease GHG and air pollution emissions if there is not an equivalent decrease in overall energy use	- -
	Disease risk reduction Reduced asthma and respiratory diseases Fewer injuries from burns due to inadequate cooking and heating appliances Less COPD, cancer and cardiovascular disease	 + ++ +		
	Equity Impacts Access to cleaner biomass and biogas cookstoves	 ++		

Strongly positive health impact ++; Positive health impact +; strongly negative health impact:--; Negative health impact: -

Table 2: Transport sector - appraisal of health implications of IPCC-assessed mitigation strategies

Mitigation strategy	Potential to reduce emissions (illustrative example)	Likely reduction of health risk factors			Additional effects, limitations and comments
		Size and direction of effect		Strength of evidence	
IPCCa Modified vehicles and fuels	21 per cent reduction in light-duty vehicle CO_2 emissions by 2030 under a high-efficiency vehicle scenario, almost all at costs less than USD 100/tCO_2	Air pollution	-to ++	Moderate	Increasing fuel efficiency could lower travel costs and thus promote more motorized transport. Alternatively, improved vehicles may be more expensive, reducing their use in low-income settings. Particulate emissions may be higher from diesel engines than from equivalent gasoline engines per unit of travel, which could worsen health. Air quality impacts of biofuels remain unclear, significant concern exists regarding biofuels production impacts on food security and nutrition for the poor.
		Physical activity	0	Weak	
		Road traffic injury	0	Weak	
		Noise	0	Weak	
		Social effects	0	Weak	
		Land use	0	Weak	
IPCCb Pricing policies regarding vehicle and fuel use and pricing of travel to urban centers or by different modes (e.g. congestion pricing)	Depends on whether target is pricing of modified vehicles and fuels (IPCCa) or land use changes and alternatives to private motorized transport (IPCCc) Congestion changes have reduced emissions by 13-30 per cent,while a subsidy for low-carbon fuel has been estimated to reduce emissions by 6 per cent	Air pollution	-to++	Weak	Pricing policies to encourage vehicles / fuel improvements are likely to lead to health benefits similar to IPCCa, but not to reduce travel. Pricing to encourage use of non-motorized transport and public transport is likely to lead to health benefits similar to IPCCc. Policies would have different effects on health equity depending on mode targeted, e.g. public transport or private, and type of pricing tool, e.g taxes or subsidies.
		Physical activity	0 to ++	Weak	
		Road traffic injury	0 to ++	Weak	
		Noise	0 to ++	Weak	
		Social effects	0 to ++	Weak	
		Land use	0 to ++	Weak	

Mitigation strategy	Potential to reduce emissions (illustrative example)	Likely reduction of health risk factors			Additional effects, limitations and comments
		Size and direction of effect		Strength of evidence	
IPCCc Land use changes and alternatives to private motorized transport	Package of walkways, cycleways and bus rapid transit could reduce emissions by 25 per cent at a cost of USD 30/tCO_2 Improved land use could reduce emissions by 21 per cent over a 20-year period at a cost of USD 91/tCO_2	Air pollution	++	Moderate	Can help ensure equity of access for people without cars. Can make walking and cycling safer for vulnerable groups, e.g children, older adults and people without cars. Increases in walking and cycling need to be accompanied by improvements in the safety of the walking and cycling environment.
		Physical activity	++	Moderate	
		Road traffic injury	++	Moderate	
		Noise	++	Weak	
		Social effects	++	Weak	
		Land use	Not applicable		

Notes: Source for potential to reduce emissions: see section 4.6 in full-text document online at *www.who.int/hia/green_economy/en/index.html*
Size and direction of likely health effects were rated from "_" (strongly negative effects) to "++" (strongly positive effects), with the midpoints "0" representing no significant effects.
Strength of evidence was rated from 0 (no evidence) through weak (small number of observational studies only, or good (theoretical or indirect rationale for an effect) to moderate (large number of observational studies, or observational studies plus clear theoretical rationale).

Table 3: Health care sector - mitigation strategies applicable to the health care sector

Mitigation strategy	Actions	GHG impact	Health co-benefits	Limitations and needs
Reduced procurement carbon footprint	Better-managed procurement of pharmaceuticals, medical devices, business products and services, food/ catering and other facility inputs	Reduced energy footprint in production and transport of unused/expired pharmaceuticals and products	Health systems: resource savings on unused/wasted products, estimated 10 per cent reduction in pharmaceuticals procurement determined feasible by England's National Health Service Disease risks: reduced risks from use of outdated/expired products, but increased risks if supply lines for refills of essential products are unreliable	Infrastructure and supply line reliability, administrative/ IT capacity for precise inventories

Table 3: Health care sector - mitigation strategies applicable to the health care sector

Mitigation strategy	Actions	GHG impact	Health co-benefits	Limitations and needs
Telehealth/telemedicine	Home patient telemonitoring and guidance Emergency response Health worker advice/ consultation/ collaboration via mobile phones	Reduced emissions from health care related travel	Health systems: more cost-effective health care Environmental risks: Reduced travel-related emissions and risk of travel-related injuries, particularly to frail and vulnerable populations Disease risks: Improved management of chronic conditions, such as diabetes and heart disease as well as emergency response Health equity: Better access to health care advice in poorly resourced remote locations	Infrastructure limitations; limited expertise
Health facilities in proximity to public transport and safe walking/ cycling (IPCC chapter 4)	Public transport options mapped during planning of buildings to locate new facilities nearby Employee incentives for public active transport use and facilities	Reduced transport-related emissions from health worker and hospital visitor travel	Environmental risk: reduced transport-related emissions Health risks: reduced traffic injury risk for health workers and hospital/clinic visitors travelling to health facilities Potential for active transport by health care workers to reduce risks of hypertension cardiac disease and diabetes Health equity: Improved access for health workers and visitors who do not have cars	Infrastructure, land availability and use limitation
Conserve and maintain water resources	Water-efficient fixtures, leakage management water safety Onsite water treatment and safe water storage in health facilities Rain water havesting, grey water recapture/ recycling	Reduced energy use for water extraction from surface /aquifer sources Reduced truck transit of water resources Reduced aquifer and ecosystem damage from water extraction	Health systems: Improved performance due to better access to safe water, saving in water fees Environmental risk: reduced water contamination from health facility activity Disease risk: Reduced disease transmission from unsafe water and drinking water Health equity: Improved access to safe, potable water in poorly resourced health facilities	Infrastructure and financing in poorly resourced settings Building codes in developed countries may require use of piped water only

11: [*Biodiverse microorganisms trigger our immune system*]

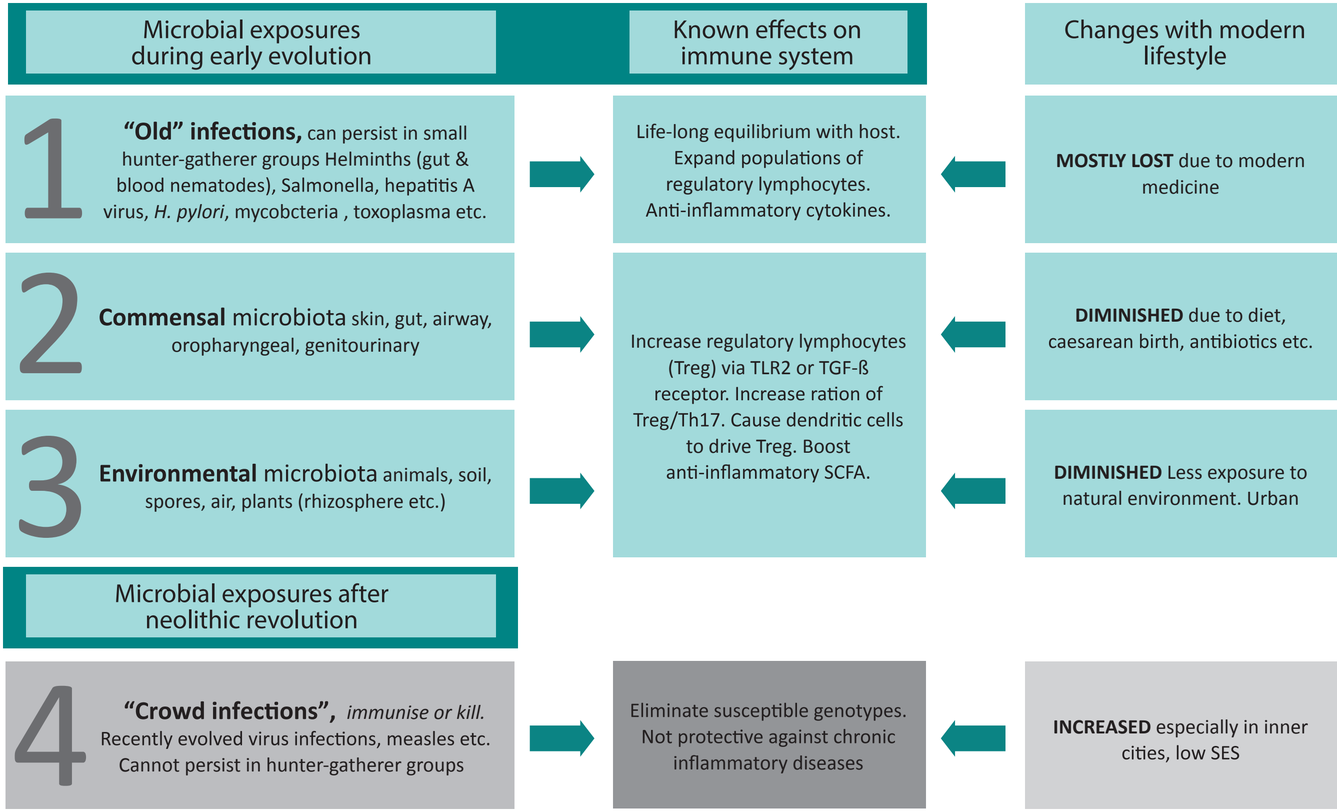
Biodiversity works on human health through a variety of ecosystem services. The evolution and stability of complex immune systems and inflammatory responses of higher vertebrates, for example, depend on biodiversity, especially microbial diversity (Rook *et al.* 2015; Rook 2013; Radon *et al.* 2007) (Figure-L2 5: System supply of microbiota from the external environment to the human organ system-L2 4).

When a higher organism is removed from the natural environment (e.g. through urbanisation or hygiene efforts) the immune system response has little or no purpose and this principally appears to be why it develops inappropriate or self-destructive responses, such as autoimmunity and allergies. This is further compounded by the rapid loss of biodiversity from human impacts on the environment through agriculture, resource extraction, and built infrastructure development generally. In a built urban environment, without biodiverse natural spaces, people are not exposed to microorganisms that provide "data" for our immune system to develop and function (Figure-L2 5: System supply of microbiota from the external environment to the human organ system-L25).

12: [*Specific health effects of air pollution*]

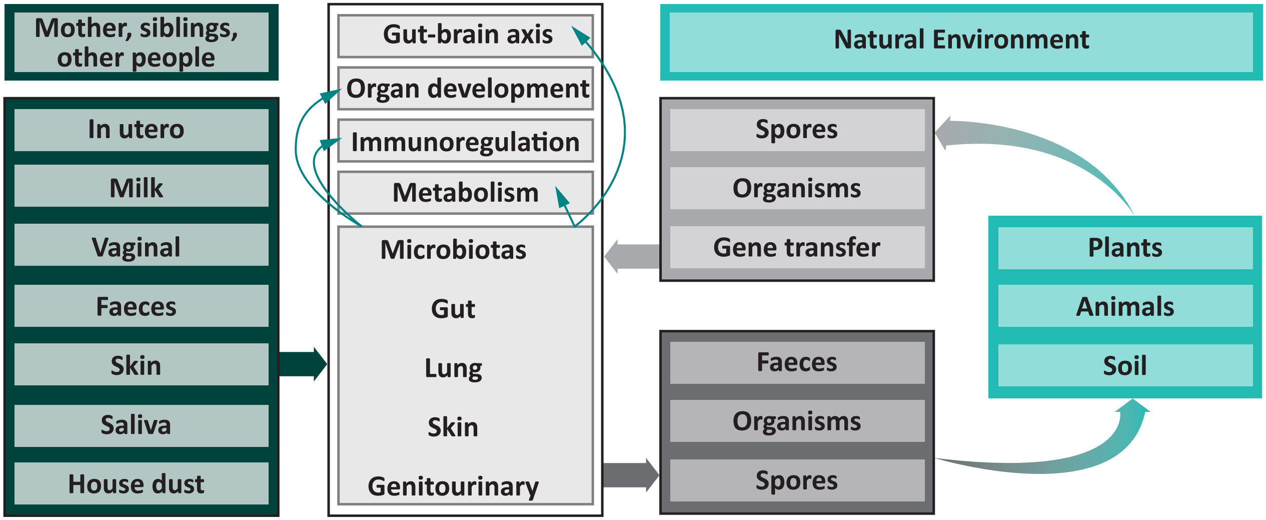
There are well-known effects of long-term exposure to air pollution on mortality (Beelen *et al.* 2014; Hoek *et al.* 2013),

Figure-L2 4: Pathways between microbial biodiversity, human immune system functioning, and disease development



Source: Reproduced from Graham Rook, ‘The old friends hypothesis and Darwinian medicine,’ in Matilda van den Bosch and William Bird, (Eds.), Oxford Textbook of Nature and Public Health: The Role of Nature in Improving the Health of a Population, Oxford University Press, Oxford UK, [Forthcoming], Copyright ©OUP, with permission from Oxford University Press

Figure-L2 5: System supply of microbiota from the external environment to the human organ system



Source: Reproduced from Graham Rook, ‘The old friends hypothesis and Darwinian medicine,’ in Matilda van den Bosch and William Bird, (Eds.), Oxford Textbook of Nature and Public Health: The Role of Nature in Improving the Health of a Population, Oxford University Press, Oxford UK, [Forthcoming], Copyright ©OUP, with permission from Oxford University Press

lung cancer (Raaschou-Nielsen *et al.* 2013), cardiovascular diseases (Brook *et al.* 2010; Cesaroni *et al.* 2014), decreased lung function in children (Eeftens *et al.* 2014; Gehring *et al.* 2013), respiratory infections during early childhood (MacIntyre *et al.* 2014) and low birth weight (Pedersen *et al.* 2013). Furthermore, evidence is emerging for the role of air pollution also in other diseases of multifactorial aetiology, for example diabetes (Eze *et al.* 2014). Vulnerable populations, such as children, elderly, pregnant women, people with underlying disease, and groups of lower income, are more susceptible to the effects of air pollution (Richardson *et al.* 2013a; Richardson *et al.* 2013b).

13: Tobacco smoke and noise also pollute the air

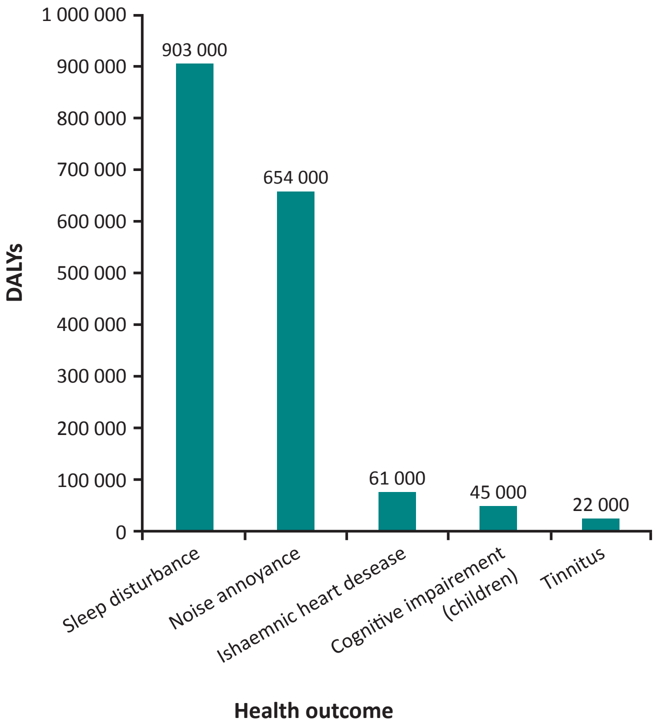
Environmental tobacco smoke levels are falling, but probably, after outdoor air pollution, account for the largest burden of disease in terms of cardiovascular disease, lung cancer, asthma, and infections (Hänninen *et al.* 2014). Globally, the WHO European Region has the highest mortality attributed to tobacco at around 16 per cent of all deaths (WHO 2014b).

Further progress in protection against exposure is required and the implementation of the *WHO Framework Convention on Tobacco Control* should be accelerated (WHO 2005).

The range of disease burden from noise pollution in the region is estimated to 1.0 – 1.6 million DALYs (WHO 2011) (Figure-L2 6). The exposure to noise is increasing as a result of continuing urbanization, rising traffic volumes, airports, railways, industries, and a decreasing availability of quiet places. Geographic information systems (GIS) can help in analysing and understanding how noise affects an ecosystem and its population (EEA 2014).

Around 20 per cent of pan-European residents are exposed to noise exceeding WHO guidelines (WHO 2009). Vulnerable groups, living less favourably close to industries or heavy traffic, are more exposed to, and affected by, health consequences of noise (Braubach and Fairburn 2010). Noise increases the risk of hypertension, hearing loss, cardiovascular mortality and morbidity, sleep disturbance, mental disorders and impaired cognitive function especially among children (Basner *et al.* 2014; Babisch 2002). The association between noise and sleep disturbance, annoyance and cardiovascular disease may be responsible for a large burden of disease (WHO 2011) and initial health impact assessments (HIAs) suggest that the health burden from noise is similar to that from air pollution (Stansfeld 2015; Tétreault *et al.* 2013). Noise is also associated with tinnitus (*Axelsson and Prasher 2000*) which can have deleterious effects on quality of life.

Figure-L2 6: Disability-adjusted life years (DALYs) attributed to environmental noise exposure in the region. Most of these DALYs can be attributed to noise-induced sleep disturbance and annoyance



Source: Basner *et al.* 2014

In the EU the Environmental Noise Directive (END) requires action plans to be drawn up for the major transport sources and the largest urban areas, which should aim to reduce the impact of noise upon the affected population. Where areas are found to be of a high acoustic quality, i.e. free from noise pollution, they should be protected by appropriate action plans.

Policies and actions to reduce noise levels in the everyday environment are needed. Environmental noise exposure should be regulated and reduced ideally at source, and exposure limits should be enforced to mitigate negative health consequences of chronic exposure. Educational campaigns for children and adults can promote both noise-avoiding and noise-reducing behaviour, and thus, mitigate negative health consequences (Basner *et al.* 2014).

14: Highly toxic chemicals: lead, asbestos, mercury and POPs

Lead is a highly toxic chemical and elevated blood lead concentration has detrimental effects on neuropsychological function and cognitive function among children (Muldoon *et al.* 1996). Fortunately, lead levels have declined in the pan-European region over past decades and so have their health impacts. Nonetheless, there is still cause for concern and in order to identify how to reduce the concentrations further, there is a need for monitoring and data gathering on lead in soil and house dust, as well as diet and drinking water, as these are causal exposure sources with a longer lead half-life than air.

Partly due to degraded living environments, higher lead level exposure is linked with lower socio-economic situation (SES) (Peters *et al.* 2011). There is an interrelated role of lead burden and SES over a lifetime in relation to healthy functioning in older age and health inequalities. An extended and more harmonized surveillance system monitoring blood-lead levels, especially in children, is required in order to identify, quantify, and reduce remaining sources of exposure (Section 2.5).

Mercury is a highly toxic compound, especially to children, also causing cognitive impairment. Exposure to mercury can be high in certain locations where risks of higher contamination of the environment and food sources occur, in addition to exposure to mercury in consumer products. Mercury uptake, through consumption of fish, still poses a problem in some countries with high fish consumption, for example Spain (Domingo *et al.* 2007).

The *Minamata Convention on Mercury* is a global, legally binding treaty to protect human health and the environment from the adverse effects of mercury. It was adopted in October 2013 and will enter into force after the fiftieth ratification. It has not yet been signed by all pan-European countries. The Convention includes a ban on new mercury mines, the phase-out of existing ones, control measures on air emissions, and the international regulation of the informal sector for artisanal and small-scale gold mining. Implementing the Convention will require multi-sectoral action – including the health sector. Its implementation will benefit health through a decrease in developmental and other neurological disorders in children and improved chances for healthy development throughout life.

Persistent organic pollutants (POPs) are ubiquitous environmental contaminants which persist in the environment, bio-accumulate through the food chain, and pose an emerging risk of causing adverse lifetime effects to human health and to ecosystems (Rostami and Juhasz 2011). Exposure to POPs has been associated with many adverse human health effects, including impaired neurodevelopment, immune and reproductive functions (Damstra 2002). Many POPs also disrupt the normal functioning of the endocrine system (Darnerud *et al.* 2010; Howard and Lee 2012), leading to disturbed hormone functioning in the body.

POP-levels in the environment, including DDT, DDE and dioxins, are declining, but are passed on from mother to child, leading to observable health effects. POPs negatively affect the environment with accumulating and unknown effects on future ecosystem functioning.

Asbestos is responsible for around 50 per cent of all deaths from occupational cancer and is one of the most widespread environmental health hazards in the pan-European region. As of 2014, about 300 million people in the region were still living in countries that have yet to ban the use of all forms of asbestos. Even after banning its use, however, asbestos still persists in the environment. Safe removal of asbestos and disposal of wastes containing it are still challenges to be addressed.

National programmes for the elimination of asbestos-related morbidity are called for in the Parma Declaration (WHO 2010a). As no risk thresholds for exposures have been identified, it is currently recommended to stop the use of all forms of asbestos (WHO 2014c).

15: *The exposure cocktail and prenatal exposures*

There is an increasing concern that low-level exposure to pollutants may have adverse health impacts, particularly during foetal, neonatal, and childhood development, potentially also through epigenetic changes (Li *et al.* 2015; Pacchierotti and Spano 2015). Studies on emerging persistent chemicals, such as phthalates, perfluorooctane sulfonate (PFOS), and bisphenol A show measurable levels in people and in some cases health effects have been demonstrated, especially among children (Au 2002).

Metals, POPs, organophosphate pesticides and other emerging chemicals have all been shown to have effects on fertility, foetal growth and cognitive function. The associated burden of disease is substantial, though the magnitude is difficult to estimate (Bellanger *et al.* 2015; Trasande *et al.* 2015).

Another emerging issue is exposure to nanomaterials. The science and application of objects smaller than 100 nanometres is evolving rapidly. The introduction of nanomaterials followed discovery of countless beneficial applications, including in health and medicine. Nanoparticles deposit in the alveoli of the respiratory system and are also capable of passing the blood brain barrier, potentially becoming neurotoxic. Since 2004 a series of experimental studies have indicated that some carbon nanotubes (CNTs) are able to cause asbestos-like effects (Poland *et al.* 2008). Current evidence of hazardous effects is not conclusive. However, potential mechanisms through which nanoparticles can induce cell damage have been reported (WHO 2013b).

The impact of early exposure to nanoparticles with possible, continued, long-term, chronic, low-dose exposure remains unknown. As complexity and uncertainty are large, risk assessment is challenging and formulation of evidence-based policies and regulations remains elusive. Methods for risk assessment of nanomaterials exist, for example *Swiss Precautionary Matrix* for synthetic nanomaterials, NanoRiskCat, and control/risk banding nano tools (WHO 2013b). On the EU level there are discussions on how to incorporate nanomaterials into *REACH-legislation*.

Current generations are exposed to many environmental pollutants and hazards simultaneously and the short- and long-term health effects of potential synergies are, to a large extent, still unknown. However, a recent study showed several environmental pollutants at measurable levels among pregnant women, causing concern for harmful effects on foetal development, early childhood, and later life (Robinson *et al.* 2015).

Almost 40 years ago it was already suggested that prenatal exposure to chemical carcinogens can have effects on subsequent generations (Tomatis 1979) and the evidence is increasing (Wild *et al.* 2013), showing risks for many chronic diseases, including cancer, obesity, immune disorders, cognitive impairments and atherosclerosis (Wang and Achkar 2015; Grandjean and Landrigan 2014; Lewis *et al.* 2013; Steliarova-Foucher *et al.* 2004). Further research is urgently required to better understand the short- and long-term health effects from combinations of various environmental exposures, as well as how to prevent harmful effects. Existing regulations and precautionary approaches for harmful exposures, especially during foetal and infant life, should be applied to prevent toxicity and unhealthy development across countries and populations.

16: The Exposome paradigm and the need for long-term investments

A paradigm shift has taken place in human environment and health research through so called "exposome" research. The exposome concept was first proposed by Wild (2005) to encompass the totality of human-environment (i.e. nongenetic) exposures from conception and onward, complementing the genome. It was developed "to draw attention to the critical need for more complete environmental exposure data in epidemiological and risk assessment studies" (Wild 2012).

The exposome concept contains several overlapping domains of non-genetic factors contributing to disease risk, including a general external domain (social, societal, urban environment, climate factors), a specific external domain (specific contaminants, lifestyle factors, tobacco, occupation), and an internal environment (metabolism, gut microbiota, inflammation, oxidative stress) (Wild 2012). The exposome paradigm calls for improvement of often uncertain exposure data, for integration of data on biological mechanisms, and for a more holistic exposure approach to address the possible health effects of mixtures of exposures. This will require long-term assessments, studying populations over time and across regions. Such projects are currently often difficult to achieve, due to short-term research policies with demands on immediate results and subsequent implementation.

17: A Strategic Approach to International Chemicals Management

UNEP's Strategic Approach to International Chemicals Management (*SAICM*) works for a chemical safe future. SAICM is a policy framework to foster sound management of chemicals throughout their life cycles in the environment. The overall objective is to ensure that by 2020 chemicals are produced and used in ways that minimize significant adverse impacts on human health and the environment.

SAICM's Overarching Policy Strategy (OPS) includes five target elements: (1) risk reduction; (2) knowledge and information; (3) governance; (4) capacity building and technical cooperation; and (5) fighting illegal international traffic. Within the OPS lies a call for appropriate action on emerging policy issues as they arise, in order to forge consensus on priorities for cooperative action. Stakeholders or others may nominate emerging policy issues for consideration of the International Conference on Chemicals Management (ICCM). So far, resolutions have been adopted on the following emerging issues:

- Lead in paint
- Chemicals in products

- Hazardous substance within the life cycle of electrical and electronic products
- Nanotechnology and manufactured nanomaterials
- Endocrine-disrupting chemicals
- Environmentally persistent pharmaceutical pollutants (EPPP)
- Perfluorinated chemicals and the transition to safer alternatives
- Highly hazardous pesticides

The fourth session of the ICCM, in 2015 endorsed "Overall Orientation and Guidance" for achieving the 2020 Goal as a voluntary tool that sets out action points and will assist in the prioritization of SAICM implementation efforts towards 2020 (SAICM 2015).

Six core activity areas were identified towards the achievement of the overall 2020 goal, namely:

1. Enhance the responsibility of stakeholders
2. Establish and strengthen national legislative and regulatory frameworks for chemicals and waste
3. Mainstream the sound management of chemicals and waste in the sustainable development agenda
4. Increase risk reduction and information sharing efforts on emerging policy issues
5. Promote information access
6. Assess progress towards the 2020 goal of minimizing the adverse effects of chemicals on human health and the environment

ICCM4 urged all stakeholders to take concerted steps to implement the "Overall Orientation and Guidance", including the 11 basic elements identified therein. The 11 basic elements that have been recognized as critical at national and regional levels to the attainment of sound chemicals and waste management include:

1. Legal frameworks that address the life cycle of chemicals and waste
2. Relevant enforcement and compliance mechanisms
3. Implementation of chemicals and waste-related multilateral environmental agreements, as well as health, labour and other relevant conventions and voluntary mechanisms
4. Strong institutional frameworks and coordination mechanisms among relevant stakeholders
5. Collection of and systems for the transparent sharing of relevant data and information among all relevant stakeholders using a life cycle approach, such as the implementation of the Globally Harmonized System of Classification and Labelling of Chemicals
6. Industry participation and defined responsibility across the life cycle, including cost recovery policies and systems as well as the incorporation of sound chemicals management into corporate policies and practices
7. Inclusion of the sound management of chemicals and waste in national health, labour, social, environment and economic budgeting processes and development plans
8. Chemicals risk assessment and risk reduction through the use of best practices
9. Strengthened capacity to deal with chemicals accidents, including institutional strengthening for poison centres
10. Monitoring and assessing the impacts of chemicals on health and the environment
11. Development and promotion of environmentally sound and safer alternatives

These activities and elements should support SAICM's aim to inspire wider stakeholder engagement and enforced and renewed commitment to implementing the Strategic Approach for placing sound management of chemicals and waste at the heart of sustainable development, in the context of the SDGs and beyond 2020. According to SAICM, safe production and sound management of chemicals throughout their lifecycle, including using safer chemical alternatives in products, would alter nothing in the profit line for responsible businesses nor damage business brands. This is based on case studies and experiences.

18: *Disrupted food systems in the pan-European region*

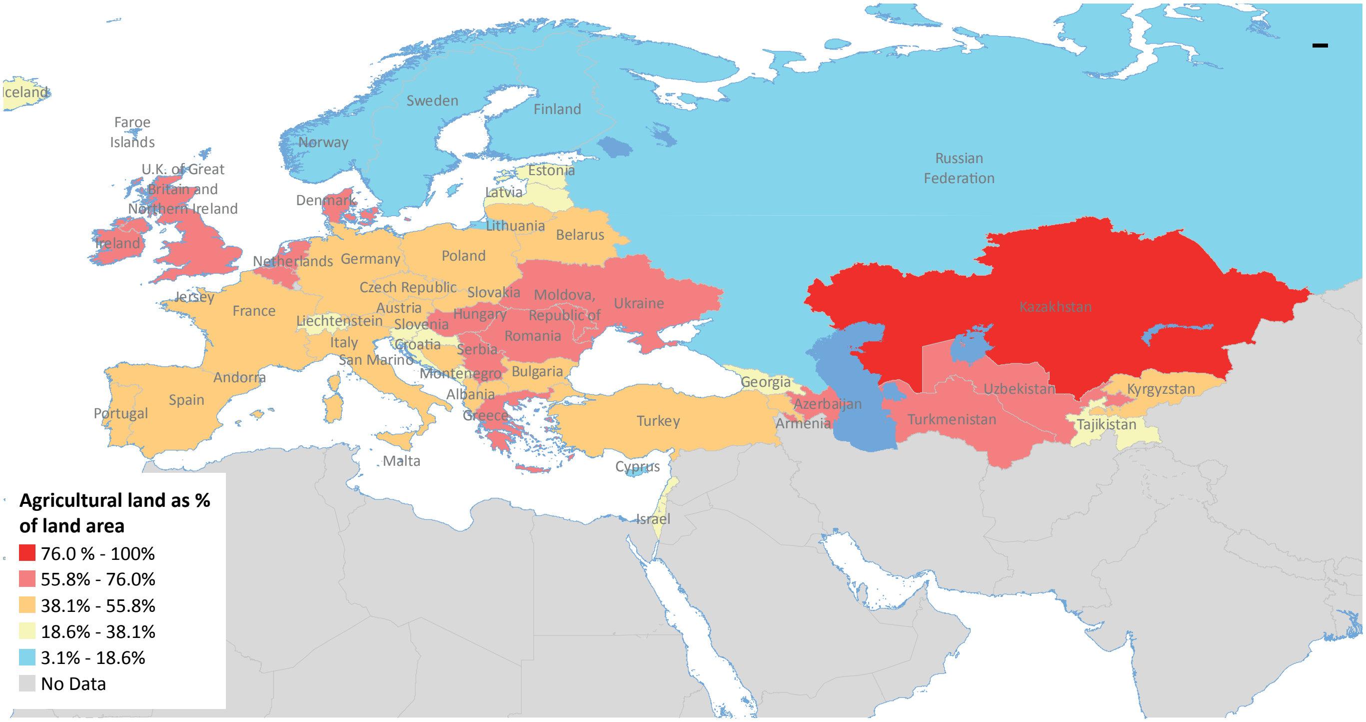
The development in the western part of the region was dominated by land use change, intensification and consolidation of agricultural systems, including intermittent use of questionable incentives, common agricultural policies and ultimately partial externalisation of its agricultural system through globalisation. Over 40 per cent of food demanded is now imported into Europe whilst 58 per cent of the land required for final demand in EU-28 is located outside of the region (Bergmann and Holmberg 2016).

In the eastern part of the region large areas of land have been abandoned where collective agriculture, although less intensive than in the west, was still highly dependent on fertilizers and chemicals and was unsustainable. Highly inefficient irrigation systems have led to water waste; as a consequence, 40 to 60 per cent of the land is highly salinized and large areas of land have been abandoned. In addition, Central Asia has been experiencing climate change above the global average, and it is predicted that if this trend continues, this would likely threaten food security in the southern part of the region. This has also led to these populations being highly dependent on imported foodstuffs.

19: *Agriculture in Western Europe*

Western Europe has one of the highest shares of land-use for urbanization, built infrastructure and production systems, including agriculture and forestry. Agriculture covers half of the EU's land area (Figure-L2 7: Agricultural land as percentage of land area, 20107) while farmers represent only 4.7 per cent of the EU's working population. Farming has had and has a big influence on Europe's landscapes and the quality of its environment. The current intense pattern of use, dominating since the 1950s, is driving deterioration and pollution of soil and surface water, as well as affecting food quality and diversity. And yet Europe remains a net importer of food with over 40 per cent coming from outside the region (Weinzettel et al. 2013). This demand for land puts pressure on economies and it has contributed, among many other factors, to undernutrition in countries trading with Europe and over nutrition in Europe (Bergmann and Holmberg 2016).

Figure-L2 7: Agricultural land as percentage of land area, 2010



The countries of Central Asia and the Caucasus have the highest share of agricultural land in the region, as indicated by red/dark red colour. In Kazakhstan almost 80 per cent of the land area is agricultural.

Source: IHPH 2013

Agriculture is also a source of pesticide residue in groundwater. Reforms from the *EU Common Agricultural Policy* (CAP) in the 1990s, and measures taken by the sector itself, have resulted in some improvements, but more are needed to balance agricultural production, rural development, biodiversity, and the environment (EEA 2015b; EEA 2011).

20: New breeding techniques

New breeding techniques are emerging rapidly from advances in genomic research, for application in crop improvement (EASAC 2015). They enable precise and targeted changes in the genome (thus, different from genetically modified organisms, (GMOs), produced previously) and may have significant potential for the sustainable intensification of agriculture and food security, when used as part of the deployment of all available approaches and building on existing good agronomic practices. Unlike chemical- or radiation-induced mutagenesis, often traditionally used as a basis for crop improvement, the new breeding techniques do not create multiple, unknown, unintended mutations throughout the genome. For several of the techniques, the resultant plant product is free from genes foreign to the species and would not be distinguishable from the product generated by conventional breeding techniques (EASAC 2015). These initiatives should be further studied and followed in terms of long-term effects on the environment and human health.

21: Ecological intensification

According to the FAO, ecological intensification is a "process that requires optimal management of nature's ecological functions and biodiversity to improve agricultural system performance, efficiency and farmers' livelihoods" (FAO 2013). It involves practical management strategies that integrate and enhance ecosystem functions associated with crop production in commercial farming systems. Examples include: increasing the diversity of plants and animals to create resilient agro-ecosystems and maintaining populations of pollinators, which benefits crop yields and may even compensate for low levels of fertiliser application. Although this seems a promising concept, it has been under debate due to lack of evidence. However, a recent study shows that it is possible to remove up to 8 per cent of land from production and maintain (and in some cases increase) yield (Pywell *et al.* 2015). With increasing evidence this may eventually promote large-scale implementation.

22: Sustainable agro-economies

It is essential to shift from the post-war food security paradigm and agricultural monoculture, to nutrition security based on more locally sourced food from diverse conservation agriculture (Fanzo *et al.* 2013). This could lead to major improvement in human health and the environment in the long-term but there are still significant obstacles, given the nature of the economy and reliance on imported foodstuffs. Nevertheless, evidence suggests that with commitment and improved food science, production losses from sustainable systems need not be significant and, if added to a reduction in food waste and over-consumption, sustainable agro-economies are possible, leading to significant benefits for both human health and the environment. But in order to succeed, soils, water and nutrient cycles, capped and degraded lands need to be restored, and agriculturally viable areas currently abandoned should be re-claimed.

23: Organic food systems

Given the current situation in the pan-European region, where only half of its food is produced locally, it seems unlikely that a shift to sustainable systems will happen in the short term.

Conservation agriculture, organic and biodynamic farming are examples of potentially sustainable food systems which may support health (Figure-L2 8: Organic farming protects both human and environmental health by reducing much of the pollution associated with conventional production-L2 8). International and national legal acts and regulations provide the rules and standards for Europe's organic production. The general principles for Europe's organic production are (Meybeck *et al.* 2014):

- Production methods that are environmentally friendly and maintain biodiversity and soil fertility.

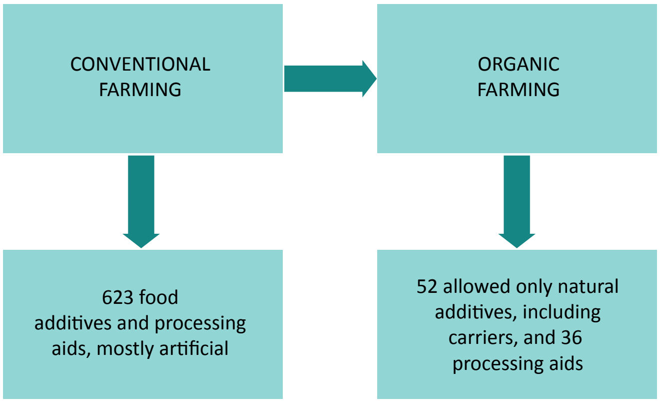
- Social criteria are important – small farms, using local means of production, activation of the country areas, and production connected to the soil.

- Organic agriculture excludes the use of synthetic fertilizers, pesticides and plant growth regulators. Only natural organic fertilizers, compost and manure; green manures; and biological crop protection methods are allowed.

- Animal production excludes the use of antibiotics (allowed only under strictly regulated conditions), hormones and genetically modified organisms. Food processing protects nutritional quality and excludes synthetic food additives – synthetic preservatives, synthetic colour additives, etc.

Organic processing standards prohibit the use of many additives, including synthetic preservatives, artificial colourings and sweeteners, which are widely used in the processing of conventional foods (Beck *et al.* 2006).

Figure-L2 8: Organic farming protects both human and environmental health by reducing much of the pollution associated with conventional production



A dietary shift to less meat and more vegetables and a reduction in use of land for biofuels (Cassidy *et al.* 2013) might ease the pressure on global land use and biodiversity (Machovina *et al.* 2015), and have a considerable co-beneficial effect on health and wellbeing (Bouvard *et al.* 2015).

24: *Case studies - Copenhagen and Astana*

In Copenhagen (Denmark) there are 350 kilometres of cycle tracks and 40 kilometres of green cycle (off-road) routes. More than one person in three commutes by bicycle to work or school every day and this is an important element in the declared goal of making Copenhagen CO_2 neutral by 2025.

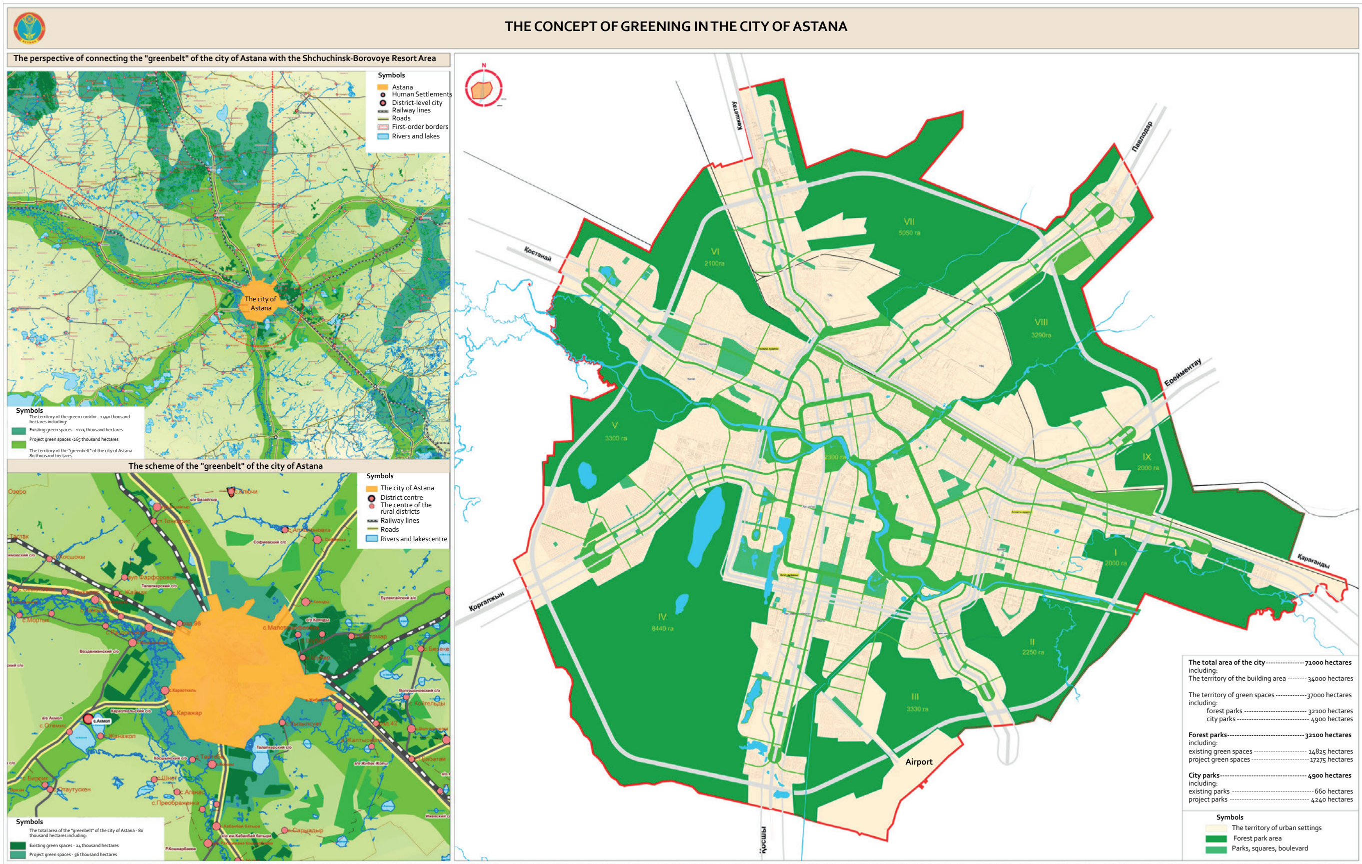
Cycling and increases in cycling in Copenhagen are supported through strategic policy, namely; 'The city of Copenhagen's bicycle strategy 2011-2025'. The policy brings together the economic, health, environmental and quality of life drivers together with decision areas including street design, street cleaning and maintenance, car parking provisions, public transport planning, parks and open space and neighbourhood renewal. Great care and attention is given to the design of the street, using both vertical and horizontal cues and devices, to support active travel. Interventions are chosen from a palette of evaluated and constantly developing designs. Cycle tracks, the preferred element in Copenhagen's cycle infrastructure, have developed a preferred design. They are found alongside many main roads, and are tarmac paths segregated vertically by low curbs from both cars on the roadway and pedestrians on the pavement. Vertical cues are also used at side road junctions, maintaining a continuity of level (and priority) for the cyclist with car traffic entering or leaving the side road having to drive over a raised platform. This junction design often also involves reducing road space for parked cars and increasing pedestrian quality with seating and trees or shrubs. At more major intersections a well-chosen and evaluated palette of other devices are used including forward stop lines for cyclists, marked routes (in blue) across the intersection and advanced green traffic signals for cyclists. Socioeconomic analyses of the bicycle initiative shows that the yearly health benefits of cycling in Copenhagen amounts to DKK 1.7 billion (€228 000 000).

Greening the city of Astana (Kazakhstan) 2007-2030: Astana has highly heterogeneous natural and technical conditions aggravated by intensive urban development. In the summer, the surface temperature of the soil in Astana reaches 65–70°C. The city has developed a greening policy to create large green areas contributing to the environmental development and the formation of a comfortable urban environment for public well-being (Figure-L2 9:The concept of greening in the city of Astana-L2 9). This policy is based on the concept of an eco-city. According to this concept, the greening scheme is based on recommendations in four different areas:

- Suburban area: creating green corridors connecting the artificial forest belt of the suburb with the natural parks that together will create an ecosystem planned to cover 1 490 hectares.
- Urban area: forest parks entering the city from all directions extending to central parts of the city and located within walking distance of residential areas. Projected area 17.2 hectares.
- Residential areas: creating parks, boulevards, and public gardens in residential areas. Projected area 4.2 hectares.
- Highways: creating a single architectural ensemble from all the elements of the landscape, containing areas of trees, shrubs, lawns and flower beds.

The city greening policy will result in green space covering about 52 per cent of the total land area, which is higher than in Berlin (30 per cent); Moscow (31 per cent); Kiev (16 per cent); Stockholm (30 per cent); and Paris (10 per cent).

Figure-L2 9:The concept of greening in the city of Astana



Source: Department of Architecture and Urban Planning of the City of Astana 2016

25: *Intra-urban health and environmental inequalities*

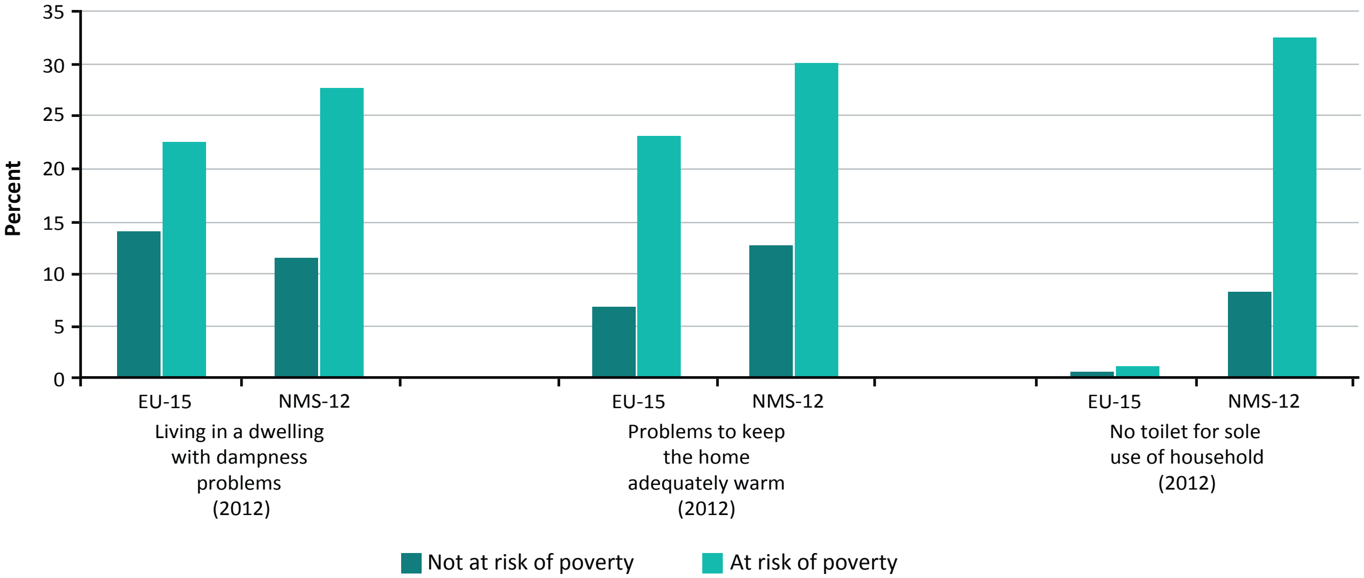
Intra-urban health inequalities are expected to grow with increasing urbanisation and with climate change (EEA 2015b; Revi *et al.* 2014; Martuzzi *et al.* 2010; McMichael 2000), counteracting WHOs goal of Health for All (Mahler 1981). For example, the increased levels of air pollution following urbanisation will be particularly prominent in deprived areas, close to traffic or industrial sites, and with lack of high quality clean and natural spaces (Clark *et al.* 2014). This causes increased mortality from inflammatory and cardiovascular diseases in affected populations (Richardson *et al.* 2013b; Chen and Kan 2008) and increases the health gap between socio-economic subgroups.

Socio-economic inequalities are today at the core of improving public health and are key concerns for authorities from local to international levels, including the Commission on Social Determinants of Health (*CSDH*) of Marmot *et al.* (2008). Efficient approaches to improve social and environmental conditions and related health determinants are necessary to counter avoidable health differences between various geographical regions and populations. There is a strong association between poverty risk and environmental inequalities, also within the EU (Figure-L2 10: Poverty risk and environmental inequalities10).

The social divide in environmental risk exposure has not yet been successfully tackled and further action is necessary (WHO 2015c). Social and environmental health determinants are often amenable to change through policy, planning and governance interventions, which can have an indirect, but substantial impact on public health. However, these kinds of synergies are complex to achieve and require monitoring of casual inference and appropriate actions from several sectors.

Intra-urban health inequalities demonstrate that a city's average availability of health and environmental resources may not be enough, but the spatial distribution of such and the allocation in relation to different housing areas and livelihoods are crucial for achieving equal health. This is

Figure-L2 10: Poverty risk and environmental inequalities



Abbreviations: EU-15: 15 EU Member states before enlargement on 1 May 2004; NMS-12: 12 new EU Member states that joined the EU before 31 December 2012 (thus, not including Croatia)

Source: WHO 2015c

particularly important for approaching health inequalities among children, spending most of their time in their local neighbourhood (Koller and Mielck 2009). This calls for a careful look at children's social and physical environments, ensuring that healthy conditions are established where they are most needed.

Green areas can help alleviate some health inequality aspects implying reduced health gaps (Mitchell *et al.* 2015; Mitchell and Popham 2008). However, due to cultural factors, gentrification, and biophysical and landscape prerequisites, natural spaces and the quality of such are often unequally distributed between groups of different socio-economic status, age, and ethno-racial characteristics (Schwarz *et al.* 2015; Jenkins *et al.* 2015; Byrne and Wolch 2009). Therefore, inequality conscious urban green planning and policies can and should play a prominent role in monitoring and counteracting health inequalities (Kabisch 2016).

Different tools for monitoring and localising health inequality indicators within cities have been developed; for example the WHO tool *Urban HEART* (Urban Health Equity Assessment and Response Tool) (WHO 2010b).

26: Creating health promoting cities

There is currently a move towards low carbon resilient cities, which has co-benefits for public health. Concepts such as *Healthy Cities*, *Green Cities* and *Sustainable Cities* are established, focusing on holistic approaches including political commitment, institutional change, capacity-building, partnership-based planning and innovative projects for improving urban environments and population health. Furthermore there is a trend that cities are becoming more health-promoting places aiming to prevent disease. For example, Hamburg has set 2030 as a target to be car free and the European target for personal car-free mobility in the city is 2050 (Nuwer 2014). These kinds of policies and targets provide opportunities to make urban environments more sustainable and healthy. It offers an outlook for rethinking what kind of cities people want and what actually constitutes a liveable city. Car-free cities render more space for public spaces, including green areas with various health advantages (Hartig *et al.* 2014).

An important aspect is to involve citizens in the decision to increase empowerment and avoid public disengagement and neglect, while creating opportunities also for social inclusion through healthier, more supportive social relations in neighbourhoods.

Urban case study

Slottsträdgården Malmö, (Sweden) – a local stakeholder initiative for social and environmental urban resilience.

Slottsträdgården "The Castle Garden" was initiated in 1994 by a group of citizens who later created a friendship association, who on a voluntary basis disseminate information about the garden and provide guided tours and other activities related to the garden. The site was an abandoned nursery in the city centre and the idea was to establish an open garden with the main aim of supporting social sustainability. The Street and Parks Department of Malmö gave the group access to the site and they began to create the garden. Gradually the department got more involved and made important investments, for example, the construction of footpaths, a café, and a greenhouse.

As the garden continued to grow the department took over some of the tasks and responsibilities. Still it is a place where the friendship association, schools and immigrants participate in farming activities. It is also a place visited by many city residents and tourists. The garden plays a certain role for the integration of immigrants into society. Malmö has a relatively large share of immigrants, with one third of the population being born outside Sweden.

A resilient and healthy city should include attractive open public spaces and promote sustainable, inclusive and healthy mobility. Some potential policies, such as a reduction of car use by increasing the attractiveness of public and active transportation combined with more cycling lanes and green spaces, may have several joint effects (see case study Copenhagen). Green and active lifestyles create co-benefits, including reduced carbon dioxide emissions and traffic congestion.

The benefits of urban green infrastructure

Urban green infrastructure delivers various ecosystem services, such as reducing the urban heat island effect (Shishegar 2014; Bowler *et al.* 2010), and air pollution (Escobedo *et al.* 2011), attenuating storm water and reducing the risk of flooding (Liu *et al.* 2014). In addition, research suggests that exposure to urban greenery may be health protective by reducing stress and increasing a population's physical activity levels (Hartig *et al.* 2014). Access to urban green spaces also promotes cognitive development among children (Dadvand *et al.* 2015), improves pregnancy outcomes (Dadvand *et al.* 2012) and mental health (Triguero-Mas *et al.* 2015), and prevents neurophysiologically induced depression symptoms (Bratman *et al.* 2015). Several studies also show reduced premature mortality in urban green areas (Gascon *et al.* 2016).

Various tools exist for evaluating and estimating costs and benefits of green or nature-based solutions. The *i-Tree software* is a state-of-the-art, peer-reviewed software suite from the United States Department of Agriculture's (US$A) Forest Service that can be applied all over the pan-European region, providing urban greenery analysis and benefits assessment, including health aspects (Nowak *et al.* 2014; Nowak *et al.* 2013).

Urban agriculture

Food security has always been a key resilience facet for people living in cities. Urban and peri-urban farming and gardening are re-emerging approaches for improving ecological performance within cities (Barthel and Isendahl 2013). Urban agriculture can also be crucial for social opportunities and new job creation with the perspective of integrating both ecological and urban services in the framework of more attractive cities (Rigillo and Majello 2014). Integrating food and agriculture in urban planning may reduce poverty, increase sustainability, biodiversity, and quality of life in European cities (Vitiello 2008). Certain concerns regarding soil contamination and plant uptake in urban areas have been raised, but recent reviews suggest that the benefits associated with urban agriculture outweigh any risks posed by elevated contaminant levels (Brown *et al.* 2016; Cruz *et al.* 2014)

27: Impact Assessments

Impact assessments enable policy makers to consider the implications of the decisions they take and provide a process through which many issues including human health and the environment can be examined (WHO 2014d).

The Strategic Environmental Assessment (SEA) Directive (European Parliament and Council of the European Union 2001) presents an opportunity to do this at a strategic level, as it requires the consideration of the likely significant effects on a range of topics including population and human health. The Directive, which came into force across the EU in 2004 and is binding for all 28 Member States, applies to a wide range of plans and programmes (European Parliament and Council of the European Union 2001). Furthermore, the parties to the United Nations Economic Commission for Europe's Espoo Convention (United Nations Economic Commission for 1991) produced the SEA Protocol (United Nations 2010), which is close to becoming a global agreement on SEA. It uses the term "environment and health" throughout, requiring health authorities to be consulted at different stages of the process.

Environmental impact assessments (EIA) may be statutorily required for some large project proposals. The EIA Directive (Council of the European Union 1985) states that the effects of a project on the environment must be assessed in order to take account of concerns to protect human health. Recent EIA Directive changes, to be transposed into national legislation by spring 2017, require that human health is included in the scoping of all EIAs (European Parliament and Council of the European Union 2014). The changes require that EIA identify, describe and assess, in an appropriate manner and in the light of each individual case, the direct and indirect significant effects of a project on population and human health.

28: Intersectoral approaches and the precautionary principle for long-term health in a healthy environment

The recognition of a need for inter-sectoral, integrated research and policy action for public health and well-being is not new (Daily *et al.* 2009; WHO 1989). In both research and the policy agenda, however, substantial inertia, due to conventional thinking or traditional values and norms, has impeded efficient solutions with high impact. In a time of changing climate, with growing populations and even higher pressure on ecosystems and natural resources, the call for value-based education and integrated approaches is urgent and a failure to respond will inevitably lead to significant, unpredictable consequences for both planetary and human health.

The precautionary principle may serve as a first approach in this world of complexity. This must not be seen as an argument for non-action in situations of uncertainty, rather, it should promote continued investigation, but where there is insufficient evidence of a potentially harmful effect, precaution should be applied as stated by Principle 15 of *The Rio Declaration on Environment and Development* (UNCED 1992).

"Late lessons from early warnings" was produced by the EEA in collaboration with a broad range of external authors and peer reviewers. The case studies cover a diverse range of chemical and technological innovations, and highlight a number of systemic problems. The "Late Lessons Project" illustrates how damaging and costly the misuse or neglect of the precautionary principle can be to human health and the environment, using a synthesis of the lessons to be learned and applied to maximising innovations while minimising harms (EEA 2013b).

29: Environmental indicators and assessment frameworks

Environmental indicators can provide insights into trends in ambient conditions, resource use patterns, and help to identify policies and governance tools to improve ecosystem functioning and human well-being. Countries within the pan-European region maintain sets of indicators linked to national, regional and global processes; these can be part of the set of internationally agreed environmental goals (IaEGs) within multilateral environmental agreements and regional conventions such as the UN Convention on Biological Diversity, UNECE Convention on Long-Range Transboundary Air Pollution, Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention) and the Convention on Non-navigational uses of Transboundary Watercourses (*UNEP Live*). The EEA maintains a set of 146 environmental indicators, 37 of which are designated as 'Core Set Indicators' and the UNECE maintains a set of environmentally relevant statistics and indicators from countries and conventions.

The indicator and analysis framework used in the GEO and EEA assessments is the DPSIR model; this is made up of five categories of interaction (D) drivers that exert pressure (P) on the environment, which as a consequence, cause changes in the state (S) of the environment, leading to impacts (I) on society and the planet and societal and political responses (R) (Stanners *et al.* 2007). In this report, indicators have been considered through the lens of seven thematic areas – climate change, air, freshwater, biodiversity, chemicals and waste, land and oceans and marine – with an overall focus on the relations between environment and human health and well-being.

In the context of health, the WHO uses DPSEEA (drivers, pressures, state, exposure, effect, action) to assess *environmental health impacts* and burden of disease, through the measureable effects of pressures through multiple exposure to hazards and their effects under multiple contextual factors such as gender, demography, poverty and inequality (Liu *et al.* 2012). The EEA has also addressed the risks associated with different chemicals and pollutants from the perspective of the precautionary principle (EEA 2013f).

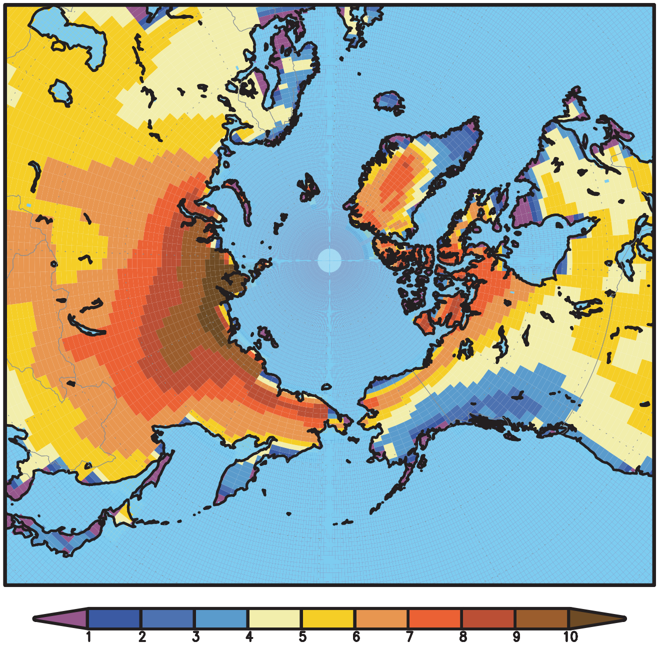
In Chapter 2 of this assessment, each theme is looked at across the DPSIR framework; the trends in each thematic area are documented based on best available information from a range of sources, including the peer-reviewed literature, national reports, intergovernmental bodies and convention secretariats, for example, European Environment Agency, Eurostat, CLRTAP, CBD and the UN system, for example, UNECE and WHO. As conclusive evidence on the impacts and effects of many pollutants on ecosystem health and human well-being is often scarce, exposure indicators are taken as proxies for effects. Responses are described in terms of policies and actions, including voluntary actions, where officially documented, that are directly targeted toward improving the environment as well as those which target relevant contextual factors. Given the irreducible nature of many of the uncertainties associated with these and existing knowledge gaps in causal linkages and data gaps, the estimates of impacts and trends presented in the following section have been confined to those issues which can be plausibly linked on the basis of best available evidence.

30: Permafrost degradation

Permafrost presently underlies nearly 25 per cent of the exposed land area of the northern hemisphere (Zhang *et al.* 2008). Under warmer climatic conditions much of this terrain would be vulnerable to subsidence, particularly in ice-rich areas of relatively warm, discontinuous permafrost (Osterkamp *et al.* 2000). Because most exchange of energy, moisture and gases between the atmospheric and terrestrial systems occurs through the permafrost's active layer, thickening of this layer as warming exposes more surface and activates deeper layers will most likely have important effects on geomorphic, hydrological and biological processes, and may have severe destabilizing effects on landforms, vegetation and inadequately constructed infrastructures (Smith and Burgess 1999).

General circulation model-based studies show the area of the northern hemisphere occupied by permafrost could eventually be reduced quite substantially in a warmer climate (Smith and Burgess 1999; Anisimov and Nelson 1996) – for example, Stendel and Christensen (2002) estimate a 30–40 per cent increase in active layer thickness by 2080s (Figure-L2 11) for most of the permafrost area in the northern hemisphere under certain Intergovernmental Panel on Climate Change (IPCC) scenarios, with the largest relative increases concentrated in the northernmost locations. Permafrost thaw can provide a feedback on climate, triggering the release of additional amounts of greenhouse gases such as methane (Michaelson *et al.* 1996).

Figure-L2 11: Temperature changes (°C) in boreal winter (December, January, February) in the lowermost model soil layer (5.7 meters) for the period 2071–2100 compared to the period 1961–1990



Source: Stendel and Christensen 2002

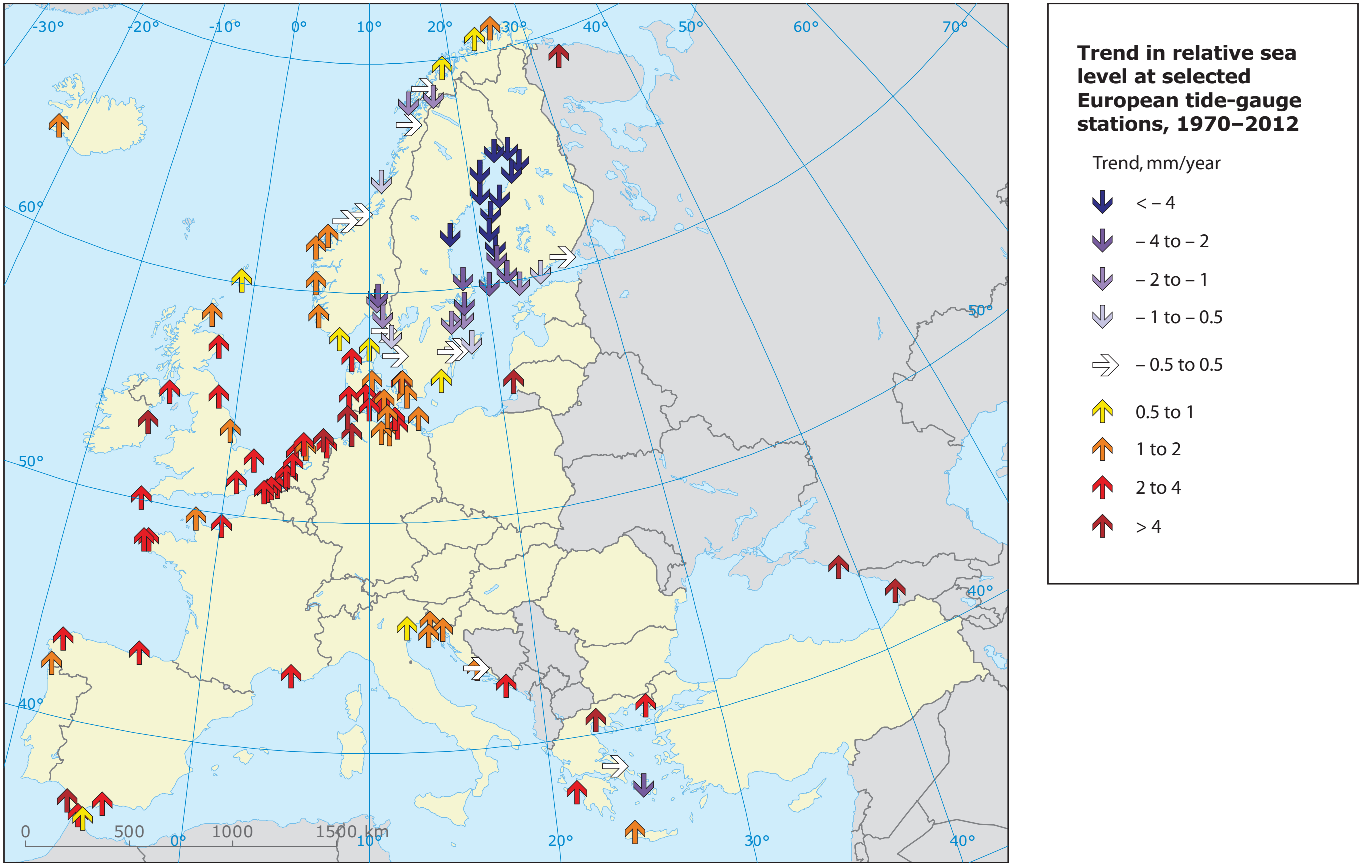
31: Relative sea level rise at selected pan-European tide-gauge stations (1970-2012)

Figure-L2 12 shows the geographical coverage of tide gauge measurements to the Permanent Service for Mean Sea Level (PSMSL), as well as the trend in relative sea level.

32: Desertification and soil degradation

Soil degradation processes occurring in the EU include erosion, organic matter decline, compaction, salinisation, landslides, contamination, sealing, and biodiversity decline (Montanarella and Tóth 2007). The adoption of the EU's Thematic Strategy for Soil (EC 2007a) formally recognized the severity of the soil and land degradation processes within the EU and its bordering countries. Available information suggests that, over recent decades, there has been a considerable increase in soil degradation driven or

Figure-L2 12: Trend in relative sea level at selected European tide-gauge stations, 1970-2012

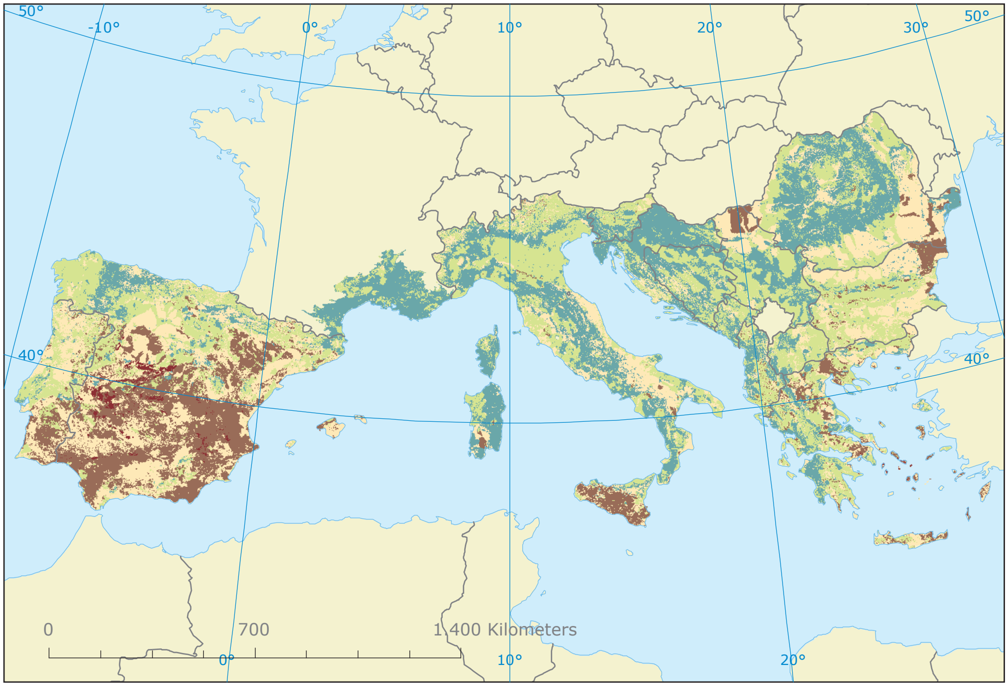


Source: EEA 2014g

exacerbated by human activity including climate change, and there is evidence that these phenomena will increase if no action is taken. Soil degradation is already intense in the dry lands of the Mediterranean and central-eastern Europe. Changes in climate leading to prolonged droughts and more irregular precipitation, in combination with the unsustainable use of water and agricultural practices can lead, in extreme cases, to desertification (EEA 2008a).

Vegetation is destroyed by forest fires; long dry periods leave exposed soils vulnerable to erosion; and droughts are often broken by intense storms that can wash away large amounts of soil. This is facilitated by low vegetative cover and poor soil conditions with low infiltration rates. According to the results of a recent assessment, based on a methodology developed within the Desertification Information System for the Mediterranean (DISMED), the sensitivity to desertification and drought is lower in the EU than in neighbouring regions. However, in the areas of Southern, Central and Eastern Europe for which data are available, 8 per cent of the territory, corresponding to about 14 million hectares, currently shows very high and high sensitivity (Figure-L2 13). The affected part increases to more than 40 million hectares if moderate sensitivities are also taken into account.

Figure-L2 13: Southern Europe, sensitivity to desertification index (SDI)



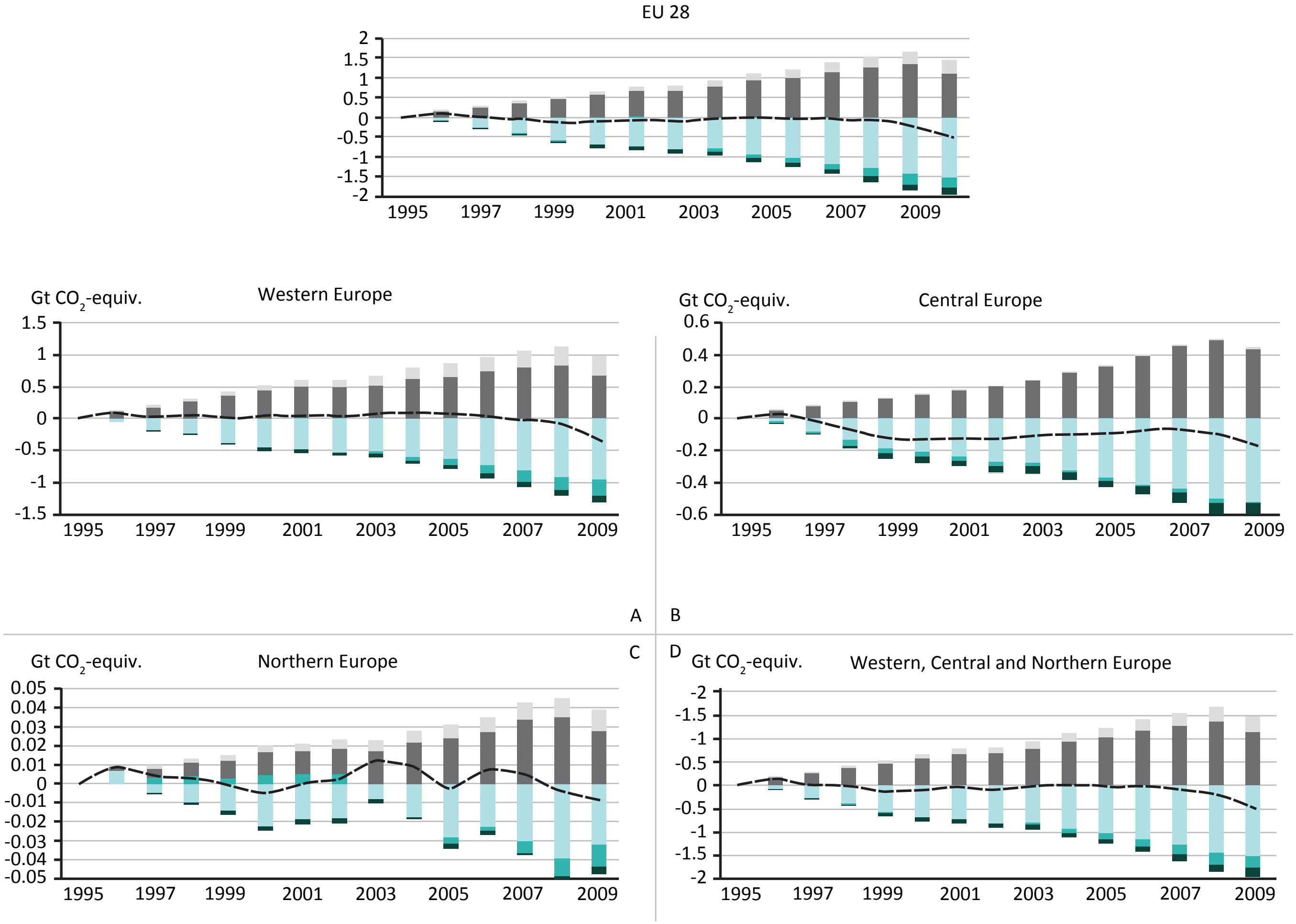
Index of sensitivity to desertification (SDI), 2008

(teal)	< 1.2	Non affected areas or very low sensitivity to desertification
(light green)	1.2–1.3	Low sensitivity areas to desertification
(light yellow)	1.3–1.4	Medium sensitivity areas to desertification
(brown)	1.4–1.6	Sensitive areas to desertification
(dark red)	> 1.6	Very sensitive areas to dersertification

Source: EEA 2009a

33: *Cumulative greenhouse gas emissions by key drivers*

Figure-L2 14: Cumulative changes in greenhouse gas emissions in five major pan-European sub-regions by key drivers, 1995–2009



Bars above the zero-line show increased emissions, relative to the 1995 baseline, whereas bars below the zero-line decreased emissions relative to the baseline. The total change in emissions is the difference between the positive and negative bars, for example, for the World in 2009, nearly 20kt of emissions were offset by 11kt of emissions, meaning there was a net increase of 9kt from 1995 to 2009.

Source: Arto and Dietzenbacher 2014

Table 4: Selected key policies that result in the reduction of greenhouse gas emissions (GHGs)

Title and reference of the EU-level measures	Content of the measure and level of action	Impacts (based on ex-post, ex-ante assessment) of benefits and co-benefits
EU 2030 Climate and Energy Framework 20/20/20 target; min. 20 per cent greenhouse gas emissions reduction in 2020, combined with a 20 per cent energy savings target compared to 1990 levels and an increase of the share of renewables in consumption to 20 per cent	...sets binding or non-binding levels of energy efficiency, carbon dioxide emission reduction, increase in renewable energy generation, etc. through EU or national actions. There are many targets, from collective targets (e.g. the 20-20-20 target in 2020, or the at least 40per cent carbon dioxide emission reduction target in 2030); to sector specific targets (e.g. emission reduction from light vehicles); and national level targets (e.g. binding national targets for renewables for 2020).	These targets and strategies enhance the impact of other measures. Meeting the 20 per cent renewable energy generation target could have a net effect of 417 000 additional jobs while a 20 per cent energy efficiency improvement could add 400 000 jobs (Ecofys 2014).
EU's Emissions Trading System (ETS) (2003/87/EC and 2009/29/EC)	...aims to cut greenhouse gas emissions cost-effectively from industry and power production. Controlled at the EU level.	Attributable emission savings are estimated at 40–80 Mt per year (carbon dioxide equivalent) during the first trading period (Laing *et al.* 2013). The ETS sector is expected to reduce 43 per cent of greenhouse gas emissions by 2030, compared to 2005 through the actions in the Directive (EC Climate Action n.d.). Furthermore, it has impacts on product pricing and promotes private investments in low carbon technology.
Effort Sharing Decision (Decision No 406/2009/EC)	...sets national emission targets for 2020 in non-Emissions Trading System sectors. The Member States define and implement actions.	Collectively, about 10 per cent reduction of greenhouse emissions compared to 2005 levels in 2020 from the non-ETS sectors (EC n.d.), to be extended until 2030 (European Council, 2014). In an analysis in 2010, only two Member States had the proper capacities in place (Forster *et al.* 2012), but the 2015d assessment finds progress to be adequate in 2015.
Renewable Energy Directive (2009/28/EC)	...requires Member States to achieve predefined national renewables targets in order to contribute to the EU's overall target. It also establishes cooperation activities. The Member States define and implement action.	The combined EU share of renewables was 15 per cent in 2013, with projections to reach 15.3 per cent in 2014, which is above the trajectory set by the Directive (EC 2015a). 25 Member States met their 2013/2014 targets (EC 2015a).

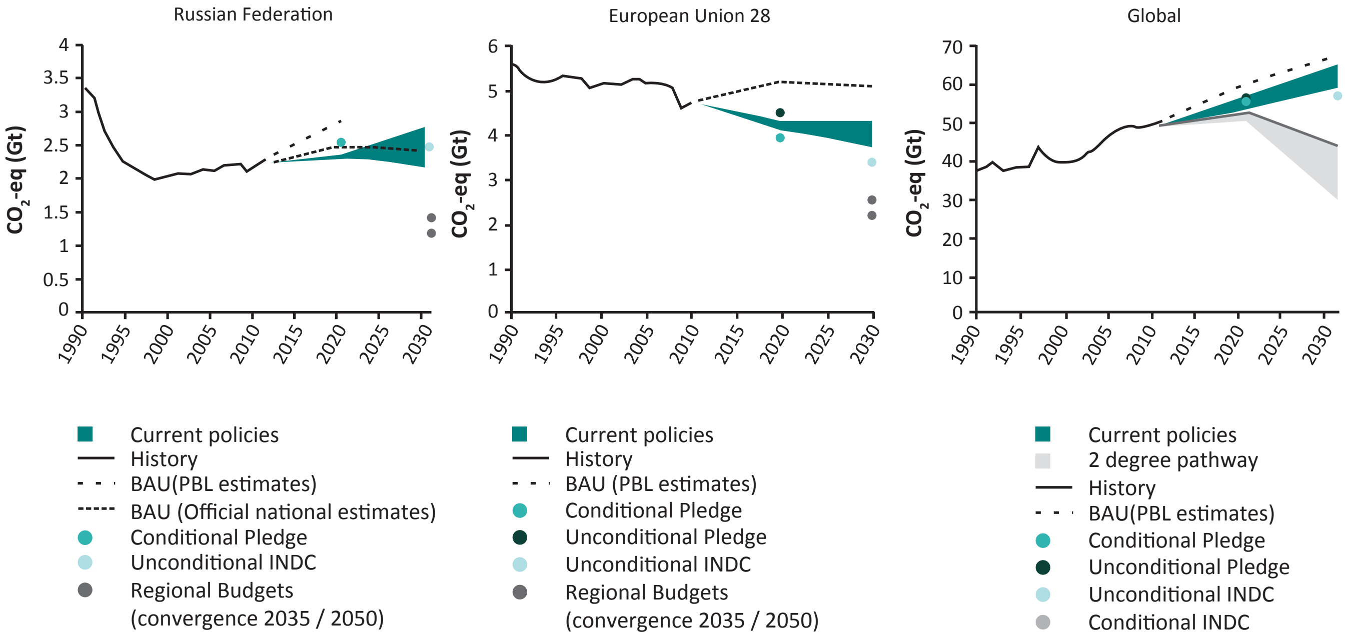
Title and reference of the EU-level measures	Content of the measure and level of action	Impacts (based on ex-post, ex-ante assessment) of benefits and co-benefits
Directive on the geological storage of carbon dioxide (CCS Directive) (2009/31/EC)	...establishes a legal framework for the safe geological storage of carbon dioxide. It complements other relevant regulation, e.g. the Environmental Impact Assessment (EIA) Directive and the Industrial Emissions Directive.	Estimations on the carbon dioxide emissions reduction impact are not readily available, due to the relative novelty of the technology and the as yet limited implementation success among Member States. The Directive will be revised after more experience is collected (Bolscher *et al.* 2014). Nevertheless, it was calculated that without CCS, the cost of meeting a 30 per cent reduction of greenhouse gas emissions in 2030 could be 40 per cent higher than with CCS (EC 2008c).
Energy Efficiency Directive (ESD) (2012/27/EC), with cogeneration and heat policies integrated in it	...establishes a set of binding national measures in order to achieve the EU's 2020 energy efficiency target, including an energy efficiency obligation system, promoting the energy services sector, mandatory rate of renovation of public buildings and many others. National targets and reports have to be prepared.	Modelling of the whole package showed that primary energy demand in 2020 could be reduced by 19.7–20.9 per cent, compared to a 2007 baseline, with a final energy demand decrease of 15.6–19.5 per cent in 2020 (EC 2011c).
Energy Labelling Directive (2010/30/EU) and the EcoDesign Directive (2009/125/EC), both revised and with many implementing regulations	...ensures that everyday electrical products such as washing machines, refrigerators and cooking appliances carry energy labels and have been designed to meet minimum energy efficiency standards. The scope of products is constantly increasing. The legal background is prepared at the EU level.	Resulting labels and standards are projected to save energy of around 166Mt oil equivalent by 2020, meaning a saving of EUR465 per year per household on energy bills. Moreover, energy efficiency measures will create EUR55Bn in extra revenue for European companies.
Energy Performance of Buildings Directive (EPBD) (2010/31/EU)	...requires Member States to put measures in place that improve the state of the building stock and changes behaviour of users. Complemented by the Energy Efficiency Directive (see above)	It was estimated that 160–210 Mtpa of carbon dioxide could be saved by 2020, fully 4–5 per cent of total EU carbon dioxide emissions in 2020, with 60–80 Mtpa of carbon dioxide energy savings by 2020. Furthermore, 280 000–450 000 potential new jobs could arise by 2020 (EC 2011b; EC 2008b).
Binding CO2 targets for new cars (Regulation 443/2009 and 333/2014) and van fleets (Regulation 253/2014 and 510/2011)	... require that new cars registered in the EU do not emit more than an average of 130g/km of carbon dioxide by 2015 (i.e. fuel consumption of ca. 5.6L/100 km of petrol or 4.9L/100 km of diesel), and a fleet average of 95g/km for all new cars by 2020. For new vans the limit was set at 175g/km of carbon dioxide by 2017 and 147g/km of by 2020.	

Title and reference of the EU-level measures	Content of the measure and level of action	Impacts (based on ex-post, ex-ante assessment) of benefits and co-benefits
Direct financial support (mainly through structural funds, but also dedicated credit lines, for example)	Decisions are mostly made at a national level, but also at the EU level.	At least 20 per cent of the EU's €960 billion budget for 2014–2020 is planned to be spent on protecting the climate.

35: *The Paris Agreement*

The Paris Agreement is intended to keep global warming well below 2ºC above pre-industrial levels, aiming at a 1.50C limit (UNFCCC 2015). Despite the decline in greenhouse gas emissions in the EU, current efforts are not sufficient to meet this goal by the end of the century. Figure-L2 15 shows projected global, EU-28 and the Russian Federation greenhouse gas emissions under current national climate policies, and a business-as-usual scenario (PBL 2015). Globally, there is a substantial emission gap between the current policy projections and the emission levels consistent with the 2ºC maximum. Furthermore, it should be noted that the future emission reductions (tabled in proposals, pledges, or intended nationally determined contributions (INDCs) are insufficient to meet the below 2ºC 'goal'.

Figure-L2 15: Global, the Russian Federation and EU-28 emissions gaps



Source: PBL 2015

The EU-28 has given an unconditional pledge of at least a 20 per cent reduction by 2020, compared to 1990 levels, further reducing to 30 per cent below, but conditional on other parties' contributions, thereby preserving room for larger reductions and reciprocity. By 2030, the EU-28 has an unconditional 40 per cent reduction target which will be achieved by INDCs.

The Russian Federation proposal suggests that a stagnation of emissions until 2030 can be achieved. This 'target' is unlikely to require additional efforts beyond the implementation of current policies. Similarly, in Europe emissions targets are driven by current policy, but a substantial emission gap is projected that is not consistent with a pathway delivering <2ºC stabilization. This assessment is supported by the findings of Gignac and Matthews (2015) in an analysis of the allocation of carbon budgets to the EU-28 and the Russian Federation under different contraction and convergence assumptions.

Explanation: expected emissions under current national climate policies (green area) vs a 'business-as-usual scenario' (dashed line). Blue dots are emissions pledges for 2020 and red dots the INDCs (conditional and unconditional). The black area (solid) is the historic emissions by region since 1990. The grey area (shaded) is global emissions that are consistent with the 2ºC pathway (UNEP 2014c). Emission outcomes (no-policies scenario) are indicated by the red bars. Grey dots are regional emission targets required to achieve the 2ºC pathway under different convergence-based allocation rules.

However, even in countries that pursue the most ambitious climate change mitigation policies, projected greenhouse gas emissions over the next few decades are not yet compatible with the target under the Paris Agreement of not more than 1.5ºC warming above pre-industrial levels by the end of the century. The European environment – state and outlook 2015 (EEA 2015c), for example, notes, "the projected reductions of EU greenhouse gas emissions as result of implemented policies are insufficient to bring the EU on a pathway towards the 2050 decarbonization target". The EU is on track to 'over-deliver' on its international and domestic 2020 targets, but is not on track towards its 2030 and 2050 targets". Other advanced industrialized countries in the region, such as Norway and Switzerland, are in a similar position. For example, Switzerland plans to reduce its emissions by 50 per cent by 2030, relative to 1990 levels, with an interim target of 35 per cent for 2025.

36: Mineralisation of CO2 in solid waste to produce products that can be used in construction

The management of CO_2 emissions by carbon capture and utilisation (CCU) is a potentially important future part of a balanced strategy for reducing greenhouse gases emissions. Carbon dioxide can be used as a feedstock for, for example, fuel, plastics and urea manufacture. For CCU processes to compete with traditional materials an adequate supply of hydrogen will be vital. As the hydrogen economy develops, CCU-related products and processes will become more cost effective and numerous and utilize significant quantities of carbon.

One currently available CCU process involves the mineralisation of CO_2 in solid waste to produce products that can be used in construction. The technology is a managed version of 'natural carbonation' whereby CO_2 gas is converted to calcium carbonate (limestone). The carbonate-reaction is managed carefully and can be used to manufacture a range of monolithic materials, including a substitute for aggregates made from virgin stone. Developed at the University of Greenwich the process is being applied in the UK in a zero emissions plant near Bristol. Carbonated manufactured aggregates are being made from air pollution control residues, but different solid wastes can be used.

The aggregates, which have a structure similar to natural oolitic limestone (Figure-L2 16) meet European 'end of waste' regulations and materials performance standards, and make a demonstrable contribution to the developing European circular economy.

Currently two UK aggregate plants are operating, but by 2019 production capacity will be 0.5 Mtpa, in which 10 ktpa of waste CO_2 will be permanently captured.

Figure-L2 16: Thin section showing an oolitic-like structure in the manufactured carbonated aggregate

Air quality

37: *Trends in other air pollutants*

Energy production and industrial sectors dominate **sulphur oxide** emissions. A reduction in the sulphur content of fuel oil and diesel fuel, technical measures such as flue-gas desulphurization, and reductions in Central European economies have led to a large reduction in sulphur dioxide emissions in the EU of more than 65 per cent since the early 1990s (Dämmgen *et al.* 2013; Tørseth *et al.* 2012). However, bottom-up calculations have shown that emissions in Eastern Europe, the Caucasus and Central Asia have again been increasing in recent years, while emissions from international shipping and atmospheric transport of pollution from China have increased steadily over the past 25 years (Klimont *et al.* 2013). Sulphur dioxide concentrations in the EU, reflecting the changes in emissions and ambient air levels, are now well below air quality regulatory limits. Air pollution remains a problem, however, in South Eastern European countries such as the Former Yugoslav Republic of Macedonia, Bosnia and Herzegovina (World Bank 2009), and Serbia (HEAL 2014), as well as in *Turkey*.

Anthropogenic emissions dominate the global **ammonia** budget. About 70 per cent of the total can be attributed to human activities, mainly agriculture through the excessive use of nitrogen fertilizers and livestock, while natural sources such as oceans and volcanoes contribute a smaller amount (Paulot *et al.* 2015; Sutton *et al.* 2008). The agricultural sector was responsible for 93 per cent of the total ammonia emissions in the EU in 2012, having decreased by only 8 per cent between 2003 and 2012 (EEA 2014c). Despite the known adverse environmental impacts of ammonia, such as acidification and eutrophication, and although ammonia is an important precursor for particle formation, international efforts to reduce emissions have so far been less ambitious than for other air pollutants. In the recent past, various studies have increased understanding of the underlying mechanisms of specific ammonia-releasing processes (Schrade *et al.* 2012; Misselbrook *et al.* 2004), which can be considered a first step towards a comprehensive emission reduction strategy. Some low emission technologies, such as the application of manure with trailing hoses and injectors, have been introduced in several countries in the pan-European region. No significant trends in atmospheric ammonia concentrations can be observed in the region. An empirical estimate indicates that ammonia emissions might increase with rising temperatures (Sutton *et al.* 2013).

Emissions of **nitrogen oxide** - the sum of nitric oxide and nitrogen dioxide - in the pan-European region - can be attributed mainly to the combustion of fossil fuels. The transport sector is the largest contributor to nitrogen oxide emissions, accounting for 46 per cent of total EU emissions in 2012 (EEA 2014c). These emissions decreased by 31 per cent between 1990 and 2009 in the EU, largely as a result of establishing advanced emission reduction technologies, and will decrease further as a result of more stringent EU norms

(Monks *et al.* 2015). However, emissions from ship traffic are expected to increase (Monks *et al.* 2015). This pattern is reflected in the abundance of atmospheric nitrogen oxide (Tørseth *et al.* 2012). A particular decline was reported for urban agglomerations (Schneider *et al.* 2015) and general declines have been seen mainly in Western and Central Europe, while observations over southern Europe and ship emissions show a less clear trend (Konovalov *et al.* 2008). As with sulphur dioxide, ship emissions play an increasingly important role in nitrogen oxide emissions in the pan-European region due to ship-engine design, the delayed implementation of regulations, and the considerable growth of the shipping sector (Kattner *et al.* 2015; Balzani-Lööv *et al.* 2014; Berg *et al.* 2012). The positive effect of progressively more demanding emission standards for street traffic vehicles has partly been offset by the increase in the distances driven, particularly up to the middle of the last decade. In addition, the increasing nitrogen dioxide to nitrogen monoxide ratio in direct vehicle emissions due to increased penetration of diesel engines and more modern engine technology leads to a smaller reduction in nitrogen dioxide than in nitrogen oxide and thus makes it more difficult to consistently meet the air quality guidelines of the WHO (Williams and Carslaw 2011).

Carbon monoxide emissions result from incomplete combustion of fossil fuels and biofuels, and exposure to them can reduce the oxygen-carrying capacity of blood (WHO 2000). Carbon monoxide emissions fell by about 27 per cent between 2002 and 2011 in the EU (Guerreiro *et al.* 2014). Exposure of the population to carbon monoxide concentrations above the EU limit values and WHO air quality guidelines is very localised and sporadic (Guerreiro *et al.* 2014).

Strictly speaking, **carbon dioxide** and **methane** are not considered air pollutants, as they are not harmful to humans, plants or materials at typical atmospheric concentrations. However, the atmospheric budgets of these climate forcers are closely linked to the above-mentioned air pollutants as they partly share the same sources, such as fossil fuel combustion or animal husbandry, and the same sink, the reaction with hydroxyl radicals. Spatial variations are small compared with the situation for reactive gases because of the long atmospheric lifetime of carbon dioxide. Moreover, total atmospheric burdens are more important than small-scale features in relation to climatological effects. Overall, carbon dioxide concentrations are still increasing, with a globally averaged growth rate of 2.9 parts per million by volume, 0.74 per cent in 2013, caused mainly by anthropogenic emissions from fossil fuel consumption and cement production (WMO 2014). Global methane concentrations have reached 253 per cent of the pre-industrial level (WMO 2014). Its concentrations increased steadily until the end of the last century when they started levelling-off (Dlugokencky *et al.* 2003), but a renewed growth in both hemispheres has been observed since about 2006 (Dlugokencky *et al.* 2009; Rigby *et al.* 2008). The underlying mechanisms are not yet fully understood; the most likely drivers are combinations of changes in anthropogenic emissions and emissions from wetlands and permafrost in response to varying precipitation and temperature patterns (Dlugokencky *et al.* 2009; Anisimov 2007; Bousquet *et al.* 2006). However, microbial activity increases with temperatures and leads to a growing methane sink (Lau *et al.* 2015). No consistent picture for methane burdens and trends in urban environments can be reported since urban methane concentrations depend strongly on single sources like gas pipeline leaks or industrial point sources. Depending on land-use management, soil and ecosystem respiration may lead to increasing or decreasing methane emissions. As soon as greenhouse gas emissions are converted to carbon dioxide-equivalent fluxes, such data have immediate relevance for climate change issues.

Airborne **trace metals**, except for mercury and arsenic, which may also occur in their gaseous form, are typically bound to particulate matter. Their concentration is often elevated in active mining and other regions with heavy industry that do not use state-of-the-art precautions - as well as in areas of high geothermal gradients with volcanic exhalations. Organisation for Economic Co-operation and Development (OECD) member nations signed a declaration on lead (Pb) in 1996, making the phase-out of leaded petrol as the number one action for each OECD country (OECD 1996). This has resulted in decreasing lead concentrations, especially in urban air, which in most areas are now below 0.02 micrograms per cubic metre, but there are still some *hotspots even in Western Europe*, with concentrations of between 0.1 and 0.5 micrograms per cubic metre. A US Environmental Protection Agency (USEPA) analysis suggested that a standard level of 0.15 micrograms per cubic metre would meet criteria for public health. By incorporating susceptibility, other authors concluded, however, that options for the standard could reasonably be lowered (Chari *et al.* 2012). In the EU, less than 1 per cent of the population in 2010–2012 was exposed to airborne lead concentrations above the EU and WHO guideline levels (EEA 2014).

Persistent organic pollutants are organic chemicals identified as being toxic, bio-accumulative, persistent and prone to long-range transport (Wania and Mackay 1993). Trends in hexachlorocyclohexanes show a significant decrease in annual average air concentrations in Europe. The pattern for other persistent organic pollutants differs between sites and between measurements in air or in precipitation (Tørseth *et al.* 2012).

Inorganic aerosols in polluted regions, especially in Western Europe and North America, were dominated by ammonium sulphate in the 1970s to 1980s. Substantial reductions in sulphur dioxide emissions removed much of the sulphate from the atmosphere in these regions. Inorganic aerosols from anthropogenic emissions are now dominated by ammonium nitrate, a volatile aerosol, which contributes substantially to particulate matter and human health effects globally, as well as to eutrophication and climate effects. The volatility of ammonium nitrate and rapid dry deposition of the vapour phase dissociation products, nitric acid and ammonia, is estimated to be reducing the transport distances, deposition footprints and inter-country exchange of reactive nitrogen in these regions (Fowler *et al.* 2015).

38: Air Quality Standards in the EU

Table 5: Air Quality Standards in the EU

Pollutant	Concentration	Averaging period	Legal nature	Permitted exceedances each year
Fine particles ($PM_{2.5}$)	25 µg/m³*#*	1 year	Target value entered into force 1.1.2010; Limit value enters into force 1.1.2015 ##	n/a
Sulphur dioxide (SO_2)	350 µg/m³	1 hour	### 1.01.2005	24
	125 µg/m³	24 hours	### 1.01.2005	3
Nitrogen dioxide (nitrogen dioxide)	200 µg/m³	1 hour	#### 1.01.2010	18
	40 µg/m³	1 year	#### 1.01.2010*	n/a
Coarser particles (PM_{10})	50 µg/m³	24 hours	### 1.01.2005**	35
	40 µg/m³	1 year	### 1.01.2005**	n/a
Lead (Pb)	0.5 µg/m³	1 year	### 1.01.2005 (or 1.01.2010 in the immediate vicinity of specific, notified industrial sources; and a 1.0 µg/m3 limit value applied from 1.01.2005 to 31.12.2009)	n/a

Pollutant	Concentration	Averaging period	Legal nature	Permitted exceedances each year
Carbon monoxide (CO)	10 mg/m³	Maximum daily 8 hour mean	### 1.01.2005	n/a
Benzene (C_6H_6)	5 µg/m³	1 year	#### 1.1.2010**	n/a
Ozone (O_3)	120 µg/m³	Maximum daily 8 hour mean	Target value entered into force 1.1.2010	25 days averaged over 3 years
Arsenic (As)	6 ng/m³	1 year	Target value entered into force 31.12.2012	n/a
Cadmium (Cd)	5 ng/m³	1 year	Target value entered into force 31.12.2012	n/a
Nickel (Ni)	20 ng/m³	1 year	Target value entered into force 31.12.2012	n/a
Polycyclic Aromatic Hydrocarbons (PAH)	1 ng/m³ (expressed as concentration of Benzo(a) pyrene)	1 year	Target value entered into force 31.12.2012	n/a

39: *Low emission zones*

Roughly 200 cities in nine EU countries operate *low-emission zones* (LEZs) or are preparing for their introduction, mainly to help meet EU health-based air quality limits. Vehicles may be banned from an LEZ, or in some cases charged to enter one, if their emissions exceed a defined level. The introduction LEZs may assist in reducing PM10 concentrations and exceedances of the *EU PM10 air quality standard*. The AIRUSE (2013) report concludes: "With respect to human health, the most important result is a reduction of carbonaceous particles and ultrafine particle concentrations". Figure-L2 17 shows an example from the German capital Berlin.

Compared with black carbon emissions, which have been reduced by 58 per cent in Berlin, PM10 emissions have fallen by only 3 per cent, and nitrogen oxides by 20 per cent. Measurements in the city of Leipzig have shown similar trends for ambient concentrations, confirming that human exposure will be reduced. Trend analyses suggest a decrease in black carbon and concentrations of particles 50–100 nanometres in diameter near roads. The study concluded that an LEZ can be very effective in reducing ambient concentrations of health-related particulate matter parameters, such as black carbon and the number of particles, even if the beneficial effects are not directly evident from the legal parameter for PM10 mass concentration (Rasch *et al.* 2013).

40: *UNECE Convention on Long-range Transboundary Air Pollution*

The UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP) is unique, worldwide, in that it closely links scientific evidence with regulatory policy, notably via its integrated multi-pollutant, multi-effect approach to identifying and implementing the most cost-effective air pollution policies. This Convention, alongside WHO standards, has contributed to improving air quality in many parts of the region.

The Convention has been joined by most countries in Western and Central Europe, but not by countries in Eastern

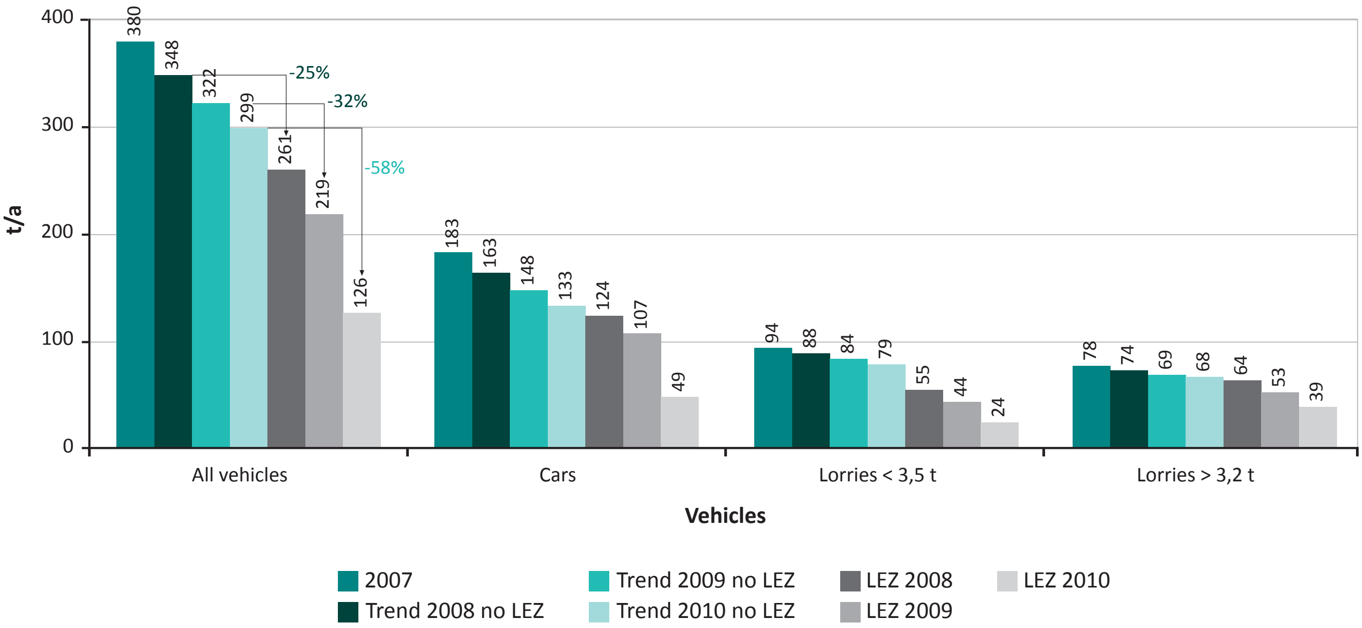
Table 6: Air Quality Standards in the EU (cont.)

Title	Metric	Averaging period	Legal nature	Permitted exceedances each year
$PM_{2.5}$ #	20 µg/m³ (AEI)	Based on 3 year average	Legally binding in 2015 (years 2013, 2014,2015)	n/a
$PM_{2.5}$ ##	Percentage reduction* + all measures to reach 18 µg/m³ (AEI)	Based on 3 year average	Reduction to be attained where possible in 2020, determined on the basis of the value of exposure indicator in 2010	n/a

*#*Standard introduced by the new *Directive*.## Limit value entered into force 1.01.2015
Limit value entered into force 1.01.2005 #### Limit value entered into force 1.01.2010
*Under the new Directive the Member State can apply for an extension of up to five years (i.e. maximum up to 2015) in a specific zone. Request is subject to assessment by the Commission. In such cases within the time extension period the limit value applies at the level of the limit value + maximum margin of tolerance (48 µg/m3 for annual nitrogen dioxide limit value).
**Under the new Directive the Member State was able to apply for an extension until three years after the date of entry into force of the new Directive (i.e. May 2011) in a specific zone. Request was subject to assessment by the Commission. In such cases within the time extension period the limit value applies at the level of the limit value + maximum margin of tolerance (35 days at 75 µg/m3 for daily PM10 limit value, 48 µg/m3 for annual PM10 limit value).
Under EU law a limit value is legally binding from the date it enters into force subject to any exceedances permitted by the legislation. A target value is to be attained as far as possible by the attainment date and so is less strict than a limit value.
The new *Directive* is introducing additional PM2.5 objectives targeting the **exposure** of the population to fine particles. These objectives are set at the national level and are based on the average exposure indicator (AEI).
AEI is determined as a 3-year running annual mean PM2.5 concentration averaged over the selected monitoring stations in agglomerations and larger urban areas, set in urban background locations to best assess the PM2.5 exposure to the general population.
Exposure concentration obligation
Exposure reduction target
** Depending on the value of AEI in 2010, a percentage reduction requirement (0, 10, 15, or 20 per cent) is set in the Directive. If AEI in 2010 is assessed to be over 22 µg/m3, all appropriate measures need to be taken to achieve 18 µg/m3 by 2020.*

Europe, the Caucasus and Central Asia (Gromkova 2012). The latter sub-regions are behind in terms of EU legislation and air pollution management practices in Western Europe (Ivanenko 2013), while the societal cost of air pollution in relation to GDP is among the highest in the pan-European region (WHO and OECD 2015). Through its Neighbourhood Policy, the EU aims to support air pollution legislation in those countries by encouraging the introduction of best available technology approaches, vehicle standards, emission ceilings and integrated pollution prevention permits, and by developing capacities and enhancing implementation (Gromkova 2012). In recent years, for instance, gas flaring reductions in Kazakhstan (Kurmanov 2012) as well as tighter standards for liquid transportation fuel and vehicles in a number of these countries are likely to contribute to improvements in air quality (PCFV 2015).

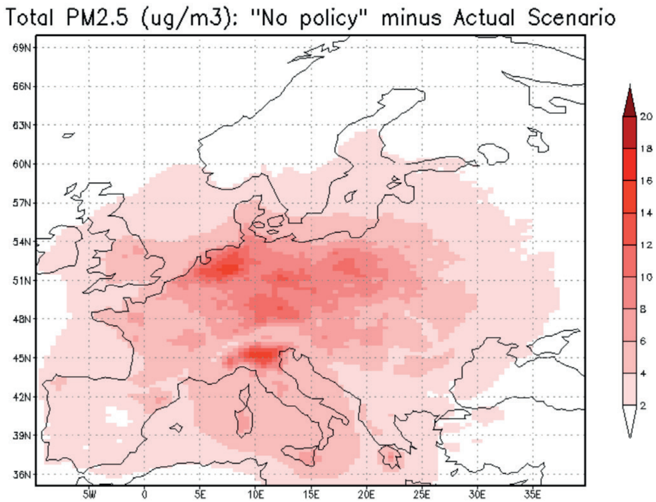
Figure-L2 17: Declining trend of diesel-fuel borne particle emissions from 2007 to 2010 and comparisons between normal urban zones and especially regulated LEZs in Berlin



Source: *http://www.umweltbundesamt.de/umweltzonen/index.htm*

41: Pan-European region, effects of introducing Integrated Pollution Prevention Control in industrial combustion plants on PM2.5 in 1990-2005 (Figure-L2 18).

Figure-L2 18: No policy scenario minus the actual scenario. The darker the red colour, the larger the air pollution reductions



Source: EEA 2010e

42: *Other key EU air quality related policies*

The Integrated Pollution Prevention Control Directive (European Parliament & European Council 2008b) and the Large Combustion Plants Directive (European Parliament & European Council 2001b) have mainstreamed the best available technologies into the industrial and power supply sectors. The associated health improvements as a result of these policies are in the range of a 30–90 per cent reduction in years of life lost in EU countries between 1990 and 2005 (EEA 2010e).

EU vehicle emission standards (European Council 1991) have been setting ever tighter limits for all new vehicles sold in the EU since 1992. In the light of recent controversy over vehicle emission standards (Thompson *et al.* 2014; Weiss *et al.* 2013; Weiss *et al.* 2011), past claims of policy effectiveness are likely to be revisited and reduced. Nevertheless, this may be a critical turning point for both policy-makers and the automotive industry in a transition to cleaner and more climate-friendly transportation. Various authorities are expanding the scope of emission tests, and tests are being re-designed to better reflect real-world driving conditions.

PR poster from Moscow advertising the use of bicycle paths

43: *Bicycle traffic in Moscow*

Moscow City government's Transport Department has developed a special programme to connect all districts in the inner city by *cycle paths*. According to this programme, about 150 kilometres of bicycle paths will be built in Moscow by 2016. In parallel, 10 000 bicycle parking places are to be built and the number of bicycle rental hubs/stations, currently more than 50, is increasing rapidly.

Biodiversity and ecosystems

44: *Eurobarometer*

According to the European Commission (2013e) Flash Eurobarometer only 44 per cent of the people interviewed are acquainted with the term "biodiversity" and know what it means; nonetheless, familiarity with the term has increased in 18 Member States (EC 2013e). Ninety-six per cent of people in the EU believe that the pollution of air and water and man-made disasters pose a threat to nature. Nine in ten people believe that the decline of forests, climate change, the endangering and disappearance of animals, the decline of natural habitats and the endangering of some plants are all serious problems. A large proportion sees the importance of halting species loss. Women are more likely than men to agree that it is a moral obligation to protect species (80 per cent compared with 73 per cent), and older respondents are more likely to do so than younger respondents. Sixty-five per cent agree that the EU should increase protected areas for nature (EC 2013e).

45: *Pan-European biodiversity hotspots*

The Mediterranean hotspot harbours the genus *Abies* with nine endemic species (50 other species are widespread in the pan-European region, Asia and North America) (Quézel and Medail 2003). For reptiles, 77 of 228 species are endemic, as well as with four genera being endemic – *Algyroides, Trogonophis, Macroscincus* and *Gallotia*. Among mammals, there are two species of special conservation value: the monk seal (*Monachus monachus*) and the Iberian lynx (*Lynx pardinus*). The lynx seems to represent a conservation success and in 2014, Europe's once rarest mammal species was moved by IUCN from "critically endangered" to "endangered", as the population showed signs of recovery and has been increasing in numbers (Simón 2012).

The Caucasian hotspot hosts 1 600 endemic species of plants with 17 endemic genera. Among vertebrates, mammals and reptiles host the largest number of endemic species (18 mammals and 20 reptiles). Mammals at risk on the IUCN Red List include the Caucasian tur (*Capra caucasica*, endangered), the Caspian monk seal (*Phoca caspica,* vulnerable) and the Armenian birch mouse (*Sicista armenica*, critical). The endemic Caucasian viper (*Vipera kaznokovi,* endangered) is also at risk.

The mountains of the Central Asian biodiversity hotspot hosts 1 500 endemic species of plants (and 64 endemic genera), but for the vertebrate groups there is considerably less endemism. Nevertheless, a number of mammal species in this hotspot are classified as endangered or as critically endangered, for example, the Saiga antelope (*Saiga tatarica*), which has suffered dramatically from habitat destruction, hunting pressure and diseases.

The Iranian Anatolic biodiversity hotspot, where just 20 per cent of the original habitat remains, hosts 2 500 endemic plant species. Along the Anatolian Diagonal, a floristic line that crosses Inner Anatolia from the southern foothills of the Eastern Black Sea Mountains in Turkey to the Mediterranean coast of Turkey, there are about 400 endemic plants, and another 1 200 other endemic species occur east or west of this line. Among vertebrates there are 10 endemic mammals, including the rodent Dahl's jird (*Meriones dahli*, endangered) and a vole that lives in Northern Iran (*Microtus quzvinensis*). There are 12 species of endemic reptiles, of which four vipers are threatened because of their restricted range: the Darevsky's viper (*Vipera darevskii*, critical), mountain viper (*Vipera albizona*, endangered), Wagner's viper (*Vipera wagneri*, endangered) and the Latifi's viper (*Vipera latifi,* vulnerable). Two salamanders of the genus *Neuregerus* are endemic: *N. microspilotus* (vulnerable) and *N. kaiseri* (endangered).

The Carpathian Mountains are the largest but most fragmented mountain range in Europe, covering parts of seven countries from the Czech Republic to Ukraine (UNEP 2007). They represent a link between the boreal forest (taiga) of Northern Europe and the Mediterranean ecosystems of the south and contain the largest pristine forests in Western and Central Europe, and primeval forests found in the Southern and Eastern Carpathians and in the Tatra Mountains. There are a large number of endemic plants and animals, including the richest community of large carnivores in Europe. Many of these endemic, alpine and glacial relict habitats and species are the result of long-term evolution, migration and adaptation processes that existed well before humans came to occupy the Carpathians.

In the pan-European region, current knowledge of biodiversity is still incomplete. Particularly for remote areas like the Iranian or Central Asian mountains and current approximations are likely to underestimate species richness (Ficetola *et al.* 2013).

46: *EU conservation status assessment*

There are three categories for assessing the conservation status of species and habitats in EU countries, with one category (unfavourable) split into two classes. Assessment parameters for species are: species range, population, suitable habitat and an evaluation of future prospects. For assessing habitats the parameters are: range, area, structure/functions and future prospects (EEA 2015h).

1. Favourable: the status of the habitat or species is stable and no imminent change of existing management or policies is needed.

2. Unfavourable: Class a – unfavourable-inadequate: no imminent danger of extinction in the foreseeable future for the specific species/habitat. However, a change in management or policy is required to return to a favourable status. Class b – unfavourable-bad: there is a threat of extinction for the habitat/species, at least regionally.

3. Unknown: species or habitats lacking data and/or having great uncertainty regarding their current conservation status.

47: *Seagrass ecosystems*

Seagrass ecosystems have important ecological functions and contribute to human-well being by protecting human infrastructure as they reduce the energy of coastal waves and limit coastal erosion and marine inundation (Gattuso *et al.* 2015). They serve also as important habitat for fish and marine invertebrate populations and sustain fisheries due to their role as fish nurseries (Hejnowicz *et al.* 2015). However, severe range reductions have been observed, particularly in areas with a medium or high human impact and in areas close to river mouths on the continental coast, including the Central Tyrrhenian Sea and the Spanish coasts (Telesca *et al.* 2015).

48: *Declines in butterfly populations and sub-regional biodiversity*

OECD models for 2010-2020 project a 10 per cent decrease in biodiversity for the EU and a 2 per cent decrease for the Russian Federation, thus biodiversity is likely to continue to decline across the region in varying degrees. The OECD assessment does not, however, present figures for other areas such as the Caucasus and Central Asia, and as such there is a large data gap on this issue. Protection measures have also helped to stabilize populations: Pellissier *et al.* (2013) showed that the abundance of 54 of 100 monitored common bird species in France increased with greater Natura 2000 coverage; the vast majority of these species were not listed under Annex I of the EU Birds Directive. Similarly positive effects of protection measures for birds have also been found on a pan-European level. The positive trends with regards to EU Annex 1 species show that conservation efforts helped in protecting species populations, with more pronounced improvements in the countries that have been EU Member States for a longer period of time (Sanderson *et al.* 2015).

Nonetheless, decreasing trends are consistent with other assessments, such as for the grassland butterfly populations (Figure-L2 19) and the Living Planet Index, which shows an overall vertebrate population decline, though with significant regional differences. The Palearctic realm appears to have undergone a less steep decline in species populations within the last 30 years (1970–2010) than the Indo-Pacific and Neotropical realms (WWF 2014), where the decline has been particularly steep.

Figure-L2 19: Grassland butterfly population index for 19: European countries, 1990–2011

Source: EEA 2013c

Birds are part of a specific assessment in the EU – the Bird Directive (EEA 2015h), with 447 wild breeding bird taxa assessed (Article 12, Birds Directive). Short-term trends in bird species populations reveal that in 2001–2012[10], 17 per cent of populations were threatened and 15 per cent near threatened. Around half of the populations are stable with a population status ranked as secure (EEA 2015h). A BirdLife study shows comparable figures at the European level, with 13 per cent of bird species assessed as threatened (Bird Life International 2015b).

49: *Threatened crops and animal breeds*

Generally, and at a global level, the highest numbers of domestic breeds of mammals and birds can be found in Europe and the Caucasus, including more than half of all

10 Only the EU -level trends are mentioned here. However, there are heterogeneous trends to be detected among the EU Member States. In some countries the short-term trends show a higher percentage of increasing populations, as in the UK or Ireland, whereas in Slovakia or Estonia there is a relatively high percentage of decreasing populations (EEA 2015b).

domestic avian breeds (FAO 2013a). As with species in the wild, many breeds are on the brink of extinction or have already disappeared – of all the domesticated mammalian breeds that have disappeared globally, 78 per cent were originally found in Europe. This trend of genetic erosion is on a slight rise, at least for the years 2010–2012, when the proportion of domestic breeds considered at risk rose from 22 to 24 per cent (FAO 2013a). Global projections for the period 2010–2020 also show a significant rise in the percentage of breeds at risk, although with a slowing rate of increase due to policy action (Tittensor *et al.* 2014).

For the 50 000–60 000 crop species and their wild relatives worldwide, there is a need to prevent genetic erosion, which is mainly caused by a shift to modern production systems (FAO 2010a) and the introduction of modern crop varieties (Leadley *et al.* 2014). Centres of diversity for wild crop relatives can be found in the eastern Mediterranean region and on oceanic islands, including the Canary Islands, the Azores, Sicily and Corsica (Bilz *et al.* 2011). While general trends are less certain for wild crop relatives than for domestic animals, individual examples show the need for specific in-situ conservation and sustainable use of wild species, such as apples and pears (*Prunus* spp.) and wild relatives of cereal crops. This view is supported by a study that shows that around 25 per cent of EU native wild crop relatives are at risk. Domesticated crop varieties generally contain relatively little genetic diversity compared to their wild relatives, highlighting the need to conserve the entire gene pool (Leadley *et al.* 2014).

50: Main threats to biodiversity

The main threats to biodiversity vary considerably between different taxa and ecological groups as well as at different spatial scales. For example, the global threats to vertebrate species including those exploited commercially are mainly direct exploitation such as hunting or fishing (for 37 per cent of populations). Land-use change and other forms of habitat loss constitute the most important threats to vertebrates, followed by climate change and other pressures (WWF 2014). For 25 780 vertebrate species categorized on the IUCN Red List, the main drivers of biodiversity loss include agricultural expansion, logging, overexploitation and invasive alien species (Hoffmann *et al.* 2010). For many mammal and bird species, hunting may be the most important threat in some areas, while for many endemic species, particularly on islands, the main threat is from invasive alien species (Leadley *et al.* 2014).

Pressures on biodiversity also vary between different realms. For the marine realm, overfishing is one of the most important pressures, whereas for terrestrial ecosystems the most severe threats are associated with habitat loss due to agriculture and land conversion. In the marine realm, too, there are other specific threats, such as ocean acidification and hypoxia (Leadley *et al.* 2014). For freshwater species, particularly fishes, waterway infrastructure and management such as the construction of dams, hydropower installations, and the abstraction of water for agriculture or drinking water often constitute direct threats (Collen *et al.* 2014; Freyhof and Brooks 2011).

51: Threats to biodiversity from agriculture

Agriculture is the main form of land use in the pan-European region, occupying 47 per cent of territory in the EU (EC 2007b). Agricultural intensification and increases in food and renewable energy production are bound to have significant effects on the extent and viability of natural ecosystems. Apart from direct interference with specific organisms through, for example, fertilization or eradication of pests and weeds, far wider-reaching and harmful intensification measures include changes to the landscape, such as terracing or drainage of peatlands and wetland forests (EEA 2008b). Seventy per cent of species of the European region linked to agro-ecosystems and 76 per cent of habitats have an unfavourable conservation status. More than 80 per cent of assessed amphibians linked to agro-ecosystems fall into the category 'unfavourable', while mammals and invertebrates are the only species groups with some favourable assessments, though this is still less than 10 per cent. Since 1980, the population of European common birds has declined by 10 per cent and, among them, farmland birds have declined by around 50 per cent. There are several reasons for the decline of farmland birds, however, the decline was mainly caused by an increased specialization and intensification of agriculture (EEA 2009b).

52: Agriculture as a source of pollution

Agriculture continues to be a large source of diffuse environmental pollution, from causing nutrient enrichment through fertilizer run-off, to pesticides with long-term residues in surface and groundwater bodies affecting freshwater biota. Amphibians, the most threatened and rapidly declining vertebrate group in the EU, are particularly vulnerable to pesticide and other micro-pollutant toxicity. The increasing diversity and amounts of new agro-chemicals impose unknown pressures and challenges, especially for long-term and cascading effects through food chains. For example, neonicotinoid pesticides (Nieto *et al.* 2014) have recently emerged as a significant new threat to many insect pollinator species, including honeybees (EASAC 2015: van der Sluijs *et al.* 2015). As another emerging pollutant issue, the effects of nano-materials and particles on most organisms and ecosystems are still largely unknown.

53: Land-use change and land management are pressures on biodiversity

Land-use change and land management have been identified as the main pressures leading to biodiversity loss globally (MA 2005a), including projections up to 2050 (OECD 2012). The OECD 2012 study analyzed the main pressures on biodiversity by looking at mean species abundance, an indicator that measures the abundance of original species relative to their assumed population size in an undisturbed pristine or primary habitat (Alkemade *et al.* 2009). The study shows that global decline has mainly been caused by land-use change and management, including conversion for food crops, which caused a 10.4 per cent decrease in mean species abundance; pasture, which caused a 5.9 per cent decrease; and to a much lesser extend bioenergy. But other drivers of change are also relevant, for example forestry, which is responsible for 2.8 per cent of loss. Other pressures include the development of infrastructure, habitat encroachment and fragmentation (all three drivers 9.6 per cent), pollution (for example, nitrogen deposition 0.6 per cent) and climate change (2.5 per cent). For the future, around 20 per cent of additional loss in mean species abundance projected for 2010–2030 will be caused by crop production and livestock farming. However, other drivers will become more dominant in the coming decades (OECD 2012). Globally, the impact of forestry and climate change will increase in the future (OECD 2012).

The mechanisms and consequences of reductions in suitable habitat through fragmentation and direct loss are well understood or documented for many organism groups, but habitat fragmentation, degradation and loss are among the most pervasive threats to biological diversity (Wilson 1992). Habitat fragmentation, in the broad sense of the term, has two different aspects: direct habitat loss, and loss of habitat quality through edge effects (Selva *et al.* 2011; Didham 2010; Fahrig 2003). A synthesis of fragmentation experiments spanning multiple biomes and scales, five continents, and 35 years demonstrates that habitat fragmentation reduces biodiversity by 13–75 per cent and impairs key ecosystem functions by decreasing biomass and altering nutrient cycles (Haddad *et al.* 2015).

In spite of the planning concept of preserving large non-fragmented areas consisting of large patches of at least semi-natural habitats, fragmentation has continued in Europe over the last 20 years and its rate is projected to increase in the future (Jaeger *et al.* 2011).

For improving landscape connectivity and reducing fragmentation, the ecological network concept was raised in North America and Europe in the late 1970s and the early 1980s. An ecological network is a system of representative core areas, corridors and buffer zones designed and managed in such a way as to preserve biodiversity, avoid fragmentation, maintain or restore ecosystem services and allow the sustainable use of natural resources through interconnectivity of its physical elements within the landscape and existing social/institutional structures (UNEP 2003). The number of projects of ecological networks and green infrastructures in Europe is increasing at all levels – local, regional, national and transnational: currently, there are ecological networks in various stages of implementation in 35 European countries (Jongman 2015; Plesník 2014; ECNC 2012). Another approach is that of high-nature-value farmland landscapes (Lomba *et al.* 2015), which is particularly relevant for rural policies.

54: Urbanization in the EU: past, present and future

Urbanization dominates the EU landscape, causing specific problems to ecosystems and biodiversity. Urban sprawl has accompanied the development of towns and cities across the EU over the past 50 years, with cities expanding their area by 78 per cent on average, while the population has grown by only 33 per cent. The dense enclosed quarters of the compact city model have been replaced by free-standing apartment blocks, semi-detached and detached houses, with more than a doubling of the space occupied per inhabitant over that period. On a straight extrapolation of current practices, a 0.6 per cent annual increase in urban area, although apparently small, would lead to a doubling of the total amount of urban area in a little over a century (EEA 2005). Residential urban areas have expanded at four times the rate of population growth, while industrial and commercial areas have grown more than seven times as rapidly since 1990 (EEA 2015g ; EEA 2013c). The EU goal of no net land take by 2050 must be met by designing a future urban environment with broad public appeal, developing a green infrastructure within urban zones of planned networks of natural or semi-natural areas managed to deliver a range of ecosystem services (EEA 2013g). With high levels of urbanization, energy demands continue to rise, bringing increased demands on land for renewable energy production and distribution, leading to conflicts of interest with the conservation of biodiversity and natural habitats (Hastik *et al.* 2015; Gove *et al.* 2013).

55: Overexploitation of forest resources

With a long-standing tradition of forestry and forest management, deforestation is no longer a threat for the region as a whole, and many forest areas, especially in Western and Central Europe appear stable. Still, unsustainable forest management, in combination with increased fragmentation and the effects of climate change, pose threats to forest biodiversity, particularly in parts of Central, Eastern, and South Eastern Europe, the Caucasus and Central Asia, and overexploitation of forest resources remains a significant pressure. Even where wood harvesting in EU is largely sustainable, dead wood – which is an important substrate for entire guilds of invertebrates and fungi – remains well below optimal levels in most forests.

On average, annual wood harvests for 24 countries representing 96 per cent of the forests in EU, are significantly under the annual mean level of growth (UNECE and FAO 2011). The total growing stock of European forests adds up to 114.2 billion cubic meters, with 96 billion available for wood supply. Growing stock in these has expanded by 8.6 billion cubic meters over the past 20 years (Table 7) representing an annual average of 0.39 per cent during this period. This assessment may however be hiding a more precarious situation for biodiversity, particularly as the data do not cover all the biodiversity hotspots of the pan-European region, particularly the Caucasus, Iranian-Anatolian zone and the mountains of Central Asia, where forests are still threatened. Large tree diameters and over-mature stands are not favoured in managed forests, so forests in the EU are largely even-aged and between 20 and 80 years old.

Table 7: Net annual increment and felling by region, 2010

Region	Net annual increment		Fellings	
	Million m3	m3/ha	Million m3	m3/ha
Russian Federation	852.9	1.3	170.0	0.3
Northern Europe	237.2	4.6	181.1	3.3
Central-Western Europe	261.0	7.8	172.4	5.0
Central-Eastern Europe	98.3	5.6	114.2	3.6
South-Western Europe	78.4	3.3	29.3	1.4
South-Eastern Europe	23.9	5.9	16.9	2.7
Europe with the Russian Federation	1 551.6	1.8	683.2	0.8
Europe without the Russian Federation	698. 7	5.4	513.2	3.5
EU-27	619.7	4.7	469.3	3.7

Source: UNECE/FAO 2011

In some parts of Europe, especially Central, Eastern (Bouriaud 2005) and South Eastern Europe (Markus-Johansson *et al.*

2010), illegal logging is still ongoing. It is one of the topics studied by the Regional Environment Centre (REC), an international organization based on a charter signed by 30 European countries and the European Commission. Poverty is the main driver of illegal logging. In most countries the highest volume of illegal logging takes place in private forests, supplying firewood for the population. The effects of illegal logging are wide ranging, including loss of habitats and biodiversity, erosion and land degradation, desertification and climate change, social disruption, and economic impacts on tourism, recreation and traditional communities. Illegal logging also leads to the erosion and degradation of river basins and affects water quality.

Despite some recent progress (Valentik 2014), illegal logging has been a problem in the Russian Federation, particularly in the east of the country, caused particularly by strong demand from China and Japan (Smirnov 2013).

However, there are attempts to overcome illegal logging, for example through legal enforcement. The EU Timber Regulation (No 995/2010 of the European Parliament and Council of the EU) lays down obligations on operators who place timber and timber products on the market, seeking to counter trade in illegally harvested timber and timber products through three key obligations. The Regulation entered into force on 3 March 2013.

In 2009, imports of wood from illegal harvesting into the EU accounted for a volume of 15–34 million cubic meters; amounting to 3–6 per cent of all wood imports and 2–4 per cent of wood for domestic use within the EU. About half of imports are traded directly, with the other half imported through third countries. If the EU is taken as one region without internal trade, then the import of illegally harvested wood is considerably lower, at 8–18 million cubic meters. At the same time, however, exclusion of the intensive internal trade results in a higher share of 6–13 per cent of total imports into the EU (Dieter *et al.* 2012).

56: *Long-term trends*

Long-term historical declines in commercial fish landings, coupled with changes to marine food webs induced by fishing, are clear signs of unhealthy fish populations (FAO 2014a). In the eastern Mediterranean and Black Sea, the total percentage of overexploited and collapsed fish stocks exceeded 50 per cent and growing populations were less than 10 per cent (Tsikliras *et al.* 2015). Dedicated policies related to managing marine fisheries and to protecting marine biodiversity were agreed upon in the 2008 EU Marine Strategy Framework Directive, but despite some recent positive results from the implementation of this and other policy instruments, current use of the natural capital of Europe's seas does not appear to be sustainable (EEA 2015i).

57: *Regulation on invasive alien species*

Invasive alien species can be defined as introduced species that compete with, prey upon or hybridize with native species, that transmit or cause disease, and affect habitats and ecosystem processes. By modifying and changing habitats, they interfere with ecosystem services and become disease vectors that influence human health, affect economic activities and damage infrastructure.

More than 12,000 alien species have already been recorded in the EU (EC 2014b ; DAISIE 2012), of which 10–15 per cent are considered harmful. Recent research and surveys point to increasing and accelerating trends of new introductions of alien species across all taxonomic groups, causally linked to increasing movements of goods and services and corresponding to globally observed patterns (Butchart *et al.* 2010; McGeoch *et al.* 2010). Particularly vulnerable species and habitats are at increased risk because alien species often invade nature reserves and protected areas (Monaco and Genovesi 2014; Hulme *et al.* 2013; Pyšek *et al.* 2013). For the EU, one out of five species classified as threatened is being directly affected by alien species (Genovesi *et al.* 2015).

Land-use change (Chytrý *et al.* 2012) and climate change can exacerbate the impact of invasive alien species on native biodiversity, increasing the number of potential invasions as species respond to a changing climate and an expansion or shift in their distribution ranges. Invasive alien species are generalists and highly adaptable, and are therefore expected to cause even more harm under climate change conditions (Bellard *et al.* 2013; STDF 2013; Walther *et al.* 2009). In recognition of this high and increasing threat, the EU has responded with regional, national and dedicated legislation through EU Regulation 1143/2014 on Invasive Alien Species, which entered into force in 2015.

Furthermore, indicators on the impact of alien invasive species in the EU have been developed across a range of spatial scales and have been based on a range of measures. The EEA has provided a major contribution to this through the Streamlining European Biodiversity Indicators (SEBI 2010) project. Indicators include cumulative numbers of alien species since 1900; alien species that are of greatest threat to biodiversity; the impacts and abundance of alien species; awareness; and costs. Data come from the European Network on Invasive Alien Species (NOBANIS) database, which at that time included data for 11 Northern European countries (NOBANIS 2012).

58: *Effects of climate change*

Climatic thresholds for the survival or reproduction of individuals, often mediating demographic changes, vary across seasons and life-history stages (Garcia *et al.* 2014). Species responses encompass physiological, phenological, and biogeographical changes, and these may have implications for ecosystem functioning and structure (Bellard *et al.* 2012). At the species level, recorded impacts of climate change include changes in physiology, phenology and bionomics, geographical distribution, for example, species moving north or to higher elevations and interaction with other species (Kovats *et al.* 2014; Hannah 2011; Huntley 2007; Parmesan 2006; Theurillat and Guisan 2001). Briophyte communities in Arctic habitats in the pan-European region have been shown to lose productivity due to less abundant snow during winters (Elmendorf *et al.* 2012a, 2012b). For their phenology, many organism groups like butterflies are linked to specific (spring) temperatures, which initiate their activity (Stefanescu *et al.* 2003). In response to climate change, 46 out of 69 studied European bumblebee species are projected to experience range contractions by 2050 (Potts *et al.* 2015), and many species groups monitored in Europe already show range shifts towards the pole (Mason *et al.* 2015). A recent meta-analysis, however, suggests that altered species interactions in response to climate change may be more important than direct effects (Ockendon *et al.* 2014).

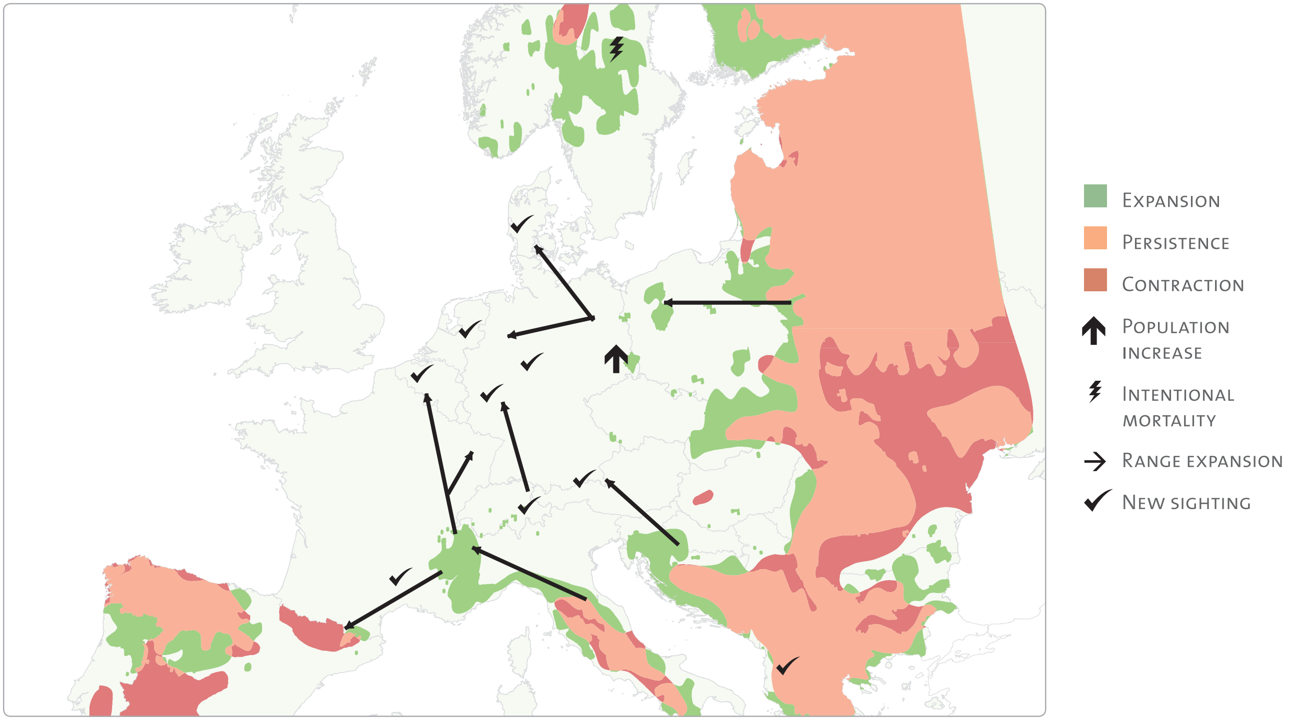
59: *Biodiversity data gaps*

Certain areas in particular suffer from biodiversity data gaps. Estimates of species richness in the Irano–Anatolian highlands or Central Asian mountains, for example, are most likely underestimates (Ficetola *et al.* 2013). Insufficient data are available for 23 per cent of the species classified under the European Red List assessment (2 250 species out of 9 735 assessed species) (IUCN 2015a), and 50 per cent of European cetaceans and turtles have not yet been assessed for EU Habitats Directive Article 17. Furthermore, among European marine species overall, 20 per cent of the species are data deficient (Nieto *et al.* 2015). For many species, detailed data on their distribution and population trends are sparse. Unequal coverage or availability of monitoring data leads to a spatial bias, with particularly sparse data for Eastern and South Eastern Europe, the Caucasus and Central Asia. Temporal gaps in data prevent the detection and interpretation of changes and trends for species and populations, and thus critically limit biodiversity knowledge, for example, when evaluating the effectiveness of conservation measures. Significant gaps also exist in genetic data (Geijzendorffer *et al.* 2015), including for domesticated animals (FAO 2013). Reasons for data gaps vary between areas and taxa, and can be due to the inaccessibility of certain regions, such as in the Caucasus, lack of local or regional capacity, or taxonomic uncertainties (Bilz *et al.* 2011). Thus, an important future need will be to close biodiversity data and monitoring gaps across the pan-European region.

60: *Wildlife management*

Wildlife management is particularly challenging for large carnivores because they are iconic species, move across boundaries due to their large range, and come into conflict with humans. Nonetheless, there are signs of stabilizing and even increasing populations after decades of decrease or even extinction.

Figure-L2 20: Expansion, persistence or contraction of the grey wolf (*Canis lupus*) population in continental Europe



Source: Deinet *et al.* 2013

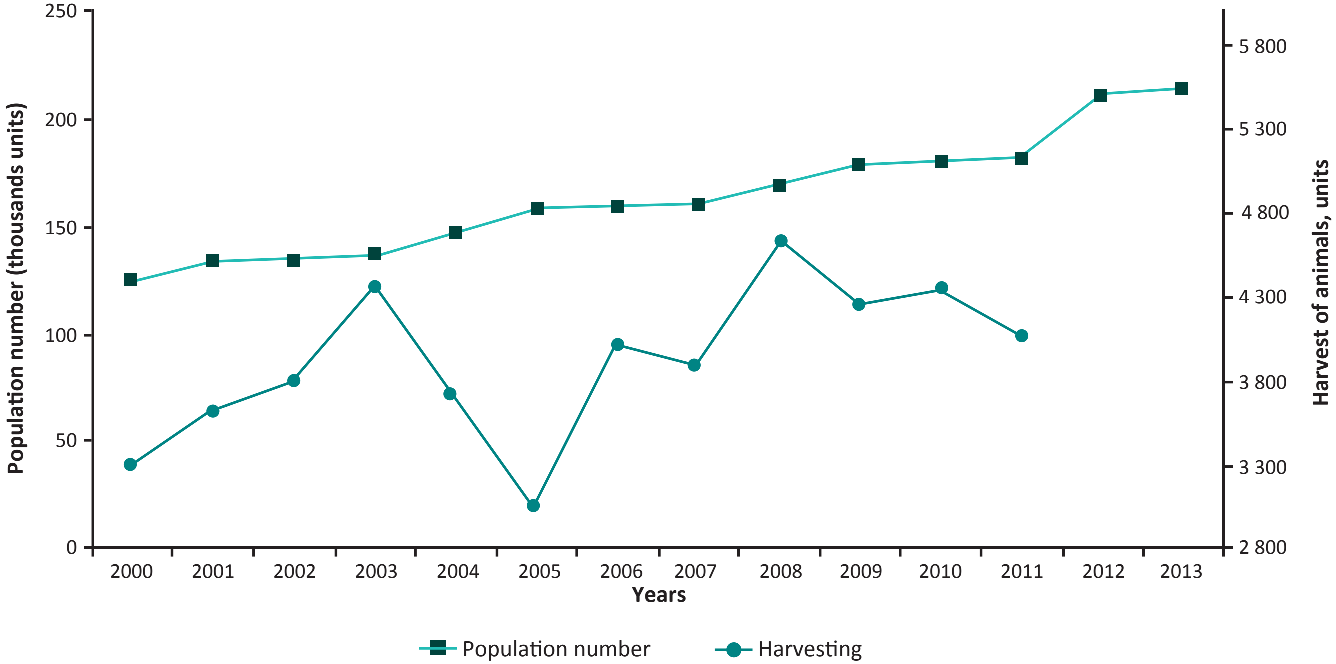
The grey wolf (*Canis lupus*), for example, now has mostly stable populations and has even expanded its range, particularly in recent years (Figure-L2 20), inter alia due to better public acceptance (Deinet *et al.* 2013). Range expansions have been observed in Central and Western European countries due to natural recolonization of modern human-dominated landscapes – for example in Germany and France – the estimated total European population seems to be more than 10 000 individuals. Overall, populations are increasing in most countries (EC 2012).

Another positive example is the brown bear (*Ursus arctos*). It occurs in 10 populations across the EU with a clear increase detected in six of them compared to a 2005 assessment (EC 2012). Populations in the Russian Federation (Figure-L2 21) have also increased over the last 13 years (WWF-Russia 2014).

61: EU Biodiversity Policies

With 18 per cent of the terrestrial area of the EU Member States, 20 per cent of forests and 4 per cent of marine waters under protection (EC 2015b; EEA 2015h), the EU has met the Aichi target to have at least 17 per cent of terrestrial and inland waters covered by protected areas by 2020 (CBD 2010). It was established by the EU Birds and Habitats Directives, that constitute the main pillars of EU policy on nature conservation and biodiversity (Gantioler *et al.* 2010; Gaston *et al.* 2008). The EU Birds Directive (Council Directive 2009/147/EC) was adopted in 1979 and established a framework and objectives for the conservation of birds throughout the EU (Donald *et al.* 2007). In 1992 it was complemented by the EU Habitats Directive (Council Directive 92/43/EEC), which targets all species and habitats of European importance not covered by the Birds Directive (Fock 2011; Graziano *et al.* 2009). Together

Figure-L2 21: Number of brown bears (*Ursus arctos*) of the wild populations in the Russian Federation and harvesting numbers, 2000–2013



Source: WWF-Russia 2014

they constitute the most ambitious and large-scale initiative undertaken to protect the biodiversity of Europe through the implementation of the Natura 2000 network (Gantioler *et al.* 2010).

Chemicals and wastes

62: Contaminated sites

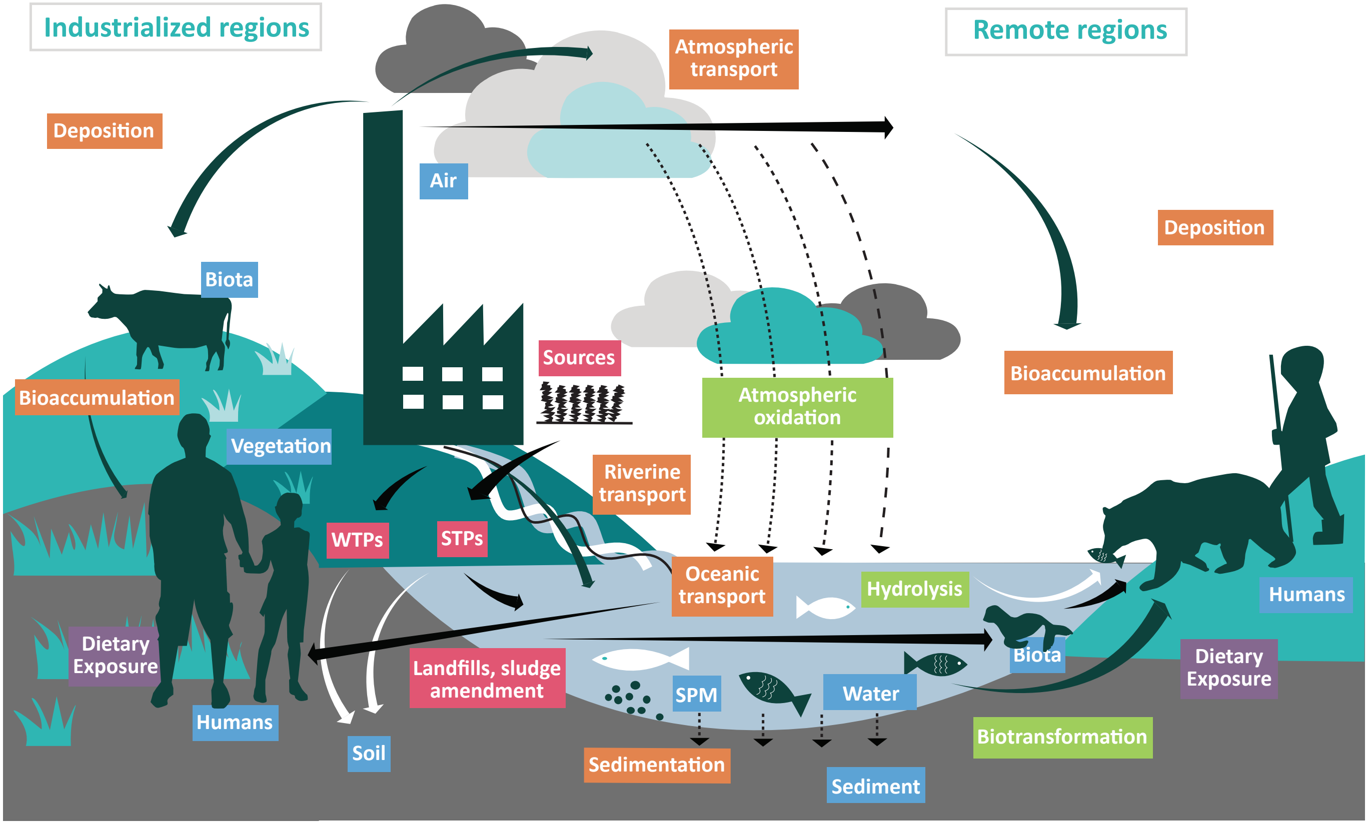
Waste generation and the use of chemicals in economic activities are main causes of local soil contamination throughout Europe. In 39 EIONET (European Environment Information and Observation Network) countries alone, an estimated number of 340 000 contaminated sites present a potential risk to humans, water, ecosystems or other receptors (van Liedekerke *et al.* 2014). Nearly 40 per cent of these sites are related to waste disposal and treatment (both authorised and illegal operations) (van Liedekerke *et al.* 2014). One common problem at landfills and waste dumping sites is the release of leachate with high levels of heavy metals and ammonia, but also other constituents. Of specific concern is that many sites that were used to dump waste in earlier decades remain to be discovered. In some regions illegal dumping still exists. Implementation of state-of-the-art waste management does not only avoid negative impacts on the environment and consequently to human health, but also reduces costly remedial measures. Remediation success stories provide evidence of the high efforts needed to succeed and the large variety of practices and techniques applied (JRC 2015).

63: Humans are exposed to chemicals

People are exposed to chemicals through air, drinking water, food and direct contact with products containing chemicals (Figure-L2 22). The routes of exposure start at the source, which may be a point source, such as emissions from industry, or a diffuse source, such as combustion in car engines or emissions from products. Once emitted, chemical pollution is transported through the environment. The route and the final destination of the pollution will depend both on the character of the source and on the chemical properties of the pollutant. From emissions to the air, pollutants can be transported long distances by atmospheric transport and be deposited on land or water bodies. Pollutants can be further transported in water or settle in sediments, often bound to suspended particulate matter (SPM). Waste water treatment plants (WTPs), or sewage treatment plants (STPs) remove some pollutants, but others continue with the water flow. Throughout transport, chemical pollutants can degrade or transform, for example through hydrolysis. Pollutants in water and on land are taken up by organisms and directly by humans. Some chemicals are bioaccumulated, which means that more is taken up than metabolized or excreted by the body or organism, so that the concentration in the body or organism increases. Chemical pollution in water, air, soil and vegetation enters the food chain and thus contributes to human exposure. People are also exposed to chemicals in the indoor environment, mainly from products containing and releasing chemicals in the home.

Effluents from wastewater treatment plants have become significant sources of chemicals released from products, personal care products and pharmaceuticals to surface waters in many countries in the EU. A recent study indicated

Figure-L2 22: Pathways through which humans are exposed to chemicals



Credit: Dr. Annika Jahnke, Helmholtz Centre for Environmental Research-UFZ, Leipzig Germany that wastewater effluents from 36 per cent of 75 investigated treatment plants from throughout Europe contained estrogenic activity (Jarošová *et al.* 2014) indicating risk of endocrine disruption in the receiving waters (more information below under 'Chemical pollution in the region').

64: *Chemical pollution in the region*

Heavy metals in air: Deposition levels (measurements in air and precipitation) of cadmium, lead and mercury decreased in the region between 1990 and 2011, on average by 51, 75 and 37 per cent, respectively (EMEP 2013). The largest reduction was seen in urban areas located close to anthropogenic sources characterized by relatively rapid emission changes. The decline in heavy metal deposition in Eastern Europe, the Caucasus and Central Asia was generally less.

POPs in air: In general, ambient air concentrations of PCBs in the northern hemisphere decreased over the past two decades (EMEP 2014; Schuster *et al.* 2010). Dioxins decreased significantly in air in Western, Central and Southern Europe, while Northern Europe and parts of Central and Eastern Europe and the Caucasus exhibited smaller reductions (EMEP 2014). The largest reduction in dioxin air concentrations was estimated for the Netherlands, Luxembourg, and Belgium (about 90 per cent), with the smallest in Azerbaijan (9 per cent), Turkey (9 per cent), and Kyrgyzstan (2 per cent) (EMEP 2014).

POPs and heavy metals in sediment and soil: Decreasing levels of POPs in the environment due to reduced emissions are evident in decreasing concentrations in sediment over time, for example in the Baltic Sea (Sobek *et al.* 2015; Assefa *et al.* 2014). However, point sources still exist throughout the pan-European region and contribute to very high levels of POPs in some areas. One example is the outlet of the Kur-Araz river system in the Caspian Sea, where coastal sediment concentrations of PCBs are of the order of one part per billion (ppb) (Aliyeva *et al.* 2013), while coastal sediment concentrations in the Baltic Sea are about 1 000 times lower (Sobek *et al.* 2015).

POPs – organochlorine pesticides (OCPs) in soil: Several countries in Central and Eastern Europe and the Caucasus and in Central Asia have historic storage sites with obsolete pesticides. The storage sites, as well as past use of organochlorine pesticides (OCPs), can contribute to elevated levels of OCPs in soil. Concentrations 250 to 1 650 times higher near obsolete pesticide sites than in background soils in Azerbaijan have been reported (Aliyeva *et al.* 2013). Concentrations of OCPs are also high in arable land in Azerbaijan compared, for example, with arable land in Turkey (Karadeniz and Yenisoy-Karakaş 2015) and the Czech Republic (Komprda *et al.* 2013).

Endocrine disruptors: Nearly 800 chemicals are known or suspected to be capable of interfering with the hormone systems of humans and wildlife, and increasing the frequency of many endocrine-related diseases and disorders (UNEP and WHO 2013). Exposure through consumer products and materials in homes may be significant (Dodson *et al.* 2012). Wastewater treatment plants that collect household sewage may therefore be a source of estrogenic activity to surface waters throughout Europe (Jarosova *et al.* 2014). Protecting society from endocrine disruptors is challenging since effects may occur long after exposure. There are several examples of confirmed links between chemicals and hormonal disorders, including:

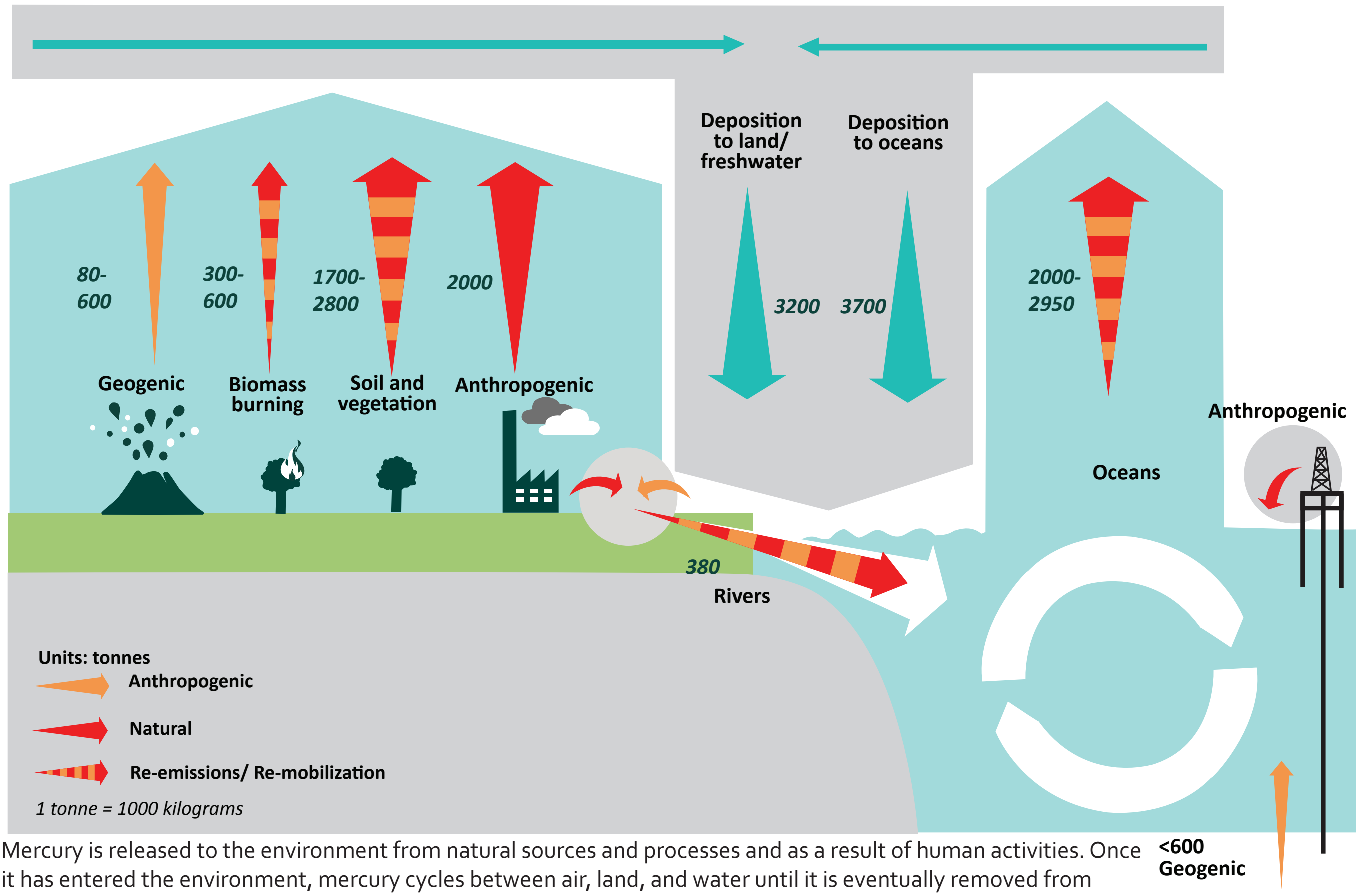
- developmental neurotoxicity with negative impacts on brain development that is linked with PCBs;
- attention deficit/hyperactivity disorder (ADHD), which is overrepresented in populations with high exposure to organophosphate pesticides (UNEP and WHO 2013); and
- late pubertal onset in boys in the polluted city of Chapaevsk (Russian Federation) associated with pre-pubertal exposure to elevated levels of dioxins (Korrick *et al.* 2011).

Polycyclic Aromatic Hydrocarbons (PAHs): PAHs are formed through combustion of fossil fuels and waste, as well as biomass burning. The urban air is contaminated by PAHs and PAHs are also released into the marine environment from combustion as well as directly from oil spills.

Nanomaterials: This is a group of substances for which there are increasing environmental levels and concern. While their production and application are growing rapidly, the data to assess the associated risks are not yet sufficient to clearly identify systematic rules to govern their use (SCENIHR 2009).

Heavy metals: a category of chemicals with serious health effects. Heavy metals like lead and mercury have serious health effects. **Lead**, which bioaccumulates, affects multiple body systems and is particularly harmful to young children (WHO 2014b). In Kazakhstan, a former lead smelter has polluted the nearby city of Shymkent, leading to very high lead concentrations in soil. The contaminated area covers some 50 square kilometres which contain houses, several schools and kindergartens. As many as 50 per cent of the Shymkent school children are estimated to have blood lead concentrations that exceed World Health Organization (WHO) recommendations (UNEP 2013c).

Figure-L2 23: Global mercury cycling



Mercury is released to the environment from natural sources and processes and as a result of human activities. Once it has entered the environment, mercury cycles between air, land, and water until it is eventually removed from the system through burial in deep ocean sediments or lake sediments and through entrapment in stable mineral compounds. Methylmercury, the most toxic and bioaccumulative form of mercury, which presents the greatest health risk to humans and wildlife, is mainly formed in aquatic environments through natural microbial processes.
Source: UNEP 2013f

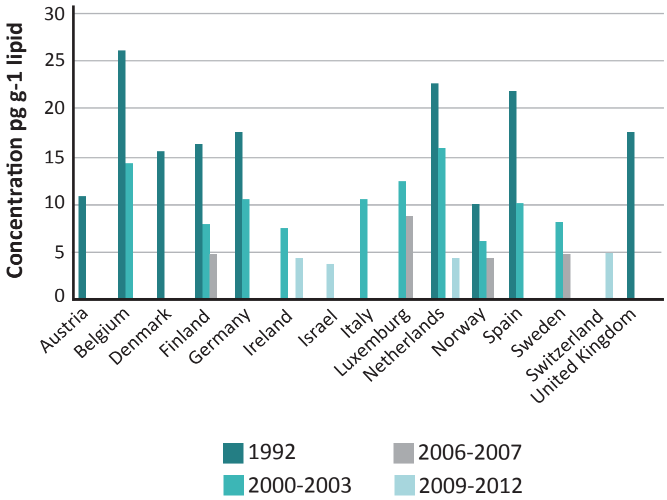
Mercury has toxic effects on nervous, digestive and immune systems, posing a particular threat to the development of the child *in utero* and in early life stages. People are mostly exposed to mercury in informal occupational situations, such as small-scale mining, but there can also be a general exposure of populations, for example through food, due to mercury pollution in the environment (WHO 2003). Mercury is still being mined in the Khaidarkan *mining operation in Kyrgyzstan*, which was until recently the last exporting primary mercury mine globally (UNEP and UNITAR 2009). Mercury emissions in the region are still significant and originate from several different sources (Figure-L2 23). The recent Minamata Convention on Mercury is a global commitment to step up the efforts to reduce negative impacts on human health and the environment from mercury (UNEP 2013d).

Asbestos is a mineral fibre which is linked to occupational diseases and still in use in Central Asia and in Central and Eastern Europe and the Caucasus (Banduch and Lissner 2013). Asbestos was produced in some countries in Central and Eastern Europe and the Caucasus between 1990 and 2000 (Banduch and Lissner 2013), with the Russian Federation and Kazakhstan among the top six producers. Although several of these countries have banned the use of asbestos, it is still used as a building material in some countries (Banduch and Lissner 2013; UNEP 2013c). Occupational diseases related to asbestos exposure have been reported in Central and Eastern Europe and the Caucasus (Banduch and Lissner 2013). Asbestos is still also present in many buildings which continue to cause exposure during maintenance, alteration and demolition (Pira *et al.* 2009).

65: *Mixed trends in monitoring chemical pollutants in the environment*

The concentration of POPs in human milk is considered a good indicator of the actual body burden, and the concentration in human milk of some POPs is decreasing over time. Although dioxin concentrations also are decreasing over time in many of the countries for which data is available (Figure-L2 24) (UNEP 2015c; RECETOX 2014), levels of dioxin-like polychlorinated biphenyls (PCBs) and dioxins are

Figure-L2 24: Toxic equivalent concentrations for dioxins in human milk from World Health Organization (WHO) milk surveys, 1992– 2012

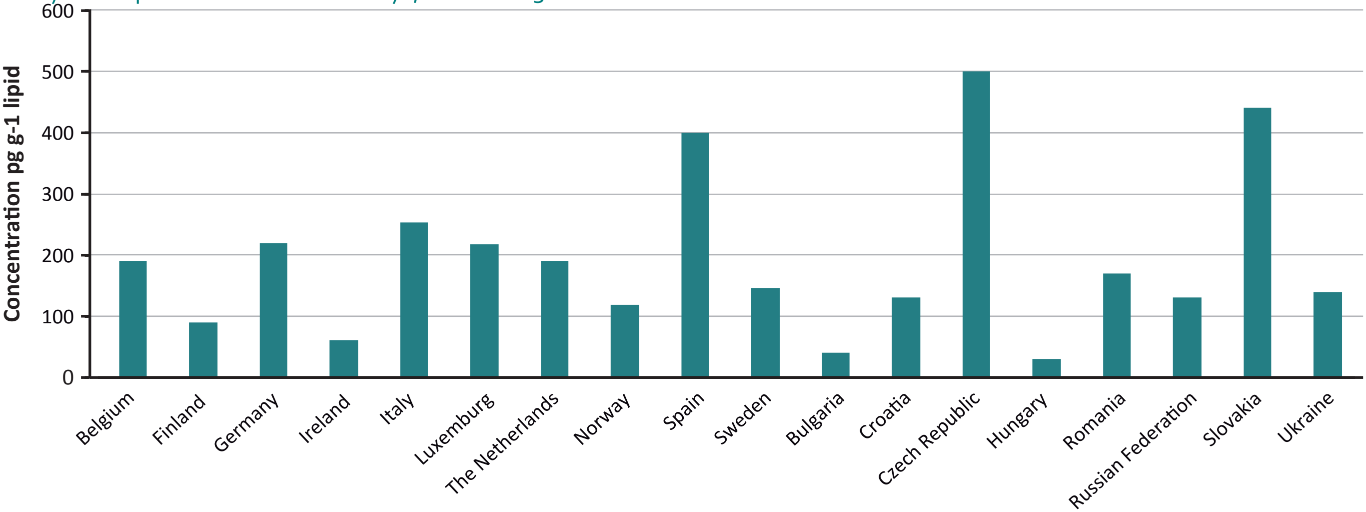


Source: UNEP 2015c

generally still considered a human health concern (UNEP and WHO 2013), particularly as the tolerable daily intake for a nursing baby might be exceeded during breastfeeding. There is growing concern about the effects of prenatal, *in utero*, POPs exposure (UNEP 2013e).

National trend monitoring programmes for human milk and blood serum only exist in Sweden and Germany. Analyses in these countries on pollutants, including PCBs, dioxins, organochlorine pesticides (OCPs) and fluorinated chemicals, show decreasing trends (UNEP 2015c). Repeated surveys in eight countries in Central and Eastern Europe and the Caucasus between 1992 and 2009 show that PCB concentrations decrease over time (RECETOX 2014), with the most significant decreases in countries that used PCBs in paints (RECETOX 2014), and levels decreased as the use was stopped. Figure-L2 25 shows concentrations of the six indicator PCBs in human milk from 18 pan-European countries, analysed as part of WHO milk surveys between 2000 and 2003.

Figure-L2 25: Concentrations of the six indicator PCBs (sum of PCB 28, 52, 101, 138 , 153 and 180) in human breast milk analysed as part of WHO milk surveys, 2000–2003



Source: Data compiled from RECETOX 2014 and UNEP 2015c. Data for countries in Central and Eastern Europe and the Caucasus was estimated from graphs in the report by RECETOX

66: *Municipal solid waste*

Municipal solid waste (MSW) according to the EU Landfill Directive is 'waste from households, as well as other waste which, because of its nature or composition, is similar to waste from households'. However, due to diverse waste management practices, some differences exist in how countries define MSW, which poses a specific challenge in assessments and in the coordination of transnational initiatives (EEA and UNEP/MAP 2014; EEA 2013h). MSW represents only a fraction of total waste, and around one quarter in OECD countries (Wilson *et al.* 2015), but countries that have efficient MSW management systems generally show good performance in overall waste management (EEA 2015a). The generation of MSW is closely linked to economic prosperity, but stable or partially reducing MSW generation in Western Europe demonstrates some decoupling of waste generation from economic growth. The EU has been influential in harmonizing reporting by Member States and beyond, but statistical data from South Eastern and Eastern Europe and the Caucasus and Central Asia need further improvement (EEA 2015a; UNECE 2015a). Increasing quantities of collected household waste may reflect increasing waste generation, but may also be due to improved collection, particularly in urban areas. Household waste generated in rural areas often remains unaccounted for.

Despite the remaining challenges, there are promising ongoing efforts under the auspices of the UNECE Working Group on Environmental Monitoring and Assessment (WGEMA) which defined the data and information to be made available as part of the pan-European Shared Environmental Information System (SEIS). Through WGEMA, Western European countries, part of the EIONET, and countries from Eastern Europe and the Caucasus, and Central Asia have agreed on 67 specific data sets that any country in the region should aim to make available and accessible on-line during 2015 (UNECE 2015b).

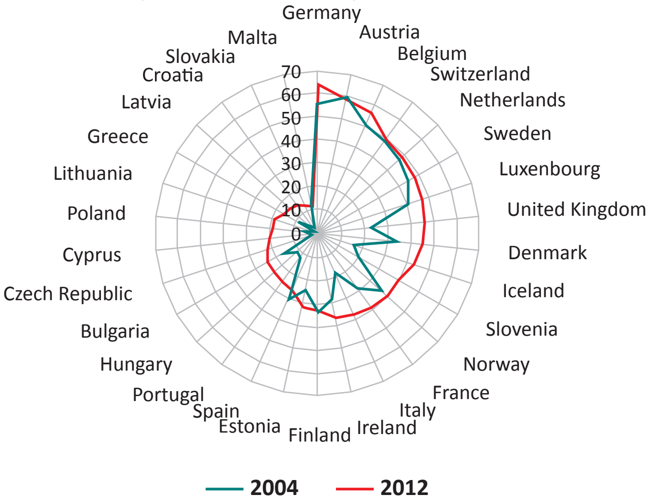
67: *MSW landfills*

Implementation of state-of-the-art sanitary landfilling needs further progress throughout Central Asia, Eastern Europe and the Caucasus. For the Russian Federation alone, the *Global Waste Management Outlook* (Wilson *et al.* 2015) reported the existence of more than 7 500 waste disposal sites in 2010, with one quarter being MSW landfills, seven per cent industrial disposal sites and 70 per cent unauthorised dumps.

68: Recycling of MSW and waste-to-energy

Recycling is a common practice throughout Western Europe, and increasingly applied in Central Europe (Figure-L2 26). Recycling levels show significant differences between countries in these subregions, with higher MSW recycling rates achieved in countries that make use of a larger variety of policy instruments (EEA 2013h). In the EU, increasing recycling has resulted in constantly declining landfill rates (percentage of all wastes going to landfills): the average MSW landfill rate in the EU was 47 per cent in 2004 but only 32 per cent in 2012 (Eurostat 2015a). The average EU MSW recycling rate, including composting and bio-digestion, has recently exceeded 40 per cent, from around 30 per cent ten years ago (Eurostat 2015a). Despite the progress, achieving the EU's long-term objective of establishing a circular economy will require far-reaching technological, behavioural and organisational change (EEA 2015a).

Figure-L2 26: Municipal solid waste recycling, including composting and bio-digestion, Western, Central and South Eastern Europe, 2004 and 2012, per cent



Only countries with recycling rates exceeding 10% in 2012 shown; 2012 recycling rates in other countries: Romania: 3%, Turkey: 1%, Montenegro: 1%

Source: Eurostat data as compiled in *The European environment – state and outlook 2015* (EEA 2015a); instead of 2004 data, 2003 data shown for Iceland; 2005 data for Poland; 2007 data for Croatia

The recovery of resources from MSW is not a central priority in Central Asia, Eastern Europe and the Caucasus. Kazakhstan statistical data report MSW recycling at 0.5 per cent, but such statistics are lacking in the majority of countries of these subregions. From the conclusions of the *Global Waste Management Outlook* (Wilson *et al.* 2015), it can be assumed that the informal sector makes a considerable contribution to recycling: manual recovery from containers is common throughout Central Asia and targets, for example, glass and plastic bottles (UNEP 2013c).

Separation of waste at source is critical to enable recycling, and even in countries with high recycling rates, this is currently better implemented for dry recyclables than for organic matter. Food waste has received much attention during recent years, however, recycling of organic wastes generally is an area that requires further progress throughout the region.

Waste that is neither recycled nor landfilled is mainly subjected to energy recovery. The majority of waste-to-energy plants around the world implementing MSW combustion with energy recovery (electricity and heat) are in the EU (Wilson *et al.* 2015), and about one quarter of EU MSW is incinerated with energy recovery (Eurostat 2015a).

69: Success story from the Republic of Moldova: reducing pesticides and PCB contamination

In cooperation with foreign donors, the Republic of Moldova succeeded in significantly reducing its old stockpiles of pesticides and PCBs. In total, 2 276 tonnes of chemicals were removed and disposed of abroad in 2007–2012. This figure includes 1 342 tonnes of pesticides and 934 tonnes of old capacitors containing PCBs from the energy sector (UNECE 2014b).

70: Hazardous waste

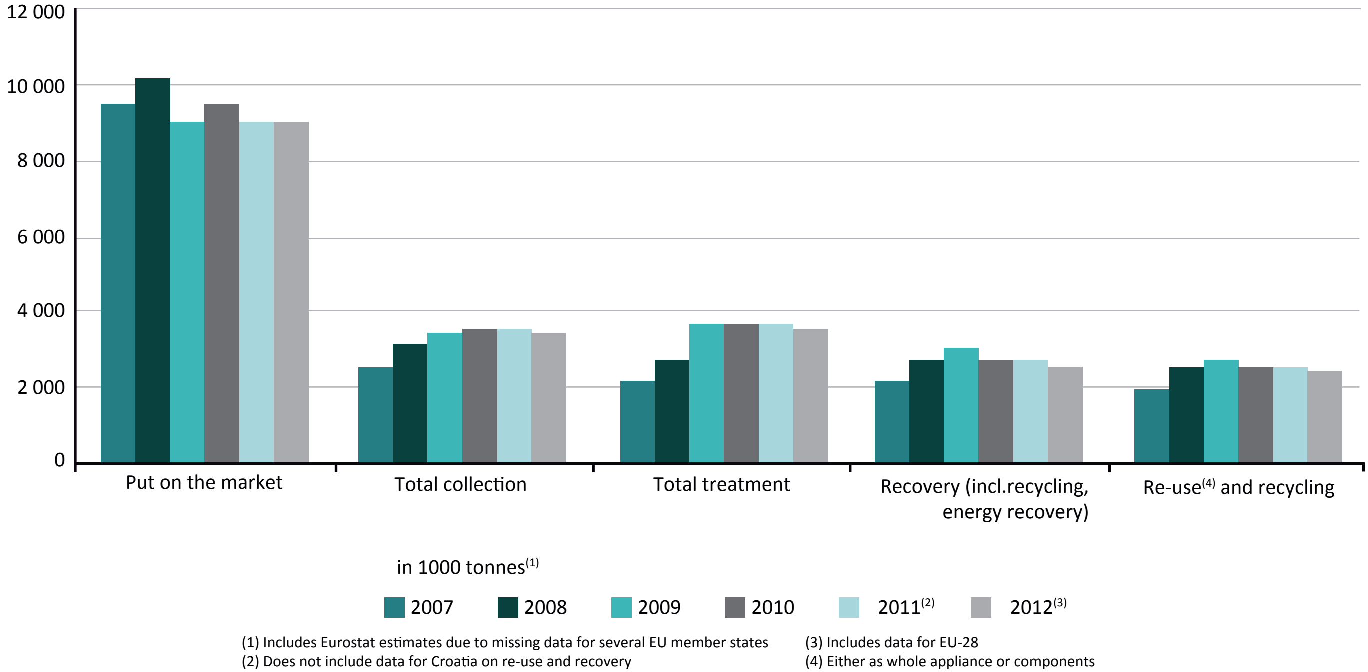
Under the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, hazardous waste is defined as categories of wastes containing hazardous substances and having hazardous characteristics (Annex I, II, III of the Basel Convention) (Basel Convention 1989) (radioactive material is not included). Waste amounts are usually referred to in absolute quantities or on a per capita basis. The waste intensity of an economy, the amount generated per unit of gross domestic product (GDP), is another way of assessing how much waste a society produces. In the region, the hazardous waste intensity of economies shows very high differences. The EU average throughout the last decade was less than 10 tonnes of hazardous waste generated per million US$ of GDP. There are much higher hazardous waste intensities in Central Asia, which generates thousands of tonnes per million US$ of GDP and the Caucasus which generates hundreds of tonnes per million US$ of GDP, due mainly to extensive mining activities (Eurostat 2015a; UNEP 2013c).

71: Waste Electrical and Electronic Equipment (WEEE) collection in the EU

The EU has set minimum targets through the WEEE Directive for separate collection of WEEE and for recycling, which has fostered implementation of WEEE management capacities in EU Member States. Until 31 December 2015 the WEEE Directive required the individual Member States to achieve a separate collection of at least 4 kilograms on average per inhabitant per year of WEEE from private households. From 2016 on, the total weight of WEEE collected has to be at least 45 per cent of the average weight of EEE put on the market in the three preceding years, and the target will become more ambitious in 2019. EU collection rates for WEEE have been growing in recent years, although the trend is slowing down. In 2012, 3.5 million tonnes (6.9 kilograms per person) of WEEE were collected separately in the EU (Eurostat 2015b), which is significantly below the level of electrical and electronic equipment put on the market (Figure-L2 27).

Collected WEEE is mainly re-used (as whole appliance or components) and recycled and, since 2010, most EU Member States have achieved a re-use and recycling rate of more than 80 per cent (EEA 2013i). Annually in the EU, about 1–2 kilograms of WEEE per person, mainly small equipment, are disposed of in mixed residual household waste, but with considerable variation between countries (Baldé *et al.* 2015). Those WEEE flows amount to 8 per cent of total e-waste

Figure-L2 27: Electrical and electronic equipment (EEE) put on the EU market and WEEE collected and treated, 2007–2012



Source: Eurostat 2015d

generation in the EU (Baldé *et al.* 2015). Gaps in statistical data for other subregions hinder comparative assessments (Baldé *et al.* 2015), while the varying lifespans of different consumer products add to the challenge of tracking collection rates for products that become waste.

72: *Detrimental effects caused by e-waste flows to other regions*

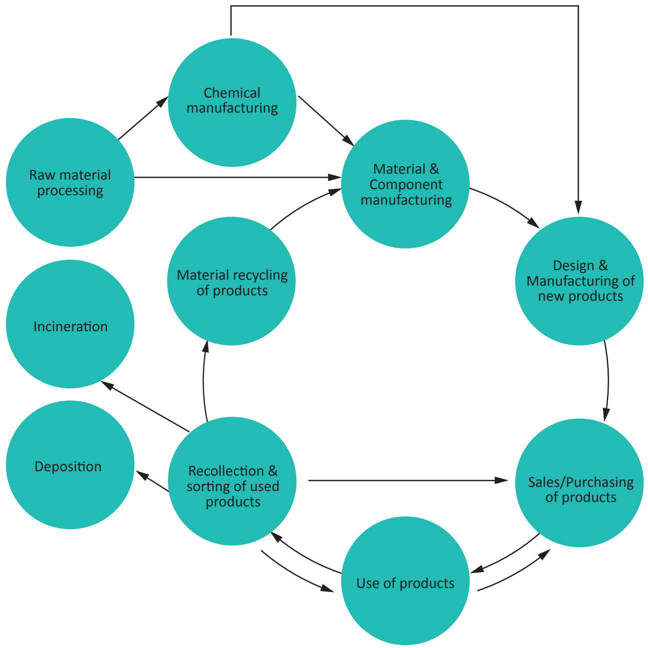
Informal processing of exported WEEE causes exposure to hazardous substances. China, which imports around 8 million tonnes of WEEE illegally every year (UNODC 2013), has been a prominent downstream destination for European WEEE (Geeraerts *et al.* 2015), although the launch of China's Operation Green Fence in 2013 might in the future divert these flows to Africa (Rucevska *et al.* 2015).

Rudimentary methods used in the informal processing of WEEE pose environmental and health risks, not only to those directly involved, but also to others as pollution can enter food and water systems. Air, soil and water can be affected by a variety of pollutants, often bio-available and accumulating (Sepúlveda *et al.* 2010). Main sources of contaminants are original constituents of electrical equipment, chemicals used in the recycling processes, or effluents from the recovery processes. Environmental impacts associated with WEEE result in a number of acute human health risks, including lung cancer and blood poisoning, with socially vulnerable groups being the most susceptible to harmful exposure (Geeraerts *et al.* 2015; ILO 2014). As one example, 80 per cent of children in Guiyu, a Chinese WEEE hotspot, suffer from respiratory diseases and lead poisoning (Sepúlveda *et al.* 2010).

73: *Life-cycle for chemicals contained in products*

Chemicals are used as feedstocks for the production of materials, for giving materials and products specific properties and functions, and as process chemicals in production, with possible emissions at different stages of the life cycle (Figure-L2 28). In addition to the flows in the figure, chemicals are also used in the maintenance of products or for protecting products during transport.

Figure-L2 28: Simplified life-cycle for chemicals contained in products



Source: UNEP 2015b

74: *EU Toy Safety Directive*

The EU Toy Safety Directive (2009/48/EC) aims to protect children from mechanical, electrical and chemical risks associated with toys. According to the latest amendment from July 2013, all toys placed on the EU market must fulfil the chemical requirements of the directive. These include a ban on carcinogenic, mutagenic and reprotoxic (CMR) substances and migration limits for a number of substances, mainly metals (KEMI 2015).

75: *Toxic toys*

A study carried out in 2012 analysed 569 different toy products on the market in Armenia, Belarus, Kazakhstan, Kyrgyzstan, the Russian Federation and Ukraine. About 30 per cent of tested products contained at least one toxic metal, while 18 per cent of the toys exceeded the Russian Federation's regulatory limits for lead and 3 per cent for mercury. One toy was found to have a lead concentration 580 times above the Russian Federation's limit. The five products with the highest lead concentration were a plastic skipping rope from Ukraine, a toy lock from Armenia, a skirt for a stuffed animal from Kyrgyzstan, a ceramic mug from Belarus, and a toy car from the Russian Federation (IPEN and GRID-Arendal 2013).

76: The business case for increasing knowledge about chemicals in products (CiP) and supply chains

Companies could benefit directly from increasing their knowledge about chemicals contained in their products and used in their supply chains:

- the use of CiP information systems enables and stimulates companies and entire product sectors to realize benefits, from achieving product safety to leading product innovation;
- most product sectors do not have suitable information systems in place to enable the reliable exchange of the chemical-content information that is needed to meet regulatory and customer demands;
- brands and retailers that only react when compelled by crises or regulations hold hidden liabilities of chemicals of concern in their products. In the past, these liabilities have incurred costs running from tens to hundreds of millions of US dollars, have tarnished brand reputations, and have resulted in losses of market share and valuation; and
- from governments and consumers to retailers and brands, access to information and awareness of chemicals in products is driving companies and customers to prefer and select inherently safer options, selections that make achieving the goals of the Strategic Approach to Integrated Chemicals Management (SAICM) possible.

Source: The business case for knowing chemicals in products and supply chains (IOMC 2014).

77: Food waste is in the policy agenda

Adverse impacts of food losses are manifold and include increased greenhouse gas emissions as well as increased use of land, water and chemicals such as fertilizers and pesticides. Globally, annual food losses cause a blue water footprint through consumption of surface and groundwater of 250 cubic kilometres, roughly three times the volume of Lake Geneva (FAO 2013b; FAO 2013c).

Video: "Food wastage footprint" by FAO

https://www.youtube.com/watch?v=IoCVrkcaH6Q

Video "Food wastage footprint 2" by FAO

https://www.youtube.com/watch?v=Md3ddmtja6s

The FAO, together with other partners, has established a pioneering global initiative on food loss and waste reduction (*SAVE FOOD*). Further, food waste was the main theme of 2014's *European Week for Waste Reduction*, which resulted in several thousand activities in more than 30 countries and the elaboration of a set of tools for various stakeholders (EWWR 2014). In 2016, France as the first country worldwide adopted a law that obliges big supermarkets to implement measures to redistribute their unused food, thus fostering donation of unsold food to charities.

In recent years, the number of initiatives addressing food wastage has exploded. Awareness of the scale of the problem is high, and bringing the subject into discussions and communications, *including comprehensive visualizations* can further increase attention. While the level of engagement is positive, greater coordination and better consideration of the complexity of influencing factors are necessary if food wastage is to be addressed as part of integrated approaches to more sustainable food systems. Simplified approaches or high-profile initiatives may engage different groups, but need to be complemented by holistic assessments. Currently, a common approach in high-income countries is to link consumer waste to low awareness as a consequence of general affluence. While this may be one factor, it is not a complete explanation: buying food once a week and accepting that some will be wasted may be an economically rational decision compared to frequent, small-quantity shopping trips (Koester 2012).

Responses to the problem of food wastage need to go beyond the currently prevailing focus on quantity. The environmental impact of wasting different foods varies considerably (FAO 2013b), related to factors such as the fertilizers and pesticides used, irrigation, and processing. In addition, impacts differ along the supply chain, both economically and environmentally. A potato in a shop, for example, is different from the same potato on the farm, since services and processing activities occur along the supply chain (Koester *et al.* 2013). Waste reduction needs to be balanced with other priorities, and indeed an economic assessment by the FAO (2014b) indicated that zero food waste is not socially optimal in economic terms. Under environmental criteria, negative trade-offs might outweigh benefits if engineered infrastructures with high-energy requirements are needed to reduce losses (FAO 2014b). The close link between food and public health also requires specific attention; the detection of high dioxin levels in chickens' eggs, and grey markets that keep old meat in the food supply chain after it has become a risk to public health, are two examples of failures in the food supply system that demand rapid responses other than waste prevention.

78: *Progress towards sound waste management in Eastern Europe, Caucasus and Central Asia*

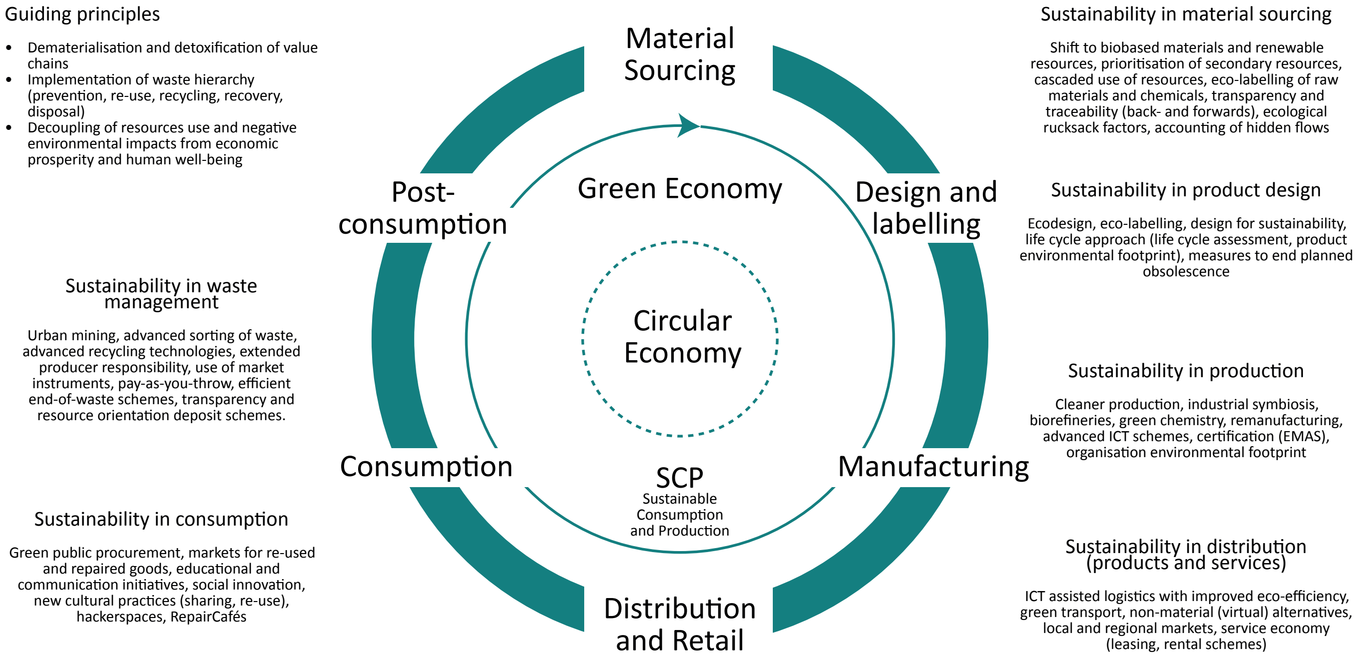
Kazakhstan which has the highest per person income in Central Asia, shows clear progress towards sound waste management (sanitary landfilling and waste-to-energy incineration), and promising trends were also identified for Kyrgyzstan and Uzbekistan (UNEP 2013c).

In Eastern Europe and the Caucasus, the example of Georgia, which developed comprehensive waste management legislation and strategies between 2012 and 2014 in the context of the EU twinning project "S*trengthening the capacities of the ministry of environment and natural resources protection in development and improvement of the waste management system in Georgia*", illustrates the value of transnational cooperation and sharing of know-how.

79: *Towards sustainable consumption and production*

Eco-innovation, aimed at significant and demonstrable progress towards the goal of sustainable development, is increasingly being applied along the whole chain of value creation (Figure-L2 29). Eco-innovation comprises technological, social and organisational innovation (EEA 2016). Decoupling of both resources use and negative environmental impacts from economic prosperity remains a central challenge of the region with its high resource dependency. Along with a shift to bio-based materials and renewable resources, circularity of material flows is a central strategy (more information on circular economy is available elsewhere in this section of the report). Tools applied to assess sustainability include ecological rucksack, life cycle assessment, product environmental footprint and organisation environmental footprint, with the latter two recommended by the European Commission (EC 2013g). In implementing life-cycle perspectives, it is essential to also

Figure-L2 29: From a linear to a circular economy and sustainable consumption and production

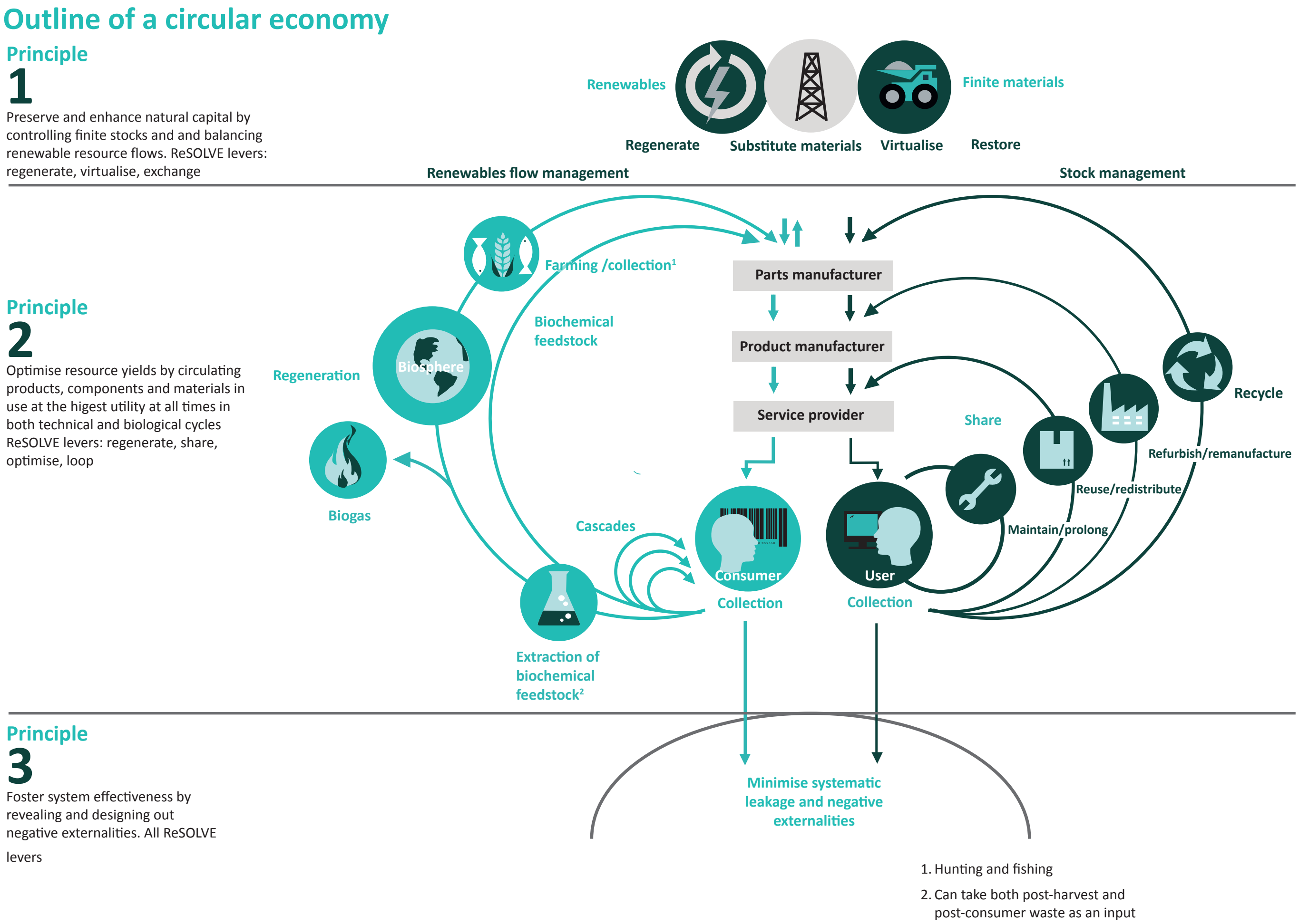


assess and take into consideration trade-offs and potential risks of new patterns in consumption and production. A shift toward a sequential and circular use of materials, including chemicals, increases resource productivity, however, it might also result into adverse concentration and accumulation of substances in products and environmental compartments and therefore requires tailored risk management strategies (Bilitewski *et al.* 2013, 2012). In developing the bioeconomy as part of an inclusive green economy, bio-based products and bioenergy derived from organic wastes and residues can help to alleviate competing requirements for food and non-food applications of biomass.

80: Circular economy

The traditional linear model of production, based on take, make and dispose, does not address the need for more sustainable use of natural resources. For more than 50 per cent of companies in the EU, material inputs represent at least 30 per cent of their total costs, and reliance on imported resources is a factor of increasing concern throughout the EU (EC 2015e). Transition to a circular economy (Figure-L2 30), based on a circularity of resources in value chains, dematerialization and a shift to renewable resources, is seen as a pathway to ensuring competitive advantage for the pan-European region and meeting the global challenge of more efficient resource use (EC 2015e; Ellen MacArthur Foundation *et al.* 2015; Wijkman and Skanberg 2015). Central elements of the circular economy include remanufacturing and product life-cycle extension schemes such as re-use and refurbishment. Remanufacturing integrates used components at an industrial scale, to supply products in like-new condition. In some sectors characterized by high-value end-of life products, the potential benefits of re-manufacturing go beyond those provided by recycling of used materials. Recycling is a key element, although it can face specific challenges, for example due to the growing

Figure-L2 30: Circular economy system diagram



Source: Ellen MacArthur Foundation 2015

complexity of products (UNEP 2013e). Life-cycle thinking requires consideration of resource optimisation at all stages of the value chain and fosters the role of the design stage.

The potential to offer significant energy and material savings while maintaining or even increasing product value is a main benefit of circular economy schemes. This underlines the importance of internalizing the environmental costs. Where it makes economic sense, for example in response to fluctuations in raw material prices, circular-economy thinking is already integrated into company strategies (EC 2015e). Shifting to circular models throughout the economic system would require significant transition costs, including investment in research and development and infrastructures, but could result in overall benefits of EUR1.8 trillion by 2030, twice the benefits of the current development path (Ellen MacArthur Foundation *et al.* 2015). In the EU alone, an expanding circular economy has the potential to create

1.2 to 3 million jobs (WRAP 2015). How well and quickly adequate skills and education for the circular economy can be developed will be decisive to realise the benefits (EEA 2016).

Video: "Re-thinking Progress: The Circular Economy"

https://www.youtube.com/watch?v=zCRKvDyyHmI

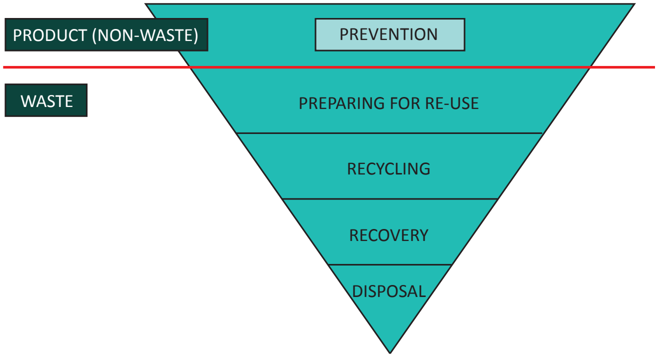
81: *Waste hierarchy*

The waste management hierarchy, or waste hierarchy, indicates the prioritization of waste management options. It is often visualized in the form of an inverted pyramid, with the most preferred option on top. Different versions of the waste hierarchy exist, depending on the region, country or context. The common element is that waste prevention stands on top of the hierarchy, suggesting that prevention of the generation of waste should be considered a key priority. At the bottom of the hierarchy, indicating the least preferred option, sits disposal of waste that cannot be prevented or valorised – landfilling or incineration without energy recovery.

Recognition of the waste management hierarchy (prevention, minimization, reuse, recycling, other recovery including energy recovery, and final disposal) is a guiding principle of the strategic framework for the implementation of the Basel Convention (Basel Convention 2011) to encourage treatment options that deliver the best overall environmental outcome under consideration of a life-cycle perspective.

The hierarchy of waste management is a cornerstone of the EU Waste Framework Directive (Directive 2008/98/EC) (EC 2015f). Its five-step waste hierarchy defines the following prioritization: Prevention, Preparing for re-use, Recycling, Other recovery (e.g. energy recovery), and Disposal (Figure-L2 31).

Figure-L2 31: Waste management hierarchy according to the EU Waste Framework Directive



Source: EC 2015a

An example can illustrate some of the challenge in managing complex waste streams. The EU Waste Framework Directive gives an option of managing any risks associated with waste so that it can be moved up the hierarchy and turned into a product. The end-of-waste process, however, is interpreted differently among Member States. For example, in the UK, a waste can be made into a lawful product; in France, once a waste has entered a waste treatment facility, every fraction or stream leaving this facility is still legally considered as waste – to obtain a national end of waste recognition for a specific stream, the operator has to prove that risks can be managed and are not higher than the ones generated by the use of the virgin (original) product or substance; and in Norway, a waste can only be a product if it has been completely detoxified by the removal of all potential contaminants, even if they are not mobile. As a result, specific wastes can only be processed into products in some EU countries, which is an impediment to the introduction of a circular economy and a disincentive to companies to develop and implement new risk management options for waste. The circular economy package adopted by the European Commission in December 2015 addresses this problem and adapts the relevant legislative framework (EC 2016a).

82: Industrial Symbiosis

One of the most powerful tools for resource efficiency is represented by industrial symbiosis, creating cooperation and synergies between two or more industries that engage in sharing and common valorisation of resources such as: materials, energy, water, assets, expertise, logistics, excess capacity, etc. Networks are not necessarily limited to industrial partners but often include non-industrial participants such as municipalities. Proximity of participants is of advantage, therefore implementation of industrial symbiosis typically is at a localised scale, such as in industrial parks, however, networks can include participants at different geographical sites.

Most common is the case that a material stream, regarded by one entity as waste, gains added value as it becomes a valuable resource for another entity. Shared use of specific equipment or common pooling of resources are other examples of symbiotic cooperation. The best-known case of a network with optimized exchange of materials and energy between dissimilar industries remains *Kalundborg* (Denmark), which became the pioneer of industrial symbiosis in the second half of the last century.

Throughout the past decade, industrial symbiosis has become a widely-prioritized strategic policy tool in the context of the green economy. Embedded in the EU's flagship initiative for resource efficiency, the Roadmap for a Resource Efficient Europe (EC 2011b) recommends exploiting resource efficiency gains through industrial symbiosis as a priority for EU Member States. In line with this, industrial symbiosis is also a focus of the EU circular economy package launched in December 2015 (EC 2016a), recognizing its high potential for delivering the circular economy. *EUR-ISA*, the European Industrial Symbiosis Association aims to connect the industrial symbiosis networks across EU Member States. The G7 Summit in June 2015, under German presidency, committed to establishing the G7 Alliance on Resource Efficiency to share knowledge and create networks, and to strengthen the pioneering role of the G7 countries in the field of resource efficiency as a signal for other countries, and industrial symbiosis was explicitly put on the alliance's event agenda already in 2015 (German Federal Government 2015).

83: Ecodesign and the key role of the design stage

Choice of materials, design and production mode determine environmental performance and the durability of a product. Recyclability and reparability of products, as well as potential re-use of components, for example in remanufacturing, are strongly influenced by the presence and complexity of substances and mixtures, and by the assembly of components. The design stage therefore has a central role in a circular economy. Extended Producer Responsibility (EPR), which extends responsibility of the producer to the collection, recovery and final disposal phase, is one element to ensuring that companies pay more attention to end-of-life (EoL) environmental performance already during product design. One example of EPR implementation is recovery and recycling schemes for sales packaging waste. For electrical and electronic equipment (EEE), EPR is implemented throughout the EU through the WEEE Directive. Furthermore, for EEE the EU Restriction of Hazardous Substances (RoHS) Directive has been influential, as it restricts the use of certain hazardous substances, such as lead, cadmium, mercury, chromium, polybrominated biphenyls and other dangerous compounds, in electrical and electronic equipment.

Recognition of the key role of the design stage is also reflected by ecodesign measures in the new circular economy package of the European Commission (EC 2016a). At present, ecodesign in the EU regulations is strongly linked to energy efficiency, since the Ecodesign Directive (Directive 2009/125/EC) refers to energy-using and energy-related products sold in the Member States. Energy labelling and ecolabelling are elements that have proven to foster the adoption of ecodesign principles.

84: [Responsible Care]

Since its inception in Canada in 1985, Responsible Care has become the chemical manufacturing industry's key initiative aimed at improved health, safety and environmental performance. Responsible Care is now being implemented in 60 other countries, the members being national chemical manufacturing associations. Together, the combined chemical industries taking part in Responsible Care account for more than 70 per cent of global chemical production (ICCA 2015). It embodies the chemical industry's commitment to sustainable development through the development of innovative technologies and other solutions to societal problems, as well as improved environmental, health and safety performance, and expanded economic opportunities (ICCA 2012b).

The Responsible Care Global Charter and the Global Product Strategy, are examples of industry-wide voluntary programmes that support safe management of chemicals by sharing best practices within the industry and among governmental and intergovernmental agencies. The Responsible Care programme hosts a publicly accessible *online chemical safety portal with detailed product information*. It also builds capacity to help small- and medium-sized enterprises (SMEs) and newly emerging chemical producers to meet increasingly high stakeholder expectations and supports research on health and environmental risks (ICCA 2012a). One of the performance indicators developed by Responsible Care measures the work time lost due to occupational injuries; it shows a decrease in time lost for the European member associations (Figure-L2 32).

Figure-L2 32: Lost time injury rates (LTIR) for chemical company employees, European countries.

LTIR is reported as the number of accidents resulting in one or more days out of work per million hours worked

Source: CEFIC 2015

85: [The 2020 goal of sound chemicals management]

The 2020 goal of sound chemicals management agreed at the World Summit on Sustainable Development in Johannesburg in 2002 (UN 2002a) is followed up through the *Strategic Approach to International Chemicals Management* (UNEP and WHO 2006), a voluntary agreement between countries and other stakeholders. In addition there are a number of multilateral environmental agreements in the field of chemicals and waste, including the Stockholm Convention on Persistent Organic Pollutants (POPs) (UNEP 2001), the Basel Convention on the Transboundary Movements of Hazardous Wastes and Their Disposal (Basel Convention 1989), the Rotterdam Convention on Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (UNEP and FAO, 1998), and the newly signed Minamata Convention on Mercury (UNEP 2013d).

86: [EU REACH legislation on chemicals]

Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH, *Directive EC 1907/2006*), the chemicals legislation of the EU, aims to protect human health and the environment through better and earlier identification of problematic chemical substances (EU 2015). This is done through four processes: registration, evaluation, authorisation, and restriction of chemicals. REACH also aims to enhance innovation and the competitiveness of the EU chemicals industry. REACH entered into force in 2007 and new provisions are being phased-in over time.

REACH places responsibility on industry to manage the risks of chemicals and to provide safety information on the substances. Manufacturers and importers are required to gather information on the properties of their chemical substances, which will allow their safe handling, and to register the information in a central database in the European Chemicals Agency (*ECHA*) in Helsinki. The agency is the central point of the REACH system: it manages the databases necessary to operate the system, coordinates the in-depth evaluation of suspicious chemicals and is building a public database in which consumers and professionals can find hazard information. The regulation also calls for the progressive substitution of the most dangerous chemicals, referred to as "substances of very high concern", when suitable alternatives have been identified.

87: *GHS implementation*
Countries agreed to introduce the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) by 2008, however, it has not yet been fully implemented across the region (Table 8) Implementing the GHS is a key component in sound management of chemicals.

Table 8: Status of implementation of GHS

Country or country grouping	Comment
The Commonwealth of Independent States (CIS): Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, the Russian Federation, Tajikistan, Turkmenistan, Uzbekistan and Ukraine.	The CIS countries have agreed on a number of voluntary standards (GOST 30333-2007, GOST 31340-2013 and GOST 32419-2013) corresponding to the 4th revision of GHS and the classification system uses all categories and classes (STANDARTINFORM 2015). Not all CIS countries have started to implement the standards (UNITAR 2012). Some countries are members of the EEC sub-region, see below.
	The countries have adopted a technical regulation on the safety of chemicals. The regulation includes an obligation to classify and label chemicals according to GHS. The agreement will enter into force once the countries have agreed on implementation details (IISD 2015).
EU candidate countries: Montenegro, Serbia, the Former Yugoslav Republic of Macedonia and Turkey	EU candidate countries have started to implement EU legislation which includes GHS requirements in the Classification, Labelling and Packaging (CLP) regulation (UNECE 2015a). In Serbia, GHS has been implemented and is fully in effect for single substances and mixtures. Turkey will as of 1 June 2016 have fully implemented the GHS (3rd revision) (Resmî Gazete 2013). As of 1 January 2015, GHS was mandatory for single substances and as of 1 June 2016, GHS will be mandatory for mixtures (GHS Legislation 2014). Turkey has also prepared a draft by-law to implement the REACH Regulation. The draft by-law is expected to be published in 2016.
Israel	Israel issued a draft revision of standard SI 2302 part 1 and informed the World Trade Organization (WTO) at the end of 2014. The draft includes 28 GHS hazard classes, including the 'hazardous to the ozone layer' class and additional labeling requirements (CEFIC 2014).
European Union (EU): Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Rep., Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom	CLP is the EU Regulation on classification, labelling and packaging of substances and mixtures. This Regulation aligns previous EU legislation on classification, labelling and packaging of chemicals to the GHS (UNECE 2015b).

Country or country grouping	Comment
Iceland, Liechtenstein and Norway	Iceland, Liechtenstein and Norway are members of the EEA. The EEA Agreement allows them to participate in the EU Internal Market, while not assuming the full responsibilities of EU membership. All new EU legislation in areas covered by the EEA is integrated into the agreement through an EEA Joint Committee decision and subsequently becomes part of the national legislation of the EEA states. This also applies to the EU Regulation which implements the GHS (UNECE 2015a).
Switzerland	On 1 February 2009, the amended Swiss chemicals ordinance, with a view to facilitate trade of chemicals that are already labelled according to GHS, entered into force (UNECE 2015a). GHS is implemented and fully in force for individual substances. Similar to the EU, there was a transition period for mixtures up to 1 June 2015, after which the GHS became mandatory. The implementation follows EU CLP (CEFIC 2014).
Albania	There is no official information about Albania implementing the GHS (UNITAR 2012).
Bosnia and Herzegovina	The Federation of Bosnia and Herzegovina has not yet started to implement the GHS (ECRAN 2015), however there is a new draft law on chemicals which includes specifications for classification and labelling in accordance with the CLP.
Georgia	As a part of the EU Association Agreements, Georgia will implement the CLP regulation which will result in Georgia complying with the GHS (ChemicalWatch 2014).

88: The 5-10 year prospect is one of deteriorating trends

The European Environment - State and Outlook (EEA 2015a) notes that, for chemicals, the 5–10 year prospect is one of deteriorating trends due to knowledge gaps and emerging chemicals of concern. The 20-year outlook shows a mixed picture with policies being likely to lead to progress while the long-lasting impacts of some chemicals may lead to continued deterioration in terms of health and ecosystem impacts (EEA 2015a). Central Asian countries were not covered by the assessment, but it is clear that in this sub-region substantial challenges remain in terms of establishing an adequate response to their lack of chemicals management (UNEP 2013c). The deteriorating trend noted for the coming years in countries covered by the assessment further underlines the need for a concerted policy response across the pan-European region.

89: Transboundary movement of wastes

Limitations in enforcement of the regulations of the Basel Convention can result in unintentional but also intentional breaches of regulations, often embedded in a chain of mainly legal operations. Links to organized crime exist, for example in illegal shipments of WEEE to other regions (Geeraerts *et al.* 2015). Grey areas and lack of control capacity are significant, and strategies for illegal export of wastes include false classification (e-waste as second-hand goods), hidden loading of freight on ships, and mixing of waste streams, with household waste mingled with recyclables (Rucevska *et al.* 2015; Wilson *et al.* 2015). Inconsistency in the regulations between the exporting and the importing countries is one critical element (Rucevska *et al.* 2015), and needs to be seen as a priority. The informal waste management sector remains little understood. Among others, informal activities contribute to a lack of reliable estimates about waste flows and a lack of enforcement of regulations.

Box 2: Preventing chemical accidents and mitigating their consequences: The UNECE Convention on the Transboundary Effects of Industrial Accidents.

Chemical accidents can cause an unexpected release of chemical substances, resulting in severe harm to human health and the environment. The UNECE Convention on the Transboundary Effects of Industrial Accidents helps countries to develop policies and measures to prevent industrial accidents, and to prepare for and respond to such accidents, with a focus on transboundary cooperation.

The convention requires Parties to identify installations holding hazardous chemical substances - above the thresholds listed in the Convention's annex I - which could impact neighbouring or downstream countries in the case of accidents; and to share this information with potentially affected Parties. The recent alignment of annex I with the Globally Harmonized System for the Classification and Labelling of Chemicals (GHS) supports national efforts across the region to harmonize the classification and labelling of chemicals and progress towards the sound management of chemicals and waste.

Guidance has been developed to support countries and industry in mitigating the risks linked with the manufacture, use, storage, handling or disposal of chemicals, and the safe management of chemical operations.

Low shipping costs and the demand for some types of used goods and constituents in some developing economies are drivers for illegal exports (Bisschop 2012).

Transboundary movement of waste is often perceived as generally undesirable, and it is evident that moving waste means additional resource consumption, and relocation of potentially harmful emissions from landfills into soil and water or from incineration into air. However, depending on the situation, and provided that transparency and precautionary measures in transport and treatment are available, it may be sensible, for example, to allow treatment of hazardous waste at high standards where such capacity exists. Nevertheless, the vast majority of movement is driven by economic criteria; persistence of illegal waste trafficking demonstrates the need to implement more effective control mechanisms.

There is no obligation to record data on non-hazardous waste shipments across and out of the pan-European region. This makes estimating the magnitude of the problem difficult, but assessments suggest that the EU exports almost half of plastics collected for recycling (Velis 2014). This not only means that resources leave the region, but also potential jobs. The majority of highly dynamic global recycling markets are outside the pan-European region, for instance in China, India, and Turkey. Turkey, for instance, imported around 30 per cent of the total trade of ferrous scrap outside the EU in the period 2010 to 2014 for steel production in the country (Wilson *et al.* 2015).

90: Circular economy package of the EU

The *circular economy initiative* adopted in December 2015 consists of an EU Action Plan for the Circular Economy, based on a set of strategies and concrete actions, with measures covering the whole cycle: from production and consumption to waste management and the market for secondary raw materials (EC 2016a). The initiative also contributes to wider EU objectives such as the energy and climate targets, resource efficiency, economic growth and employment. It takes forwards aspects of the EU's flagship initiative for resource efficiency (EC 2011d), which is part of the Europe 2020 growth strategy under the vision of a "smart, sustainable and inclusive Europe".

91: Critical raw materials

Critical raw materials are identified on the basis of their high importance for the economy and their high supply risk. For the EU, the European Commission has created a list of *critical raw materials* which includes rare earths, cobalt and niobium.

92: Waste prevention

Examples of progress in waste prevention prioritization:

- In the EU, the Waste Framework Directive requires Member States to establish national waste prevention programmes. Several hundred waste prevention measures are included in the programmes (EEA 2015j). However, although many countries included measures to foster innovative business models, repair, reuse and ecodesign in their programmes, the majority of policy instruments focus mainly on information and awareness raising (EEA 2016; 2015j). The monitoring of national waste prevention programmes within EIONET, gathered by the European Topic Centre on Sustainable Consumption and Production in collaboration with EEA, is presented in an *information hub on waste prevention*
- Ending planned obsolescence, understood as one priority, is increasingly addressed in policy strategies. However, further progress is required throughout the region, including implementation of regulatory mechanisms. Legislation against obsolescence has been introduced in France: (1) the French Government Decree no. 2014-1482 with producer's obligations to reveal to consumers how long appliances are minimally intended to last; and (2) the French Law on Energy Transition, which entered into force on 19 August 2015, which defines planned obsolescence as a crime that will be prosecuted.
- Participatory initiatives that bring different actors together contribute to awareness-raising and strengthen the sense of common responsibility for waste prevention and sustainable use of resources: one example is the European Week for Waste Reduction (*EWWR*) The initiative encourages public authorities, private companies and civil society to get involved and to organise or join activities. In 2014, nearly 12 000 activities were registered, which reached an estimated 24 million direct participants and up to 170 million indirect participants.
- Social innovation encouraging new cultural practices with sustainable material flows (up-cycling, do-it-yourself, sharing), and citizens who understand sustainability competence (including waste-to-resource) as a guiding principle of personal creativity and self-confidence, in a wider sense of welfare-oriented living models, reflect shifts in conceptual understanding of society and citizenship, resulting in changed behavioural patterns. Fostering this process by enabling and rewarding policy frameworks requires further progress.

93: Civil society responses for a circular economy

Turning waste into a resource has also been taken up by civil society initiatives and citizens throughout the region. Hacker spaces and repair cafes are examples of a new social phenomenon, citizens inventing new social practices and networks to overcome resource-intensive, wasteful consumption practices through non-commercial arrangements. Such initiatives are often characterized by strong social engagement and personal motivation of a group to provide opportunities for shared access to know-how, practical competencies, and basic support to encourage product durability, re-usability and reparability. Increasing numbers of networks that receive considerable public attention through social media, mainly in urban areas in Austria, Belgium, France, Germany, Netherlands and the UK, are positive examples of experimentation in sustainable consumption practices (ETC/SCP and ETC/WGME 2014; UBA 2014). Local initiatives and micro-projects in neighbourhoods, such as schools, predominate, but some have become international networks – *the repair cafe movement* has grown in the past five years to have more than 750 repair cafés in more than 18 countries where people meet to learn repair skills and related practices.

Other people engage with areas of open-source technology, including software updates and improvement. In a reaction to product dysfunctionalities based on hard- and software restrictions and/or incompatibilities, especially of personal computers, mobile phones and other electronics, *hacker spaces* have developed as community-oriented physical places where people share their interest in tinkering with technology, meet and work on their projects, and learn from each other.

To increase their outreach, more and more initiatives are connecting within urban areas, regions, and even reaching out internationally to create broader networks engaging in a collaborative economy. One such network that arose in recent years, *OuiShare*, was initially supported by EC funding to create urban and national collaborative economic networks to organize support for capacity building needed locally and internationally.

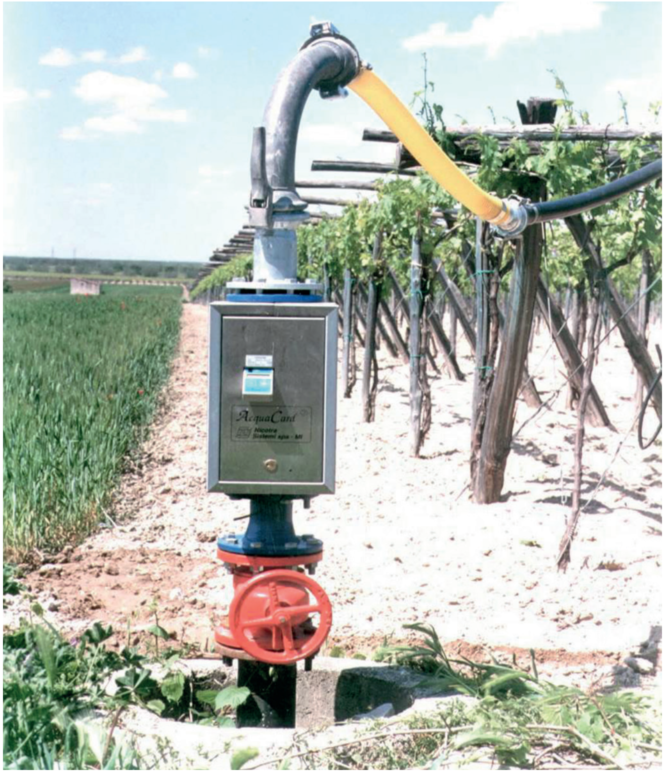
Freshwater

94: Economic and fiscal instruments to manage water demand and encourage water saving in Belarus

Belarus levies tax on water abstraction and applies pollution tax for disposing of wastewater. The rates of tax on water abstraction depend on the use for which water is withdrawn. The rates of tax for discharging wastewater are differentiated by the kind of recipient water body. The lowest rate is for discharging wastewater into watercourses and the highest fee – to discourage this practice – for disposing wastewater into the ground. The tax is also levied for storing sludge produced at wastewater treatment facilities. The tax rates are revised annually and tend to increase. The charges are applied for the provision of water supply and sewerage services by utilities. Since 2013, progressive tariffs for these services have been introduced. The basic subsidized tariff is applied when water use does not exceed 140 litres/capita/day, while a much higher tariff is charged for the water used over this threshold. Wastewater tariffs typically follow the same structure as water tariffs. The cross-subsidies between industry and household consumers, used widely until recently to increase affordability of water services to the population, have been gradually eliminated (UNECE 2016a).

Manually controlled irrigation hydrants for opening and closing water flow in the Apulia region, Italy
Credit: Dr. Nicola Lamaddalena

95: Example of water use efficiency device



Irrigation hydrants for automatic, selective and controlled water distribution, equipped with a hydraulic device coupled with electronic components. The quantity of water supplied can be programmed by an electronic card assigned to farmers
Credit: Dr. Nicola Lamaddalena

96: Water-Energy Nexus: the Amu Darya and Syr Darya

A difficult situation can be observed on large rivers in Central Asia, illustrating the Water-Energy Nexus. The Amu Darya and Syr Darya are the principal rivers of the Central

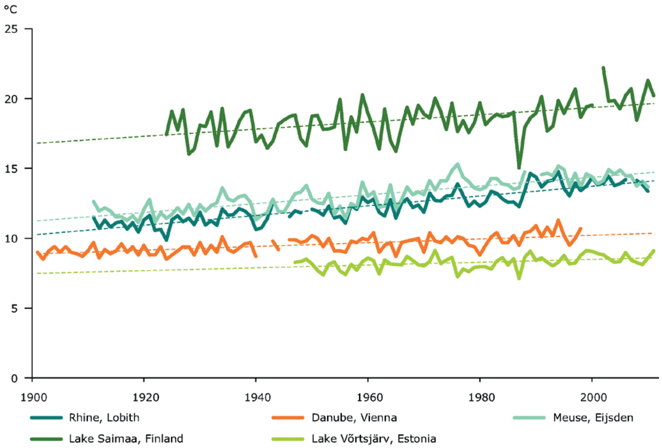
Electronic card, the portable device enabling farmers to decide on when and how much water they want to apply, monitor their water consumption and check on the remaining volume of water
Credit: Dr. Nicola Lamaddalena

Asian water network, and are under pressure from many competing demands for water for irrigation and hydropower, as well as the environment. When the transboundary river basin countries were part of the Soviet Union, water and energy resources were managed regionally via a system of reservoirs and power stations along both rivers (Ziganshina 2012). In Soviet times, the regulation of river flow for the Amu Darya and Syr Darya Rivers was adapted to the needs of irrigated farming in the lower reaches; at the same time, a centralized energy supply in the autumn and winter seasons was provided from other regions of the Soviet Union to the Soviet republics located in the upper reaches of these rivers. Water releases for power generation at hydropower plants were reduced in autumn-winter and the water was accumulated in the reservoirs for subsequent release during the growing season. Surplus electric power produced by hydropower plants upstream during the growing season was transferred to other regions through the joint energy grid of Central Asia, which is currently not functioning. Immediately after becoming sovereign states, the Central Asian countries replaced the old centralized management system for water and energy in the region by a joint management scheme based on intergovernmental cooperation. For this purpose, in 1992 they signed an agreement on cooperation in joint management, use and protection of water resources of inter-state sources. However the agreement does not refer to energy cooperation. In this situation, the upstream countries increased water releases to generate electricity from reservoirs in winter periods in order to cover a deficit of energy. Implementation of the large-scale plans for the development of hydropower in the upper reaches of the Amu Darya and Syr Darya Basins is likely to further aggravate contradictions between the upstream and downstream countries regarding the types of and regimes for water use for these rivers if no balance of interests, acceptable to all States, is found between demands for water for hydropower and for irrigation (Strengthening Water Management and Transboundary Water Cooperation in Central Asia: the Role of UNECE Environmental Conventions, UNECE 2011).

97: Trends in water temperature of large European rivers and lakes

Water temperature has increased in major European rivers by 1-3°C over the last century as result of thermal pollution by cooling water and wastewater intakes from treatment plants as well as an increase of air temperature caused by global warming. Water temperatures in large lakes have increased by about *0.1-0.3°C per decade* as observed in lakes across Europe (Figure-L2 33).

Figure-L2 33: Trends in water temperature of large European rivers and lakes

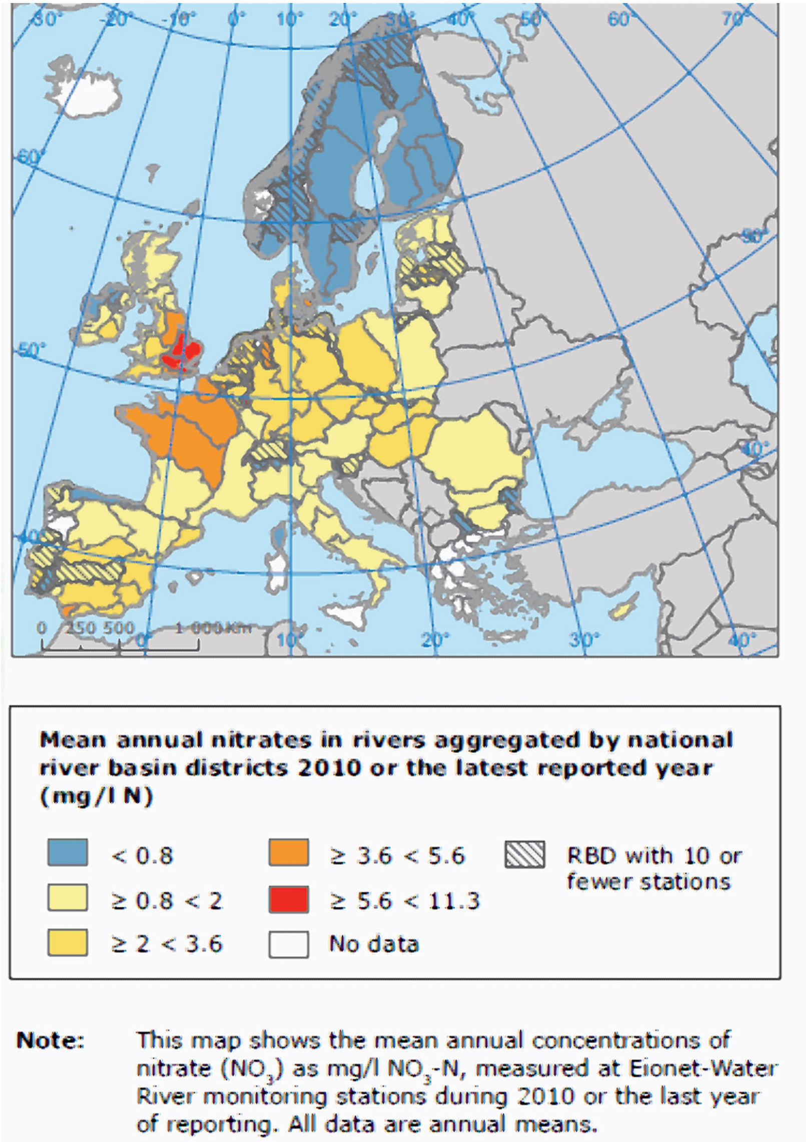


Source: EEA 2012a

The surface water temperature of some rivers and *lakes in Switzerland* has increased by more than 2 °C since 1950.

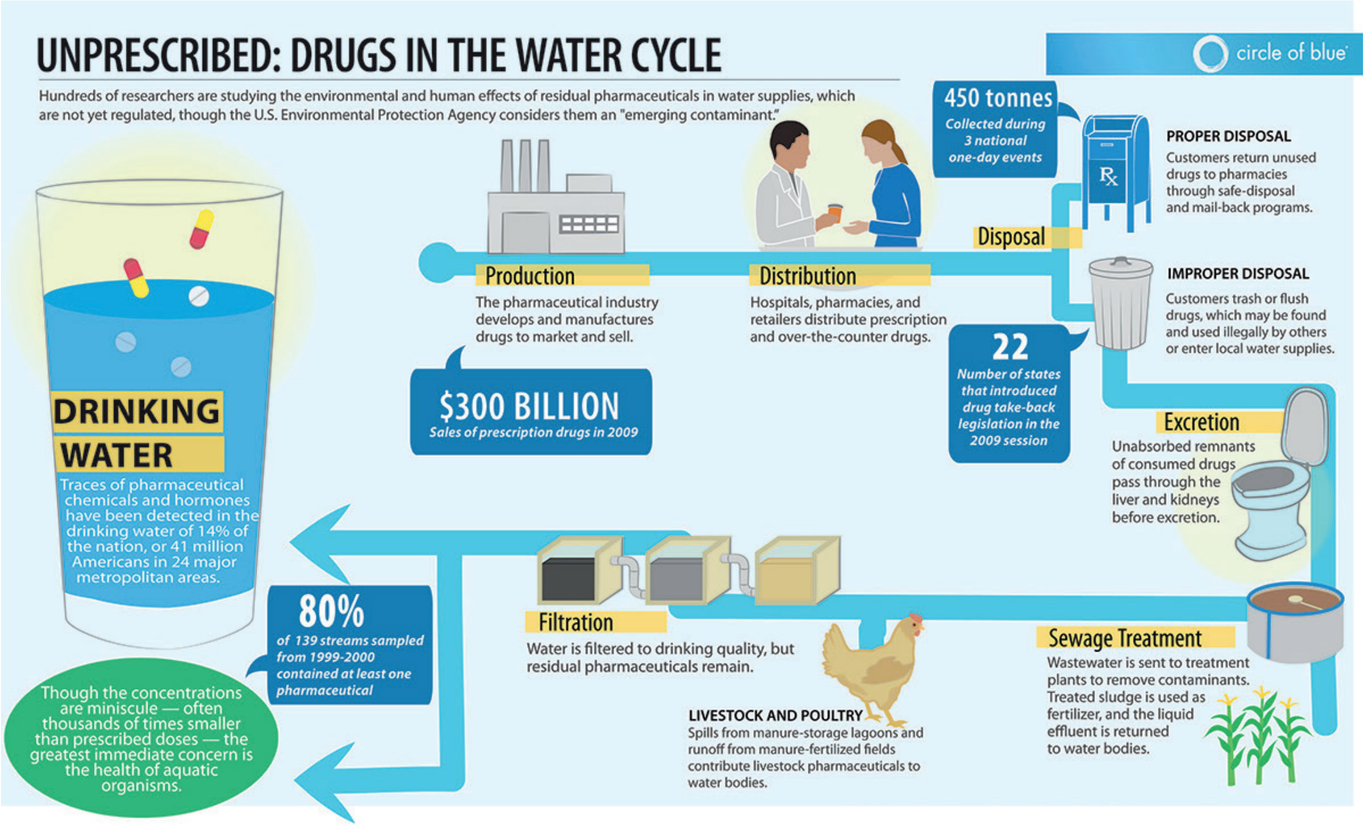
98: *Mean annual nitrates in rivers in Europe*

Figure-L2 34: Mean annual nitrates in rivers in Europe Annual mean river nitrate concentration averaged by River Basin Districts of the EU-27 and European Free Trade Association, 2010



Source: Eurostat 2012b

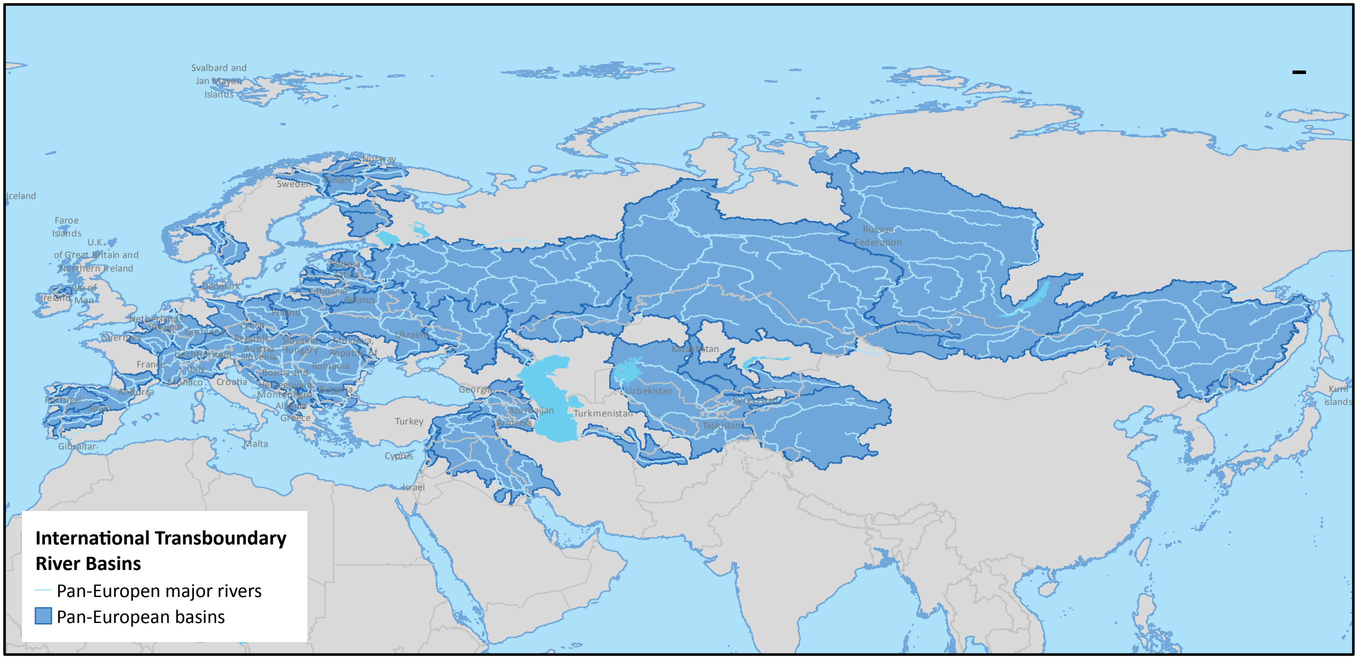
99: [Circle of Blue](#)



Sources: Associated Press, Carlifornia Department of Resources and Recycling, IMS Health, USGS

100: International freshwater catchments in the pan-European area

Figure-L2 35: Map juxtaposing national borders of the 54 countries on international river basins. There are 147 international river basins in the pan-European region, 12 of which are lakes



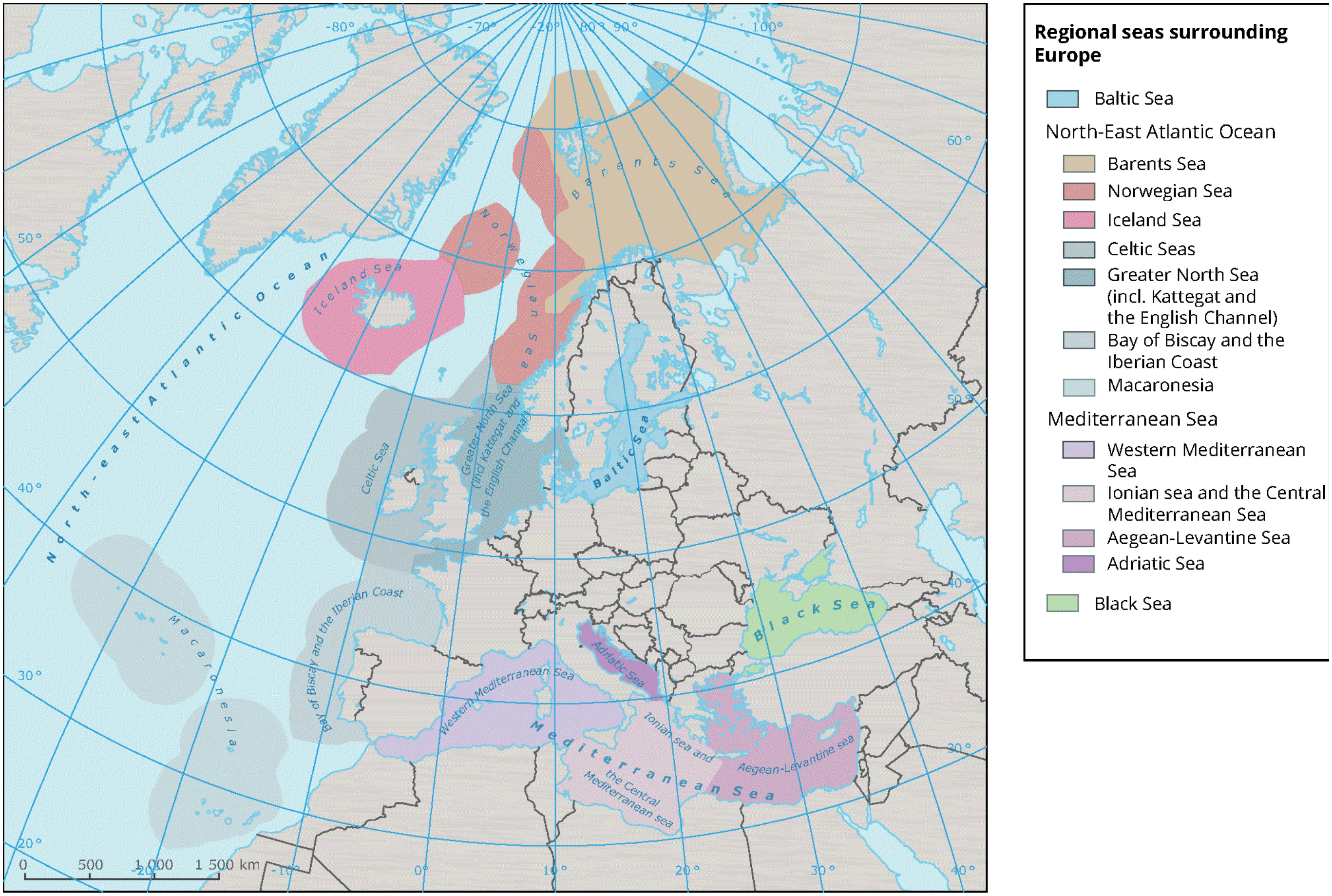
Source: Adapted from *http://ir-s01.ethz.ch/*

101: SDG 6: Ensure availability and sustainable management of water and sanitation for all

Sustainable Development Goal 6 aims to ensure availability and sustainable management of water and sanitation for all. Targets 6.2 (achieve access to adequate and equitable sanitation and hygiene for all) and 6.3 (improve water quality) proposes to ensure safe access to drinking water, sanitation and hygiene for all and specifically calls for improvement in water quality (target 6.3), sustainable water withdrawals (target 6.4) and implementation of integrated water resources management including transboundary cooperation (target 6.5). For the first time, there is an acknowledged need to protect aquatic ecosystems (target 6.6) and to preserve ambient water quality. Ambient water quality is key to enhancing ecosystem services in support of social and economic activities – improving and maintaining the health of water ecosystems used for drinking, irrigation and recreation and the use of water for human activities in a sustainable way. Moreover, the inclusion of *water management in the SDGs*, with an explicit reference to transboundary cooperation represents a significant increase in scope since the MDGs.

102: *Extent of the pan-European regional seas*

Figure-L2 36: Pan-European seas

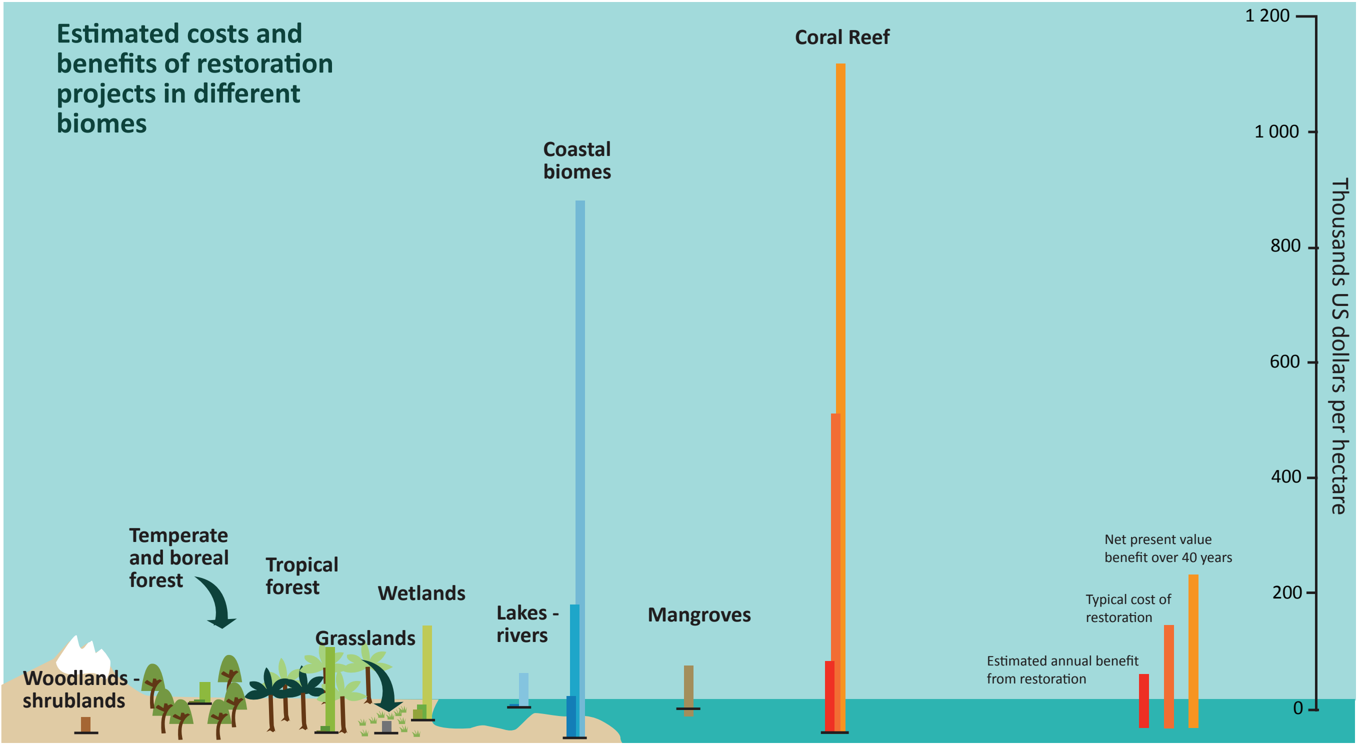


Source: http://www.protectedplanet.net/

103: *Ecosystem valuation and natural capital*

Since Costanza *et al.* (1997) put forward their estimated value of global ecosystem services and natural capital, many attempts have been made to improve the capabilities of economic methods to estimate the value of seas and oceans. While useful for raising awareness in situations where natural resources and ecosystems are insufficiently protected, the monetization of the benefits humans receive from nature may, however, be misleading. The recent estimates published by Costanza *et al.* (2014) and de Groot *et al.* (2012) suggest that coral reefs, coastal wetlands and coastal systems are the biomes whose values would be the highest, while the value attributed to open oceans could be lower than all other biomes, including terrestrial ones. Figure-L2 37

Figure-L2 37: Estimated costs and benefits of restoration projects in different biomes



Source: TEEB 2010

shows estimated costs and benefits of restoration projects in different biomes.

Estimating the benefits from the seas and oceans in monetary units could lead to the adoption of cost-benefit analysis as a relevant criterion for deciding whether or not to protect the marine environment. An example of this is the large-scale cost-benefit analyses regarding mitigation of eutrophication for the Baltic Sea conducted by the BalticSTERN research network (SwAM 2013). However, this kind of valuation can only be used when assumptions of reversibility for ecological processes and of substitutability for natural capital are valid (EEA 2015k). Furthermore, this kind of approach used to estimate the value of the world's ecosystem services and natural capital has limited utility in policy-making perspectives. This also can lead to purely market-based management of human activities using the sea's natural capital, and to privileging the maintenance of some marine ecosystem services, those with immediate economic value and neglecting other services that are not easily monetized; that is, those from the regulation and supporting category (EEA 2015k). In this context, it is important to emphasize that natural capital is not the same as nature; natural capital is the basis of production in the human economy and the provider of ecosystem services. Therefore, any socio-economic valuation of the pan-European region's natural capital, while an important tool to integrate monetary values into economic systems and related policies, should go hand-in-hand with the recognition that economic valuation will not fully include the intrinsic value of nature or the cultural and spiritual services it provides (EEA 2015a). However, new methods are being developed that include some of those values as shown by the BalticSTERN study, which clearly indicated substantial benefits of non-use values (Ahtiainen *et al.* 2014). The rationale behind the need to properly value our oceans and coasts is also demonstrated by several large, complex studies conducted under the framework of The Economics of Ecosystems and Biodiversity (TEEB). The TEEB approach applied to oceans and coasts provides opportunities to be more inclusive of a variety of methodologies and to be designed and developed from a wide range of research. It may draw attention towards the socio-economic benefits of healthy, productive and sustainable oceans and seas. In the broader sense, the TEEB approach should show the benefits of preserved and well-maintained oceans and their services to both human well-being and our vital biomes.

104: The world's fish stocks

The FAO (2014: 2010) estimates that presently roughly 30 per cent of the world´s fish stocks have been overfished, more than 50 per cent are fully exploited and only 20 per cent of the stocks are harvested at levels of under-or-moderate exploitation. The signatories to the Plan of Implementation of the United Nations World Summit on Sustainable Development (WSSD) (UN 2002) committed to maintain or restore fish stocks to sustainable levels – defined as maximum sustainable yield (MSY), the maximum use that a renewable resource can sustain without impairing its renewability through natural growth and replenishment. The WSSD commitment was supposed to be achieved rapidly, and where possible not later than 2015 (UN 2002). The WSSD objectives, however, have not been reached, and it is recognized that the environmental, economic and social long-term sustainability of many fisheries in the world are not being maintained (Worm *et al.* 2006; Pauly *et al.* 2002).

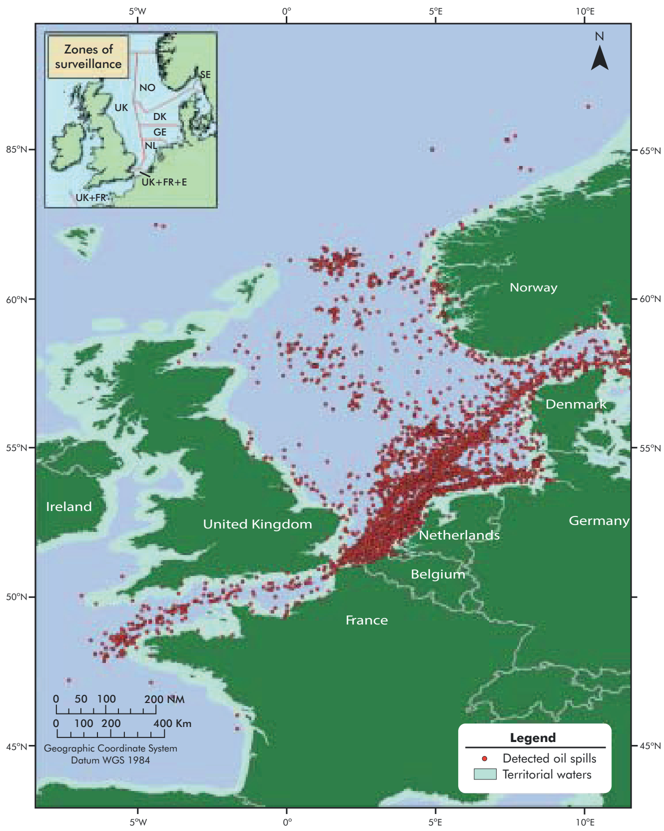
105: Various socio-economic drivers

Oceans, seas and marine resources support human well-being by contributing to poverty eradication, food security, the creation of sustainable livelihoods and jobs, human health and protection from natural disasters (EEA 2015a, 2015k; UN 2015c).

The oceans currently provide 11 per cent of the animal protein consumed by people around the world (FAO 2014c). Today, aquaculture in the EU and the European Free Trade Association's (EFTA) area produces about 1.8 million tonnes of fish, shellfish and crustaceans annually, generating a turnover of around €3.2 billion and supporting 65 000 jobs (EEA 2015k). Furthermore, the development of marine aquaculture in the pan-European region has made up for the fall in the commercial fish catch (EEA 2015k).

The demand for seafood and other socio-economic drivers indicate an overall intensification in maritime activities in the pan-European region, including a significant spread of commercial fishing, a vast growth in global maritime transport and trade, the expansion of oil and gas extraction, installation of oil platforms and pipelines and of new industries such as

Figure-L2 38: Oil spills in the North Sea



More information can be found on the website of the Joint Research Centre – European Commission at http://serac.jrc.it wind and tidal power plants. Activities are also expanding to areas further offshore, including the search for and mining of open and deep-sea biological and mineral resources. Finally, future perspectives estimate that even more demands will be put on the seas, given projections of consumption and production patterns and the growth of the maritime economy (EEA 22015a, 2015k). Furthermore, coastal areas are attractive for living, tourism and recreation, resulting in increasing population density, urbanization and infrastructure development along the region's coastlines (EEA 2015k; MA 2005b).

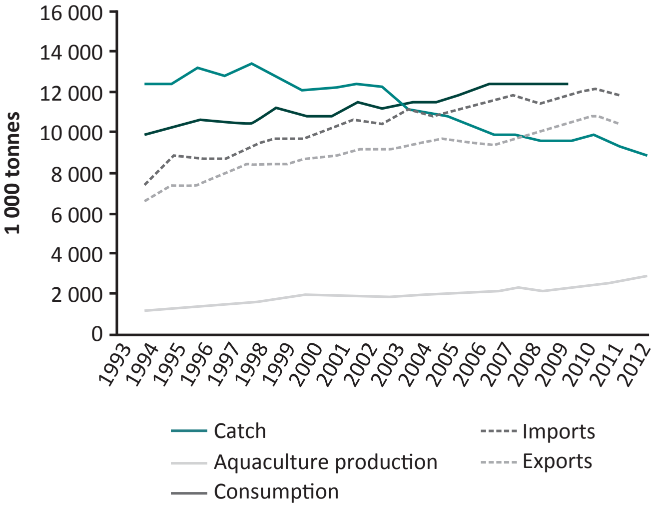
Oil pollution – a never-ending story

Oil pollution of the seas and oceans is a good example of how human maritime activities and infrastructure such as shipping, harbors, utilities development and petroleum extraction continue to degrade marine ecosystems through releases of hydrocarbons. The level of ecological impact is often related to the intensity of activities. However, many regulations and agreements provide instruments for surveillance, control and decrease of oil spill incidents (for example, the Bonn Agreement, a number of IMO Conventions such as Ballast Water Management Convention (BWMC), the International Convention for the Prevention of Pollution from Ships (MARPOL) and the International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC)). The example below shows how the density of spills is closely related to the major shipping lanes and maritime traffic, as well as to the amount of surveillance, which varies from one area to another. From 1998 to 2004, as represented in Figure-L2 38, a total of 4 900 oil spills were detected in the North Sea by the surveillance of the members of the Bonn Agreement (Belgium, Denmark, France, Germany, Netherlands, Norway, Sweden and the United Kingdom).

106: Endangered fish stocks in Europe

Since 1993, Europe's total fish catch has decreased, while human consumption of fish products has steadily increased. The top five commercial species – Atlantic herring (*Clupea harengus*), Atlantic mackerel (*Scomber scombrus*), European sprat (*Sprattus sprattus*), sand eels (*Hyperoplus, Gymnammodytes, and Ammodytes*) and Atlantic cod (*Gadus morhua*) – made up half of the EU North East Atlantic catch in 2013. Europe relies heavily on fish imports to meet demand, which reached 8.4 million tonnes in 2012, with 6.3 million tonnes coming from non-European countries and about 2 million tonnes from Iceland and Norway. The 2012 net supply of fish reached 12.32 million tonnes, almost a 12 per cent increase on 1998 levels due to an increase in imports (Figure-L2 39). Aquaculture production, almost entirely for the EU market, has also increased in this period, as have imports and exports of fish. The increase in EU exports has come mostly from wild capture fisheries (EUMOFA 2014).

Figure-L2 39: EEA-32 and Western Balkans, total fish catch, aquaculture production, fish consumption, fish imports, and fish exports, 1993–2012, in '000 tonnes



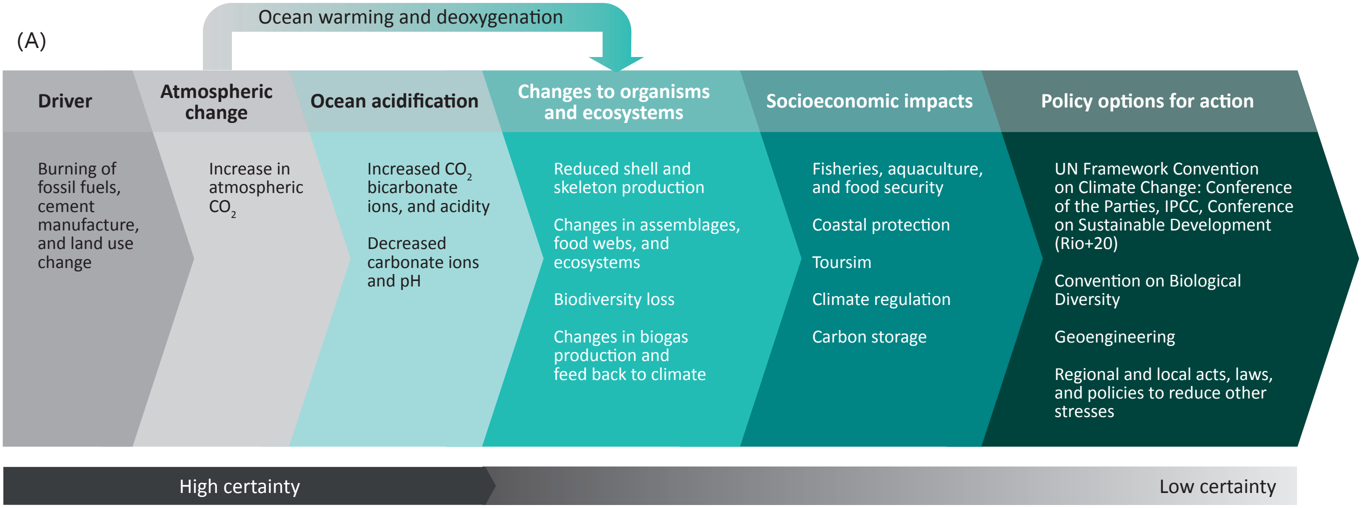
Source: EEA 2015k; FAO Fishstat database

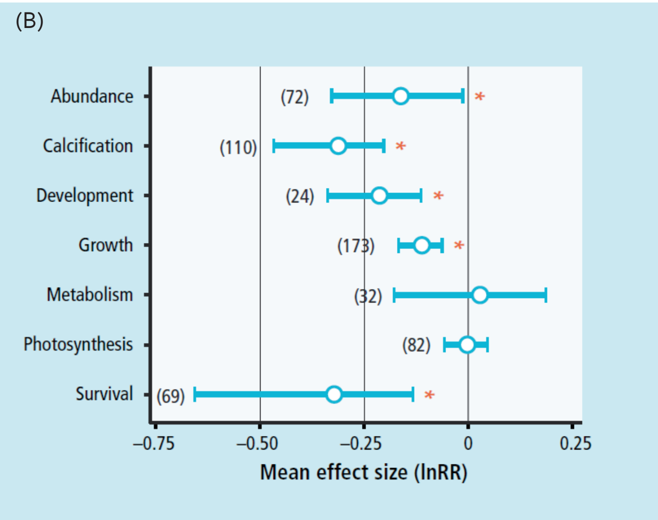
Data gaps in fish stock assessments

An increasing proportion of stocks have been assessed in the European Atlantic waters, the North Sea and the Baltic Sea. The number of stocks that, according to available estimates, are fished at levels corresponding to MSY has gone up from only two in 2003, to 13 in 2009 and to 27 in 2012. The number of stocks with full MSY assessments increased from 34 in 2005 to 35 in 2009 and to 46 in 2014. Significant progress has been made in the number of stocks with quantitative information from 59 in 2003 to 71 in 2014, as a result of the introduction of new methods by the International Council for the Exploration of the Sea (ICES) in 2013. In the Mediterranean and Black Seas, the number of assessed stocks rose from 29 in 2007 to 104 in 2012. Despite this, knowledge is still limited, as the total number of stocks commercially exploited is considerably higher (EC 2014b).

Few statistics are available for assessing the exploitation of commercial stocks in the Caspian Sea and most pan-European northern and eastern seas. In the Caspian Sea, the well-known examples are the collapse of the sturgeon (*Acipenseridae*) sought for its caviar and the drastic fall in anchovy (*Engraulidae*) catches between 2000 and 2001 (CEP 2007).

Figure-L2 40: Ocean acidification





(A) Overview of the chemical, biological and socioeconomic impacts of ocean acidification and of policy options. (B) Effect of near-future acidification (seawater pH reduction of ≤0.5 units) on major response variables estimated using weighted random effects meta-analyses, with the exception of survival, which is not weighted. The log-transformed response ratio (lnRR) is the ratio of the mean effect in the acidification treatment to the mean effect in a control group. It indicates which process is most uniformly affected by ocean acidification, but large variability exists between species. Significance is determined when the 95 per cent confidence interval does not cross zero. The number of experiments used in the analyses is shown in parentheses. The * denotes a statistically significant effect.

107: *Trophic downgrading*

A trophic level of an organism is its position in a food web. Levels are numbered according to how far particular organisms are along the chain from the primary producers at level 1; to herbivores at level 2; predators at level 3; carnivores at level 4; and top carnivores at level 5. Typically, the higher the trophic level, the higher economic value of the fish. Fishing further down the trophic levels is largely a result of overharvesting fish at higher levels (Pauly *et al.* 1998).

108: *Ocean Acidification*

Anthropogenic ocean acidification and global warming share the same primary cause, which is the increase of atmospheric CO_2, the drivers, impacts and policy options are presented in Figure-L2 39 (Gattuso *et al.* 2014).

109: *Current shipping in the Arctic*

Reductions in sea ice extent, duration and thickness are likely to increase human presence and activities in the Arctic (Ragen *et al.* 2008). The Arctic Marine Shipping Assessment (PAME 2009) mapped the distribution of shipping activities under various use classes: minerals, oil and gas, major fisheries, summer sealift, marine tourism and research.

Longer ice-free seasons and reduced ice coverage could increase shipping activity and enhance the impact of resource exploration, development and production on vulnerable coastal species, such as; polar bears, walruses, seals and many seabird species. Potential effects of shipping include pollution, noise, physical disturbance related to ice-breaking and waste. The number and range of cruise ships moving further north, travelling to previously untouched coastal areas, may also increase the pressure on coastal ecosystems (Hall and Saarinen 2010; Hall 2010), including pollution, disturbance and increased risk of defense kills and biological invasion.

110: *Biodiversity pressures, impacts, trends and outlook*

Seas and oceans act as a coherent ecosystem. Across all of Europe's regional seas, marine biodiversity is in poor condition with only seven per cent of marine species assessments indicating favourable conservation status. Effects of climate change, for example acidification, add to the cumulative impacts (EEA 2015a). Impacts on biodiversity lead to the loss of ecosystems' resilience and associated functions with negative effects on the quantity, quality and sustainability of goods and ecosystem services. Habitat communities integrate biodiversity loss at different scales, possibly reflected in gradual and delayed shifts in their state.

According to the EEA (2015k), a continuing decline of marine and coastal biodiversity jeopardizes essential ecosystem services. Some improvements have been made in the past decade, due to the implementation of targeted policy action and committed management efforts, but even more dedicated resources and regulations will still be insufficient, notably at wider scale, to reach commonly agreed targets (good environmental status in 2020 and halt of biodiversity loss as defined by the MSFD, Habitat Directives and EU Biodiversity Strategy).

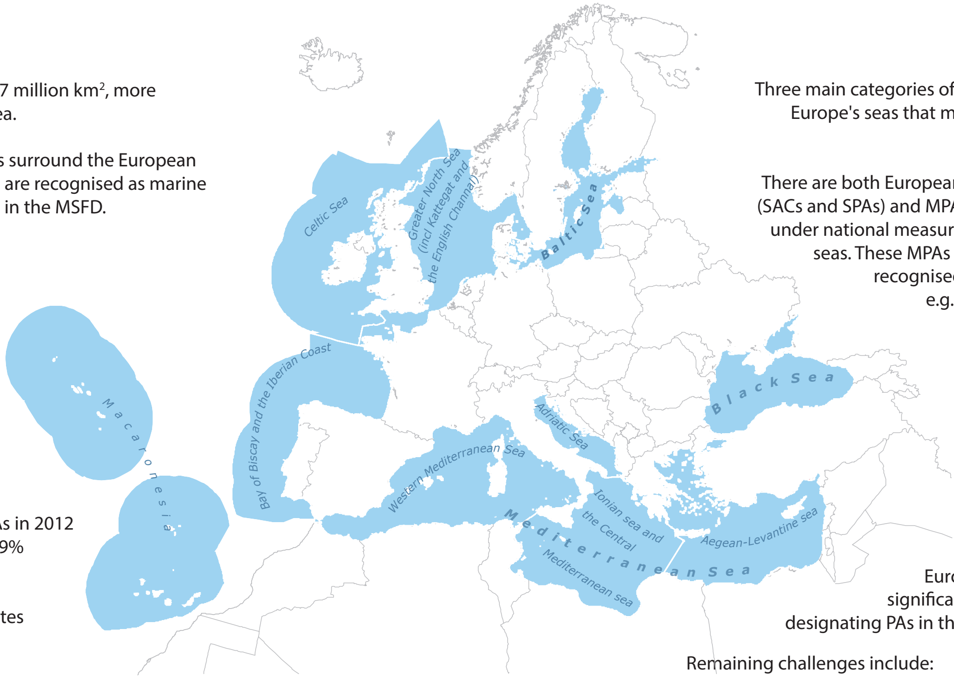
111: *Marine protected areas – a key conservation measure*

Marine protected areas (MPAs) can act as a key conservation measure to safeguard marine ecosystems and biodiversity, as well as the services these ecosystems provide (Figure-L2 40). The use of networks of marine reserves, for both conservation and fisheries' management, has been widely considered and partly implemented at pan-European and global scales (EEA 2015k, 2015o; UN 2015c). MPAs, nested within an ecosystem-based management approach, have consistently emerged as one of the most important tools in halting the oceans' decline and promoting their recovery. Indeed, MPAs that exclude fishing have been shown repeatedly to enhance the abundance, size and diversity of marine species in these areas (EEA 2015k). The Convention on Biological Diversity (CBD) Aichi Target 11 calls for at least 10 per cent of coastal and marine areas to be conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas by 2020 (Hastings *et al.* 2012). However, most of the Parties are not on track to meet this 2020 CBD commitment. The recent (2011) World Database on Protected Areas analysis indicated that only 1.6 per cent of global oceans are protected in MPAs (Hastings *et al.* 2012).

Figure-L2 41: Europe's regional seas, and fast facts on EU MPA networks

Europe's seas cover 5.7 million km², more than Europe's land area.

Some 13 regional seas surround the European continent: 10 of these are recognised as marine regions or subregions in the MSFD.



Three main categories of MPAs exist in Europe's seas that may contribute to a network.

There are both European marine sites (SACs and SPAs) and MPAs designated under national measures in Europe's seas. These MPAs are often also recognised as RSC sites, e.g. OSPAR MPAs.

Total coverage of MPAs in 2012 was 338 000 km² or 5.9% of Europe's seas.

Marine Natura 2000 sites covered 4%.

National sites covered 1.9%.

The Greater North Sea has the highest MPA coverage, at 17.9%.

Macaronesia has the lowest MPA coverage, at 0.8%.

Europe has made significant progress in designating PAs in the last decade.

Remaining challenges include:

– Ensuring the MPA networks across Europe are ecologically coherrent;

– Ensuring MPA networks across Europe are effectively managed.

Source: EEA 2015e

The EEA has provided a recent overview on progress made to date in establishing MPAs and MPA networks in Europe's seas, specifically MPAs reported by EU Member States up to and including 2012 (EEA 2015e). Total coverage of MPAs in 2012 was 5.9 per cent of the area of Europe's seas. It also discusses how best to assess the effectiveness of these MPAs and determine their effectiveness in protecting biodiversity across Europe's seas. Furthermore, the recent results also show that global conservation targets based on area alone will not optimize the protection of marine biodiversity. More emphasis is needed on better MPA design, durable management and compliance to ensure that MPAs achieve their desired conservation value (Edgar *et al.* 2014).

112: Ecological regime shifts

The presumed common mechanism of ecosystem regime shifts due to overfishing is a trophic cascade (Möllmann *et al.* 2011; Cury *et al.* 2005 and 2003), that is a top-down restructuring of the marine food web. Examples of such successive changes can occur at all trophic levels – piscivorous fish, planktivorous fish, zooplankton and phytoplankton – and in combination with other drivers – climate change, eutrophication and the introduction of invasive species – and were proposed as the cause of ecosystem regime shifts in the Baltic and the Black Seas (Möllmann *et al.* 2009; Casini *et al.* 2008; Möllmann *et al.* 2008; Daskalov *et al.* 2007). In the Baltic in the late 1980s, due to a combination of overfishing and climate change, the fishing community moved from cod to herring (Köster *et al.* 2005 and 2003; MacKenzie and Köster 2004). Furthermore, the high nutrient loads, oxygen depletion and low salinity have all contributed to the significant reorganization of the Baltic ecosystem, including primary producers of planktonic communities. Similarly, in the Black Sea, successive overfishing and the depletion of large pelagic predators combined with global warming, high nutrient loads and the introduction of the invasive alien comb jellyfish (Mnemiopsis leidyi) have led to radical ecosystem regime shifts, including the collapse of fisheries (Daskalov 2002).

113: Eutrophication – cumulative impacts

Excessive nutrient inputs result in significant changes in vulnerable marine regions. The increase of primary production, excessive plant growth and algal blooms, changes in the nutrients cycling, shifts in marine plankton community structures and general environmental degradation are all direct effects of human-induced eutrophication (Ferreira *et al.* 2010; Ménesguen *et al.* 2006). Furthermore, the decay of algal biomass leads to increased oxygen consumption especially in bottom waters and, under severe eutrophic conditions, to the formation of hypoxic or even anoxic, oxygen-depleted or oxygen starved dead zones in coastal areas. Such zones, which are very difficult to reverse, are generally growing in the region's semi-enclosed seas (Carstensen *et al.* 2014; Diaz *et al.* 2010; Helcom 2010; Rabalais *et al.* 2010). Nutrient enrichment is similarly related to harmful algal blooms outbreaks, associated with mortality events of benthic and pelagic marine fauna, and with various types of human fish and shellfish poisonings (EEA 2015k).

The evidence is growing that eutrophication, in combination with other human and environmental stressors including over-exploitation, habitat degradation, the introduction of invasive species and climate change, may lead to profound modifications of the structure of marine ecosystems, especially in coastal areas and semi-enclosed seas. Such radical transformations, for instance in the Baltic and Black Sea ecosystems, have resulted in a change from species-rich productive ecosystems to those dominated by lower trophic species.

Climate change is likely to intensify eutrophication processes and their impacts in pan-European seas in various ways (Carstensen *et al.* 2014). Global warming may lead to enhanced precipitation in the catchment of the Baltic Sea (Radtke *et al.* 2012; Kjellström *et al.* 2011), possibly leading to changes in nutrient loads. Furthermore, water warming will affect phytoplankton growth and organic material decay rates and reduce oxygen solubility, possibly extending the occurrence of hypoxia (EEA 2015k; Carstensen *et al.* 2014; HELCOM 2013).

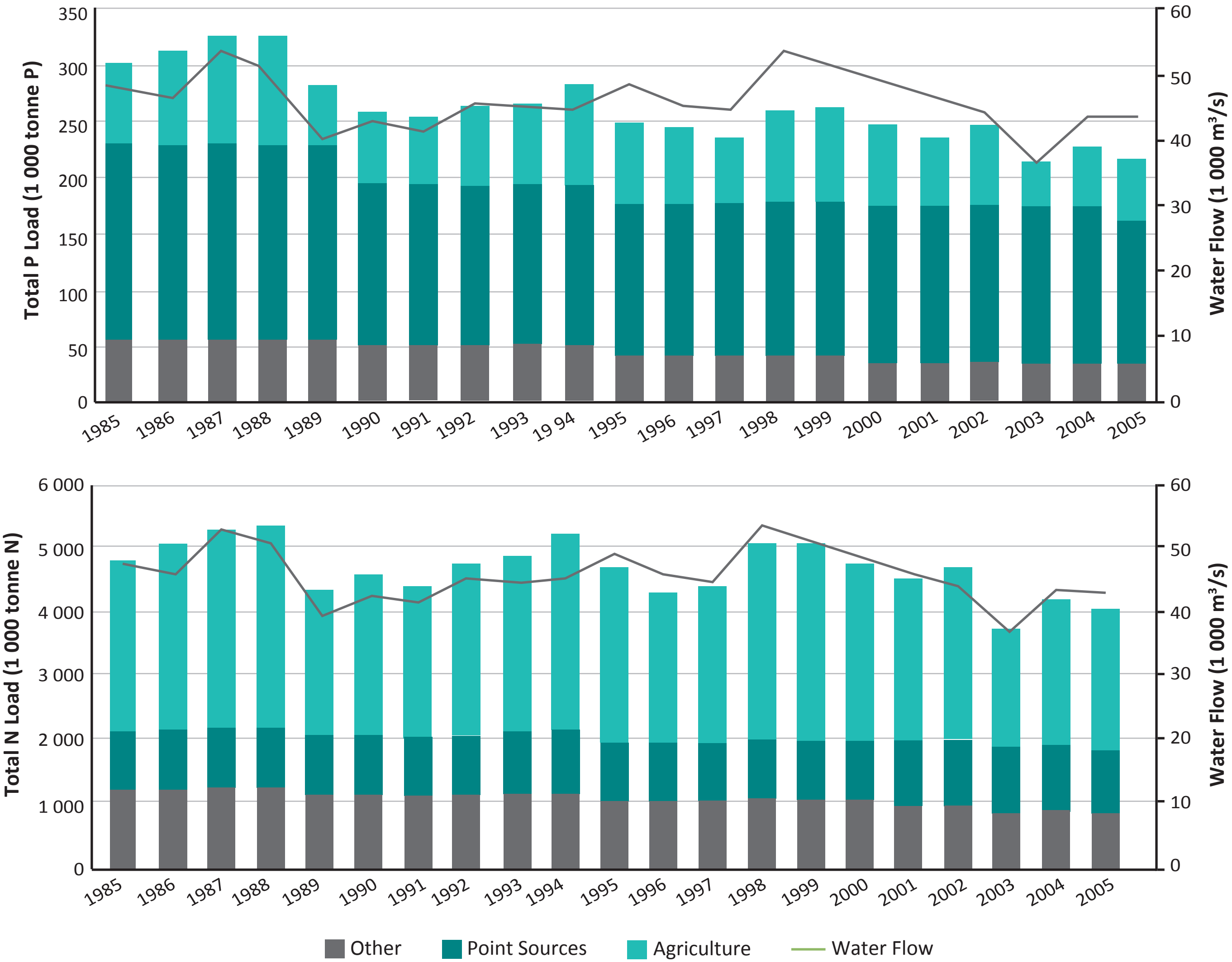
114: Eutrophication – responses and slow progress

The policies addressing nutrient reduction resulted in a measurable decrease of nitrogen and phosphorus inputs entering transitional, coastal and marine waters in regional seas. However, other than in the North Sea and to some extent the Baltic Sea, annual nitrogen exports from land to the sea did not change significantly between 1985 and 2005 (Figure-L2 42).

Furthermore, nutrient loads from agriculture show a good correlation with riverine freshwater discharges into the Atlantic and North Sea regions (Radach and Pätsch 2007; Grimvall *et al.* 2000), suggesting that an apparent decrease in agricultural nitrogen inputs does not necessarily reflect reduction of fertilizer use. This might be related to the diffuse characteristic of the sources and watershed export dynamics, for instance of accumulated stocks of nitrogen in the soil (Radach and Pätsch 2007). It is further enhanced by the slow decrease of nutrient atmospheric inputs (Bouraoui *et al.* 2009). Therefore, there may be long time lag between actions taken to reduce nutrient releases into waters, lands and atmosphere, and the effective decline of eutrophication in the seas.

This is why assessing the effectiveness of policies addressing marine eutrophication is complex. A reduction of nutrient emissions was obtained through policies concerning different sources of nutrient pollution across the EU, such as: i) the 1991 Nitrates Directive; ii) the 1991 Urban Waste Water Treatment Directive; and iii) the 2013 Clean Air Policy Package, aimed at reducing nitrogen emissions to the

Figure-L2 42: Regional seas, phosphorous (left) and nitrogen (right) loads, 1985–2005

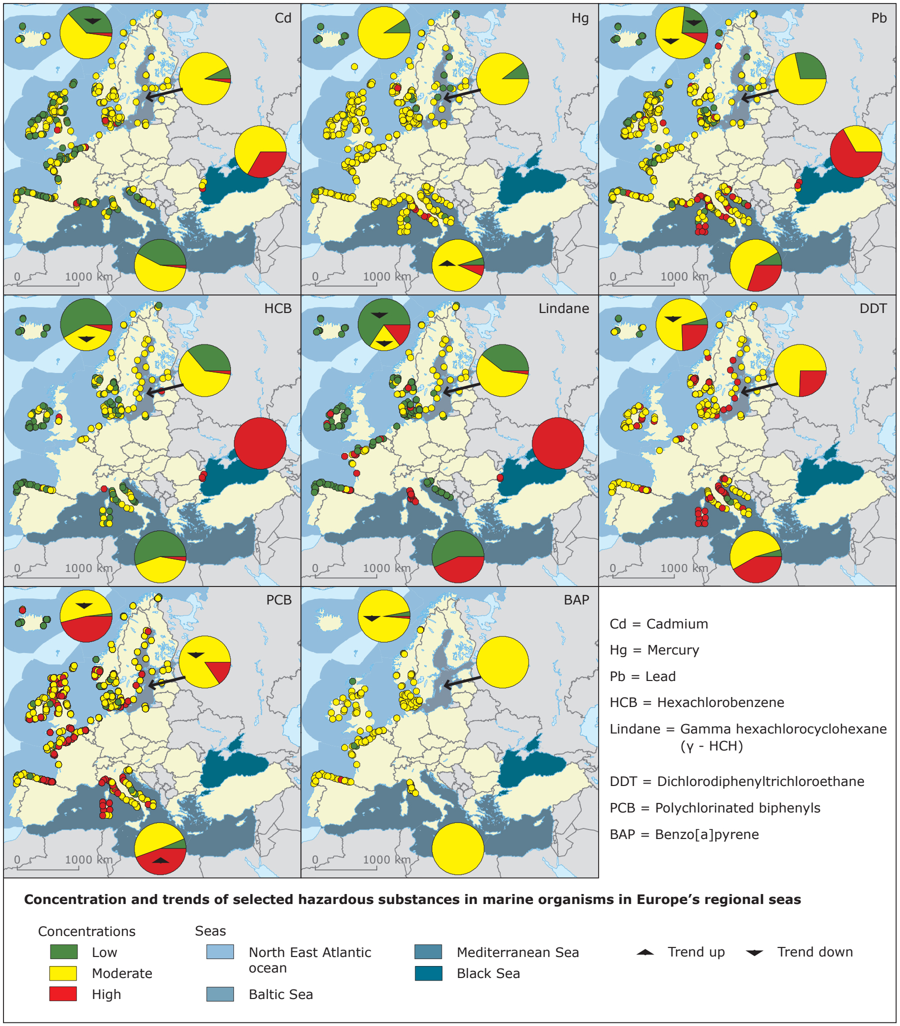


Source: Bouraoui *et al.* 2011; Grizzetti *et al.* 2012

atmosphere. Whereas further reductions of nutrient inputs will require addressing agricultural practices through the EU's Common Agricultural Policy (CAP), it is expected that recent reforms of the CAP will induce, for example, a drop in fertilizers use on agricultural lands, by decoupling agricultural subsidies from production. Finally, the environmental targets and assessments will be continuously fixed and conducted through the Regional Seas Conventions, the European Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFD). These will allow appraisal of the effectiveness of policy efforts to halt eutrophication and significant losses in ecosystems' services and natural capital. The annual economic costs of eutrophication of the pan-European seas are very significant.

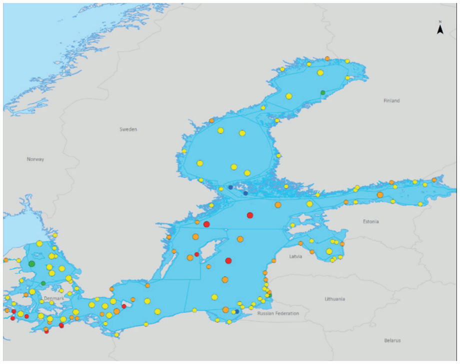
115: Persistent organic pollutants (POPs)

Figure-L2 43: Hazardous substances in the marine environment



Source: EEA 2015k

The aggregated assessment for eight hazardous substances, or groups, in marine organisms in regional seas around Europe in 2012: the Northeast Atlantic, Baltic Sea, Black Sea and Mediterranean Sea; Each map shows locations where the substance was measured, and coloured to indicate which class was registered; green, low concentrations; yellow, moderate concentrations; or red, high concentrations. In addition a pie chart is presented on the map showing the percentage of each class within each of the four regional seas. Furthermore, any regional trend observed between 2003–2012 for a particular class is indicated by an arrow.



Source: HELCOM 2010

Integrated classification of the hazardous substances status in the Baltic Sea (144 assessment units). Blue, high; green, good; yellow, moderate; orange, poor; and red, bad status. High and good statuses suggest areas not disturbed by hazardous substances, while moderate, poor, and bad statuses reflect areas disturbed by hazardous substances. Large dots represent assessment units of the open basins; small dots represent coastal assessment units that are mainly located in the territorial waters delimited by the grey line. Other grey lines represent the divisions between the sub-basins.

116: *Health and environmental effects*

There is growing evidence of a broad range of health and environmental outcomes from various hazardous pollutants: impaired reproduction in animals, immunotoxicity, carcinogenicity, damage to reproductive, immune and endocrine vital systems, and development of disorders mutation and chronic diseases. The endocrine disrupting effects of some organic contaminants has been recognized as potentially one of the major impacts on wildlife in marine and freshwater ecosystems (EEA EEA 2012f; Kortenkamp *et al.* 2011; Escher and Hermens 2002). Furthermore, impacts on ecosystems include adverse effects from long-term exposure to low or sub-lethal concentrations of single chemicals or mixtures of chemicals. The understanding of the effects of mixtures of pollutants is now a key issue for chemical impact assessments (EEA 2015a, 2015k). Bioaccumulation and bio-magnification in marine food webs result in high concentrations of many POPs and mercury in, for instance, filtering marine mollusks, top predators including marine mammals, marine birds and tuna. The consumption of contaminated seafood from pan-European seas could contribute significantly to levels of these hazardous substances and novel emerging contaminants in the blood of targeted human populations, and might therefore lead to the introduction of restrictions and regulations (Falandysz *et al.* 2006). Furthermore, evidence is growing that early-life or prenatal exposures, through the maternal transfer of contaminants, may be related to low survival and reproductive failures in marine mammals, birds and several reptiles groups. These processes might be trans-generational, with potential consequences for natural populations of long-lived marine species (Rowe 2008).

117: *Marine litter impacts*

In addition to large debris, there is growing concern about microparticles measuring from less than 5 millimetres to as small as 1 micrometre. They are a very heterogeneous group, varying in size, shape, colour, chemical composition and density. Sea surface microplastics were found in mean concentrations of 115 000 – 1 050 000 particles per square kilometre in the northwestern Mediterranean Sea, with a maximum of 4 860 000 particles per square kilometre, giving an estimated weight of more than 1 000 tonnes for the whole basin (Galgani 2015). The highest microplastic concentrations in sediment were found on beaches and in harbours of the southern North Sea, with concentrations of up to 391 microplastic debris per kilogram of dry sediment (Claessens *et al.* 2011).

Adverse effects of marine litter vary and are dependent on the nature and size of the debris, quantities, species or populations affected (Table 9). A wide range of species is known to encounter marine debris, including birds, commercially important fish, marine mammals and invertebrates. Some of these species are considered threatened or near threatened according to IUCN. The effects vary according to the type of debris and the species concerned, but direct physical harm and mortality are widely reported by Gall and Thompson (2015), and there is growing evidence of effects at a range of levels of biological organization from sub-organismal (Rochman 2015) through to effects on assemblages and ecosystem services (Green *et al.* 2015). Other studies also show how microplastics are ingested both by planktonic crustaceans and benthic invertebrates (Setälä *et al.* 2016, 2013).

In its declaration, more than 200 experts from the 2013 International Conference on Prevention and Management of Marine Litter in European Seas (ICPML 2013) listed the main management measures needed to support a significant reduction of litter in the marine environment: develop an integrated waste management infrastructure to support waste prevention; collection, recycling and energy recovery; improve scientific knowledge; reduce marine litter at all relevant levels; give priority to sources of marine litter that have the strongest impact; raise awareness; further develop regional action plans for Europe's regional seas; collaborate with international institutions to address the transboundary aspects of marine litter; encourage financial support; share expertise and knowledge; and develop a network of stakeholders. Some of these management measures will support the transition to an inclusive green economy.

Table 9: Summary of adverse effects of the marine litter by compartment of the marine environment and type of impacts

Compartment of the marine environment	Type of impact	Impacts
INTERTIDAL and BEACH LITTER	Human health and well-being	Release of chemicals, medicines and additives from debris and microparticles Injury by glass and metallic debris
	Economic (tourism)	Aesthetic impact Reduced revenues Reduced recreational opportunities
FLOATING LITTER	Environmental	Entanglement of marine organisms Dispersion of chemicals Dispersion of invasive alien species
	Safety	Vessel damage, cost of rescue
	Economic (fishing)	Lost nets Fishing net damage Reduced and/or contaminated catch
SEA FLOOR LITTER	Environmental	"Ghost" fishing by derelict fishing gear New habitats Smothering of natural sedimentary habitat and introduction of new hard substrata Release of chemicals
	Economic	"Ghost" fishing by derelict fishing gear Damage to and loss of fishing gear
INGESTED LITTER	Environmental	Chemical/toxicological effects, Health effects (occlusions, etc.)

118: Tehran Convention –Environmental Governance for the Caspian Sea

When the Framework Convention for the Protection of the Marine Environment of the Caspian Sea (*Tehran Convention*) entered into force in August 2006, it created a comprehensive governance structure for common responses to transboundary environmental problems in the Caspian Sea region. It was the first legally-binding agreement among the Seas littoral states Azerbaijan, Iran, Kazakhstan, Russian Federation and Turkmenistan and for that reason hailed by the UN Secretary General as a "significant step forward for the region" to "benefit the health and livelihoods of millions of people". Since then, the Caspian states have used the Convention's framework to substantiate their efforts and negotiate further international treaties in main areas of environmental concern which should lead to further improvements in coming years.

The exploitation of oil and gas is a major commercial activity in the Caspian Sea. In order to better manage the high environmental risks that come with it, the littoral states have negotiated the Aktau Protocol Concerning Regional Preparedness, Response and Cooperation in Combatting Oil Pollution Incidents. The Protocol's objective is to harmonize national oil pollution preparedness and emergency systems and to provide for a regional cooperation mechanism to that effect. It is projected to enter into force in early 2016.

Much of the pollution in the Caspian Sea stems from land-based sources brought in through tributary rivers or other run-offs. As an enclosed water body, the Caspian Sea is particularly vulnerable and pollution has a strong transboundary character affecting all riparian countries. Therefore, the Caspian states initiated the Moscow Protocol for the Protection of the Caspian Sea against Pollution from Land-based Sources and Activities. It harmonizes the Parties' approaches to tackle land-based pollution from point sources like industry waste water run-off or from diffuse sources like agricultural production. The Protocol is signed by all Parties and is expected to enter into force in the course of 2016.

Isolated from the world's oceans for millions of years, the Caspian Sea is home to a number of endemic species and vulnerable habitats. With increasing international ship traffic, the introduction of alien species is particularly destructive to the unique Caspian Sea ecosystem. The Ashgabat Protocol for the Conservation of Biological Diversity addresses these threats through common country approaches on species and habitat protection, including through coastal and marine protected areas. This effort and agreement is especially noteworthy, as the legal status and therefore the marine borders of the Caspian Sea remain undecided. The Ashgabat Protocol was agreed at COP5 in 2014 and so far, is signed by three Parties and ratified by one.

Big commercial projects and activities in and around the Caspian Sea, for example in the area of oil and gas extraction, often have an adverse effect on neighbouring countries. In order to jointly assess the environmental risks and to avoid conflicts, the Caspian countries developed the Protocol on Environmental Impact Assessment (EIA) in a Transboundary Context. Drawing from the UNECE Espoo Convention on transboundary EIA. The Protocol constitutes an essential instrument for regional environmental policy and for engaging the public in the process. It is in its final stages of negotiation and will be further discussed at COP6 in 2016.

Despite respectable progress in recent years, information on the state of the Caspian Sea's *environmental conditions* - needed for sound environmental policy making - is still lacking and often incomparable. In an attempt to harmonize the collection and access to environmental data as well as to share the information among the countries, the Caspian states initiated negotiations on a draft protocol on monitoring, assessment, access to and exchange of environmental information. The protocol will capitalize on a reporting system, state of the environment reporting, and the Caspian Environment Information Centre which is a website for information exchange already established by the countries. An expert Working Group on Monitoring and Assessment is accompanying and feeding into the protocol development. With negotiations having started only recently in 2015, such a legally binding international agreement would be the first of its kind worldwide.

These efforts undertaken within the framework of the Tehran Convention show that the Caspian states have developed a strong legal basis and governance structure for international environmental policy in the Caspian Sea region in recent years. In the coming years, the Parties, with the support of the international community, will increasingly focus on the implementation of these agreements.

Land

119: *Definitions of land and soil and the four major soil functions and services.*

The EU Thematic Strategy for Soil Protection (EC 2006a) describes soil as "*the top layer of the Earth's crust, formed by mineral particles, organic matter, water, air and living organisms. It is the interface between earth, air, water and hosts most of the biosphere*. Land on the other side is "*the terrestrial bio-productive system that comprises soil, vegetation, other biota, and the ecological and hydrological processes that operate within the system"* (UNCCD n.d.).

Soil quality (Karlen *et al.* 1997) involves various characteristics that summarize the inherited value of the soil, which is a very dynamic and complex eco-system regulated by the interaction of physical, chemical and biological processes acting simultaneously. Literally known as the Earth's *skin*, the soil produces more than 95 per cent of the global food needs and provides numerous other functions and services (EC 2006a). Although a final consensus on the definition of soil quality has yet to be reached, one of its most prominent indicators is related to soil organic matter (SOM) content, otherwise described as the *elixir* of soil's life, and having a paramount impact on all soil ecosystem services from biomass production to climate regulator (FAO and ITPS 2015).

Soils are both sources and sinks of organic carbon (OC) and the global terrestrial ecosystem at 1 metre depth contains more than 1 206 *Pg* C (Hiederer and Köchy, 2011), which is twice the amount present in the atmosphere, but such C stocks could be higher considering that often soils are much deeper than one meter. A more recent concept is the soil critical zone (Banwart 2011) that uses a holistic framework for integrated studies of water with soil, rock, air and biotic resources in the near-surface terrestrial environment. Furthermore, the term soil security (Amundson *et al.* 2015) is often associated with food security due to continuing high rates of soil degradation globally (Lal 2014) as well as in Europe (EC 2012c), and to stress the need for further action in soil conservation (Dumanski 2015). Soil losses by accelerated erosion are a warning that soon the world might be "running out of dirt" (Baveye *et al.* 2011). The planet loses 75 billion tonnes of topsoil annually (UNCCD 2012), while a UK government report in 2009 warned that 2 million tonnes of topsoil are being eroded by wind and rain every year in the UK alone. The economic damage of soil degradation in England is in the range of £150-250 million per year while the target is that by 2030 all England's soils should be managed sustainably (DEFRA 2011). Unfortunately, attempts at binding international legal agreements have so far failed to protect soils from degradation (Montanarella 2015), and the progress made by the Global Soil Partnership (GSP) has been slow.

Supporting services include soil functions of crucial importance such as primary production for terrestrial vegetation, soil formation, rock weathering, nutrient cycling and release of nutrients. It is widely recognized that nutrient cycling is the largest contributor of goods and services, providing annually about 51 per cent of the total value (US$33 trillion) of all ecosystem services (FAO 2011b).

Soil provisioning services offer habitat for biodiversity, storing as much as 7 750 tonnes H_2O down to ha^{-1} and supply food, biomaterials (timber, fiber and biofuel), raw materials, foundations for buildings, infrastructure and renewable energy production.

Soil regulating services filter and buffer water, regulate hydrological flows, stabilize gas circulation (CO_2/O_2 balance, O_3 for UVB protection and SOx levels), regulate global climate (temperature and precipitation) and provide erosion control when the soil is covered with vegetation on slopes. Finally, soil provides cultural services in terms of recreation, cognitive value and preservation of archaeological heritage (Haygarth and Ritz 2009). All of the above services have a direct impact on people's lives, as they involve a range of services that are essential and include health, nutrition, income, basic materials, good social relations and finally environmental security (Dominati *et al.* 2010).

There are millions of microorganisms in one teaspoon of soil but about only one per cent of them have been identified (Wall *et al.* 2012). This enormous gene pool has provided humanity with streptomycin (discovered by Nobel Prize winner Selman Abraham Waksman), saving millions of lives from tuberculosis and other infectious diseases. Soil is an enormous source for the production of biopharmaceutical products (Ling *et al.* 2015) as a train of soil bacterium called *Mycobacterium vaccae* has been proven to trigger serotonin which can cure a variety of ailments. The 2015 Nobel Prize winner in medicine, Satoshi Ōmura discovered a novel therapy against infections caused by roundworm parasites using soil biota.

120: UN International Year of Soil

2015 was proclaimed by the UN General Assembly as the International Year of Soil. Soil degradation continues to be a global environmental problem, with severe consequences for food security, especially in low income countries. The planet annually loses 75 billion tonnes of topsoil due to erosion; this is accompanied with additional negative consequences for biodiversity loss and accelerated climate change effects. The pan-European region is affected by these degradation processes, which for the EU alone cost €80 per year to each inhabitant, or a total up to €38 billion annually.

121: *Rates of water erosion of soils in Europe*

Water erosion is the most documented soil erosion type in the scientific and technical literature in Europe (Figure-L2 44), and it may take various forms, from the removal of the uppermost thin layer of the soil (sheet erosion) to the formation of deeper rills or even gullies that cannot be removed by ploughing when runoff is concentrated on slopes. Soil erosion affects soil functions through the loss of this resource or the degradation of its quality, for example, decrease in nutrient contents which, isolated or combined, may lead to a decline in crop yields. When soil particles are exported downstream, they may also lead to numerous 'off-site' impacts such as muddy flooding or siltation in reservoirs and rivers.

Model outputs and experimental measurements indicate the strong variability of soil loss rates at the hillslope scale (between 0.01 and >50 t ha^{-1} yr^{-1} (Eurostat 2015; Cerdan *et al.* 2010). According to Cerdan (2010), the highest sheet and rill erosion rates are measured in vineyards (mean of 17.4 t ha^{-1} yr^{-1}) and in cropland (3.6 t ha^{-1} yr^{-1}). In contrast, the proportion of eroded material that is exported from larger river catchments (> 1 km^2 or even 1000 km^2) is much lower (from 0.01 to 10 t ha^{-1} yr^{-1}), reflecting the importance of sediment storage processes, such as colluvial or alluvial deposits, when considering larger scales (Vanmaercke *et al.* 2015). Several studies highlight the need for a better understanding of the interaction between the different water erosion processes, as most of the information is available on rill and sheet erosion. Gully erosion rates can reach much higher values in local areas (up to 455 t ha^{-1} yr^{-1}), mainly in Mediterranean countries (Verheijen *et al.* 2009). Furthermore, other processes known to generate significant soil losses, such as tillage erosion, crop harvesting or mass movements (landslides) should also been taken into account in order to quantify cumulative soil losses in Europe. Table 10 provides a summary of the ranges of erosion rates generated by these processes and reported in the literature for Europe.

Table 10: Current soil erosion rates in Europe

Erosion type	Mean rates t ha^{-1} $year^{-1}$	Maximum rates t ha^{-1} $year^{-1}$
Rill, sheet erosion	0.1 -8.8	23.4
Gullies	n/a	455
Wind erosion	0.1 – 2.0	15
Tillage erosion	3.0 – 9.0	n/a
Slope engineering	n/a	454
Crop harvesting	1.3 – 19.0	n/a

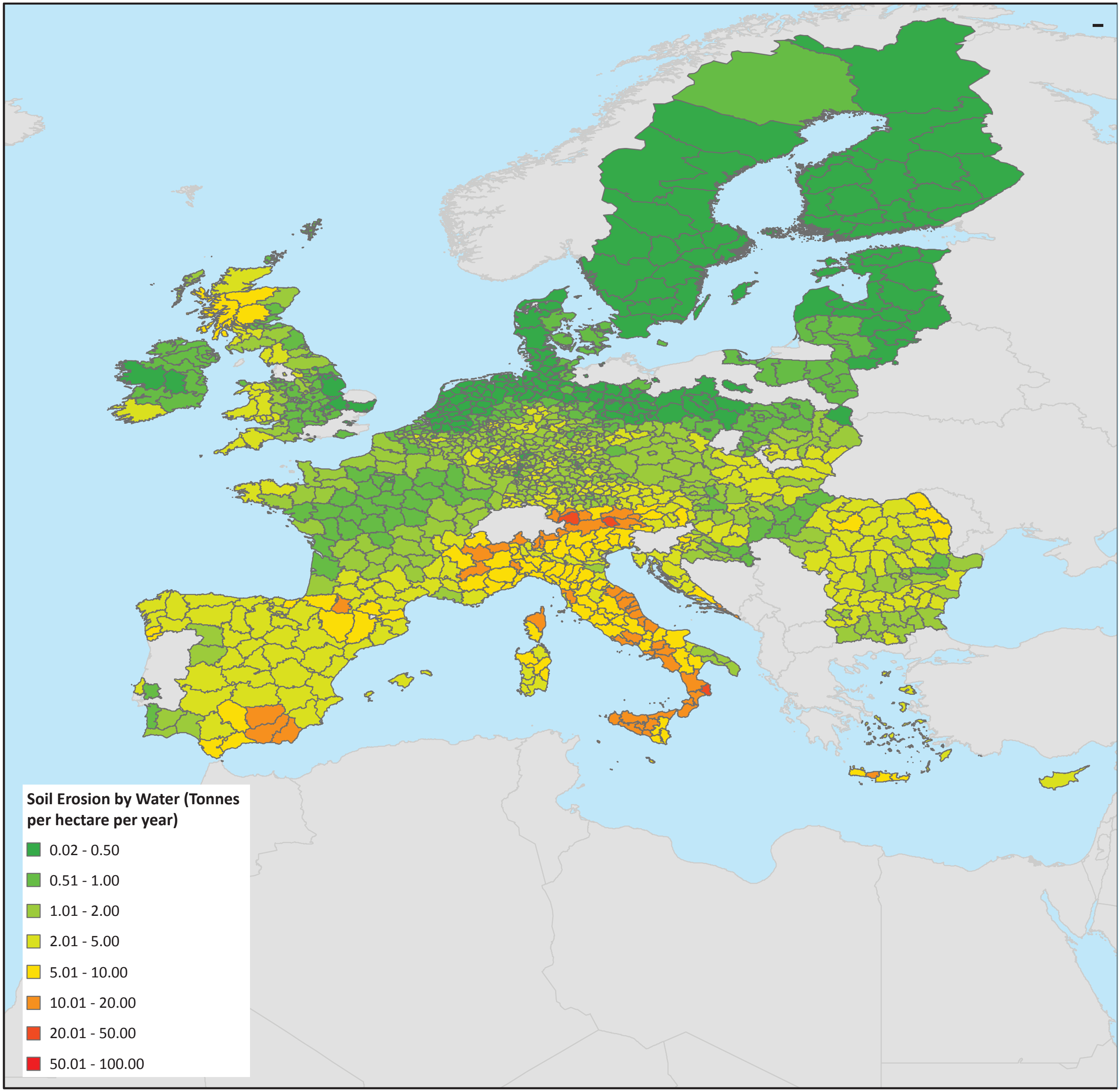
n/a: not available.

Source: Adapted from Verheijen *et al.* 2009

Those rates need to be compared to the tolerable soil loss rate estimated to a maximum of 1 t ha^{-1} yr^{-1} based on soil weathering rates and African dust deposition, which can reach up to 0.2 t ha^{-1} yr^{-1} in Southern Europe. This limit also takes into account the effect of accelerated erosion on the decrease in water quality observed in European rivers (Verheijen *et al.* 2009).

There is no consensus among scientists on the regions that are the most affected by water erosion in Europe. The analysis of a large set of experimental plot data (2 741 plot-years collected at 81 sites in 19 countries) by Cerdan *et al. (*2010), suggests that soil erosion mainly affects the hilly loess areas of Western and Central Europe, as well as the piedmont areas of the major European mountain ranges. In contrast, other analyses based on modeling show that erosion rates are higher in Mediterranean regions (Eurostat 2015c). The literature clearly shows that problematic erosion rates occur in both Northern and Mediterranean European regions, depending on local conditions such as, topography, soil, rainfall erosivity as well as land use and management. However, as the soil resource available is strongly variable across Europe (for instance the presence of thick loess deposits in Northwestern Europe vs. thinner and stonier soils in the Mediterranean region), this difference should be taken into account when investigating the impact of soil erosion rates on land degradation. The discussion should not be limited to a comparison of individual erosion rate values.

Figure-L2 44: Soil erosion in Europe, 2010



Source: EUROSTAT 2010

122: *Scale of wind erosion of soils in Europe*

In addition to water erosion, wind erosion caused by the simultaneous occurrence of high wind velocity, susceptibility of loose surface particles and insufficient surface protection is mainly concentrated in arid or semi-arid agricultural areas, where it leads to land degradation and to the deterioration of air quality (Funk and Reuter 2006). Wind erosion occurs predominantly on the Northern European Plain (northern Germany, eastern Netherlands and eastern England) and in parts of Mediterranean Europe (Verheijen *et al.* 2009). However, this process has been under-studied compared to other erosion phenomena (Borrelli *et al.* 2014a). Current evaluations indicate that wind erosion can be a significant problem in regions covering between 2.9 per cent (high susceptibility) and 5.3 per cent (moderate susceptibility) of the total EU surface area (Figure-L2 45).

A conservative assessment for the whole of Europe estimates the total cost of erosion in the range of €6 200 to €62 500 million. The severity of this problem has been acknowledged through the adoption of the EU Thematic Strategy for Soil Protection by the European Commission on 22 September 2006 (Montanarella 2007). However, to date, before the possible adoption of a Soil Framework Directive, soil degradation is only addressed indirectly in the framework of environmental policies. From 2015 onwards, the new Common Agriculture Policy (CAP) introduced a new policy instrument in Pillar 1, otherwise known as the Green Direct Payment. This accounts for 30 per cent of the national direct payment envelope and will reward farmers for respecting three obligatory agricultural practices, such as the maintenance of permanent grassland, creation of ecological focus areas and diversification of crops. As the green direct payment is compulsory, it has the advantages of introducing practices that are beneficial for the environment and climate change mitigation on most agricultural areas in use, and improving biodiversity also in other forms of land use, including ecological focus areas and permanent grasslands (EC 2014c).

123: *Rehabilitation of contaminated sites*

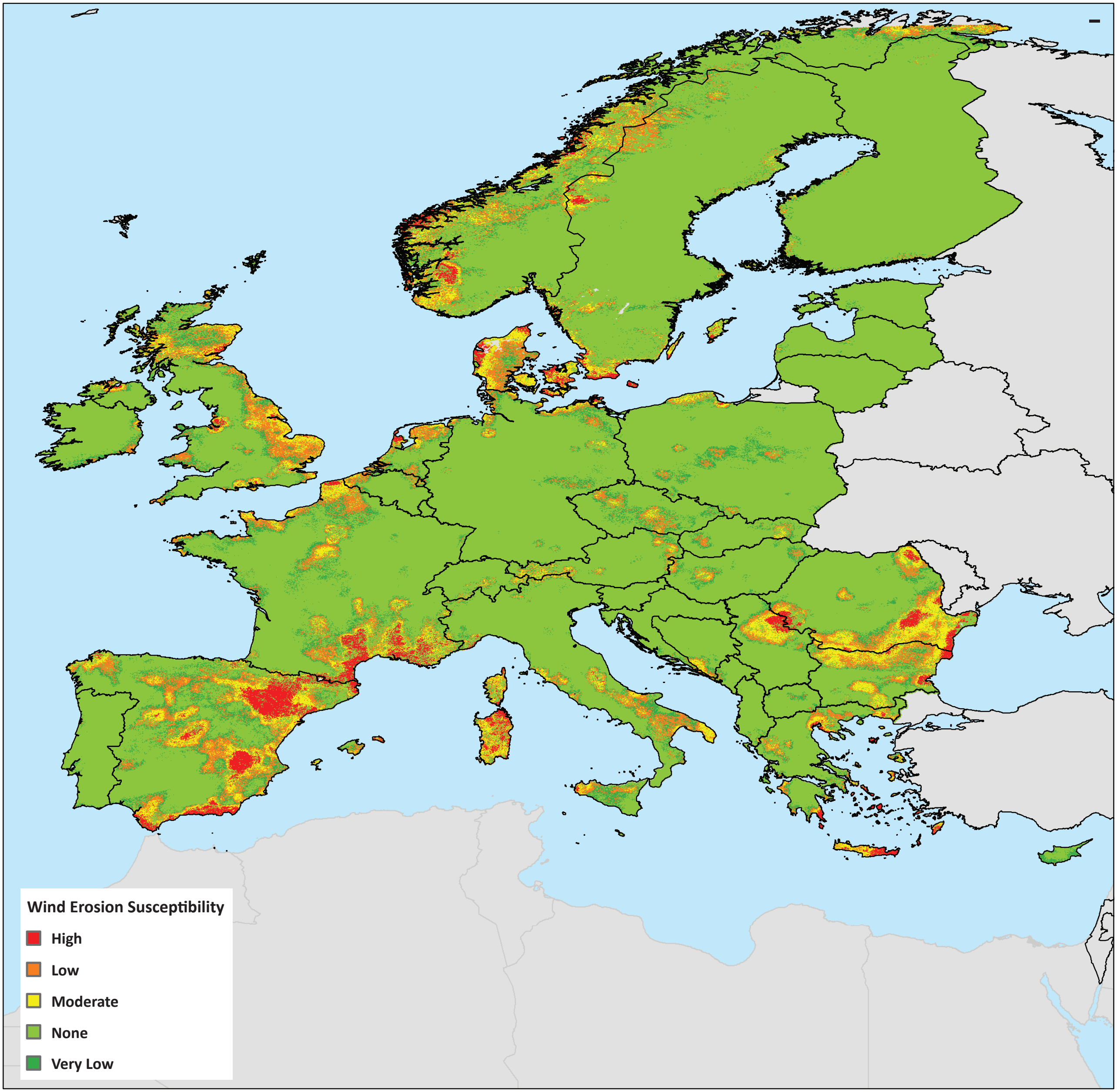
The EC has promoted several positive experiences in the EU, spreading good practices among the member states as in the case of brownfield regeneration and soil revitalization. These can contribute to sustainable land management and provide an alternative to additional land take of around 275 ha/day in the EU28. Tackling past soil pollution is also an efficient way of limiting soil sealing, hence preserving agricultural land or green areas, and their ecosystem services. Brownfields have been affected by their former uses, and the surrounding land may have real or perceived contamination problems, and hence require interventions to bring them back to beneficial use. Nevertheless, in most cases, it is difficult to apply the polluter pays principle as the polluter may have already disappeared, and is either not liable according to the law (historical contamination) or cannot face remediation costs for economic reasons.

Among the many problematic cases throughout the EU, 29 *success stories* have already been achieved by fostering dialogue among interested parties at the local level, using new methodologies for *in situ* treatment and applying risk-based land management. A good example comes from Slovakia, where a programme for remediation of sites is under way (Malý 2015). Other key issues recognized as crucial for addressing soil contamination include efficient technology transfer, adopting modern comprehensive legislation and accelerating good communication among stakeholders, from authorities in charge to the public, following the *Aarhus convention principles*.

124: *Soil resources of Central Asia*

Central Asia is commonly associated with deserts, but in reality it is a region of high diversity of landscapes and corresponding soils. There is a distinct latitudinal aridity gradient from its northern steppe ecosystems, followed by intermediate dry steppes and semi-deserts, to the most southern part where there are desert ecosystems. Consequently, the soils in the more humid north are humus-rich Chernozems, while the intermediate zone still has fertile soils and the south is dominated by alkaline soils with very poor chemical, physical and biological properties. Two

Figure-L2 45: Wind erosion susceptibility in Europe using the index of Land Susceptibility to Wind Erosion (ILSWE) predicted for 36 European countries (at a spatial resolution of 500m)



Source: Borrelli *et al.* 2014b

major rivers of the region are Syr Darya and Amu Darya that terminate in the Aral Sea. The Amu Darya delta is one of the most ancient centers of agriculture in the world, cultivated for at least 5 000 years (Tsvetsinskaya *et al.* 2002).

The highest mountainous ranges are concentrated in the southeastern part of the region, mostly in Kyrgyzstan and Tajikistan. They are affected by various types of soil degradation, including overgrazing, which commonly results in increased erosion and soil compaction. The northern-most fertile areas of the region are used for wheat production. However, extensive tillage of the virgin lands has affected the natural balance of the ecosystems and been impacted by strong wind erosion and in accelerated soil organic carbon loss due to oxidation.

The vast areas of dry steppes and semi-deserts are commonly used as rangelands. These flat and slightly undulating landscapes initially had soils affected by elevated alkalinity and salinity due to the marine origin of sediments. The area of saline soils in Kazakhstan, including the alkaline soils and their associated complexes, reaches 111.55 million hectares, or 41 per cent of the national territory (Borovskii 1982). All of the areas close to the two major rivers and especially their deltas are irrigated, and are used for the production of cotton, wheat and rice. Fruits and vegetables are also produced, either with or without irrigation.

The Central Asian region has the worst situation with soil resources, due to mountainous topography, the abundance of salt-containing sediments and an arid climate. The main drivers of soil degradation there are climate change (aridization), population growth and smallholder-based farming.

Regarding erosion, a clear trend throughout the East European plain, including the Russian Federation, is the increase in the soil erosion rate during the last 20–25 years, compared with the average rate for the previous 140-150 years-long plowing period (Golosov *et al.* 2011).

The increasing population in Central Asia requires future growth of agricultural production both for internal use and export, which may lead to greater pressures on soils and agro-ecosystems. The main pressure on soils in the region is improper soil and water management due to the lack of investment, poor coordination of land and water use, and unsatisfactory implementation of novel agro-technologies. The main challenges to soil productivity are soil degradation processes such as soil salinization, water and wind erosion, and nutrient depletion and improper management. On the other hand, "natural" pre-existing drivers include an arid climate, saline parent material, and complex and rugged relief.

125: *Soil sealing in the Mediterranean region: the case of technosols and Maltese islands*

Technosols that are described as *soils with a significant amount of artefacts introduced by humans or sealed by technic hard materials*. Cities, roads, mines, refuse dumps, oil spills, coal fly ash deposits are all Technosols. (IUSS Working Group, The World Reference Base (IUSS Working Group WRB 2015). The WRB is an international system used to classify soils. The WRB is the official nomenclature adopted in the EU to harmonize the classification of soils and accelerate dissemination of soils-related information among the Member States.

126: *Challenging the carbon loss in European soils*

A new *Good Agricultural and Environmental Conditions* (GAEC) standard on soil organic matter protection includes a ban on arable stubble burning and an obligation not to plough wetlands and carbon-rich soils. The greening aspect of the first pillar of the CAP, as proposed by the Commission, would improve the situation further, particularly in relation to erosion and soil organic matter (EC 2012). Some 45 per cent of soils in Europe have low or very low organic matter content (0–2 per cent organic carbon). This is particularly the case in the soils of many southern European countries (Zdruli *et al.* 2004), but is also evident in parts of Belgium, France, Germany, Norway and the United Kingdom (SmartSoil 2015). A key driver is the conversion of woodland and grassland to arable crops. At a global level, land-use conversions and drainage of organic soils for cultivation are responsible for about 10-12 per cent of all greenhouse gas emissions (Smith *et al.* 2007), while agricultural activities contribute, both directly and indirectly, account for about 30 per cent of total anthropogenic emissions (IPCC 2014d). Nevertheless, predictions are that this share could increase drastically.

EU soils contain more than 70 billion tonnes of organic carbon (Lugato *et al.* 2014), which is equivalent to almost 50 times the EU's annual greenhouse gas emissions. In 2009, European cropland emitted an average of 0.45 tonnes of CO_2 per hectare (much of which resulted from land conversion). The conversion of peatlands and their use is of particular concern. For instance, although only 8 per cent of farmland in Germany is on peatland, this area is responsible for about 30 per cent of total greenhouse gas emissions for the entire farming sector (De Vos *et al.* 2015). However, with appropriate management practices, soil organic matter can be maintained and even increased. Apart from peatlands, particular attention should be paid to the preservation of permanent pastures and the management of forests soils. Keeping carbon stocks is thus essential for the fulfilment of present and future emission reduction commitments deriving from the implementation of the Soil Thematic Strategy (EC 2012c). The Life and Soil Protection report (DG Environment 2014) from the EU LIFE Environment programme identifies building soil organic matter as one of four headline priority issues, along with reducing soil erosion, the remediation of contaminated land and promoting targets for soil protection.

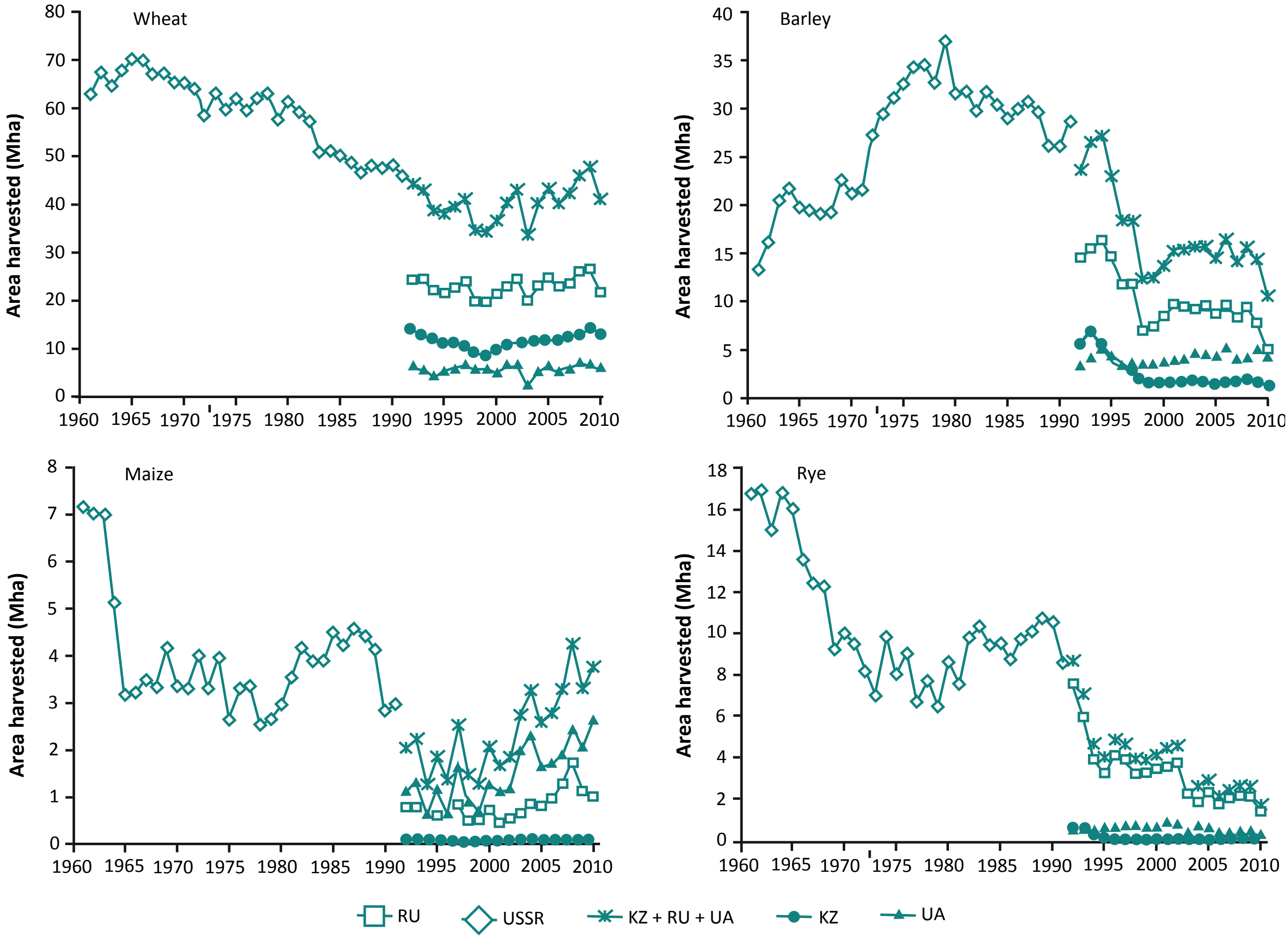
127: Socio-economic factors of land abandonment in Eastern Europe and Central Asia

The breakup of the former USSR and the Council for Mutual Economic Assistance (COMECON) in 1991 began a period of transition from state-controlled to market-driven economies across Eastern Europe and Central Asia that resulted in a fundamental transformation of their agricultural systems and land-use. These transitional economies went through a stage of decline from 1991 to 2000. This economic and social crisis was particularly hard in rural regions, where state support of agriculture ended and rural development ceased almost entirely; where average life expectancy declined from 69 to 65 years, and male life expectancy in rural areas of the Russian Federation declined from 61 to 53 years (Prishchepov *et al.* 2013). As farming subsidies declined, the high cost of imported herbicides, fungicides and insecticides caused farmers to cut back on their use. Fertilizer use fell by 85 per cent in the Russian Federation and Ukraine and by almost 90 per cent in Kazakhstan between 1990 and 2000. Total grain production fell by more than 50 per cent during the same period (FAO 2013e). Between 1990 and 2000, investments in the Russian Federation agricultural sector declined from $39 billion to $2 billion (Prishchepov *et al.* 2013).

This free-fall in agricultural production in the Russian Federation, Ukraine and Kazakhstan slowed by 2000 and signs of recovery have been observed in all three countries since 2002-2005, clearly coinciding with the broader economic recovery of the entire region. Due to recovery of some agricultural subsidies and at least the partial success of reforms, fertilizer and machinery use has increased during the past few years. The use of mineral fertilizer has tripled since 1999 in Kazakhstan and doubled in the Russian Federation and Ukraine, but current application rates represent only a fraction of the amounts applied in the late 1980s (Lioubimtseva and Henebry 2012). A return to the 1980s application rates is unlikely and unnecessary, as they were frequently excessive. Between 1996–2000 and 2001–2008, overall yields had grown from 1.3 t/ha to 1.83 t/ha (FAO 2013e). Although weather remains a very important determinant for grain yield, improvements in crop management practices, fueled by growing state subsidies since 2005, have contributed to the recent increase and stabilization of crop yields (Liefert *et al.* 2013). However, this did not reduce the scale of land abandonment as marginal arable lands grew unprofitable and were gradually abandoned even under high grain demand. In addition, the area under cereals has continued shrinking from 50 million hectares in 1996–2000 to 45 million hectare in 2001–2008 (FAO 2013e).

The share of harvested land under various major crops has changed in a different way (Figure-L2 46). Wheat has been the primary cereal crop in terms of area harvested and shows a slight increase in harvested area after the half-century of decline that followed the Virgin Lands expansion

Figure-L2 46: Trends of harvested land under various major cereal crops



Source: adapted from Lioubimtseva *et al.* 2013

decline. Barley has been a significant secondary crop, but declines in area harvested began in the mid-1970s and further accelerated through the mid-1990s. Rye, which is largely restricted to the Russian Federation, has declined substantially since 1991, and shows no evidence of recovery. Maize continues to be a minor crop regionally, but the harvested area has been increasing steadily since the mid-1990s, particularly in Ukraine (Lioubimtseva *et al.* 2013).

128: Crisis of the livestock sector in Eastern Europe and Central Asia

The loss of pasturelands occurred at an even larger scale as compared to arable lands. Between 1992 and 2006, the Russian Federation lost almost half of its meat production: the number of cattle dropped from nearly 20 million to 10.3 million heads, the number of pigs fell from more than 36.3 million to 18.7 million, and the number of sheep dropped from

20 million to 7 million (FAOSTAT 2013). In Kazakhstan, there were 33.9 million sheep in 1992, but by 1999 that number had dropped 75 per cent to 8.6 million (Lioubimtseva and Henebry 2009). The drop in livestock inventories led in turn to a drop in demand for feed grain and pastures across the region. Although the free-fall in livestock inventories has slowed since 2000, large industrial farms have been shifting away from livestock and toward crop production (Ioffe *et al.* 2012), and livestock inventories continue to decrease, particularly in areas with extensive herding, such as Central Asia, Kazakhstan and semi-arid and arid zones of the Russian Federation (Lioubimtseva and Henebry 2009, 2012). Between 1991 and 2001 meat production in the Russian Federation, Ukraine and Kazakhstan shrunk by 50 per cent (OECD 2002).

129: *Global food trade and its implications for land use*

While the dynamics of land use and economic development have long been intertwined, globalization is today an important driver shifting world ecological-economic relationships (Kastner *et al.* 2014; Fischer-Kowalski and Haberl 2007). Pressures on land systems are a key consequence, often associated with land use and land cover change (Schaffartzik *et al.* 2015; Henders and Ostwald 2014). Understanding and altering Europe's economic relationships between human activities and anthropogenic landscapes requires not only an appreciation of processes that occur within European borders, but also a consideration of the indirect linkages between populations and lands that lie on either sides of regional boundaries (Wiedmann 2009). Europe imports large quantities of food from, and is highly integrated within and dependent on, global flows of land use embodied in trade. Weinzettel *et al.* (2013), measuring in terms of global hectares, found that in 2004, the area of Europe west of the Ural Mountains had a per capita consumption of up to 2.5 global hectares. Indeed, considerable net subsidies to Western European final demand originated in land use in the Russian Federation and Eastern Europe, with China, Africa and Latin America also playing strong roles (Bergmann and Holmberg 2016; see Figures-L2 47, 48 and 49). In Western and Eastern Europe and the Russian Federation respectively, 33 per cent and 27 per cent of croplands that were embodied in imports were in the form of manufactured goods or services. The percentages of forest land used in imports that were associated with final demand in manufactured goods and services were especially intense, at 73 per cent and 69 per cent respectively for the two sub-regions (Bergmann and Holmberg 2016).

Figure-L2 47: Food production and food trade dynamics

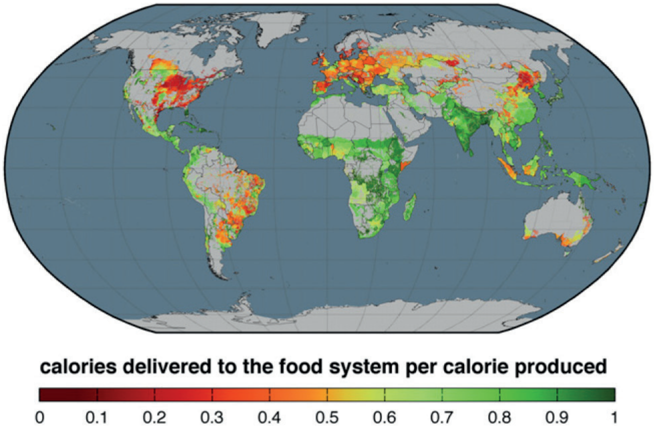


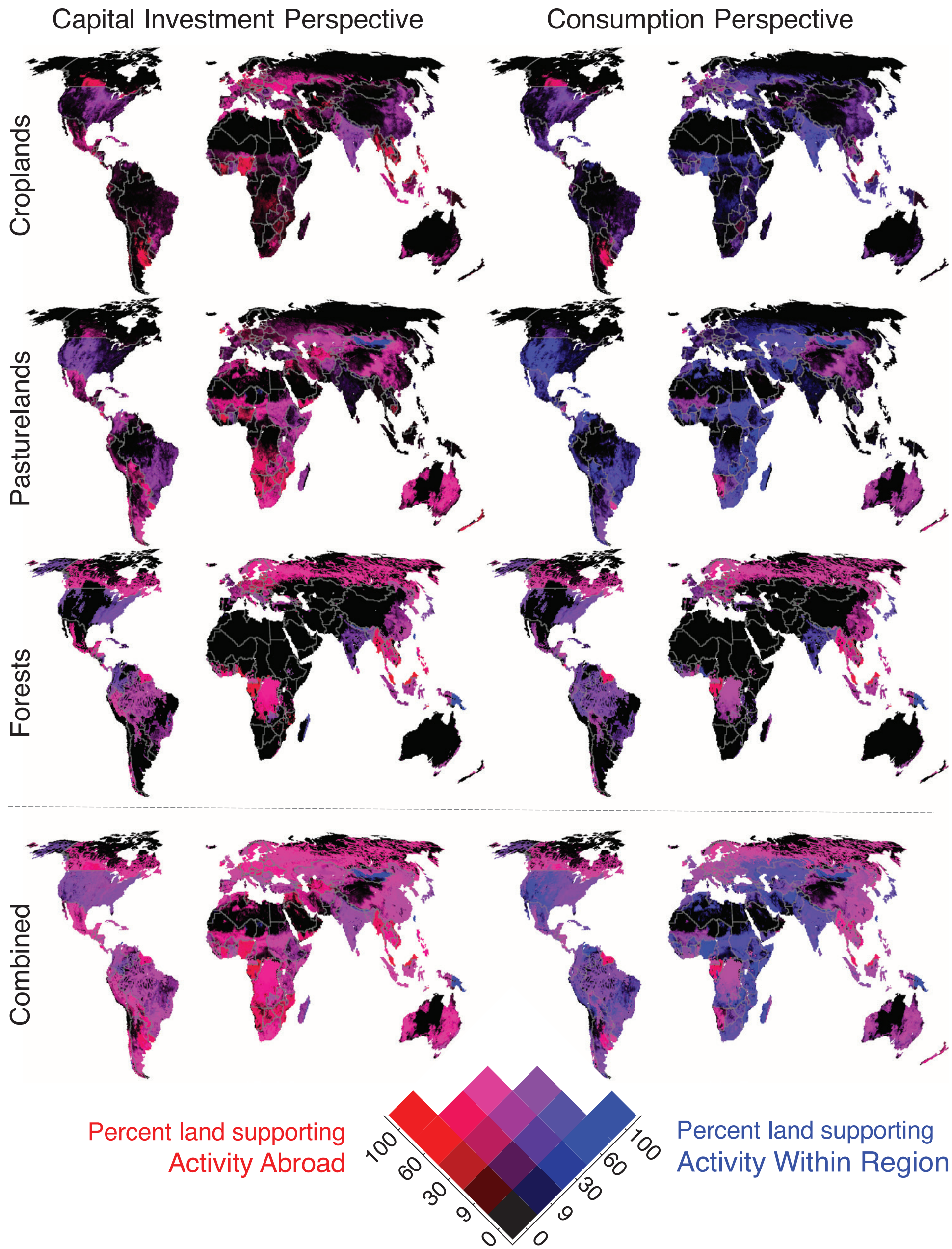
Figure-L2 46: The world map of crops for humans illustrates how certain continents, including Europe, use land inefficiently, cycling nutrients through crops mainly for livestock and other purposes such as biofuels to satisfy demand for animal products and cheap transportation.
Source: Cassidy *et al.* 2013

Two world maps illustrate how global trade and the force of capital influence how land and biocapacity is used, creating huge impacts on the. proportion of food/bioproduct "miles" and storage which increase further economic costs and which also lead to deterioration in nutrient value of the food, increase risks of disease transmission and waste.

130: *Green infrastructure and its health effects*

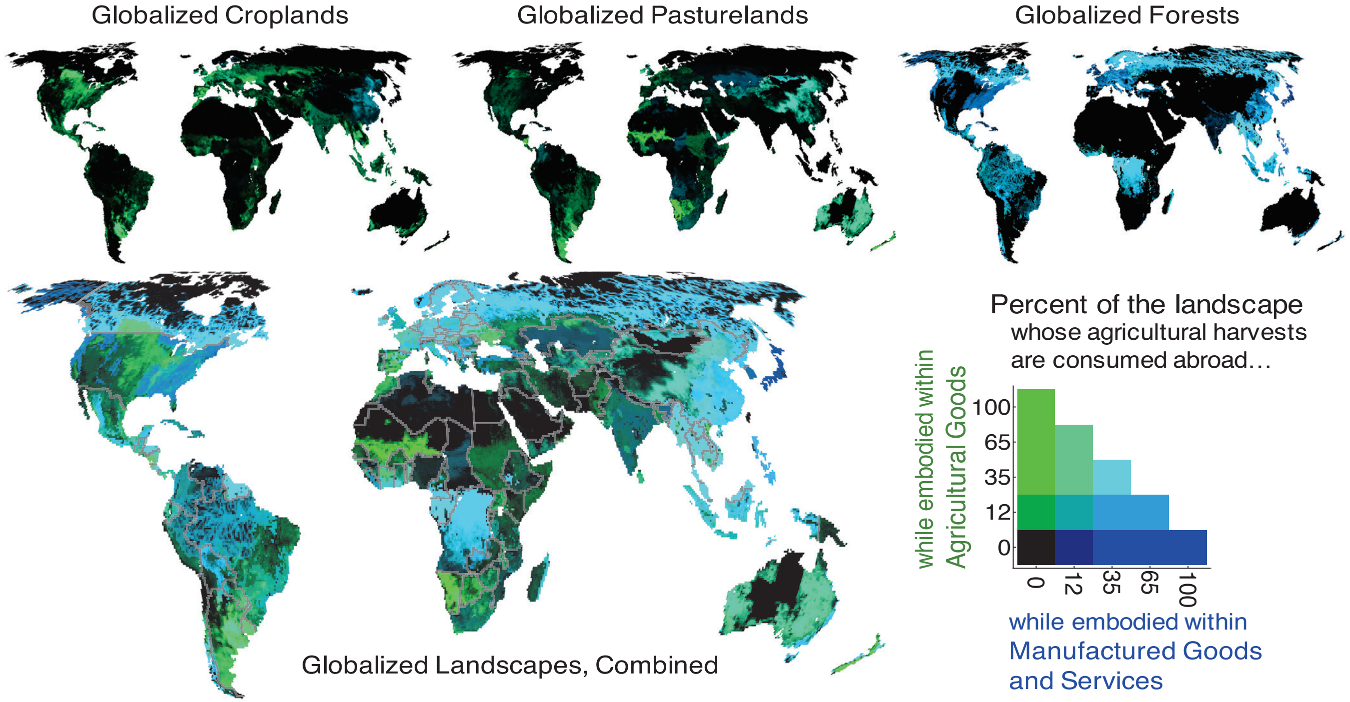
Green infrastructure (GI) as a concept is particularly relevant to the Western European highly developed landscape and is defined as a network of natural and semi-natural features, green spaces, rivers and lakes that intersperse and connect villages, towns and cities. It might also be described as ecological restoration (EEA 2014h). When appropriately protected, planned, designed and managed, GI has the

Figure-L2 48: Different perspectives on the globalization of lands in 2007 - Eckert IV projections



Source: Bermann and Holmberg 2016

Figure-L2 49: Relative roles played by agricultural commodities versus manufactured ones and services in globalizing lands - Eckert IV projections



Source: Bermann and Holmberg 2016

potential to deliver a wide range of benefits: from providing sustainable transport links, to mitigating and adapting to the effects of climate change, to promoting health and wellbeing. GI has an important contribution to make to public health, with a body of evidence demonstrating reductions in overall all-cause mortality, cardiovascular disease, obesity, benefits to pre-natal health, and reductions in depression, stress and anxiety, together with increases in subjective feelings of well-being. The beneficial effects appear to be particularly prominent in disadvantaged urban communities (Kirby and Russell 2015; Kuppuswamy 2009). *Greenbelts* as undeveloped open spaces that surround urban areas are typical of metropolitan regions, and when protected can prevent urban sprawl and add significant value to planning policies. However, they do not necessarily contain the growth of urban sprawl or suburbanisation (Siedentop *et al.* 2016).

The GI effects are thought to operate through several mechanisms:

(1) increased physical activity (i.e. green spaces afford opportunities for walking, cycling, jogging, recreational sports and play);

(2) increased sunlight exposure which increases Vitamin D and circadian efficiency;

(3) increased social contact (i.e. via impromptu or planned social interactions);

(4) psychological restoration (i.e. simply looking at or walking in green space promotes rapid psychological and physiological changes that have been demonstrated using

self-report scales, and objective physiological measures of change, such as mobile electroencephalograms and by measurements of cardio-parameters, blood pressure and salivary cortisol.

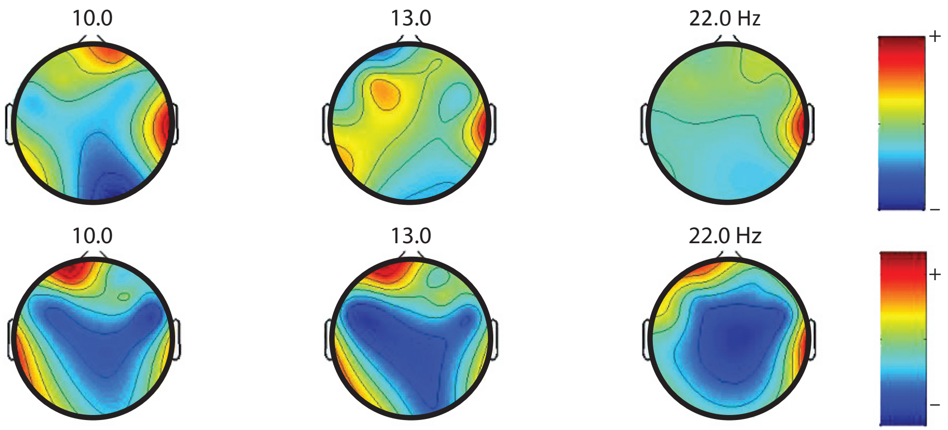
The impact of urban green space on the brain

The images below (Figures-L2 50) represent the output from a mobile electroencephalogram (EEG) and show clear differences in brain activity measured by EEG whilst moving through an urban green space (top row) and an urban busy space with no green space (bottom row). These images illustrate changes, in particular in the frequency in brain waves: Alpha waves (9-13 Hz) are associated with relaxed state; beta waves (22-27 Hz) are associated with alert states; 13Hz refers to the edge of alpha and beta activation. The warmer a color (red being warmest) the more activation at that site. The cooler colors (dark blue being coolest) refer to decreases in activation. A greenish color refers to no change or change of little note. This shows one can notice increases in frontal activation across alpha and beta in the urban busy walk (at the edge of the circle, the point of contact with the electrical node). This activation may be explained by the relative increase in attention that may be required due to features of the walk such as traffic and road crossings.

The impact of urban green space on physiological stress

A UK study measured the concentrations of cortisol - the stress hormone - found in human saliva, in adults who were unemployed (or otherwise not employed), aged 35-55 and living in socially disadvantaged city areas in Central Scotland (Figure-L2 51). The study found significant differences in physiological stress in people living with different quantities of green space in the living environment. Diurnal cortisol concentrations typically fall across the day in steep gradient for individuals who are regulating stress well. This is the pattern the study found for those people living with higher levels of green space (the black solid line). People suffering from chronic stress and exhaustion typically have lower levels of cortisol, producing a blunter gradient, the pattern found in the people living with lower levels of green space (the dotted line). This has important health implications because dysregulation of the daily pattern of cortisol secretion, part of our circadian rhythms, is associated with an array of negative health outcomes including major depressive disorders (Thompson *et al.* 2012).

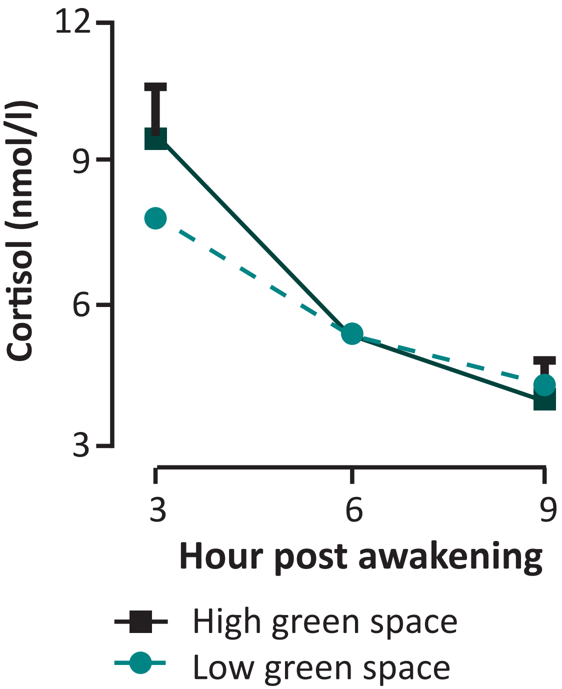
Figure-L2 50: Brain activity measured by EEG whilst moving through an urban space with green space and an urban space without green space



Top: Green walk Bottom: Urban Busy
10 Hz = alpha, 13 Hz = alpha/beta edge, 22 Hz = beta

Source: Neale *et al.* In press

Figure-L2 51: Concentrations of cortisol



Source: Thompson *et al.* 2012

Preservation of ecosystem diversity/ protected land

Biodiversity is vital for human health, underpinning ecosystem functioning that provides services such as water and air purification, pest and disease control and pollination. Reduced contact with the natural environment and "friendly" microbes, for example, is linked with reduced immunity to disease (Rook 2013). Environmental microbes supplement and diversify the composition of symbiotic microbial communities we pick up from our family and other people, which in turn play significant roles on our physiology. Some vital microbes for immunity have been almost eliminated from the urban environment through loss of natural land to the built environment. A lack of these friendly microbes and bacterial contact can lead to insufficient development of white blood cells that defend the body against infection, particularly those called T-cells: the foot soldiers of the immune system that attack foreign invaders in the bloodstream. We therefore need to maintain the microbal diversity of the environment in order to drive essential regulation of the immune system.

In high-income urban settings, illnesses associated with failing immuno-regulation are increasing, particularly chronic inflammatory diseases such as allergies, autoimmune diseases and inflammatory bowel diseases (Rook 2013). There is also an increase in diseases associated with another consequence of disturbed immuno-regulation: long-term background inflammation manifested as persistently raised C-reactive protein (CRP) and associated with cardiovascular disease, metabolic syndrome, insulin resistance and obesity (Rook 2013). Some cancers that are increasing in prevalence are also associated with poorly controlled inflammation, as is Alzheimer's disease. Diminishing microbial diversity from the natural environment is implicated in all of these diseases. Protecting public health therefore depends upon protecting biodiversity and natural environments.

131: *"City of Tomorrow"*

The development in Malmö, Sweden, built for the European Housing Expo, was completed in 2001 and branded the "City of Tomorrow" (City of Malmö 2006). The development 'Bo01' accounts for 25 ha and includes around 500 houses as well as restaurants, cafes, business and recreational areas; incorporates SuDS throughout; and makes visible the drainage system, centred around a saltwater canal, which is fed with sea water through a pump system and receives stormwater at multiple points via gravity. The water flows in small channels around the development; multiple features are used to collect the rainwater. The site aims to increase biodiversity through green walls and roofs, vegetated ponds and rain gardens. Bo01 had a strong focus on improving biodiversity from the outset via bird boxes, maximising native flora, no mown lawns and green roofs. A recent survey showed health and well-being benefits to residents and passersby.

132: [Protocol on Soil Conservation to the Alpine Convention]

Based on the fact that there are no laws specifically on soil protection in most Alpine countries, the Soil Conservation Protocol to the Alpine Convention, with its exhaustive approach, has set reference levels since 2005. One of the central objectives is the sustainable preservation of soil. The protocol points out that soil is a characteristic element of nature and landscape, and an integral part of the ecological balance, especially with regard to water and nutrient cycles. Soil functions must also be guaranteed and preserved or restored for economic utilization, as a space for human settlement and transport. The Protocol also aims at limiting erosion and minimizing the input of substances harmful to soil. The Precautionary Principle must ensure the functionality of soil for future generations. In this sense, in case of risk of serious and sustained damage, it is also necessary for protection to be given priority over utilization. The Protocol recommends an economical use of soil, with the indication of substitute materials and the recycling of raw materials. Highland and lowland moors, characterized by high organic matter content and fertility, should be preserved, as the medium-term goal is to completely discontinue the use of peat for industrial purposes. The *Protocol on Soil Conservation* can be seen as good basis to for strengthening joint implementation through intense trans-national cooperation and coordination.

133: [Giving Soils a voice]

Currently, more than 85 organizations are supporting the *People4Soils* Civil Society Coalition for Action, which started in 2014. Poeple4Soils is an open network of European non-governmental organizations (NGOs), research institutes, farmers' associations and environmental groups. The main aim of this network is to strengthen soil protection as a common good through better regulation and governance within the EU and its Member States. Reaching higher political recognition, the network will mobilize organizations and EU citizens with a public petition in 2016 through the *European Citizens' Initiative* (ECI) in which citizens have the right to recommend EU legislation.

Strengthening environmental governance

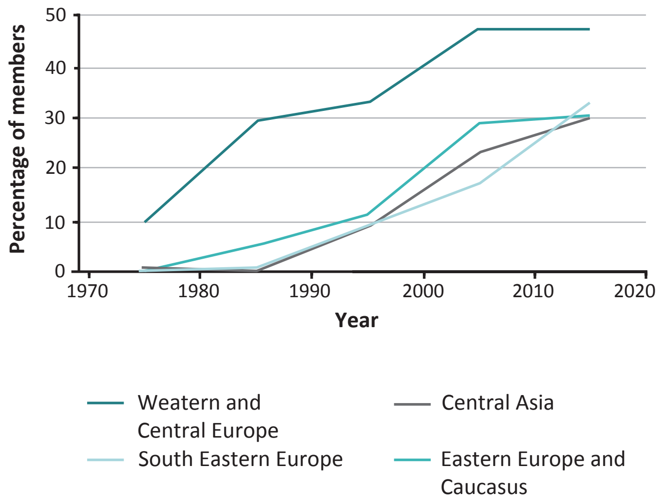
134: [Participation in MEAs by pan-European countries]

Since the early 1970s a multitude of bilateral, regional and global environmental treaties and other policy instruments, such as supranational laws and regulations, action programmes, joint declarations and resolutions, and decisions by international organizations and governing bodies of MEAs, have emerged (*http://www.informea.org/*).

Around 950 MEAs were enacted worldwide between 1970 and 2015 (*http://iea.uoregon.edu/).* Moreover, the existing body of environmental law in the EU amounts to some 500 directives, regulations and decisions (EEA 2015). Countries of the region were also active participants in the Millenium Development Goals (MDGs), and now the 2030 Agenda for Sustainable Development and the SDGs.

More than 90 MEAs can be regarded as particularly relevant for the regional priorities and thematic areas covered in this assessment. Many of the pan-European countries have joined these MEAs (Figure-L2 52), albeit with considerable variation across sub-regions and in coverage across priority

Figure-L2 52: Participation in MEAs



Data source*: http://iea.uoregon.edu/*

areas. Participation by every country in the region in MEAs has increased since 1995 but with slower rates for the countries of South Eastern Europe, Eastern Europe, the Caucasus and Central Asia, than for the countries of Western and Central Europe.

135: EU Business@Biodiversity Platform

Within the framework of the thematic *EU Biodiversity Strategy to 2020*, the EU Business and Biodiversity (B@B) Platform was launched in 2008 to facilitate and promote actions by the business community in favour of biodiversity. In Phase one of the platform's work, participants worked together to provide inputs to documents, workshops, questionnaires and consultations on several aspects of business and biodiversity, covering six sectors: agriculture, forestry, finance, food supply, non-energy extractive industry and tourism. Phase one has also been effective in terms of communication activities and increasing awareness of the ways that business can support biodiversity. The platform also invested significantly in benchmarking of best practices where the main challenge was the development of methodologies that accommodate the needs of all sectors. Some useful good practice examples concerning, in particular, the monitoring of biodiversity have also been developed. Importantly, Phase one of the platform also encouraged the creation of *national business and biodiversity platforms*. Since 2014, *Phase two* of the platform has taken a different approach; firstly, it is open to all sectors and aims to engage businesses more actively. Secondly, it helps coordinate and raise awareness of other national and international business and biodiversity platforms. Finally, in order to deliver tangible results, the platform is currently working with businesses on three concrete workstreams: natural capital accounting, innovation for business and biodiversity, and access to financing and innovative financing mechanisms.

The EU Platform will address business issues at a pan-European level, while national platforms will focus on translating EU work into a national context by addressing business concerns at a local or Member State level. The national platforms vary in their membership structure; some include business and government representatives, others also have civil society representatives.

136: The Portuguese Green Growth Commitment

The Portuguese Green Growth Commitment (GGC) is the National Strategy for the transition to a green and low carbon economy within a sustainable development perspective. The GGC seeks to lay the foundations for a commitment to policies, goals and targets that foster a development model able to reconcile essential economic growth with lower consumption of natural resources, social justice and quality of life. It was approved by the Council of Ministers in April of 2015 and involves a coalition of more than 90 stakeholders.

The vision is to promote in Portugal green economic growth with national and international visibility, stimulating green economic activities, promoting the efficient use of resources and contributing to sustainability. There are 14 quantified goals for 2020 and 2030 in the three dimensions of the vision - Growth, Efficiency and Sustainability.

Priorities were established to focus efforts on a feasible number of initiatives benefiting from selective investments in strategic areas. GGC is based on 10 pillars (Water, Waste, Agriculture and Forestry, Energy and Climate, Mobility and Transport, Manufacturing and Extractive Industries, Biodiversity and Ecosystem Services, Cities and Territory, Sea and Tourism) and covers six catalyzers (Financing, International Promotion, Taxation, Research, Development and Innovation, Information and Participation and Public Procurement). Implementation of the GGC started in July of 2015. The governance of GGC includes an executive secretariat and thematic working groups and a set of indicators has been designed for monitoring progress.

137: Financing the transition: the 4Rs of system reform (UNEP Inquiry)

Harnessing the financial system is essential if we are to make a successful transition to a low-carbon, resilient and sustainable global economy. Complex environmental challenges – including resource scarcity, natural capital degradation, and climate change – pose multiple risks and opportunities for the more than US$300 trillion in assets that make up the financial system. Overcoming these challenges requires a systemic response – combining both market and policy innovation. In January 2014, UNEP established an Inquiry to identify policy options that would strengthen the alignment between the financial system and sustainable development. What the Inquiry found was a 'quiet revolution' in policy and practice, captured in its global report, *"The Financial System We Need"*. Looking ahead, the tasks for financial system reform in the face of climate change can be summarised as the 4Rs of capital raising, enhanced responsibilities strengthened risk management and systematic reporting:

1. Capital Raising: Considerable financial innovation will be required to mobilise the sums required for the transition, with a critical arena being the world's US $100trillion debt capital markets: Issuance of 'green bonds' grew three-fold in 2014 to US $36bn. New voluntary principles and standards are emerging to ensure market integrity.

2. Enhanced Responsibilities: An increasing number of countries – including the Netherlands, the UK, as well as South Africa – have clarified that fiduciary obligations do not preclude the consideration of material sustainability factors in the investment process. Re-establishing financial purpose is also being pursued at a systemic level, with the Dutch Central Bank recently reconfiguring its mandate to focus on sustainable prosperity alongside financial stability.

3. Risk Management: Awareness of the potential for sustainability factors to pose prudential risks has been building among financial regulators. In 2015, The Bank of England's Prudential Regulation Authority published the world's most detailed assessment of climate risks to the national insurance sector, focusing on physical risks, liability risks, and transition risks. Policymakers can help to strengthen this trend by encouraging the use of sustainability stress tests, considering air pollution, carbon emissions, natural hazards and water stress.

4. Systematic Reporting: Better flows of information underpin all of these tasks – from capital markets to the end customer. Twenty-seven of the world's leading stock exchanges are now working together to include sustainability into their listing requirements for companies. Enhancing disclosure by financial institutions is the next task: the new French Energy Transition Law requires institutional investors to undertake carbon footprints of their investment portfolios, and disclose their contributions to advancing the low-carbon transition and international climate change objectives.

Taken together, these four steps will not just help to ensure a smooth transition to a climate secure economy, but could also contribute to the efficiency and effectiveness of the financial system as a whole.

138: Tehran Convention: Environmental governance for the Caspian Sea

When the Framework Convention for the Protection of the Marine Environment of the Caspian Sea (*Tehran Convention*) entered into force in August 2006, it created a comprehensive governance structure for common responses to transboundary environmental problems in the Caspian Sea region. It was the first legally-binding agreement among the Seas littoral states Azerbaijan, Iran, Kazakhstan, Russian Federation and Turkmenistan and for that reason hailed by the UN Secretary General as a "significant step forward for the region" to "benefit the health and livelihoods of millions of people". Since then, the Caspian states have used the Convention's framework to substantiate their efforts and negotiate further international treaties in main areas of environmental concern which should lead to further improvements in coming years.

The exploitation of oil and gas is a major commercial activity in the Caspian Sea. In order to better manage the high environmental risks that come with it, the littoral states have negotiated the Aktau Protocol Concerning Regional Preparedness, Response and Cooperation in Combatting Oil Pollution Incidents. The Protocol's objective is to harmonize national oil pollution preparedness and emergency systems and to provide for a regional cooperation mechanism to that effect. It is projected to enter into force in early 2016.

Much of the pollution in the Caspian Sea stems from land-based sources brought in through tributary rivers or other run-offs. As an enclosed water body, the Caspian Sea is particularly vulnerable and pollution has a strong transboundary character affecting all riparian countries. Therefore, the Caspian states initiated the Moscow Protocol for the Protection of the Caspian Sea against Pollution from Land-based Sources and Activities. It harmonizes the Parties' approaches to tackle land-based pollution from point sources like industry waste water run-off or from diffuse sources like agricultural production. The Protocol is signed by all Parties and is expected to enter into force in the course of 2016.

Isolated from the world's oceans for millions of years, the Caspian Sea is home to a number of endemic species and vulnerable habitats. With increasing international ship traffic, the introduction of alien species is particularly destructive to the unique Caspian Sea ecosystem. The Ashgabat Protocol for the Conservation of Biological Diversity addresses these threats through common country approaches on species and habitat protection, including through coastal and marine protected areas. This effort and agreement is especially noteworthy, as the legal status and therefore the marine borders of the Caspian Sea remain undecided. The Ashgabat Protocol was agreed at COP5 in 2014 and so far, is signed by three Parties and ratified by one.

Big commercial projects and activities in and around the Caspian Sea, for example in the area of oil and gas extraction, often have an adverse effect on neighbouring countries. In order to jointly assess the environmental risks and to avoid conflicts, the Caspian countries developed the Protocol on Environmental Impact Assessment (EIA) in a Transboundary Context. Drawing from the UNECE Espoo Convention on transboundary EIA. The Protocol constitutes an essential instrument for regional environmental policy and for engaging the public in the process. It is in its final stages of negotiation and will be further discussed at COP6 in 2016.

Despite respectable progress in recent years, information on the state of the Caspian Sea's *environmental conditions* - needed for sound environmental policy making - is still lacking and often incomparable. In an attempt to harmonize the collection and access to environmental data as well as to share the information among the countries, the Caspian states initiated negotiations on a draft protocol on monitoring, assessment, access to and exchange of environmental information. The protocol will capitalize on a reporting system, state of the environment reporting, and the Caspian Environment Information Centre which is a website for information exchange already established by the countries. An expert Working Group on Monitoring and Assessment is accompanying and feeding into the protocol development. With negotiations having started only recently in 2015, such a legally binding international agreement would be the first of its kind worldwide.

These efforts undertaken within the framework of the Tehran Convention show that the Caspian states have developed a strong legal basis and governance structure for international environmental policy in the Caspian Sea region in recent years. In the coming years, the Parties, with the support of the international community, will increasingly focus on the implementation of these agreements. The UNEP Regional Office for Europe administers the interim Secretariat of the Tehran Convention.

139: *EU Neighbourhood policy*

The *European Neighbourhood Policy* (ENP) governs the EU's relations with 16 of the EU's closest eastern and southern neighbours: to the south Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, State of Palestine, Syria and Tunisia, and to the east Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine. The Russian Federation takes part in cross-border cooperation activities under the ENP but is not a part of the ENP as such.

The ENP was launched in 2003 and developed during 2004, with the objective of avoiding the emergence of new dividing lines between the enlarged EU and its neighbours and instead strengthening the prosperity, stability and security of all. It is based on the values of democracy, rule of law and respect of human rights. The ENP is based on the European Neighbourhood Instrument (ENI) with a budget of EUR15.4 billion for the period 2014-2020 as the main financial instrument for implementing the ENP, and provides the bulk of EU funding to the 16 ENP partner countries. The ENI builds on the achievements of the previous European Neighbourhood and Partnership Instrument (ENPI), and ENI supports strengthening of relations with neighbouring countries and brings tangible benefits to both the EU and its partners. Implementation of the ENP is based on various frameworks of cooperation: bilateral cooperation; regional cooperation; neighbourhood-wide; and cross-border cooperation including a specific programme on cooperation within civil society.

The priorities of the ENP include good governance, including justice and security, sustainable economic development, trade, transport, energy, and the environment, and social and human development, including education, health, people-to-people contacts and civil society, based on tackling common challenges and issues of mutual interests. Within the ENP a variety of programmes of implementation, financial instruments and technical assistance mechanism have been established to strengthen capacities within the wider pan-European region. Cooperation in the area of environment has contributed to improving the quality of life of citizens in partner countries by providing access to basic environmental services such as water supply, wastewater treatment and solid waste management.

140: *Greening Economies in the Eastern Neighbourhood - EaP-GREEN*

The 'Greening Economies in the European Union's Eastern Neighbourhood' (EaP GREEN) programme supports the six Eastern Partnership (EaP) countries to move towards a green economy by decoupling economic growth from environmental degradation and resource depletion. These countries are: Armenia, Azerbaijan, Belarus, Georgia, Republic of Moldova and Ukraine. The EU and other donors financially support the programme. It is jointly implemented by four international organisations (OECD, UNECE, UNEP, and UNIDO).

The programme aims to improve public policies and bring change on the ground through assessments, development of policies and policy instruments, capacity building, and demonstration initiatives. Recent progress includes: the development of Green Economy roadmap/action plans (in Belarus and in the Republic of Moldova); launching policy and regulatory reform on sustainable public procurement and economic instruments (in Armenia, Republic of Moldova, and Ukraine); and reforming legislations and institutions on Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) (in Armenia, Azerbaijan, Belarus, Georgia, Republic of Moldova, and Ukraine). As for demonstration initiatives, a number of resource efficient and cleaner production assessments and trainings have been conducted (in Armenia, Azerbaijan, Belarus, Georgia, Republic of Moldova, and Ukraine). Also, a new contract for exporting of organic products (6.3 million euro) was leveraged (in Ukraine) and training was provided to boost the production and domestic consumption of organic products.

141: *Aarhus Convention*

The UNECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters was adopted on 25th June 1998 in the Danish city of Aarhus at the Fourth Ministerial Conference on the Environment for Europe. The Aarhus Convention is a unique environmental treaty. It links environmental rights and human rights, acknowledges that we owe an obligation to future generations, establishes that sustainable development can be achieved only through the involvement of all stakeholders, links government accountability and environmental protection, and focuses on interactions between the public and public authorities in a democratic context.

The subject of the Convention goes to the heart of the relationship between people and governments. It is not only an environmental agreement; it is also a Convention about government accountability, transparency and responsiveness.

The Convention grants the public rights and imposes obligations on its Parties and public authorities regarding access to information, public participation, and access to justice. The Convention also requires its Parties to promote these principles in the negotiation and implementation of international environmental decision-making processes and within the framework of international organizations in matters relating to the environment.

In 2003, the Protocol on Pollutant Release and Transfer Registers (PRTRs) to the Aarhus Convention - also known as the Kyiv Protocol - was adopted. It is the first and only legally binding agreement on PRTRs that requires information to be publicly disclosed on the release and transfer of a large number of listed pollutants through online databases or registers. Free web-based access to geo-referenced environmental data empowers the public, decision makers in government and industry, scientists, and journalists to make informed choices. Furthermore, a well-established network of environmental data gathered and stored by PRTRs allows industries to validate their efforts in reaching sustainability.

Source: *http://www.unece.org/env/pp/welcome.html*

142: Public participation in the EU's Water Framework Directive on River Basin Management Plans

Article 14 of the EU's Water Framework Directive on River Basin Management Plans includes the following provisions related to public participation:

(Article 14)

1. Member States shall encourage the active involvement of all interested parties in the implementation of this Directive, in particular in the production, review and updating of the river basin management plans. Member States shall ensure that, for each river basin district, they publish and make available for comments to the public, including users: (a) a timetable and work programme for the production of the plan, including a statement of the consultation measures to be taken, at least three years before the beginning of the period to which the plan refers; (b) an interim overview of the significant water management issues identified in the river basin, at least two years before the beginning of the period to which the plan refers; (c) draft copies of the river basin management plan, at least one year before the beginning of the period to which the plan refers.

   On request, access shall be given to background documents and information used for the development of the draft river basin management plan.

2. Member States shall allow at least six months to comment in writing on those documents in order to allow active involvement and consultation.

3. Paragraphs 1 and 2 shall apply equally to updated river basin management plans."

Source: *http://ec.europa.eu/environment/water/participation/pdf/waternotes/water_note12_public_participation_plans.pdf*

143: Public participation in environmental impact assessment and strategic environmental assessments

Environmental assessment is a procedure that ensures that the environmental implications of decisions are taken into account before decisions are made. Environmental assessment can be undertaken for individual projects, such as a dam, motorway, airport or factory, on the basis of Directive 2011/92/EU (Environmental Impact Assessment (EIA) Directive) or for public plans or programmes on the basis of Directive 2001/42/EC (Strategic Environmental Assessment (SEA) Directive). The common principle of both Directives is to ensure that plans, programmes and projects likely to have significant effects on the environment are made subject to an environmental assessment, prior to their approval or authorisation. Consultation with the public is a key feature of environmental assessment procedures.

The Directives on Environmental Assessment aim to provide a high level of protection of the environment and to contribute to the integration of environmental considerations into the preparation of projects, plans and programmes with a view to reducing their environmental impact. They ensure public participation in decision-making and thereby strengthen the quality of decisions. The projects and programmes co-financed by the EU (Cohesion, Agricultural and Fisheries Policies) have to comply with the EIA and SEA Directives to receive approval for financial assistance. The Directives on Environmental Assessment are therefore crucial tools for sustainable development.

Source: *http://ec.europa.eu/environment/eia/home.htm*

144: *Environmental Performance Reviews*

UNECE has more than 20-year experience in using peer review mechanisms to improve policies and their implementation in the areas of environment, innovation, housing and land management, and trade.

The UNECE Environmental Performance Reviews (EPRs) were launched in 1993 by countries represented at the second Environment for Europe Ministerial Conference. The UNECE EPRs cover the countries of Eastern Europe, Caucasus, Central Asia and South Eastern Europe. The current third cycle of reviews focuses on environmental governance and financing in a green economy context, and countries' cooperation with the international community and environmental mainstreaming in priority sectors.

The reviews address legal, policy and institutional frameworks, financing of environmental policies and projects, protection of air quality and water resources, biodiversity and protected areas, and waste management. They also look into integration of environmental considerations in agriculture, industry, transport, energy, forestry, tourism and health sectors. The practical measures that have been implemented as a result of the EPRs include the strengthening of environmental institutions, the adoption of new legislation and policy documents, introduction of economic instruments for environmental protection, increase of governmental expenditures for environmental protection and other measures.

International expertise for the reviews is provided by governments and international organizations including UNEP, OECD, WHO, EEA and OCHA. Peer review is carried out by the UNECE member States in the UNECE Committee on Environmental Policy.

Source: *http://www.unece.org/env/epr.html*

Outlooks and emerging issues

145: *Domestic material consumption, material intensity and material footprint in the region*

Domestic material consumption (DMC) is an indicator designed to capture the territorial consumption of primary materials, whether they are sourced from domestic extraction or imported. As such DMC is a territorially-defined metric for consumption, while material footprint (MF) is a consumption-based metric that takes into account upstream material flows involved in producing products, rather than just the tonnage of the product itself. In doing this it provides a far superior indicator of where responsibility for final consumption of primary materials is located (Schandl *et al.* 2016).

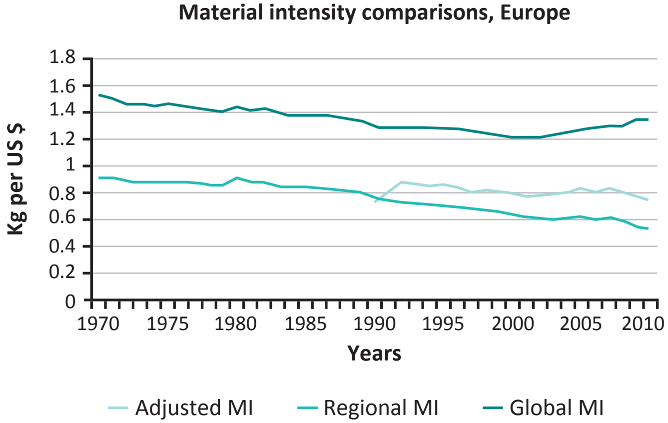
As for material intensity (MI), it corresponds to the amount of natural resources that go into creating a unit of economic

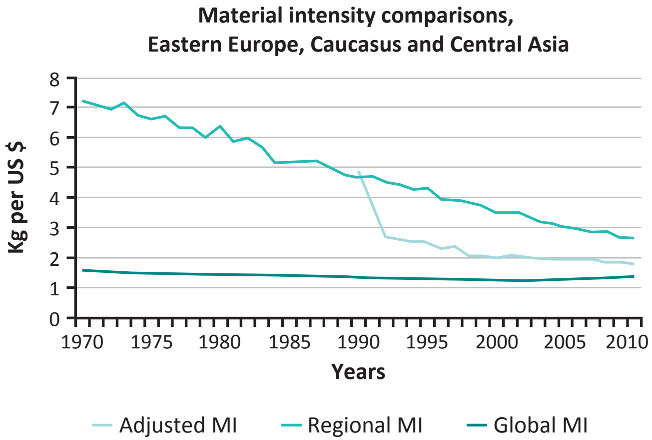
Table 11: Definition of natural resource consumption indicators used in this section

Indicator	Definition
Domestic material consumption (DMC)	Raw material extracted from the domestic territory + all raw material imports - all raw material exports
Material intensity (MI)	Amount of natural resources that go into creating a unit of economic output measured by the ratio of Domestic material consumption (DMC) to gross domestic product (GDP)
Material footprint (MF)	Global allocation of used raw material embodied in products to the final demand of an economy

Source: Wiedmann *et al.* 2015; European Commission 2014

Figure-L2 53: Material intensity comparisons in Western and Central Europe and Eastern Europe, the Caucasus and Central Asia, 1970–2010





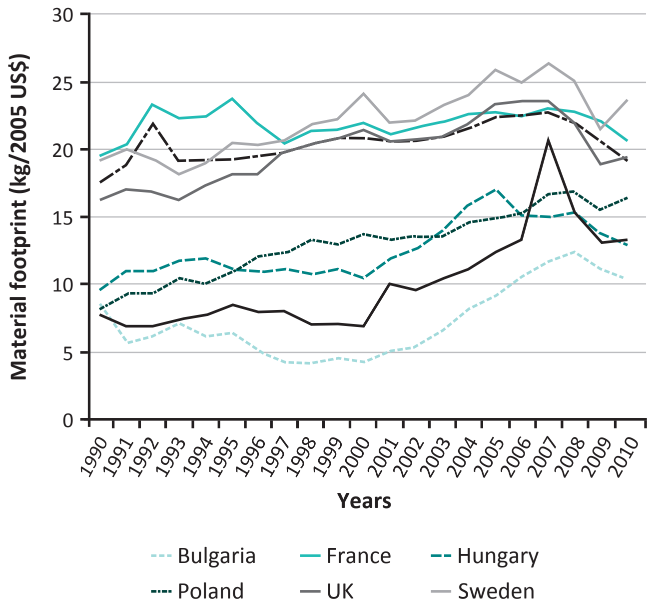
Source: Schandl *et al.* 2016

output, measured by the ratio of domestic material consumption (DMC) to gross domestic product (GDP). Table 11 provides a definition of the indicators used in Section 4.2.1 Natural resource consumption and waste.

In terms of the amount of natural resources that go into creating a unit of economic output on a DMC basis, i.e. the material intensity, the pan-European region shows considerable diversity (see Figure-L2 53). At around 0.5 kilograms per US$ (kg/US$) in 2010 and on a downward trajectory, material intensity in Western and Central Europe is below the 1.4 kg/US$ global average, while in Eastern Europe, the Caucasus and Central Asia it is around 2.6 kg/US$ but steadily declining. If, however, material use also takes the direct and indirect material content related to trade into account, Western and Central Europe's material intensity is closer to 0.8 kg/US$ and has stagnated since the early 1990s, while for Eastern Europe, Caucasus and Central Asia it is close to the global average at around 1.8 kg/US$.

These figures are possibly the result of a combination of factors, including a more eco-efficient and service-oriented domestic economic structure in the more advanced countries in Western and Central Europe, higher wages, and also the tendency of countries with higher levels of environmental and health standards to transfer material-intensive production to other parts of the world (Schandl *et al.* 2016). It should also

Figure-L2 54: Intra-regional differences in material footprint in selected EU countries, 1990–2010



Source: UNEP Live

be noted that there are significant intra-regional differences in the EU, with the material footprint of older Member States being significantly higher than that of the countries of the former Eastern Bloc (Figure-L2 54).

Despite the progress achieved in reducing DMC, the region faces a formidable challenge to decouple natural resource consumption from economic growth in absolute terms to levels that are both fair and sufficient from a regional and global sustainability point of view without compromising economic performance or human well-being. The region needs to approach and ultimately achieve absolute decoupling of its material footprint from economic growth – factoring in imports and burden shifting, reducing intra-regional and global burden shifting to zero and eliminating sub-regional differences in natural resource-use efficiency.

See references to Supplementary Information

See links to Supplementary Information

ACRONYMS AND ABBREVIATIONS

10YFP	10-year framework of programmes on sustainable consumption and production patterns
ADHD	Attention deficit/hyperactivity disorder
AEI	Average exposure indicator
AGMIP	Agricultural model intercomparison and improvement project
AIDS	Acquired immune deficiency syndrome
AP4	Fourth Swedish national pension
AZE	Alliance for Zero Extinction
BaP	Benzo(a)pyrene
BAT	Best available technology
BC	Black carbon
BECCS	Bio-energy with carbon capture and storage
BIG-E	Batumi initiative on green economy
BioCCS	Biomass plus carbon capture and storage
BISE	Biodiversity Information System for Europe
BOD	Biochemical oxygen demand
BP	British Petroleum
BWMC	Ballast Water Management Convention
CA	Central Asia
CACILM	Central Asian Countries Initiative for Land Management
CAFF	Conservation of Arctic Flora and Fauna
CAP	Common Agriculture Policy
CARIFONET	National health databases and health service indicators in Central Asian republics
CBD	Convention on Biological Diversity
CCS	Carbon capture and storage
CCU	Carbon capture and utilization
CDC	US Centers for Disease Control and Prevention
CEFIC	European Chemical Industry Council
CEIP	Centre on Emission Inventories and Projections
CEP	Committee on Environmental Policy
CEU	Central European University
CFP	Common Fisheries Policy

CH_4	Methane
CHLM	Committee on Housing and Land Management
CIS	Commonwealth of Independent States
CiP	Chemicals in products
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLP	Classification, labeling and packaging
CLRTAP	UNECE Convention on Long-range Transboundary Air Pollution
CMIP5	Coupled model inter-comparison project phase 5
CMR	Carcinogenic, mutagenic and reprotoxic substances
CMS	Convention on Migratory Species
CNTs	Carbon nanotubes
CO	Carbon monoxide
CO_2	Carbon dioxide
CoE	Council of Europe
CoL	Catalogue of life
COM	Communications
COMECON	Council for Mutual Economic Assistance
COP	Conference of the Parties
COP21	21st Conference of the Parties
t	chronic obstructive pulmonary disease
CRP	C-reactive protein
CSDH	Commission on Social Determinants of Health
CSIRO	Commonwealth Scientific and Industrial Research Organization
CSLF	Carbon Sequestration Leadership Forum
DAISIE	Delivering Alien Invasive Species Inventories for Europe
DALYs	Disability-adjusted life year
DD	Data deficient
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DE	Domestic material extraction
DEFRA	Department for Environment Food & Rural Affairs
DISMED	Desertification Information System for the Mediterranean

DKK	Danish krone
DMC	Domestic material consumption
DOHaD	Developmental origins of health and disease
DPSEEA	Drivers, pressures, state, exposure, effect, action
DPSIR	Drivers, pressures, state, impact, responses
DRBM	Danube river basin management plan
DRIFT	Dutch Research Institute for Transitions
EaP	Eastern partnership
EaP-Green	Greening economies in the eastern neighborhood
EASAC	European Academies Science Advisory Council
EBM	Ecosystem-based management
EC	European Commission
ECDC	European Centre for Disease Prevention and Control
ECEHH	European Centre of Environment and Human Health
ECHA	European Chemicals Agency
ECI	European Citizens' Initiative
ECNC	European expertise centre for biodiversity and sustainable development
EDCs	Endocrine disrupting compounds
EDs	Endocrine disruptors
EEA	European Environment Agency
EEC	Eastern Europe and Caucasus
EECCA	Eastern Europe, Caucasus and Central Asia
EEE	Electrical and electronic equipment
EEG	Electroencephalogram
EfE	Environment for Europe
EFSA	European Food Safety Authority
EFTA	European Free Trade Association
EIA	Environmental impact assessment
EIONET	European Environment Information and Observation Network
EM-DAT	International emergency disasters database
EMEP	European Monitoring and Evaluation Programme
EMPA	Eidgenössische Materialprüfungs- und ForschungsAnstalt (Swiss Federal Laboratories for Materials Testing and Research)

END	Environmental Noise Directive
ENI	European Neighbourhood Instrument
ENP	European Neighbourhood Policy
ENPI	European Neighbourhood and Partnership Instrument
EPBD	Energy Performance of Buildings Directive
EPPP	Environmentally persistent pharmaceutical pollutants
EPRs	Environmental performance reviews
EQSD	Environmental Quality Standards Directive
ESD	Energy Efficiency Directive
ESPAS	European strategy and policy analysis system
ET	Environmental technologies
ETC/SCP	European Topic Centre on Sustainable Consumption and Production
ETC/WGME	European Topic Centre on Waste and Materials in a Green Economy
ETH	Swiss Federal Institute of Technology in Zurich
ETS	European Emissions Trading System
EU	European Union
EU BON	European Biodiversity Observation Network
EUMOFA	European Market Observatory for Fisheries and Aquaculture Products
EUR-ISA	European Industrial Symbiosis Association
EWWR	The European Week for Waste reduction initiative
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FRR	Fonds de Réserve pour les Retraites
FYROM	Former Yugoslav Republic of Macedonia
GAEC	Good agricultural and environmental conditions
GBIF	Global Biodiversity Information Facility
GCC	Green car congress
GCM	General circulation models
GDP	Gross domestic product
GEF	Global Environment Facility
GEMS-Water	Global Environmental Monitoring System for Water
GEO	Global environment outlook

GEO BON	Group on Earth Observations Biodiversity Observation Network
GEO/GEOSS	Group on Earth Observations/Global Earth Observation System of Systems
GESAMP	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection
GFCM	General Fisheries Commission for the Mediterranean
GGC	Portuguese green growth commitment
GHG	Greenhouse gases
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
GI	Green infrastructure
GIS	Geographic information systems
GMOs	Genetically modified organisms
GOST	A set of technical standards maintained by the Euro-Asian Council for Standardization, Metrology and Certification
GRID	Global Resource Information Database
GSP	Global Soil Partnership
HEAl	Health and Environment Alliance
HELCOM	Helsinki Commission/Baltic Marine Environment Protection Commission
HiaP	Health in all policies
HIAs	Health impact assessments
HIV	Human immunodeficiency virus
HLPE	High Level Panel of Experts on Food Security and Nutrition
IAEA	International Atomic Energy Agency
IaEGs	International agreed environmental goals
IAS	Invasive alien species
IBA	Important bird areas
ICCA	International Council of Chemical Associations
ICCAT	International Commission for the Conservation of Atlantic Tunas
ICCM	International Conference on Chemicals Management
ICCM4	Fourth session of the International Conference on Chemicals Management
ICES	International Council for the Exploration of the Sea
ICPDR	International Commission for the Protection of the Danube River
ICPMLES	International Conference on Prevention and Management of Marine Litter in European Seas
ICSD	Interstate Commission on Sustainable Development
ICSU	International Council for Science

ICZM	Integrated coastal zone management
IEA	International Energy Agency
IFREMER	Institut français de recherche pour l'exploitation de la mer
IGEG	The Institute for Global Economic Growth
IGMS	Global intergovernmental and multi-stakeholder consultation
IHMS	Institute of Hydrometeorology and Seismology of Montenegro
IHPH	Institute for Hygiene and Public health
IIASA	International Institute for Applied Systems Analysis
IISD	International Institute for Sustainable Development
ILO	International Labour Organization
ILSWE	Index of land susceptibility to wind erosion
IMO	International Maritime Organization
INBO	International Network of Basin Organizations
INDC	Intended nationally determined contributions
IOMC	Inter-Organization programme for the Sound Management of Chemicals
IPBES	Intergovernmental science-policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IPEN	International POPs (Persistent Organic Pollutant) Elimination Network
IPPC	International Plant Protection Convention
IRENA	International Renewable Energy Agency
ISDE	International Society of Doctors for the Environment
ISI-MIP	Inter-sectoral impact model intercomparison project
ISPRA	Institute for Environmental Protection and Research
ISSC	International Social Science Council
ITPS	Intergovernmental Technical Panel on Soils
IUCN	International Union for Conservation of Nature
IUSS	International Union of Soil Sciences
IUU	Illegal, unregulated and unreported
IWMI	International Water Management Institute
JRC	Joint Research Centre- The European Commission's science and knowledge service
JTFEI	Joint Task Force on Environmental Indicators
KEMI	Swedish Chemicals Agency

LDN	Land degradation neutrality
LDNW	Land degradation neutral world
LEZs	Low-emission zones
LIFE	Financial instrument for the environment
LLC	Limited liability company
LRT	Long-range transport
LSCE	Laboratoire des sciences du climat et de l'environment
LTIR	Lost time injury rates
MA	Millennium Ecosystem Assessment
MARPOL	International Convention for the Prevention of Pollution from Ships
MDGs	Millennium Development Goal
MEAs	Multilateral environmental agreements
MED-EUWI	Mediterranean Component of the European Union Water Initiative
MERS	Middle East respiratory syndrome
MF	Material footprint
MI	Material intensity
MNHN	Muséum National d'Histoire Naturelle
MNPRA	Ministry of Nature Protection of the Republic of Armenia
MONECA	Environmental monitoring in Central Asia
MPAs	Marine protected area
MSFD	Marine Strategy Framework Directive
MSPD	Maritime Spatial Planning Directive
MSW	Municipal solid waste
MSY	Maximum sustainable yield
NAMA	National mitigation actions
NASA	National Aeronautics and Space Administration
NCDs	Non-communicable diseases
NEAFC	North East Atlantic Fisheries Commission
NEC	European Commission's National Emission Ceilings
NERC	Natural Environment Research Council
NGOs	Non-governmental organizations
NMVOCs	Non-methane volatile organic compound

NO	Nitrogen monoxide
NOBANIS	European Network on Invasive Alien Species
NOEL	No observed effect level
NO_x	Nitrogen oxides
NSR	Northern sea route
O_3	Ozone
OC	Organic carbon
OCHA	Office for the Coordination of Humanitarian Affairs
OCPs	Organochlorine pesticides
OECD	Organization for Economic Co-operation and Development
OIE	World Organization for Animal Health
OPRC	International Convention on Oil Pollution Preparedness, Response and Co-operation
OPS	Overarching policy strategy
OSCE	Organization for Security and Cooperation in Europe
OSPAR	Convention for the Protection of the Marine Environment of the North East Atlantic
PAHs	Polycyclic aromatic hydrocarbons
PAME	Protection of the Arctic Marine Environment
PBL	Netherlands Environmental Assessment Agency
PBT	Polybutylene terephthalate
PCBs	Polychlorinated biphenyls
PCFV	Partnership for Clean Fuels and Vehicles
PEBLDS	Pan-European Biological and Landscape Diversity Strategy
PEEN	Pan-European Ecological Network
PERSEUS	Policy-oriented marine Environmental Research in the 25 Southern European Seas
PFOS	Perfluorooctane sulphonic acid
PM	Particulate matter
$PM_{2.5}$	Fine particle less than 2.5 micrometers in diameter
POP	Persistent organic pollutant
PR	Public relations
PRTR	Pollutant Release and Transfer Registers
PSMSL	Permanent Service for Mean Sea Level
R&D	Research and development

RCP	Regional climate projections
REACH	Registration, Evaluation, Authorization, and Restriction of Chemicals
REC	Regional Environment Center
RECETOX	Research Centre for Toxic Compounds in the Environment
REIN	Regional Environmental Information Network
RLI	Red list index
RoHS	Restriction of the Use of Certain Hazardous Substances
RSC	Regional Sea Conventions
SAICM	Strategic Approach to International Chemicals Management
SAP	Scientific Advisory Panel
SARS	Severe acute respiratory syndrome
SCBD	Secretariat of the Convention on Biological Diversity
SCENIHR	Scientific Committee on Emerging and Newly Identified Risks
SCP	Sustainable consumption and production
SDGs	Sustainable development goals
SDI	Sensitivity to desertification index
SDS	Sand and dust storms
SEA	Strategic environmental assessment
SEBI	Streamlining European biodiversity indicators
SEE	South Eastern Europe
SEI	Stockholm Environment Institute
SEIS	Shared environmental information system
SES	Socio-economic situation
SETIS	European Commission's Strategic Energy Technologies Information System
SHS	Second-hand smoke
SI	International system of units
SIC ICWC	Scientific-Information Center of the Interstate Coordination Water Commission of the Central Asia
SOC	Soil organic carbon
SOER	European environment — state and outlook 2015 report
SOM	Soil organic matter
SPM	Suspended particulate matter
SRES	Special report on emissions scenarios

STDF	Standards and Trade Development Facility
STPs	ewage treatment plants
TBT	Tributyltin
TCDD	Tetrachlorodibenzodioxin
TEEB	The Economics of Ecosystems and Biodiversity
TN	Total nitrogen
TP	Total phosphorus
TWAP	Transboundary Waters Assessment Programme
UBA	United Bank for Africa
UFIREG	Ultrafine particles – cooperating with environmental and health policy
UFZ	Helmholtz Centre for Environmental Research
UGSI	Urban green space indicator
UHI	Urban heat island
UK	United Kingdom
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
UNDESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNEP-DHI	UNEP-DHI Partnership – Centre on Water and Environment
UNEP-WCMC	United Nations Environment Programme -World Conservation Monitoring Centre
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Emergency Fund
UNIDO	United Nations Industrial Development Organization
UNISDR	United Nations Office for Disaster Risk Reduction
UNITAR	United Nations Institute for Training and Research
UNODC	United Nations Office on Drugs and Crime
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation

UNSD	United Nations Statistical Commission
UNSIC	United Nations System Influenza Coordination
Urban HEART	Urban health equity assessment and response tool
US EPA	US Environmental Protection Agency
USA	United States of America
USAID	United States Agency for International Development
USD	United States dollar
USDA	United States Department of Agriculture
USSR	Union of Soviet Socialist Republics
UVB	Ultra violet B rays
vPvB	Very persistent and very bio-accumulative pollutants
WCMC	World Conservation Monitoring Centre
WEEE	Waste electrical and electronic equipment
WEI+	Water exploitation index
WFD	Water Framework Directive
WGEMA	UNECE Working Group on Environmental Monitoring and Assessment
WHO	World Health Organization
WMO	World Meteorological Organization
WOCAT	World Overview of Conservation Approaches and Technologies
WPLA	Working Party on Land Administration
WRAP	Waste & Resources Action Programme
WRB	World reference base
WSSD	World Summit on Sustainable Development
WTO	World Trade Organization
WTPs	Water treatment plants
WWF	World Wide Fund for Nature
ZNLD	Zero net land degradation

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Chapter 1

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Chapter 2

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Link 2.1.19 Toy Safety Directives http://ec.europa.eu/growth/sectors/toys/safety/index_en.htm

Link 2.1.20 Goal 12 http://www.uneplive.org/SDGs/index/12

Link 2.1.21 green chemistry http://www.oecd.org/env/ehs/risk-management/sustainablechemistry.htm

Link 2.1.22 EU's circular economy strategy http://ec.europa.eu/environment/circular-economy/index_en.htm

Link 2.1.23 Stockholm Convention http://www.pops.int/

Link 2.1.24 Rotterdam Convention http://www.pic.int

Link 2.1.25 Basel Convention http://www.basel.int/

Link 2.1.26 Minamata Convention http://www.mercuryconvention.org/

Link 2.1.27 Rotterdam's circularity centre http://www.circularitycenter.com/

Link 2.1.28 renewable freshwater resources are used for agricultural, industrial and domestic purposes [http://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources-2/assessment-1]

Link 2.1.29 TWAP 2016 http://twap-rivers.org/indicators/

Link 2.1.30 UNECE Water Convention http://www.unece.org/env/water/

Link 2.1.31 UN Water Courses Convention http://legal.un.org/ilc/texts/instruments/english/conventions/8_3_1997.pdf

Link 2.1.32 Ramsar Convention on Wetlandshttp://www.ramsar.org/about-the-ramsar-convention

Link 2.1. 33 EC 2015 http://ec.europa.eu/environment/water/infographics.htm

Link 2.1.34 Policy-oriented Marine Environmental Research in the Southern European Seas http://www.perseus-net.eu/site/content.php

Link 2.1.35 Joint Research Centre, European Commission http://ec.europa.eu/eurostat/statistics-explained/index.php/Agri-environmental_indicator_-_soil_quality

Link 2.1.36 Natural hazards http://earthobservatory.nasa.gov/NaturalHazards/view.php?id=83268

Link 2.1.37 The Declaration on Agricultural Diversification http://www.cffresearch.org/Paris_Declaration_Programme-@-The_Declaration_on_Agricultural_Diversification.aspx#sthash.JTURosyL.dpbs

See links to chapter 3

Link 3.1.1 MEAs http://www.informea.org/

Link 3.1.2 10YFP http://www.unep.org/10yfp/

Link 3.1.3 Global Subsidies Initiative of IISD: http://www.iisd.org/gsi/htt

Link 3.1.4 EU Eco-Innovation Action Plan http://ec.europa.eu/environment/eco-innovation/discover/publications/index_en.htm).

Link 3.1.5 LIFE http://ec.europa.eu/environment/life/

Link 3.1.6 European Emissions Trading System (ETS) http://ec.europa.eu/clima/policies/ets/index_en.htm)

Link 3.1.7 Germany on Nation Climate Initiative https://www.klimaschutz.de/de).

Link 3.1.8 Eco http://www.ecoportalca.kz/en/

Link 3.1.9 EU's European Neighbourhood Policy http://ec.europa.eu/enlargement/neighbourhood/overview/index_en.htm

Link 3.1.10 EU's Enlargement Policy http://ec.europa.eu/enlargement/countries/check-current-status/index_en.htm

Link 3.1.11 Aarhus Centres http://www.osce.org/secretariat/161651

Link 3.1.12 Organization for Security and Cooperation in Europe http://www.osce.org/secretariat/188886?download=true

Link 3.1.13 three pillars http://ec.europa.eu/environment/aarhus/index.htm

Link 3.1.14 E-Justice portal http://ec.europa.eu/environment/aarhus/justice.htm

See links to chapter 4

Link 4.1.1 WaterGAP2.2 results prepared within the ISI-MIP initiative http://www.ISI-MIP.org

Link 4.1.2 WaterGAP2.2 within the TWAP project (http://www.geftwap.org/water-systems/river-basins)

See links to layer 2

Link 1 data only available for 28 of the 54 pan-European countries http://www.euro.who.int/en/home).

Link 2 European Health Report Targets and beyond – reaching new frontiers in evidence http://www.euro.who.int/en/data-and-evidence/european-health-report/european-health-report-2015/ehr2015.

Link 3 WHO Health in the Green Economy http://www.who.int/hia/green_economy/en/

Link 4 WHO Framework Convention on Tobacco Control http://www.who.int/fctc/en/

Link 5 Minamata Convention on Mercury http://www.mercuryconvention.org/

Link 6 Swiss Precautionary Matrix http://www.bag.admin.ch/nanotechnologie/12171/12174/index.html?lang=en

Link 7 REACH-legislation http://ec.europa.eu/environment/chemicals/nanotech/index_en.htm

Link 8 SAICM http://www.saicm.org/

Link 9 EU Common Agricultural Policy http://ec.europa.eu/agriculture/cap-post-2013/

Link 10 Centre for Health Promoting Water and Risk Communication, Atlas on water and health http://131.220.23.155/atlas/online/index.php

Link 11 The Concept of greening in the city of Astana. http://www.saulet.astana.kz/plan/12/

Link 12 CSDH http://www.who.int/social_determinants/thecommission/en/

Link 13 Urban HEART http://www.who.int/kobe_centre/measuring/urbanheart/en/

Link 14 Healthy Cities http://www.euro.who.int/en/health-topics/environment-and-health/urban-health/activities/healthy-cities

Link 15 Green Cities http://europeangreencities.com/

Link 16 Sustainable Cities http://www.sustainablecities.eu/

Link 17 The i-Tree software (http://www.itreetools.org/)

Link 18 The Rio Declaration on Environment and Development http:\www.unep.org\Documents.Multilingual\Default.asp?documentid=78&articleid=1163

Link 19 UNEP Live http://uneplive.unep.org/

Link 20 environmental health impacts http://www.who.int/quantifying_ehimpacts/en/

Link 21 Turkey http://tuikapp.tuik.gov.tr/cevredagitimapp/hava_ing.zul

Link 22 hotspots even in Western Europe, http://www.eea.europa.eu/themes/air/interactive/pb

Link 23 Directive http://ec.europa.eu/environment/air/quality/legislation/directive.htm

Link 24 low-emission zones http://www.presse.ademe.fr/wp-content/uploads/2014/06/ADEME_benchmark-LEZ_juin2014.pdf

Link 25 EU PM10 air quality standard http://ec.europa.eu/environment/air/quality/standards.htm

Link 26 cycle paths http://data.mos.ru/datasets/897

Link 27 mining operation in Kyrgyzstan http://www.grida.no/publications/rr/mercury/

Link 28 SAVE FOOD http://www.fao.org/save-food/en/

Link 29 European Week for Waste Reduction http://www.ewwr.eu/en

Link 30 including comprehensive visualizations http://www.foodisforeating.org/

Link 31 Kalundborg http://www.symbiosis.dk/en

Link 32 EUR-ISA http://www.eur-isa.org/

Link 33 online chemical safety portal with detailed product information http://www.icca-chem.org/en/Home/ICCA-initiatives/global-product-strategy/chemical-information-search/

Link 34 Strategic Approach to International Chemicals Management http://www.saicm.org/

Link 35 Directive EC 1907/2006) http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006R1907

Link 36 ECHA http://echa.europa.eu/

Link 37 European Economic Area (EEA) http://www.efta.int/eea

Link 38 Guidance http://www.unece.org/env/teia/guidelines.html

Link 39 circular economy initiative http://ec.europa.eu/environment/circular-economy/index_en.htm

Link 40 critical raw materials http://ec.europa.eu/growth/sectors/raw-materials/specific-interest/critical/index_en.htm

Link 41 information hub on waste prevention http://scp.eionet.europa.eu/themes/waste_prevention

Link 42 EWWR http://www.ewwr.eu/en

Link 43 the repair cafe movement http://repaircafe.org/

Link 44 hacker spaces http://hackerspaces.org/

Link 45 OuiShare http://ouishare.net/en

Link 46 0.1-0.3°C per decade http://www.eea.europa.eu/data-and-maps/indicators/water-temperature-1/assessment

Link 47 lakes in Switzerland http://www.bafu.admin.ch/umwelt/indikatoren/08605/08609/index.html?lang=en

Link 48 INFOGRAPHIC http://www.circleofblue.org/waternews/wp-content/uploads/2011/11/pharm-copy-large.jpg

Link 49 ETHZ http://ir-s01.ethz.ch/

Link 50 Sustainable Development Goal 6 http\--www.unwater.org-sdgs-a-dedicated-water-goal-en-

Link 51 water management in the SDGs http://www.unwater.org/publications/publications-detail/en/c/292840/

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Link 53 Tehran Convention http://www.tehranconvention.org/

Link 54 environmental conditions http://www.grida.no/publications/caspian-sea/

Link 55 Soil erosion in Europe, 2010 http://ec.europa.eu/eurostat/statistics-explained/index.php/File: Soil_erosion_by_water_(tonnes_per_ha_per_year),_2010,_EU-28,_100_m_cell_size.png)

Link 56 success stories http://esdac.jrc.ec.europa.eu/public_path/shared_folder/doc_pub/RemediatedSites_Brownfields_success%20stories.pdf

Link 57 Greenbelts http://click.icptrack.com/icp/relay.php?r=20238421&msgid=197065&act=G6QI&c=1400471&destination=http%3A%2F%2Fec.europa.eu%2Fenvironment%2Fintegration%2Fresearch%2Fnewsalert%2Farchive%2Fgreen-infrastructure.htm

Link 58 The Protocol on Soil Conservation http://www.alpconv.org/en/convention/protocols/Documents/SoilProtocolEN.pdf

Link 59 People4Soils http://www.people4soil.eu/index-en.php

Link 60 European Citizens' Initiative http://ec.europa.eu/citizens-initiative/public/welcome?lg=en

Link 61 organizations and governing bodies of MEAs, have emerged (http://www.informea.org/).

Link 62 Around 950 MEAs were enacted worldwide between 1970 and 2015 (http://iea.uoregon.edu/).

Link 63 Participation in MEAs http://iea.uoregon.edu/.

Link 64 EU Biodiversity Strategy to 2020 http://ec.europa.eu/environment/nature/biodiversity/comm2006/2020.htm

Link 65 national business and biodiversity platforms http://ec.europa.eu/environment/biodiversity/business/links-to-platforms/national-platforms-in-europe_en.htm

Link 66 Phase two http://ec.europa.eu/environment/biodiversity/business/index_en.htm

Link 67 "The Financial System We Need" http://web.unep.org/inquiry/publications

Link 68 Tehran Convention http://www.tehranconvention.org/

Link 69 environmental conditions *http://www.grida.no/publications/caspian-sea/*

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Link 74 carried out by the UNECE member States in the UNECE Committee on Environmental Policy. *http://www.unece.org/env/epr.html*

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