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Knowledge for Action

Empowering the transition to a sustainable Europe

European Environment Agency

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Foreword

The publication of this report follows a period of extreme weather events around the world, including floods and fires in Europe this summer. Following the Sixth Assessment Report of the Intergovernmental Panel on Climate Change published in August 2021, UN Secretary-General António Guterres issued a 'code red for humanity'. Our future depends on urgent climate action.

Next year marks 50 years since the 1972 United Nations Conference on the Environment in Stockholm; the first global conference to make clear the intrinsic value of the natural environment within the broader socio-economic context in which we live. Principles were adopted for the sound management of the environment and yet, 50 years later, human activities have become even less environmentally sustainable.

A recent Unicef report highlights how almost half of the world's 2.2 billion children are already at extremely high risk from the impacts of the climate crisis and pollution. This points to a challenging future and underlines our failure to live up to the ambition of intergenerational equity that was central to the first definition of sustainable development put forward by the Brundtland Commission in 1987. There is still time to act but the window is closing fast as we now understand that small changes in the climate and the continued degradation of natural systems can have profound impacts on how and where we live. We can create a better future globally but we have to do things differently, do them together and act with much greater urgency.

The European Green Deal reflects this need for systemic change and puts sustainability at the heart of EU policy-making. But we are still in the process of turning such ambitions into policies and actions, and we currently understand the challenges better than we understand already available solutions and their implementation.

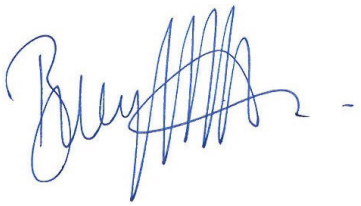
Moreover, our generation has more knowledge than ever to act now; too much knowledge some would even argue. This brings the relationship between knowledge and action to the fore. Unprecedented investments this century in monitoring systems, data and analytical techniques provide a rich basis for informing actions. But we need to go beyond a focus on what knowledge is required and better understand how to further strengthen knowledge analysis, uptake and use across societies to support the transformative systemic changes at the speed and scale needed.

This requires fundamental changes in the 'knowledge system' supporting governance and decision-making in Europe and globally. We have already seen such a paradigm change in understanding and policy for sustainability. Now, similar change is needed for knowledge if we want a system that reflects the changing relationship between science, policy and society and that supports the capacity for wise decision making; in other words, a knowledge system for sustainability transitions.

Developing such a system must be a collective endeavour. With this report, the EEA and its partners are contributing to developing such a system. This will ultimately help achieve the 2030 vision set out in the EEA-Eionet ([1]) strategy 2021-2030 of enabling a sustainable Europe through trusted and actionable knowledge for informed decision-making on priorities and solutions, in line with Europe's policy ambitions.

This means we need to move from words to action if we want to create a future with an environment that supports current and future generations rather than puts them at risk. And we must do so urgently.

Hans Bruyninckx
Executive Director, European Environment Agency



([1]) The European Environmental Information and Observation Network was established in 1994 under EC Regulation No 1210/90 of 7 May 1990 on the establishment of the EEA.

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Executive summary

Addressing Europe's unprecedented environmental challenges will require policies, investments and knowledge to be brought together to transform the systems driving unsustainability while maximising the environmental, social and economic co-benefits. The question is no longer why or whether sustainability transitions are necessary, but how to take action to make them happen at the required speed and scale.

The need for far-reaching change is reflected by the European Green Deal (EGD) and its associated strategies, as well as the complementary proposal for an 8th Environment Action Programme (8th EAP). Their ambitions can be considered unprecedented, putting sustainability at the heart of EU policymaking by calling for profoundly transformative change to address systemic challenges while simultaneously achieving prosperity within environmental limits. While the new policy landscape provides an initial roadmap, more detailed policy responses continue to be developed, translating these short-, medium- and long-term ambitions into actions where implementation is underway. This creates new demands and opportunities for knowledge — knowledge for action towards systemic transformation.

In this context, Chapters 2 to 6 summarise Europe's progress to date on key environment and climate goals and give a concise overview of the main ambitions in five key policy areas. For each, an initial assessment is provided of how current policy ambitions respond to the need for systemic transformations, plus reflections on how knowledge can better support action to achieve change. Chapters 7 and 8 consider how knowledge can empower action since ensuring that relevant and credible knowledge is used by decision-makers is now a greater challenge than ever.

For biodiversity and ecosystems, there is an ambitious ecosystem protection and restoration agenda with key 2030 targets, including that 30 % of the EU's land and sea areas are designated as protected, with 10 % under strict protection. These are complemented with strategies and targets to address the main drivers of biodiversity loss, especially in relation to agriculture and the food system. For climate and energy, the European Climate Law sets a medium-term target of at least 55 % reductions in net greenhouse gases (GHGs) compared to 1990 levels by 2030 and a long-term target of climate neutrality by 2050. This is accompanied by ambitions to transform energy and power systems, a cleaner fuel system for hard-to-electrify sectors, a smart mobility system with 90 % emission cuts from the transport system by 2050, as well as strengthening climate adaptation for a climate-resilient society.

The circular economy and resource-efficiency agenda calls for keeping Europe's resource consumption within planetary boundaries, reducing its consumption footprint, and doubling the circular material use rate over the next decade. As regards human health and the environment, there is a longer-term vision for zero pollution and a toxic-free environment which is underpinned by a range of EU-level 2030 pollution-reduction targets, alongside aims to address emerging pollutants such as pharmaceutical residues, pesticides and microplastics. There is an ambition for a fundamental change in the production and consumption of chemicals to safe- and sustainable-by-design. Finally, a range of overarching sustainability visions have been defined, such as 'citizens live well, within the planetary boundaries in a regenerative economy where nothing is wasted, no net emissions of greenhouse gases are produced and economic growth is decoupled from resource use and environmental degradation'.

At the level of strategic ambitions and aspirations, under the EGD the current policy landscape responds well to the need for systemic transformations in all five policy areas. Compared to previous policy packages, under the EGD the strategies and initiatives mainly take a broader system perspective, including links to the global dimension, reflecting a new understanding of sustainability challenges and responses that embrace the need to address the root causes of unsustainability. At least at the ambition level, a clear departure from silo-based approaches towards a much stronger alignment and integration across different policy domains can be observed. This trend towards a more integrated and holistic approach is also reflected in a stronger integration of environmental, social and economic objectives, including aspirations regarding financial investments (e.g. for biodiversity), social justice (e.g. for climate adaptation) and behavioural change (e.g. for mobility). Therefore, to date, policy developments at the strategic level have put a strong foundation in place to guide and align actions across policy areas and administrative scales.

However, when it comes to the operationalisation of these headline aspirations and ambitions, many open questions remain in relation to their orchestration and implementation at the European, national, regional and local levels. It remains to be seen how the further development of underpinning legislative proposals, investments and progress regarding stronger implementation will deliver against ambitions. Currently, the degree to which ambitions have been translated into more defined or quantitative targets varies. For example, while quantitative mid-term and longer-term targets have been defined

for climate change mitigation, the policy framework for the circular economy and resource use still lacks concrete targets that go beyond waste management. Similarly, quantitative targets for chemicals are largely absent. It is also unclear how some of the overarching sustainability visions — such as 'a regenerative growth model that gives back to the planet more than it takes', from the 8th EAP proposal — can be practically defined, measured and operationalised. In addition, a range of policy gaps prevail, such as the lack of an overarching framework integrating environment and health, and the absence of a strategy for making Europe's agriculture carbon neutral.

Knowledge has been identified as a key enabler of action and transformative change in previous State of the European Environment (SOER) assessments, the EGD and the 8th EAP proposal. Given that policy initiatives are at different stages of development and comprise a diverse range of ambitions, measures and actions, there is a need to develop, integrate and use different types of knowledge. This includes better knowledge and understanding regarding key environmental and climate challenges. Gaps remain in data and indicators to better support policy implementation — for example, in relation to marine species, non-protected species and habitats, ecosystem condition and services, quality of materials, environmental footprints and mixtures of chemicals. Better monitoring of progress is required in certain areas, such as the circular economy. In other cases, further assessments are needed to improve knowledge in areas such as the effectiveness of conservation measures, trade-offs and co-benefits of mitigation measures and consumer behaviour.

There is also a strong need to invest in developing solutions-oriented knowledge, such as new business models for circularity, nature-based solutions, technical choices for climate mitigation, and opportunities for transformational change in rural areas. Given the benefits of holistic approaches and solutions that span multiple policy domains, particular attention is required regarding policy effectiveness and coherence. Understanding the interlinkages, synergies and trade-offs within and between policy domains and responses is crucial to avoid shifting problems from one area to another and to ensure a socially just and economically viable transformation. A range of tools and approaches are available to support policy alignment, such as nexus analysis. Their use is vital given that diverse policy mixes are needed to realise Europe's envisaged transformation — fiscal, sectoral, industrial, welfare, education, employment, regional, innovation and research policies — which also means that knowledge supporting action must integrate the environmental, economic, social, behavioural and governance aspects of sustainability. Examples of such knowledge include a better understanding of systems and systemic challenges, macroeconomic insights, measurement and assessment of progress towards sustainability, as well as the use of foresight for participatory knowledge co-creation processes.

Beyond the focus on what knowledge is required, there is also a need to better understand how to strengthen knowledge development, uptake and use. While policy developments have clearly recognised the role of knowledge in supporting systemic transformation, realising these ambitions requires consideration of the whole knowledge system that links science with policy and action. Knowledge systems include the practices, routines, structures, mindsets, values and cultures affecting what and how knowledge is produced, by whom and how it is communicated. In times of greater questioning of established institutions and scientific advice, scientific evidence must be communicated in a transparent and accountable way that explicitly and honestly assesses uncertainties, ambiguities and tensions. Collaborative, co-creation and partnership approaches to knowledge development are crucial in this context. They include interdisciplinary and transdisciplinary approaches for more integrated knowledge developments; public-private partnerships to promote societal, ecological and economic transformations; the integration of citizen science; and partnerships at the science-policy-society interfaces to better facilitate the uptake and use of knowledge. There are many established and emerging initiatives in this area, such as knowledge centres and information and stakeholder platforms.

In an ideal knowledge system, the development, uptake and use of knowledge would be organised as an iterative and holistic co-creation process with a broad spectrum of societal actors. However, in the context of systemic transformations towards sustainability, this is often challenged by the incommensurability of world views, competing and vested interests, multidimensional objectives, and a lack of trust, time and resources. In addition, the current knowledge system — built around research, monitoring, data, indicators and assessments — has important limitations. These include being fragmented, compartmentalised, elitist, exclusive, hegemonic and often disconnected from action by focusing on problems rather than solutions and how to implement them. This raises the question of whether it is sufficient to address the existing knowledge gaps, complement them with additional knowledge and introduce more participatory, interdisciplinary and transdisciplinary approaches — or do we need a new knowledge system for systemic transformation?

In the context of sustainability ambitions that aim for transformational change in society, a knowledge system that supports the capacity for wise informed decision-making is essential. This means going beyond creating knowledge about the world to rapidly creating the wisdom about how to act appropriately. The coming years offer the opportunity to develop a more comprehensive picture of such a knowledge system for Europe and how it could be achieved at the necessary scale and pace. Development of a European knowledge strategy would determine what knowledge is needed and provide direction that would shape new practices. Such a strategy could underpin the transformation of the current knowledge system to one that reflects the changing relationship between science, policy and society and creates, organises and uses diverse knowledge to empower the transition to a sustainable Europe.


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1 Setting the scene

The *European environment — state and outlook 2020* (SOER 2020) concluded that Europe faces persistent environmental challenges of unprecedented scale and urgency. Addressing them will require policies, investments and knowledge to be brought together to transform the systems driving unsustainability while maximising the environmental, social and economic co-benefits (EEA, 2019f). The current context for realising such ambitions is one of urgency, uncertainty and complexity. The question is no longer why or whether sustainability transitions are necessary but how to make them happen at unprecedented speed. For example, reductions in greenhouse gas (GHG) emissions in the three decades to 2050 will need to occur more than twice as quickly as has been achieved in the three decades since 1990.

The need for such far-reaching change is reflected in the European Green Deal (EGD), the European Union's strategy for growth that aims to transform the EU into a fair and prosperous society with a modern, resource-efficient and competitive economy. The EGD includes environment and climate objectives, such as no net emissions of GHG in 2050, the decoupling of economic growth from resource use, and protecting, conserving and enhancing the EU's natural capital. These objectives are complemented with a range of socio-economic goals aimed at protecting citizens' health and well-being and ensuring this transition is just and inclusive (EC, 2019). Achieving the EGD is foreseen through a broad range of supporting strategies and policy instruments. These include frameworks for transforming key systems, such as food (Farm to Fork Strategy (EC, 2020h)), energy, mobility (European Sustainable and Smart Mobility Strategy (EC, 2020l)) as well as buildings and industrial production (A New Industrial Strategy for Europe (EC, 2020i)). They also include cross-cutting strategies for reducing resource use and Europe's consumption footprint (Circular Economy Action Plan (EC, 2020d)); for protecting and restoring nature (EU Biodiversity Strategy for 2030 (EC, 2020f)); and creating a toxic-free environment (Zero Pollution Action Plan (EC, 2021c) and Chemicals Strategy for Sustainability (EC, 2020g)).

The EGD is complemented by a proposal for the 8th Environment Action Programme (8th EAP) which shares the same long-term vision and environmental priority objectives as the EGD and also aims to achieve the environmental objectives of Agenda 2030 and the Sustainable Development Goals (SDGs) (EC, 2020q). The 8th EAP proposal is based on a regenerative growth model that aims to give back to the planet more than it takes through a set of profoundly transformative policies that provide European and national policymakers and other stakeholders with a clear framework for action. Its goal is to strengthen the integrated approach to policy development and implementation and increase coherence and synergies between actions across all levels of governance. A monitoring framework will be developed that measures progress towards these objectives. This framework will contribute to the EU's overall efforts to measure progress towards sustainability, well-being and resilience and indicate whether or not Europe is on track to achieve systemic transformation. The 8th EAP proposal identifies knowledge as a key enabler for achieving sustainability objectives with the aim of ensuring that policy and action are based on the best-available scientific knowledge and that the environmental knowledge base and its uptake are strengthened.

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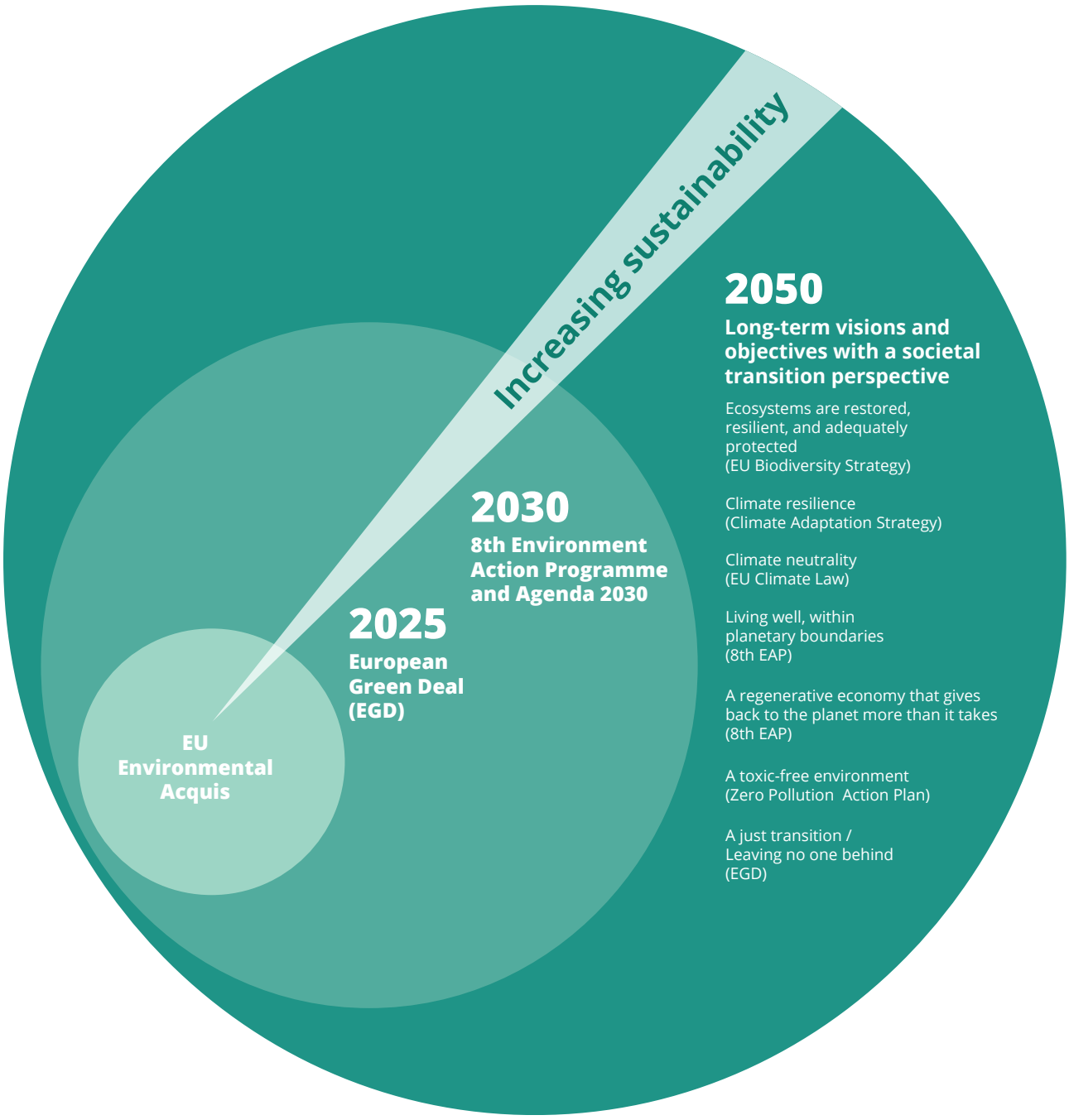
'On 4 December 2019, the EEA published its report entitled 'The European Environment – state and outlook 2020' and its results are sobering. The current environmental, climate and sustainability challenges are of an unprecedented scale and urgency requiring immediate and concerted action and systemic solutions... On 11 December 2019, the European Commission responded to these challenges with the adoption of the European Green Deal...' (EC, 2019)

Since the 1970s, a range of European environment and climate policies have been adopted which currently form the most comprehensive set of environmental standards in the world. Yet, the ambitions set out in the EGD, its strategies and in the 8th EAP proposal are unprecedented. They put the need for transformative change to address systemic challenges and achieve prosperity within environmental limits at the heart of EU policy. The result is a new policy landscape which aims to address short-, medium- and long-term time horizons via a range of policies, strategies and instruments that increasingly connect the environmental, economic, social and governance dimensions of sustainability (Figure 1.1). This also means that policies are in different stages of development and maturity. While the EGD provides an initial roadmap, policy responses continue to be formulated as more detailed plans are developed translating these long-term ambitions into actions and implementation currently underway. The EGD's ambition for all EU actions and policies to contribute to meeting its objectives also brings policy coherence to the fore.

Figure 1.1 **The EU environment and climate policy landscape**



Source: EEA.

SOER 2020 identified important areas where urgent action is needed during the next 10 years, including linking knowledge with action (Box 1.1). Europe's long-term sustainability ambitions create new opportunities and demands for knowledge. Knowledge needs have been addressed by SOER over the years and the calls for change are not new. SOER 2010 highlighted the need to support more accountable and participatory decision-making by providing access to information and engaging people in collecting data and sharing knowledge (EEA, 2010). SOER 2015 emphasised the gap between available, established monitoring, data and indicators and the knowledge required to support transitions. It called for action to widen the knowledge base in the coming decade by investing in a better understanding of systems science, forward-looking information, systemic risks and the relationships between environmental change and human well-being (EEA, 2015). SOER 2020 identified the need for improved knowledge about the systems driving environmental pressures, pathways to sustainability, promising initiatives and barriers to change. It also called for the better linking of knowledge with action. Generating, sharing and using relevant knowledge to the full will require changes in the knowledge system linking science with policy and action, including developing new skills and institutional structures (EEA, 2019f).

The COVID-19 crisis has highlighted how sustainability and well-being are inextricably linked. Environmental and sustainability goals and building societal resilience have become increasingly prominent in discussions around economic recovery packages, demonstrating a greater funding commitment to achieve such goals. However, there was a similar response to the 2008 financial crisis with a green economy focus, which subsequently shifted to fiscal consolidation and addressing sovereign debt crises. The COVID-19 crisis has also demonstrated how policy- and decision-making are possible with an incomplete yet fast-developing knowledge base and in a situation of uncertainty and controversy.

Box 1.1 SOER 2020: Where does Europe go from here? Key areas for action

Strengthening policy implementation, integration and coherence: Full implementation of existing policies would take Europe a long way to achieving its environmental goals up to 2030.

Developing more systemic, long-term policy frameworks and binding targets: The coverage of long-term policy frameworks needs to be extended to other important systems and issues, starting with the food system, chemicals and land use.

Leading international action towards sustainability: Europe cannot achieve its sustainability goals in isolation. The EU has significant diplomatic and economic influence which it can use to promote the adoption of ambitious agreements in areas such as biodiversity and resource use.

Fostering innovation throughout society: Changing trajectory will depend critically on the emergence and spread of diverse forms of innovation that can trigger new ways of thinking and living.

Scaling up investments and reorienting finance: Although achieving sustainability transitions will require major investments, Europeans stand to gain hugely — both because of avoided harms to nature and society, and the economic and social opportunities they create.

Managing risks and ensuring a socially fair transition: Successful governance of sustainability transitions will require that societies acknowledge potential risks, opportunities and trade-offs, and devise ways to navigate them. Policies have an essential role in achieving just transitions.

Linking knowledge with action: Achieving sustainability transitions demands diverse new knowledge, drawing on multiple disciplines and types of knowledge production. This includes evidence about the systems driving environmental pressures, pathways to sustainability, promising initiatives, and barriers to change.

This report draws on SOER 2020 and its associated stakeholder interaction process, as well as on recent knowledge developments. It places them in the context of the new policy landscape with a focus on the role of knowledge as an enabler of action and transformational change. It considers Europe's progress towards environment and climate goals and what this means for systemic transformation. It explores how the knowledge base can support action to achieve this and how its development, uptake and use can be strengthened. Achieving transformational change needs improvements in the coherence of both policy and actions. This requires the careful consideration of interlinkages, synergies and trade-offs and the integration of different types of knowledge. Societal responses to sustainability challenges are at different stages of development — e.g. identifying emerging issues, understanding them, identifying and evaluating responses — so the question of what knowledge is needed to support these different stages is also considered.

The report looks at these issues from a range of perspectives: first, those relating to key policy areas — biodiversity and ecosystems (Chapter 2); climate change mitigation and adaptation (Chapter 3); circular economy and resource use (Chapter 4); and human health and the environment (Chapter 5). A systems perspective with a particular focus on food, energy and mobility is integrated throughout Chapters 2 to 5. Secondly, a broader perspective is taken on sustainability trends, prospects and responses (Chapter 6). Thirdly, the report also considers how knowledge can empower action and the need to consider knowledge development, uptake and use as an iterative, participative and holistic process (Chapters 7 and 8).

More than ever, ensuring that relevant and credible knowledge is used by decision-makers is a major challenge. The assumption that more knowledge results in better policies and leads to improvements in environmental outcomes does not reflect real-world experience. For example, the EU standards for air quality are not as stringent as the World Health Organization's air-quality guidelines. Fish and shellfish stocks continue to be overfished despite knowledge that they are being exploited beyond the limits for sustainability. Negative trends and outlooks for biodiversity led to ambitious policy measures but, to date, these have not halted the loss of biodiversity and ecosystem degradation, with targets repeatedly set, missed or extended.

Knowledge is one factor informing decision-making while many others act as barriers to change. Effectively supporting sustainability goals requires fundamental changes in the knowledge system supporting governance and decision-making. How to make this happen is a big question. Developing the type of knowledge system that builds societal capacity to navigate in a rapidly changing world is an ongoing endeavour. However, short-term actions are needed for long-term change. As a knowledge actor, the EEA and its partners are responding to this challenge. While this report is not a comprehensive analysis and does not claim to have all the answers, it aims to contribute to the collective efforts to meet Europe's sustainability ambitions.

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2
Biodiversity and ecosystems

Is Europe protecting, conserving and enhancing biodiversity and ecosystems?

SOER 2020 concluded that natural capital is not yet being protected, conserved and enhanced in accordance with policy ambitions (EEA, 2019f). Currently, only 27 % of the EU's assessed protected species and 15 % of habitats hold favourable conservation status, and Europe has yet to achieve its overall target of halting biodiversity loss by 2020 (EEA, 2020k). Europe has reached the 2020 global target for designating terrestrial and marine protected areas, and some species have recovered, but most other specific targets have not been achieved (EEA, 2019f).

Although policy measures targeted at natural capital have delivered benefits in some areas, many problems persist, and some are getting worse. For example, although reducing pollution has improved water quality, Europe is still a long way from achieving good ecological status for all water bodies by 2020, and wetlands and floodplains remain widely degraded. Efforts to reduce pressures on marine ecosystems have had some positive effects in some regions but the condition of marine ecosystems is generally poor (EEA, 2020g). Landscape fragmentation continues to increase, damaging habitats and biodiversity. Land and soil degradation remains a concern across many parts of Europe, and the loss of soil functions is impeding sustainable land management. Air pollution continues to impact biodiversity and ecosystems, and 65 % of Europe's ecosystem area is exposed to excessive input of atmospheric nitrogen, causing eutrophication (EEA, 2020a).

Looking ahead, trends in the five main direct drivers of biodiversity loss — changes in land and sea use, overexploitation, climate change, pollution and invasive alien species — are expected to persist. Indeed, the impacts of climate change on biodiversity and ecosystems are expected to intensify. Socio-economic activities, such as agriculture, fisheries, transport, industry, resource extraction and energy production, as well as urban sprawl, continue to exert demands on Europe's biodiversity and ecosystems, with the food system a main driver of pressures and impacts.

What are Europe's ambitions for biodiversity and ecosystems?

The EGD and the 8th EAP proposal aim to protect, preserve and restore biodiversity and enhance natural capital. To date, policy measures have not halted the loss of biodiversity and ecosystem degradation, with targets repeatedly set, missed or extended. The EU Biodiversity Strategy for 2030 recognises the need to step up ambition as biodiversity protection is incomplete, restoration has been small scale, and the implementation and enforcement of legislation has been insufficient (EC, 2020f). The EU Biodiversity Strategy for 2030 strives to be more successful and sets ambitious targets to address the main drivers of biodiversity loss. It recognises the need to accompany targets with greater implementation efforts and places full implementation and enforcement at the heart of the new Strategy.

'A key leverage point for staying within the limits of the planetary boundaries on nutrients, land system change and freshwater is to transform the food system' (EEA and FOEN, 2020)

The Strategy sets out commitments to expand the network of protected areas to cover 30 % of the EU's land and 30 % of its sea area (with 10 % under strict protection) along with the integration of ecological corridors as part of a Trans-European Nature Network. All protected areas must be effectively managed with clear conservation objectives and appropriate monitoring. The Strategy also focuses on restoring ecosystems and aims to enhance the EU's natural capital by developing an EU nature restoration plan with legally binding targets to improve the protection of intact habitats and restore degraded areas.

The EU Biodiversity Strategy for 2030 is complemented by related strategies, such as a new EU Forest Strategy, EU Strategy for Healthy Soils and Zero Pollution Action Plan for air, water and soil (EC, 2021c). The EU Forest and Soil Strategies aim to address the main drivers of biodiversity loss and set concrete

targets for restoration. The goal of the Zero Pollution Action Plan is to reduce pressures on biodiversity, particularly from nutrients, pesticides and chemicals of concern.

Agriculture is the most frequently reported pressure on habitats and species and in relation to pollution (EEA, 2020k, 2021d). The Farm to Fork Strategy (EC, 2020h) is the EU's plan for food system transformation which aims to reduce pressures from agriculture on biodiversity and ecosystems. It calls for a major transformation of European food systems to make them 'fair, healthy and environmentally friendly' and includes targets to reduce chemical, pesticide and fertiliser use, reduce nutrient losses, and increase the percentage of agricultural land under organic farming to 25 % by 2030. It is envisaged to work in tandem with the EU Biodiversity Strategy for 2030, new common agricultural policy (CAP) instruments and strategic plans, and the foreseen Integrated Nutrient Management Action Plan to lead to more sustainable practices.

How do current policy developments respond to the need for systemic transformation?

At the strategy level, policy developments in relation to biodiversity and ecosystems have clearly recognised the need for systemic transformation and the interrelated nature of objectives in relation to natural capital, transforming the economy and reducing environmental risks to health and well-being. The EU Biodiversity Strategy for 2030 and Farm to Fork Strategy have enabling transformative change as a core objective, are comprehensive in scope and integrated with some other policy domains, including social and economic ones.

Systemic transformation requires addressing the underlying drivers of environment and climate pressures. The EU Biodiversity Strategy for 2030 explicitly addresses the five main direct drivers of biodiversity loss. It also highlights the role of the food system in driving biodiversity loss and the part played by biomass in transforming the energy system. The Farm to Fork Strategy takes a wider food system perspective and goes beyond a production focus to address the whole supply chain and consumption. This broader system perspective reflects a new understanding of sustainability challenges and responses. Transforming the food system requires the engagement and collective efforts of all actors across the food value chain. While the Farm to Fork Strategy provides a roadmap of policy action and initiatives (both legislative and non-legislative), it acknowledges that a legislative proposal foreseen for 2023 is necessary to accelerate and facilitate the transition to a sustainable food system.

Biodiversity loss, ecosystem degradation and the sustainability of food systems are global issues. The EU Biodiversity Strategy for 2030 and the Farm to Fork Strategy integrate the global dimension and foresee the EU playing a role in leading by example and contributing to setting global standards. This is largely presented as an opportunity, including reinforcing the EU's competitiveness, but leading by example also requires greater efforts to address the externalisation of environmental pressures and unsustainable practices to other parts of the world and reduce Europe's environmental footprint.

Systemic transformation also requires consideration of interlinkages, synergies and trade-offs within and across policy domains. For example, nature-based solutions are foreseen as a key response to the connected challenges of biodiversity loss and climate change. The EU Biodiversity Strategy for 2030 proposes that a significant proportion of the EU budget dedicated to climate action is invested in biodiversity and nature-based solutions. The EGD also foresees a sustainable blue economy playing a central role in alleviating the multiple demands on land resources and tackling climate change. However, this will require an integrated approach across the land-sea continuum to ensure that environmental pressures are reduced and not just shifted from land to sea.

'The biodiversity crisis and the climate crisis are intrinsically linked. But just as the crises are linked so are the solutions.' (EC, 2020f)

Investment is essential for financing systemic transformation. The EU Biodiversity Strategy for 2030 highlights how investing in nature protection and restoration will be critical for Europe's economic recovery from the COVID-19 crisis, with natural capital investment recognised as being one of the most important fiscal recovery policies offering multiple benefits (EC, 2020f). Targets are not enough on their own; reflecting these priorities in the budget is crucial. Under InvestEU, a dedicated natural capital and circular economy initiative will be established with the aim of mobilising at least EUR 10 billion over the next 10 years. The relationship between biodiversity and ecosystems and societal resilience and well-being is also reflected in the greater integration of environmental and social objectives, including those focused on greening urban environments and improving knowledge, education and skills, contributing to a socially just transition.

Policy developments are encouraging, and some key gaps have been addressed, notably soils, although targets regarding land are still lacking. Land-use choices play a critical role in how the food, energy and mobility systems as well as the built environment impact biodiversity and ecosystems (EEA, 2019f). Although Europe's biodiversity and ecosystems are currently not in a sufficient state to underpin long-term sustainability

goals, this is not due to a lack of ambitious policy objectives. The need to improve on past performance is reflected in the strong focus in the EU Biodiversity Strategy for 2030 on implementation, legally binding targets and recognition that stronger implementation support and enforcement is required. As regards protection, it is foreseen that every Member State will have to ensure its fair share of effort to collectively meet targets on protected areas while recognising that each country has a different quantity and quality of biodiversity. As for restoration, investments in green and blue infrastructure, development of ecological corridors and cooperation across borders among Member States will be promoted and supported. Therefore, while EU policy will provide the framework, implementation of many of the objectives will need to happen at the national level, and it remains to be seen how these ambitions are translated into policies, actions and outcomes in the Member States.

The EGD ambition that all EU actions and policies will contribute to preserving and restoring Europe's natural capital brings policy integration and coherence to the fore as enablers of systemic transformation. However, to date, in the agricultural sector, environmental integration into the CAP has not prevented the continued loss of biodiversity and environmental degradation, which points to the need for much more ambitious and far-reaching efforts (EEA, 2019f). Developments around the new CAP clearly illustrate the challenges in ensuring a clear alignment between the CAP and the ambitions of the EGD, the EU Biodiversity Strategy for 2030 and the Farm to Fork Strategy. They also highlight that systemic change inevitably challenges established policies, jobs, investments, behaviours and norms which can provoke resistance and act as a barrier to change.

This indicates the need to build and engage coalitions of actors in ways that can support transformative change. There are lessons to be learnt from previous experience whereby the conservation sector defined what had to be done but the sectors whose activities were driving biodiversity loss had no ownership of the agenda. Therefore, governance changes are a key enabler. The development of a new European biodiversity governance framework under the EU Biodiversity Strategy for 2030 aims to ensure co-responsibility and co-ownership by all relevant actors by mapping obligations and commitments and setting out a roadmap to guide their implementation.

Systemic transformation demands actions across society. The EU Biodiversity Strategy for 2030 embraces a partnership approach and aims to ensure that environmental and social interests are embedded in business strategies through an initiative on sustainable corporate governance and building a European Business for Biodiversity movement. Civil society's role as a compliance watchdog will also be supported.

In summary, to date, policy developments have established a strong foundation — one that also guides and aligns actions across policy areas and administrative scales. In the coming years, it remains to be seen how the further development of legislative proposals, investments and progress regarding stronger implementation delivers Europe's ambitions to protect, preserve and restore biodiversity and ecosystems. Knowledge will play an important role in this process as supporting systemic transformation creates new demands and opportunities for knowledge.

How can knowledge support action to achieve change?

Europe's actions to protect, preserve and restore biodiversity and enhance natural capital are at different stages of development and comprise a diverse range of ambitions, policies, measures and management actions. Supporting these requires the development, integration and use of different types of knowledge as biodiversity and ecosystems are complex, with a lot of spatial variability and no single measure that can capture the impact of human activities.

The EU Biodiversity Strategy for 2030 identifies some specific actions which need to be taken over the next decade by the research and knowledge community. These include the development of criteria and guidance to support the designation, protection, management and restoration of biodiversity and ecosystems, including target setting. While the latest assessments under the Nature Directives show improved data availability, key gaps remain, especially for marine species (EEA, 2020k). There are also data gaps in relation to non-protected species and habitats, while reporting on ecosystem condition and services is a relatively new area with limited availability of data with appropriate spatial and temporal resolution. Research can help develop the design of a monitoring programme and identify ways of better using existing data, but this must be complemented with investment in new monitoring programmes that address these gaps.

In terms of assessing progress, the Biodiversity Information System for Europe (BISE), Water Information System for Europe (WISE), Forest Information System for Europe (FISE) and upcoming Land Information System for Europe (LISE) provide access to available data and assessments, while the establishment of an EU Soil Observatory will also address an important gap. However, new data and indicators are needed to enable an evaluation of the role of the Natura 2000 network in achieving the targets of the EU Biodiversity Strategy for 2030, while countries' monitoring capacity must also be improved (EEA, 2020k). There are also challenges in integrating current data: for example, while individual assessments under the Water Framework Directive can be considered robust, differences between approaches limit detailed and comparative analysis at the European scale.

It can also take time to move from data to knowledge. The EU Court of Auditors recently concluded that the EU framework provides only limited protection of marine biodiversity in

practice and that regulatory tools linking the EU's marine biodiversity policy with its fisheries policy do not work well in practice (European Court of Auditors, 2020). This was supported by a knowledge base developed by the EEA and the European Environment Information and Observation Network (Eionet). It took approximately 10 years from initial efforts on data integration and analysis to produce assessments of solutions that can help steer the EU towards achieving the ecosystem-based management of Europe's seas (EEA, 2020g).

The urgent need to improve the condition of Europe's biodiversity and ecosystems requires better knowledge on the effectiveness of conservation measures. While it is more cost-effective to protect and preserve biodiversity and ecosystems, the current condition of many European ecosystems indicates restoration will be key to achieving policy ambitions. Ecosystem restoration can take many forms, ranging from passive rewilding, restoring extensive agricultural practices, to active engineering of landscapes. While there are knowledge gaps, there are also decades of experience to draw on.

The complex nature of biodiversity conservation and the need for enhanced scientific support for policy was highlighted in the EU Biodiversity Strategy for 2030 which established a Knowledge Centre for Biodiversity to track and assess progress, including in relation to implementation, foster partnerships, and underpin policy development (EC, 2021g). These partnerships and the need to integrate scientific and lay knowledge can build on long traditions of naturalist recording and citizen science. The European Commission analysed best practices on how citizen science can contribute to environmental monitoring as the basis for taking structured actions across Europe (EC, 2020b).

Developing more interdisciplinary partnerships also creates opportunities for a more integrated approach to knowledge development. Currently, data is collected and assessed through a range of reporting processes, e.g. the Marine Strategy Framework Directive, Nature Directives, the Water Framework Directive and the common fisheries policy. It would be beneficial to compare these to identify key gaps in informing actions: for example, developments in remote-sensing supported by the Copernicus Land Monitoring Service and its products. Europe's ambitions for a sustainable blue economy also highlight the need for knowledge that can support analysis across the land-sea continuum. This includes monitoring multiple environmental pressures and impacts, such as pollutants and their cumulative effects, and assessing whether they are actually being reduced rather than just shifted from land to sea.

Knowledge supporting effective responses will be key to achieving Europe's ambitions for biodiversity and ecosystems. The relationship between biodiversity and climate is particularly important as climate change will continue to impact biodiversity and ecosystems. Therefore, knowledge is needed on these impacts and how conservation strategies can address them as part of protection and restoration efforts.

The development of nature-based solutions aims to address these connected challenges. Investing in research, innovation and knowledge exchange will be essential to develop the most effective nature-based solutions that maximise co-benefits and address trade-offs, e.g. related to climate adaptation, ecosystem restoration, disaster-risk reduction and providing carbon sequestration (Chapter 3). The Horizon Europe programme, the EU's key funding programme for research and innovation, includes solution-orientated missions on soil health and food, as well as healthy oceans, seas, coastal and inland waters. In addition, a future Horizon Europe programme will include a long-term strategic research agenda for biodiversity, including a science policy mechanism to support the implementation of biodiversity commitments with greater funding (EC, 2020f).

As agriculture is the most frequently reported pressure on biodiversity and ecosystems, transformation of the European food system is necessary to achieve policy ambitions (EEA, 2021d). This will require a shift to more sustainable food production that makes better use of nature-based solutions, reduces the levels of inputs (e.g. pesticides, fertilisers), integrated and more circular nutrient management, and greater use of sustainable agroforestry or agro-ecological production methods. This demands further development of the knowledge base, while a new Horizon Europe partnership for safe and sustainable food systems aims to establish a research and innovation governance mechanism to engage food system actors in delivering solutions with environmental, economic and social co-benefits. This would be complemented by greater efforts towards knowledge sharing as access to knowledge is vital to enable food system actors to change practices. Transformation of the energy system also affects biodiversity and ecosystems. The risks created by increasing some sources of biomass and other renewable energy must be better understood. The resource nexus concept (Chapter 3) can be used to analyse interlinkages, trade-offs and co-benefits. The forthcoming Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) nexus assessment will analyse the interlinkages and interdependencies between climate, water, food, energy and health through their relationship with biodiversity and ecosystem services to support the development of policy options.

Integrating the value of biodiversity and ecosystems into decision-making is seen as a way of reflecting their real contribution to society and providing incentives for better management. Europe has invested in the development of natural capital accounts through the Knowledge Innovation Project on Integrated Natural Capital Accounting which has also contributed to the development of an international statistical standard (Box 2.1). Studies have also valued the benefits of the Natura 2000 network at between EUR 200-300 billion per year and the investment needs of the network are expected to support as many as 500 000 additional jobs (EC, 2020f). However, the area of natural capital accounting also highlights the relevance of different values and perspectives when

'Transforming social and economic systems means improving our relationship with nature, understanding its value and putting that value at the heart of our decision making.' (UNEP, 2021)

developing and using knowledge. For some, there are clear benefits in putting a monetary value on nature and integrating natural capital into economic frameworks. Whereas, for others, nature has an intrinsic value which should not be reduced to a monetary value.

Looking ahead, SOER 2020 presented a discouraging outlook for biodiversity and ecosystems, although it emphasised that this outlook is not fixed and depends on choices made today. Evaluating the potential outcomes of different choices can be informed by forward-looking information, such as projections and scenarios. However, the availability or regular use of such knowledge for biodiversity and ecosystems is not the same as other policy domains, such as climate, energy and air pollution. This may reflect the high level of spatial variability and the lack of one or two key metrics that can be used to represent a much more complex area in the way that GHG emissions and average temperature are often used for climate change. However, given the role that biodiversity and ecosystems play in underpinning societal well-being and resilience, the development of qualitative scenarios that explore the potential impacts of policy choices can inform responses and support action.

In summary, knowledge development needs range from basic data on the distribution and condition of species and habitats to analysis of complex interlinkages and interdependencies (Chapter 6). However, there is also enough knowledge to act, especially regarding nature-based solutions and restoration. Furthermore, a partnership approach to knowledge development will be fundamental in supporting transformative change (Chapter 8).

Box 2.1 Natural capital accounting

A new statistical framework to improve accounting for biodiversity and ecosystems in national economic planning and policy decision-making was adopted by the United Nations Statistical Commission in March 2021. It enables countries to use a common set of rules and methods to track changes in ecosystems and their services. The new framework goes beyond gross domestic product and ensures that natural capital accounts complement existing economic accounts. The framework presents internationally recognised statistical principles and recommendations for the valuation of ecosystem services and assets. The European Commission will propose a revision of the Regulation on European Environmental Economic Accounts (EEEA) to expand its coverage to include a new module on natural capital accounting, fully consistent with the UN System of Environmental-Economic Accounting — Ecosystem Accounting (SEEA-EA).

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3
Climate change mitigation and adaptation

Is Europe achieving climate neutrality and increasing its climate resilience?

The EU has made substantial progress in reducing GHG emissions. Total emissions in the EU-27 declined by 24 % (excluding LULUCF) between 1990 and 2019 (EEA, 2021a) as a result of the combined effect of policies and measures, and economic factors, and will meet its target to reduce emissions to at least 20 % below 1990 levels by 2020. The share of energy consumed from renewable sources in the EU-27 increased steadily from 10.2 % in 2005 to 19.7 % in 2019.

Energy efficiency has also improved since 1990, although from 2015-2018, final energy demand increased again — driven in particular by greater demand from the transport sector — before stabilising in 2019. This trend puts Europe's prospects to meet its 2020 energy-efficiency target at risk.

Looking ahead, the medium- and long-term outlook for climate and energy is less positive. Based on Member States' projections (excluding LULUCF), which have yet to fully reflect all national energy and climate plans, the EU-27 would arrive at a GHG emission reduction of 36 %, falling short of the previous (pre-EGD) 40 % target for 2030. Even faster rates of emission reductions will be required to meet the recently raised policy ambitions under the EGD (see next section) which demand structural changes at an unprecedented pace (EEA, 2020m).

Climate change hazards and risks are increasing and are expected to further intensify and aggravate, requiring adaptation and building up societal resilience. While the consideration of climate change adaptation at the European level, the national level and in cities has increased in recent years, progress towards adaptation and resilience is difficult to measure (EEA, 2020h). Although all EU Member States have prepared climate adaptation strategies or plans, to date, adaptation activities have been mainly aimed at developing knowledge, awareness or policy, while implementation and monitoring are lagging behind (EEA, 2020n).

What are Europe's ambitions for climate change mitigation and adaptation?

Under the umbrella of the EGD, the EU has recently raised its policy ambitions for climate change mitigation, adaptation and energy, while the European Parliament and the Council of the European Union have reached a provisional agreement on the first-ever European Climate Law (EC, 2020r). This sets a time horizon with a medium-term target of at least 55 % reductions of net GHGs compared to 1990 levels by 2030 and a long-term and legally binding target of climate neutrality by 2050.

The overarching ambitions of the Climate Law are underpinned by a new set of related strategies and legislative proposals to help operationalise the new EU ambitions. As regards climate change mitigation and energy, the EU policy framework now includes significantly more components (e.g. on hydrogen, offshore wind, batteries and a revised renewable-energy financing mechanism), building upon a range of key initiatives. The aim of the Energy System Integration Strategy (EC, 2020k) is a more efficient and circular energy system, a cleaner power system and a cleaner fuel system for hard-to-electrify sectors. Similarly, the ambition of the EU Hydrogen Strategy (EC, 2020c) is the deployment of hydrogen on a large scale across all hard-to-decarbonise sectors by 2030. In parallel, the Strategy on Offshore Renewable Energy (EC, 2020m) aims to double EU offshore wind-energy capacity by 2030 (from the current 30 GW to 60 GW) and to achieve a 10-fold increase to 300 GW by 2050.

A 'Fit for 55' package (EC, 2021d) consisting of 13 interconnected proposals has been adopted by the European Commission to deliver on the target of at least 55 % reduction of net GHGs by 2030 as agreed in the Climate Law. The package aims to strengthen already existing policies and introduce new policy initiatives and covers pricing instruments, targets, rules (e.g. related to fuels and CO_2 performance for cars and vans) and support measures (e.g. a new Social Climate Fund). Revisions are either being proposed or are underway for a range of current Directives and Regulations, including: the EU Emissions Trading

System (EU ETS) (EC, 2020o), the Energy Taxation Directive (EU, 2003), the Effort Sharing Regulation (EU, 2018d), the Regulation for the Land Use, Land Use Change and Forestry Sector (LULUCF) (EU, 2018c), the Renewable Energy Directive (EU, 2018b) and the Energy Efficiency Directive (EU, 2012). In addition, a new Carbon Border Adjustment Mechanism is proposed. Beyond the 'Fit for 55' package, revisions of the Energy Performance of Buildings Directive (EU, 2010a) and the Regulation on the Governance of the Energy Union and Climate Action (EU, 2018e) are foreseen as well.

The related new Methane Strategy (EC, 2020n) aims to put Europe in a global leadership position for reductions in methane emissions — the second most important contributor to climate change after carbon dioxide. This strategy also has a particular focus on land and agriculture, in addition to emissions of methane from waste and energy. For transport and mobility, the new Sustainable and Smart Mobility Strategy (EC, 2020l) is aiming for 90 % emission cuts from the transport system by 2050 by focusing on profound transformations and structural change. As regards buildings and energy, the goal of the Renovation Wave for Europe initiative (EC, 2020j) is to at least double the annual energy renovation rate of residential and non-residential buildings by 2030. The measures to meet the climate and energy targets also provide some synergies with and co-benefits from reducing air pollution (Chapter 5).

Even if drastic climate mitigation measures are implemented immediately, Europe will have to tackle far-reaching climate impacts and risks. There is a renewed commitment for Europe to become a climate-resilient society, through a new EU Strategy on Climate Adaptation (EC, 2021b). This promotes four overarching objectives for building climate resilience to the unavoidable impacts of climate change: smarter adaptation, faster adaptation, more systemic adaptation, and international adaptation action.

How do current policy developments respond to the need for systemic transformation?

Recent major assessments, such the Intergovernmental Panel on Climate Change (IPCC) Special Report on Global Warming of 1.5 °C (IPCC, 2018), the latest UN Environment Programme (UNEP) Emissions Gap Report (UNEP, 2020) or SOER 2020 (EEA, 2019f), all emphasise the severeness of the global climate crisis and the need to significantly and immediately step up climate action towards net-zero emissions goals by mid-century. The significant increase in overall EU climate ambition responds well to the conclusions. However, some studies suggest that even stronger GHG emission reductions of up to 65 % by 2030 would be needed to be fully consistent with the 1.5 °C global warming scenario from the IPCC (UNEP, 2019).

The EU Climate Law is also an important part of global climate leadership, contributing to encouraging developments in global climate policy. Recently, several countries have followed the European example and announced similar climate mitigation ambitions, such as China (carbon-neutrality by 2060), Japan (net-zero GHG emissions by 2050) and South Africa (net-zero carbon emissions by 2050). At the same time, the USA has rejoined the Paris Agreement and proposed a net-zero GHG target by 2050. Taken together, these countries or regions with (proposed) mid-century carbon-neutrality targets now cover about 63 % of current global GHG emissions (UNEP, 2020).

The need for systemic transformation appears to be well reflected in the new strategies underlying the EU Climate Law. For example, the scope of the Sustainable and Smart Mobility Strategy (EC, 2020l) is comprehensive and covers all modes of transportation including the challenging sectors of maritime transport and aviation. It also focuses on a range of enablers, such as public and private investment, incentivising user demand for low-carbon or even zero-emission options, and behavioural change. For energy, some of the new ambitions are also more systemic in character with a recognition that the different system components must be aligned simultaneously. For example, the Energy System Integration Strategy (EC, 2020k) explicitly aims to transform today's largely linear energy system (with associated wasteful flows of energy) into an integrated and circular system that puts energy efficiency first, reuses waste heat, and makes use of locally available energy sources such as biological wastes and residues.

Climate mitigation and energy ambitions are also increasingly integrated with other policy domains. For example, the crucial role of the circular economy and resource efficiency for Europe's decarbonisation are now clearly articulated (Chapter 4). While these ambitions from the different climate, energy and mobility strategies provide a roadmap towards systemic change, they must be made operational through subsequent legislative proposals and binding targets. Since this process has only just begun, the potential and suitability of these strategies to deliver Europe's rapid and strong decarbonisation remains to be seen.

The role of agriculture (in particular livestock) and soils in climate mitigation remain understated and under-represented in EU policy, despite the fact that they account for about 10 % of the EU's total GHG emissions (Eurostat, 2021d). For the EU-27 countries, the livestock sector alone accounted for 53 % of human-induced methane (CH_4) emissions in 2018 (rising from 45 % in 1990), and for 9 % of anthropogenic nitrous oxide (N_2O) emissions (increasing from 8 % in 1990 (calculated from the EEA greenhouse gases data viewer). In addition, soils — if managed properly — can significantly contribute to carbon sequestration. The Farm to Fork Strategy aims to increase the sustainability of the livestock sector. However, progress will depend on the revision of the Industrial Emissions Directive (EU, 2010b) as well as on national interventions implemented under the future CAP. The proposed revision of the EU's LULUCF Regulation could, if ambitious enough, also significantly increase the contribution from the agricultural sector to achieve Europe's 2030 and 2050 climate targets. Likewise, the Methane Strategy (EC, 2020n) could contribute

positively to emission reductions from agriculture. However, this focuses primarily on improving measurement and reporting and soft measures (e.g. promotion of good practices) and lacks concrete and binding reduction targets. Overall, no broader and comprehensive strategy has emerged from the European Commission with the goal of making Europe's agriculture carbon neutral.

While recent or upcoming EU legislative proposals will provide the overarching framework, the operationalisation and implementation of the Climate Law will depend on actions and measures in Member States. A critical question is how they intend to operationalise these ambitious targets. A key instrument in this context — as well as for climate adaptation — will be the Regulation on the Governance of the Energy Union and Climate Action (EU, 2018e), which requires the regular preparation and update of integrated National Energy and Climate Plans (NECPs) as well as a national long-term climate strategy. These two elements must be consistent with each other and will have to be scrutinised at EU level. Such efforts must be part of broader policy frameworks that enable systemic change, including addressing consumption patterns and lifestyle changes.

To this end, the aim of the new European Climate Pact (EC, 2020p) is to provide a platform for EU citizens and society at large to foster climate awareness and to stimulate actions towards consumer changes in areas such as green mobility, buildings, skills, or food and diets. However, such initiatives alone aimed at changing individual behaviour will not be sufficient to enable wider system change. They need to be embedded in broader actions, such as making products with a low-carbon footprint the cheapest option, making it easier for consumers to switch to low-carbon transport, or facilitating private citizens and corporate businesses to install citizen/community-driven renewable energy.

The design of the COVID-19 recovery packages will most likely be the single most determining factor in shaping how the European climate mitigation (and mainly adaptation) pathway towards 2030 and beyond will look. Although the recent pandemic has led to a temporary reduction in GHG emissions due to less economic activity, emissions are likely to increase again once economic activities resume in full. Strong reductions in emissions as well as significant progress on climate adaption can only be expected if COVID-19 economic recovery action is used as an opportunity to pursue strong decarbonisation and to step up investments in adaptation and building climate resilience. Although carbon prices have increased recently, measures and incentives are still necessary to achieve carbon prices that fully reflect externalities. The EU ETS could be a key instrument in helping to achieve steep increases, but only if the current revision is ambitious and sufficiently far-reaching. Sustainable finance is another key enabler, with the new EU taxonomy (EU, 2020b) an important first step to redirect capital flows towards sustainable projects and to screen investments from a climate perspective.

The new EU Adaptation Strategy (EC, 2021b) clearly articulates the need for transformative action and offers a far-reaching framework covering all economic sectors. Its priority objective of 'smarter adaption' includes a call for better data and knowledge so that decisions on adaptation action can be based on the most robust data and risk-assessment tools. This relates directly to the role of knowledge and sharing of good practices and solutions through adequate interfaces for knowledge exchange and use. 'Faster adaptation' refers to the need to speed up adaptation actions and to move from the currently predominating soft measures (e.g. adaptation strategies and plans, awareness campaigns, etc.) to rolling out solutions across Europe to achieve comprehensive adaptation implementation. 'More systemic adaptation' calls for integrating adaptation into macro-fiscal policy, embracing nature-based solutions (Chapter 2) and embarking on local adaptation actions.

Across all these priorities, the EU Adaptation Strategy aims to foster solutions with a focus on broader societal transformations and adaptation measures to deliver co-benefits for the environment, human health and well-being and economic sectors. However, most adaptation implementation action must happen at national to local levels. It remains to be seen how the new adaptation ambitions, in combination with the latest research and innovation programme, will affect the necessary speeding up of smart and systemic adaptation implementation at all levels of governance and geographical scales.

How can knowledge support action to achieve change?

A key challenge in the coming decade will be to achieve the high ambitions and targets for Europe's rapid decarbonisation and greater climate resilience, as set out in the EU Climate Law and its related strategies. Deep and systemic transformations will be needed across European production and consumption systems and, more broadly, across society, which will require putting in place the right measures, actions and enabling conditions. While there is sufficient knowledge to embark on this pathway towards sustainability, strengthening the knowledge base in the coming years will be required to further guide Europe's transformation process.

As regards climate mitigation measures, a better understanding of the effects and effectiveness of existing public policies and measures, at both the European and national level, is needed to optimise the role of governments in steering the policy mix and incentivising change. As Europe steps up the implementation of a wide variety of solutions for climate neutrality, trade-offs with other societal goals and environmental ambitions will arise. An early indication of such trade-offs and the potential co-benefits of mitigation efforts is needed. This also includes a better understanding of how best to address any unintended side effects of mitigation measures in a systematic way. Such knowledge is crucial to ensure policy coherence and maximise the benefits of mitigation.

The resource nexus concept is one of the existing tools to explicitly shed light on trade-offs and co-benefits, recognising that climate mitigation, energy and air quality are interconnected across space and time with food, water, land, materials and ecosystems (Hoff, 2011). An example is the use of solid, liquid and gaseous biomass fuels to reduce GHG emissions in the energy system against factors that negatively affect the carbon balance of these biomass fuels (e.g. direct and indirect land clearance to grow trees or crops, losses of soil carbon during harvesting, supply-chain, processing and transporting emissions, and the time delay before saplings are large enough to absorb GHG emissions at the same rate as the harvested trees). All of these factors must be considered together and in relation to land-use demands and food security, biodiversity, ecosystems, air quality and health considerations (EEA, 2019f, 2019c; Fritsche et al., 2020). Several recent research projects (e.g. MAGIC, SIM4NEXUS, DAFNE) focusing on nexus issues could help to inform policy choices in the coming years, as could new knowledge on the agriculture, forestry and other land-use sectors (AFOLU) (Box 3.1).

Transition processes towards a rapid decarbonisation of Europe's current production and consumption systems are highly complex and uncertain, and must be underpinned by broader societal change, such as changes in business models, lifestyles, values and consumption patterns. Since these processes cannot be planned and implemented in a linear way, governments have to find ways to manage unintended consequences, to reconcile opposing interests and to steer actions towards long-term sustainability. For example, there is a strong need to rapidly phase out environmentally harmful subsidies (such as support for fossil fuels or certain agricultural practices) in a socially just manner, while avoiding replacing these with new subsidies for potentially harmful innovations. At the same time, different policy signals are required (including pricing) to help promising niche initiatives and instruments become mainstream, such as energy-as-a-service models, industrial symbiosis, or energy communities. All this points to the need for a larger, polycentric set of nested institutions and organisations at various governmental levels, including regional and local. Knowledge is required on how to enhance such polycentric climate governance structures. When it comes to social dynamics, existing and new knowledge on factors influencing behavioural change and consumption choices, such as the SHIFT framework (White et al., 2019), can guide policy actions towards stimulating climate-friendly user choices.

Box 3.1 The management of land and its impact on climate change mitigation, adaptation and biodiversity

Reaching carbon neutrality by 2050 will put pressure on how agriculture, forestry and other land-use activities are managed in the so-called AFOLU sector. Strong GHG emission reductions are needed in this sector whilst ensuring that terrestrial carbon sequestration compensates for those GHGs that cannot be avoided in other sectors. At the same time, the AFOLU sector will need to provide food security, materials for a circular economy, and adapt its management and production practices to a changing climate while avoiding land-management practices that have negative impacts on ecosystem services (e.g. biodiversity and water storage) or cause other problems such as nitrogen pollution.

Emissions of GHGs from AFOLU can be avoided through sustainable farming practices that either favour a lower intensity of production or increase the amount of soil carbon stored on the land (nature-based solutions). Afforestation measures that increase the carbon stored in forests are needed along with harvesting practices that leave residuals on the forest grounds, thereby increasing carbon storage and supporting biodiversity. At the same time, the AFOLU sector is very sensitive to climate change impacts like droughts, with some areas in southern Europe expected to become unsuitable for agricultural production in a few decades (with detrimental impacts on food security). Other adverse effects include an expected increase in alien species resulting in the deterioration of forest conditions (impacting carbon sequestration and forest harvesting), and an increasing risk of forest fires which might be further aggravated if forest residues are not harvested because of biodiversity considerations.

It is important to balance the different demands on the AFOLU sector (food and material production, carbon sequestration, supporting biodiversity) with the various environmental and climate pressures the sector is generating. Various policies address elements of the AFOLU sector, such as the CAP, the Renewable Energy Directive in relation to bioenergy, the Energy Union Governance, including the LULUCF Regulation, setting targets on GHG emissions and removals, and the EU Biodiversity Strategy for 2030. At present, there is no integrated European policy to address finding the balance between the diverging objectives of sustaining agricultural production, climate adaptation and reduced climate and environmental impact. What might be good for biodiversity — low-intensity farming — might lead to food security problems and may result in greater production demand outside the EU, with associated climate and environmental impacts. However, reducing food waste and changing diets could at least partially compensate for the lower yields resulting from low-intensity farming.

Such cross-cutting insights are important to ensure that policy action on land management is guided towards the most sustainable solutions — environmentally, economically and socially. For example, many options exist in the forest-based bioeconomy to mitigate climate change, including increasing carbon stocks on forest land and in harvested wood products, and using wood to substitute other materials or fossil fuels. However, there are trade-offs among these options, which should be fully considered from a system perspective (Fritsche et al., 2020).

'Lifestyle changes are a prerequisite for sustaining reductions in GHG emissions and for bridging the emissions gap. Around two thirds of global emissions are linked to the private household activities according to consumption-based accounting. Reducing emissions through lifestyle changes requires changing both broader systemic conditions and individual actions.' (UNEP, 2020)

Beyond energy, mobility and food as key levers for change, major challenges towards climate-neutrality in Europe include a major refurbishment of large parts of Europe's building stock in terms of energy use and efficiency, profound changes in a range of carbon-heavy industries (e.g. cement, steel) (EEA, 2019f), as well as incentives and actions to steer consumption choices towards climate-proof options. The latter would also include public procurement and corporate consumption (e.g. company cars) choices. All this requires new insights and knowledge on issues such as how deep decarbonisation can be achieved quickly enough, its impacts on jobs, economic performance and competitiveness more broadly, the need for new skills for fundamentally reconfigured labour markets, and how such deep structural change can be achieved without creating social inequalities.

Furthermore, a range of more fundamental knowledge questions remain about technological choices and prioritisations. These include the potential for and limitations of carbon capture and storage technologies, the production of batteries for electric vehicles (from a resource-efficiency and material cycle perspective), hydrogen production, the opportunities and challenges around mitigating (methane) emissions from livestock, and the climate mitigation potential of a circular economy (Chapter 4).

For both climate adaptation and mitigation, a key knowledge challenge facing greater climate resilience is related to the implementation of policy ambitions. Major barriers are typically a lack of both funding and legal frameworks that provide solid ground for action. The pace of climate adaptation must be speeded up and national-level efforts better linked and aligned. To achieve the latter, it is necessary for front-runner countries ('adaptation champions') to improve the transfer of knowledge around solutions and responses to those hindered by limited capacities. In particular, new insights are needed into factors which ensure the success of context-specific local adaptation measures. The EEA's Climate-ADAPT platform is a key tool for knowledge sharing and mutual learning and is also recognised in the new EU Climate Adaptation Strategy. There are also gaps in the current understanding of the cost-effectiveness of adaptation measures. However, it should be noted that not all measures can be meaningfully quantified in terms of costs and benefits or economic losses/costs of inaction. This applies, for example, to a number of social values (e.g. recreational benefits, aesthetics) and to monetising ecological thresholds.

The new EUR 100-billion EU research and innovation programme, Horizon Europe, is well aligned with these knowledge challenges. It includes a solution-oriented Mission on Adaptation to climate change, including societal transformation, which aims to prepare Europe to deal with climate disruptions and scaling-up solutions for resilience (EC, 2021h). Furthermore, a Digital Twin on Climate Change Adaptation will be developed as part of the Destination Earth (DestinE) initiative (EC, 2021e).

As a result of the COVID-19 crisis, the EU4Health programme has been proposed with the aim of reinforcing public health systems, speeding up their digitalisation, and tackling cross-border health threats, including capacities for climate-related health impacts. In that context, the European Climate and Health Observatory, part of the EU Adaptation Strategy and co-managed by the EEA and the European Commission, is a new knowledge platform to support Europe in preparing for and adapting to the health impacts of climate change by providing access to relevant information and tools. In addition, the EEA and the Copernicus Climate Change Service (C3S) are jointly developing the European Climate Data Explorer (hosted on Climate-ADAPT), which provides interactive access to climate information from the C3S to facilitate the development and implementation of adaptation actions at the national and subnational level.

For climate adaptation, it is necessary to improve the knowledge around the trade-offs and co-benefits of adaptation measures. For example, although the use of nature-based solutions to adaptation and disaster-risk reduction is promoted by the EU Adaptation Strategy, it is frequently hampered by relatively high costs compared to grey infrastructure measures, and their long-term environmental and societal benefits are often not fully understood. More broadly, the need for a better understanding of trade-offs and co-benefits points to promoting a systemic perspective to adaptation implementation that considers both the challenges and opportunities inherent in simultaneously pursuing environment, economic and social objectives.

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4
Circular economy and resource use

Is Europe's economy becoming circular and resource efficient?

Over the past 10-15 years, Europe has made progress towards the circular economy and has become more resource efficient, albeit slowly. Total material consumption has declined, and waste management improved, resulting in a slow increase in the circular material use rate. Water abstraction has also declined (EEA, 2019f).

However, some recent trends are less positive. For example, the amount of waste generated rose steadily in the period 2012-2018 (Eurostat, 2021c) in spite of the EU's long-standing goal to reduce it. The unsustainable use of materials continues to dominate the economic system, with the lifespan of products in key value chains decreasing and single-use applications increasing. Substances of concern in products, the degradation of material quality during use, collection and processing, and certain product designs limit the potential of recycled materials to replace virgin materials and thus their ability to reduce environmental pressures associated with virgin material extraction. Europe's land resources are still being depleted through intensive use and land take with only 13.5 % of new developments on recycled land (EEA, 2020f). At sea, marine resources continue to be overexploited with the marine environment suffering from multiple pressures from human activities (EEA, 2020g).

The outlook for 2030 is rather mixed and huge implementation gaps remain. Further implementation of policies which were in place before 2020 are expected to drive improvements, especially for waste management. However, these are not considered strong enough to effectively address a range of pressures, including material consumption, use of water resources and land take is likely to further increase. Europe is not yet on track towards a truly circular economy (EEA, 2019b). However, a large range of new strategies and policies, including those addressing key value chains and product sustainability, were adopted in 2020, with more concrete policy proposals to come during the next couple of years which could change the outlook to 2030 and beyond.

'... the resource use related to current European production and consumption patterns puts Earth's life-support systems at risk and with it society and the foundation for economic development.' (EEA and FOEN, 2020)

What are Europe's ambitions for resource use and the circular economy?

Both the EGD and the 8th EAP proposal aim to decouple economic growth from resource use and accelerate the transition to a circular economy. The main strategy for implementing these objectives is the Circular Economy Action Plan (CEAP), supported by the Critical Raw Materials Resilience Communication, the New Industrial Strategy for Europe, the Bioeconomy Strategy and the existing significant body of legislation on waste. The CEAP calls for keeping Europe's resource consumption within planetary boundaries, reducing its consumption footprint and doubling the circular material use rate within the next decade.

The CEAP is framed as a transition agenda as the actions will require considerable changes in how materials and products are designed, marketed, used and handled at their end of life, requiring all societal actors to change. One of the key elements of the CEAP is the Sustainable Products Initiative. This aims to extend product lifespans, including through design requirements, and to incentivise the high-quality recycling of materials as well as lower carbon and environmental footprints.

'The EU needs to (...) advance towards keeping its resource consumption within planetary boundaries, and therefore strive to reduce its consumption footprint and double its circular material use rate in the coming decade.' (EC, 2020d)

Priority is given to value chains with high environmental and resource impacts, namely electronics and information and communications technology (ICT), batteries and vehicles, construction and buildings, packaging, plastics, textiles, food, water and nutrients, while land take will be addressed in the Strategy for a Sustainable Built Environment. These priorities have already led to sectoral voluntary initiatives, such as the European Plastics Pact and the Global Fashion Agenda, bringing together different actors along the value chain.

To date, while consumption patterns and behaviours have been mainly addressed through voluntary measures, such as providing consumers with information, the CEAP takes some cautious steps towards empowering and incentivising more 'circular' consumer choices (e.g. 'right to repair'), and the mandatory greening of public procurement.

How do current policy developments respond to the need for systemic transformation?

At the strategy level, policy developments related to the circular economy and resource use have clearly recognised the need for the systemic transformation of the economy. The new policy framework is aiming for a fundamental redesign of materials, products and processes, business models, and the way materials and products are used in the economy, as well as for collaboration across the value chain. It addresses some of the factors that currently limit the potential of recycling to meet material demand (EEA, 2019f). The planned Sustainable Products Initiative aims at reorienting product design, use and end of life towards a circular model, and goes well beyond the current dominant policy focus on waste management. The first concrete example is the proposed EU Batteries Regulation which addresses the sustainable sourcing of materials, lifetime extension, production and the use phase. The goal of the planned strategy on textiles is a comprehensive set of measures to change unsustainable production and consumption patterns, such as fast fashion and prevailing linear business models, towards a circular model. Another example is the planned Integrated Nutrient Management Plan foreseen in both the Farm to Fork Strategy and the CEAP, which aims for a systemic change in nutrient management, including nutrient recovery, thereby reducing nutrient losses (Chapter 2).

The EGD's overall ambition for circular economy and resource use is to decouple the latter from economic growth. The CEAP goes beyond the decoupling paradigm and recognises that Europe's consumption footprint should be reduced and resource use should stay within planetary boundaries. Nine such boundaries have been identified: climate change; change in biosphere integrity; stratospheric ozone depletion; ocean acidification; biogeochemical flows, namely interference with the phosphorus and nitrogen cycles; land-system change; freshwater use; atmospheric aerosol loading; and the introduction of novel entities. Europe's consumption footprint already exceeds the planetary boundaries for nitrogen and phosphorus losses and land-system change while safe limits for freshwater use can be transgressed both locally or regionally (EEA and FOEN, 2020).

Meeting the objective to double the circular material use rate by 2030 — the only overall quantitative objective in the action plan — will require a considerable acceleration of pace, given that it only increased marginally over the past decade (from 10.4 % to 11.9 % in the period 2009-2019 (Eurostat, 2021a). Major efforts in both reducing resource use and radically increasing the use of waste as a resource will be needed to achieve this objective. Since around one fifth of materials used are fossil fuels, the planned decarbonisation of the energy mix will contribute to this goal.

Overall, the policies focus on materials. However, policy actions to reduce the use of other resources are also envisaged, e.g. nutrients (Integrated Nutrient Management Plan), land take (Strategy for a Sustainable Built Environment), marine resources (Action plan to conserve fisheries resources and protect marine ecosystems) and water (Water Reuse Regulation (EU, 2020a)).

Compared to the ambition level for climate change, for which quantitative mid-term and longer-term targets have been set (Chapter 3), the policy framework for circular economy and resource use still lacks concrete targets that go beyond waste management. While targets for waste management have recently been strengthened and extended in EU waste legislation, and waste-prevention targets will be developed by 2024 (WFD 2018), no targets are currently envisaged for reducing resource use.

Circular economy policies are being integrated more and more with other policy domains. For example, climate change mitigation and energy policies increasingly acknowledge the roles circular economy and resource efficiency could play towards the 2050 climate neutrality target (Chapter 3). The Bioeconomy Strategy aims to increase the circularity of the

biobased sectors (EC, 2018). Preventing substances of concern from entering products and removing them from material cycles are key conditions for a long-term safe and sustainable circular economy. Both the Chemicals Strategy for Sustainability (EC, 2020g) and the CEAP foresee measures supporting the transition to non-toxic material cycles (Chapter 5). Reorienting finance towards circular economy solutions is supported by the EU Taxonomy Regulation (Chapter 6), targeting circular economy investments as one of six environmental objectives. Moreover, circular economy solutions need substantial research and innovation as well as fostering new skills. Innovations towards circular solutions, especially in technologies and business models, are highlighted as key levers of change in the CEAP, the New Industrial Strategy and the Chemicals Strategy for Sustainability, while any mention of social innovation is limited.

Europe's supply chains are highly globalised and it relies heavily on imports for many of the resources and products consumed on its territory, in particular metals and fuels, but also textiles and consumer electronics, often creating a high environmental burden in the countries of origin (Chapter 6). One response is the planned legislative initiative addressing human rights and environmental due diligence across value chains (European Commission DG JUSTICE, 2020). The CEAP also aims to support a global shift to a circular economy. Initiatives include embedding circular economy objectives in free trade agreements, the recent launch of the Global Alliance on Circular Economy and Resource Efficiency (GACERE), a global agreement on plastics, and exploring the feasibility of defining a 'safe operating space' for natural-resource use.

In summary, most policy ambitions have yet to be translated into concrete legislative proposals. Furthermore, it remains to be seen how far the planned activities and measures will be able to contribute to the objective of doubling the circular-material use rate, to reduce Europe's consumption footprint and to stay within the planetary boundaries for resource use. There are major economic and social barriers to such a deep transformation (Chapter 6). Putting these ambitions into concrete policies and implementing them so that they deliver on Europe's objectives for a resource-efficient and circular economy must be underpinned by sound knowledge.

How can knowledge support action to achieve change?

The overall ambition to keep material consumption within planetary boundaries needs further elaboration. Material use has a different character than the nine planetary boundaries that influence the stability of the global biophysical system. High material consumption is one of the drivers of unsustainability pushing the earth system towards these boundaries. Defining scientifically based targets for material resource use could be inspired by the planetary boundaries framework and could identify how many renewable and non-renewable resources might be extracted in a sustainable way without transgressing critical thresholds while leaving resources for future generations. Given that each raw material has its specific profile for environmental and climate impact, this would require material-specific assessments then combining these into an assessment of the total impacts.

Improving the monitoring of Europe's progress towards the circular economy is key for assessing the effectiveness of circular economy policies. Developments are underway to generate additional data to fill some identified knowledge gaps, including on food waste, reuse, substances of concern in products, and green public procurement (EC, 2020d). The Bellagio process, led by the Italian government and the EEA (EPA Network et al., 2020), developed a set of seven principles for monitoring the circular economy. These principles underline that moving towards the circular economy is a transition process and that the circular economy is not a goal in its own right but rather a means to reduce environmental and climate impacts from production and consumption. The principles address what must be monitored (e.g. material and waste flow indicators, environmental footprint indicators, economic and social impact indicators and policy and process indicators) and how to monitor (including indicator selection, types of data sources, monitoring and governance structure).

'Monitoring the transition towards a circular economy needs to holistically consider all relevant initiatives — public and private — across the economy. It should capture the full extent of changes happening to the material and waste flows, products over their life cycles, business models, and consumer behaviour, including the economic, environmental and social dimensions of these changes.' (EPA Network et al., 2020)

Due to limitations in available statistics, monitoring is currently focused on material inputs to the economy and waste outputs at a macroeconomic level, while other aspects are less well understood. As information on the quality and losses of materials and wastes is sparse, new classification codes for international trade and manufacturing would be useful to identify the circular use of materials. Moreover, harmonised data for monitoring processes that can lead to more circularity are largely lacking and the use of novel or experimental data sources will probably be required to improve information on, for example, reuse, remanufacturing, repair, refurbishment, new business models, and green/circular public procurement. Likewise, there is a severe lack of knowledge on product properties that can enable more circularity, such as repairability, product lifetimes and the presence of substances of concern. Whereas statistics typically focus on material flows (input, output), circularity is also aimed at managing material stocks (the urban mine). This generates the need for information on the quantity and quality of materials being used.

To date, the use of environmental footprint indicators for monitoring purposes has been limited by a lack of specific policy objectives to reduce environmental footprints as well as factors such as timeliness, the range of environmental pressures included in the environmentally extended input-output models that are the basis of such indicators and comparability of estimates. Development of these indicators has mainly been pursued through research projects. However, in recent years, Europe's statistical system has also generated environmental footprint indicators, while the European Commission's FIGARO project aims to create regularly updated datasets that will improve timeliness, the consistency of international estimates and accuracy (Eurostat, 2019). There are also environmental footprint indicators based on life-cycle analysis (LCA) methodologies which cover a broader range of pressures and impacts. In addition, environmental footprints can provide further insights into the impacts of consumption — for example, identifying hot spots in terms of industries, products and services — and can be used to model policy options that address both the resource efficiency of production and changes in consumption patterns.

Systemic transformation demands addressing the underlying drivers of Europe's still largely linear and resource-heavy economy. Key drivers include business models that are optimised for the high throughput of products, the globalisation of value chains taking advantage of considerable differences in labour costs and environmental standards, and the fact that the cost of materials and products often does not reflect the environmental and climate impacts. More circular solutions requiring less material input and generating less waste are already partially available but often not (yet) economically viable. New, more circular business models have been identified as possible enablers of a circular economy. However, their scaling up requires a better understanding of the conditions that make them economically viable and socially accepted, how they can be financed, what their overarching social and economic effects will be, and how effective they actually are in reducing environmental pressures. Moreover, the effectiveness of actions that reduce the demand for products and resources could be reduced through rebound effects. This is well researched for energy efficiency but much less understood for resource use.

The move towards a circular economy will require both technical and social innovation in business models, and behavioural changes across society, from individual citizens and from public and corporate institutions, and knowledge that supports such changes, including assessing their potential benefits and trade-offs. In particular, better evidence is needed to support policies aiming to trigger changes towards 'circular' behaviours, including knowledge of the social and economic impacts of behavioural change.

A wider use of footprint and LCA methods is required to support the more specific policies for making key value chains more circular, non-toxic and resource efficient — electronics and ICT, construction and buildings, batteries and vehicles, packaging, plastics, textiles, food, water and nutrients. Additional assessment methods are needed to evaluate the effectiveness of policies and material management strategies to maintain the functionality of materials and products at a high level over a longer period of time as such information is not generated by current LCA-based methods. This will require applying a systems approach to an analysis of these value chains (Chapter 6).

Systemic transformation also requires the consideration of interlinkages, synergies and trade-offs within and across policy domains. Resource use and waste generation are strongly affected by macroeconomic developments and by policies that do not directly address them, including environmental and climate policies. Integrating circular economy goals into the design of EGD policies can create significant potential for synergy and co-benefits. The Renovation Wave for buildings is a good example of this which must be supported by reliable knowledge on solutions that lead to both energy efficiency and the sustainable and circular use of materials.

To some extent, forward-looking information about future material demand and the related environmental and climate impacts is available at the global level, indicating greater demand for most materials. However, such information is largely missing for Europe. Furthermore, policies to transition energy and mobility systems towards sustainability are likely to require large volumes of materials to develop new infrastructure. While this has been analysed for certain (critical) raw materials, less information is available for other materials or for the implementation of the EU's digitalisation agenda.

Analysis has started to integrate the potential benefits of reducing resource use, and circular solutions, into climate change mitigation models. Meanwhile, the potential benefits

and trade-offs of circular-economy solutions for biodiversity and nature and for the zero-pollution ambition are not yet well understood. Given that globally, resource extraction and processing account for more than 90 % of global biodiversity and water stress impacts (IRP, 2019), this link demands much more attention. For example, biobased materials are increasingly being promoted as more sustainable alternatives to fossil-based plastics or building materials with embedded high environmental impacts, and compostable/biodegradable plastics can play a role in reducing plastic pollution from certain products (EEA, 2020b). Yet, the upscaling of biobased materials production also poses potential risks associated with increasing pressures on land, water and biodiversity (EEA, 2018, 2021d). Policy for sustainable products requires evidence about the actual sustainability of biobased materials as against other materials, as well as knowledge on the possible impacts of a large-scale move from non-renewable to biobased materials.

Information concerning the effectiveness of policies to reduce resource use and prevent waste is very sparse, hampering proper implementation. Developing this evidence requires, inter alia, disentangling the effect of policies from the effects of macroeconomic developments and from policies not targeted at resources and waste, as well as a higher granularity of data. The evidence base is much better regarding the effectiveness of policies for improving waste management and increasing recycling, as valuable insights have been gained over the past few years by analysing the policies employed and their outcomes. The recent revision of key waste Directives builds on this knowledge — for example, by defining minimum requirements for producer responsibility schemes with the aim of enhancing their effectiveness. The strengthened mandate for the EEA to assess waste prevention (EU, 2018a), combined with the mandatory evaluation of national waste-prevention programmes and a mandate for the European Commission to propose waste-prevention targets, will improve the evidence base for waste-prevention policies. Similar efforts are required to analyse the effectiveness of policies addressing resource use and its environmental impacts.

Box 4.1 Circular economy in the plastics, textiles and buildings value chains

The plastics and textiles value chains are examples of highly linear and unsustainable value chains. Many plastic products and textiles are based on fossil fuels and designed for a short service life. Complex material designs and the inclusion of substances of concern hamper recycling and lead to leakage into the environment (EEA, 2019e, 2020i, 2020j).

Buildings, on the other hand, are long-lived structures and design choices before and during their construction determine their energy and resource use for many years. More circular options include reducing the embedded impacts of building materials, designs that enable circular, efficient and flexible use, and designs and conditions that make reuse and recycling economically viable (EEA, 2019a).

Making these value chains circular and sustainable requires, inter alia, identification of key sustainability issues and hot spots along the value chains (including where and how much substances of concern enter the value chain); knowledge of options for improvement and system dynamics; impacts on the environment and climate; opportunities and challenges created by different solutions; the roles of different actors in changing the system, including cooperation between public and private actors; and the effectiveness of policies and interactions between different systems. Finally, it requires analytical frameworks and data for monitoring change and evaluating change processes and outcomes.

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5
Human health and the environment

Is Europe protecting the health and well-being of citizens from environmental risks?

Europe has successfully reduced some of the environmental risks to its citizens' health and well-being. Over the last 20 years, there have been reductions in emissions of the main air pollutants and in the levels of well-known persistent organic pollutants in the environment. Health benefits from the restrictions of hazardous substances under the REACH Regulation amounted to more than EUR 2.1 billion annually in the period 2010-2020 (ECHA, 2021). However, improvements in the emissions of most air pollutants slowed after 2010 and the volumes of most chemicals of concern emitted into the environment, including many persistent ones, are not regularly monitored.

The quality of Europe's drinking and bathing water is generally high and has improved in recent years. In addition, concentrations of the main air pollutants and their related impacts on human health have declined. For example, it is estimated that premature deaths caused by fine particulate matter ($PM_{2.5}$) declined by 13 % in the period 2009-2018, while premature deaths due to NO_2 halved (EEA, 2020a).

However, air quality continues to be of concern. In 2018, around 34 % of the EU's city dwellers were exposed to pollutant concentrations that exceeded at least one of the EU's air-quality standards and 99 % to levels above the WHO's air-quality guidance values (EEA, 2020a). This has been driven by transport emissions, among other factors, with transport also the main cause of environmental noise: 20 % of the EU's population live in areas where traffic noise levels are considered harmful to health, with little improvement since 2012. At the same time, the preservation of quiet areas (areas of good environmental acoustic quality) is lagging behind.

Robust data is lacking on the exposure to and toxicity of chemicals of concern. Therefore, risks to health are not well understood. For example, concerns are growing around the accumulation of mixtures of chemicals, exposure to persistent chemicals, chemicals with endocrine-disrupting properties, and chemicals that are toxic to the neurological and immune systems, potentially impairing children's development.

Moreover, socio-economically disadvantaged groups tend to live in areas with low environmental quality which can lead to social health disparities. Some evidence suggests that air pollution can increase human susceptibility to COVID-19 (EEA, 2020e), although further research is required before a robust assertion can be made.

The outlook for 2030 as regards reducing environmental risks to health and well-being is uncertain. Existing policies are expected to further reduce air pollution (EC, 2021j). The number of people exposed to traffic-noise levels that are harmful to health is expected to rise, although the COVID-19 pandemic has increased the level of uncertainty regarding estimates. Continued emissions, the accumulation of pollutants in the environment, and exposure to complex mixtures of chemicals are likely to increase impacts on human health. However, recently adopted policies, such as the Chemicals Strategy for Sustainability and the EGD's zero-pollution ambition, have the potential to change this outlook.

'The COVID-19 crisis has amplified the urgency of addressing societal challenges together with strong and concerted action on climate and other environmental crises.' (OECD, 2021)

What are Europe's ambitions for human health and the environment?

The EGD and the 8th EAP proposal introduce the longer-term ambition for zero pollution and a toxic-free environment, with the aim of protecting Europe's ecosystems and its citizens' health. The EU Action Plan Towards Zero Pollution for Air, Water and Soil (EC, 2021c) aims to prevent, minimise and remediate pollution from air, marine and freshwater, soil, and consumer products. It defines a set of EU-level pollution reduction targets to be met by 2030. It integrates existing measures and includes many initiatives that address the persistent implementation gap, and aims to improve the existing legislative framework, including the Industrial Emissions Directive. Monitoring will be strengthened by setting up the Zero Pollution Monitoring and Outlook Framework, complemented with a new European Environment and Health Atlas to be developed by the EEA.

In addition to increasing the ambitions concerning well-known pollutants and sources, the goal of the Action Plan is to address emerging pollutants, such as pharmaceutical residues, persistent and mobile chemicals, pesticides, and micro-plastics, as well as important pollution sources not yet sufficiently addressed such as agriculture and households. It acknowledges the persistent health impacts of air pollution in Europe and aims to bring air-quality standards closer to the guidelines recommended by the World Health Organization. It also provides for measures to reduce noise pollution, and to fill the current gap concerning the protection of Europe's soils from contamination.

The Chemicals Strategy for Sustainability (EC, 2020g) is a key element of the zero-pollution ambition and responds to many of the shortcomings identified in the current legislative framework on chemicals. It aims for fundamental change in the production and consumption of chemicals in Europe by fostering an industrial transition to producing and using chemicals that are safe- and sustainable-by-design, and banning the most harmful chemicals for use in consumer products.

Policy ambitions increasingly recognise the value of the environment for people's physical and mental well-being. As the share of the population living in urban areas continues to rise, green spaces are being lost. The EU Biodiversity Strategy for 2030 aims to reverse this trend by promoting the integration of green infrastructure and nature-based solutions into urban planning and development. It will establish an EU Urban Greening Platform, in coordination with the European Covenant of Mayors, to help mobilise funding and capacity building. There is also a stronger focus on human health in the new EU Adaptation Strategy, including by establishing the European Climate and Health Observatory (Chapter 3).

How do current policy developments respond to the need for systemic transformation?

SOER 2020 identified the need for a stronger framework integrating environment and health in which risks to health are managed by considering hazard, exposure and vulnerability, and supported by a stronger knowledge base (EEA, 2019f). At the strategy level, policy developments, such as the 8th EAP proposal, have recognised that protecting the well-being of present and future generations depends on a healthy environment and thriving ecosystems which provide a safe operating space for economies (EC, 2020q). The EU Biodiversity Strategy for 2030 and the Farm to Fork Strategy also integrate health and well-being in their objectives.

Policy developments show a higher level of ambition to protect European citizens from adverse health impacts due to environmental stressors, particularly chemical pollution. However, while actions regarding air pollution are intended to be strengthened by bringing protection standards in line with WHO health recommendations, and a new target has been introduced to halve the use and risk of pesticides, overall quantitative goals and targets have not been defined for chemical pollution more broadly.

The Zero Pollution Action Plan recognises and aims to reduce inequalities in citizens' exposure to pollution and access to green spaces. The objective is to set up a register identifying trends, disparities and inequalities across EU regions. Europe's Beating Cancer Plan will also interact with the Zero Pollution Action Plan to boost actions addressing environmental determinants of cancer (EC, 2021a). However, an overarching framework able to integrate policy approaches across the environment and health domains and consider dimensions of environmental quality as well as social factors, such as economic circumstances, behaviours and demographics, is still lacking.

Systemic transformation requires addressing the underlying drivers of environmental stressors to health and well-being. Agriculture, domestic heating, energy supply, industry, and transport are the main drivers of poor air quality. Climate and energy policies have significant potential synergies with reducing air pollution (EC, 2021j) (Chapter 3). The Farm to Fork Strategy aims to increase the sustainability of the livestock sector which is the main source of ammonia emissions. However, progress will depend on the revision of the Industrial Emissions Directive (EU, 2010b), integration into national air-pollution control programmes and on national measures implemented under the CAP. The decarbonisation of domestic heating is addressed in the revision of several existing climate- and energy-related Directives and Regulations and in a Renovation Wave for Europe (EC, 2020j). In this latter initiative, high health and environmental standards are key principles to be followed during renovation, although it would be beneficial to ensure that the aim of reducing air pollution (including indoor air pollution) assumes greater prominence.

Transport contributes to multiple health impacts, particularly air pollution and noise. The Sustainable and Smart Mobility Strategy (EC, 2020l) acknowledges that past efforts and policy measures have yet to adequately address the costs of transport to society. It aims for zero-emission mobility and takes a wider systems perspective aiming to harness synergies to reduce GHG emissions, air pollutants and noise. It emphasises that it is crucial that mobility is available and affordable for all and that a just transition is necessary for sustainable mobility.

A broader systems perspective is also taken in the Chemicals Strategy for Sustainability. This sets out a long-term vision which aims to guide actions across policy areas and by different stakeholders. The new paradigm of a toxic-free hierarchy makes the principle of avoidance the priority, through safe- and sustainable-by-design, before minimising exposure and remediation. The need to improve on past performance is reflected in actions to enhance implementation. This includes stronger risk-assessment strategies for chemical mixtures and strengthening requirements on chemicals with environmental and human health toxicities previously not addressed or only to a limited extent, such as persistency, mobility and bioaccumulation properties. The strategy also addresses key enablers of systemic transformation with actions regarding investments, finance, innovation and skills. It addresses the global dimension with Europe aiming to set standards that apply across global value chains and set the example for sound management of chemicals globally. However, quantitative goals and targets are lacking and the strategy acknowledges that the transition to safe and sustainable chemicals needs stronger policy and financial support and a concerted effort from all stakeholders (EEA, 2020c).

Systemic transformation also requires consideration of interlinkages, synergies and trade-offs within and across policy domains. Policy developments are taking a more integrated approach. For example, the objective of the Zero Pollution Action Plan is to integrate separate policies on pollution while the Chemicals Strategy for Sustainability is aiming for non-toxic material cycles that use waste as a resource and contribute to a clean, circular economy.

'... safe and sustainable chemicals will be vital to offer new solutions and support both the green and digital transitions of our economy and society.' (EC, 2020g)

The EGD emphasises the need for a just transition. SOER 2020 highlighted the pronounced regional differences in social vulnerability and exposure to environmental health hazards across Europe. From a health and well-being perspective, a just transition is broader than economic prosperity and a focus on developing employment opportunities and skills. It also means addressing inequalities in vulnerabilities, exposures and impacts which requires better coherence between social and environmental policies on health, climate change, energy poverty, air and noise pollution and urban design.

In summary, to date, policy developments have aimed to build stronger foundations to reduce environmental risks to health and deliver zero pollution. However, it remains to be seen in the coming years how well the further development of legislative proposals, investments and progress on stronger implementation deliver this ambition. An integrated framework for environment and health is still lacking and the One Health approach, which aims to integrate public health, animal health, plant health and the environment, has potential, including for addressing issues such as antimicrobial resistance. Knowledge will play an important role in achieving policy goals. This is highlighted in the Chemicals Strategy for Sustainability where developing and sharing a comprehensive knowledge base is seen as fundamental to realising objectives within Europe as well as supporting action by other countries to achieve the SDGs.

How can knowledge support action to achieve change?

Europe's actions to protect European citizens' health and well-being are at different stages of development and include a diverse range of ambitions, policies, measures and management actions. Supporting these requires the development, integration and use of different types of knowledge as various environmental stressors interact with each other and with biological factors and social and economic circumstances to determine health and well-being outcomes.

Monitoring that establishes a baseline as well as tracking progress is necessary to inform implementation of the broad range of policies that will contribute to achieving zero pollution. SOER 2020 stated that regular monitoring of emissions and the presence of pollutants in the environment focuses on a few well-known, well-regulated pollutants and legacy substances of very high concern. Mature monitoring systems for air pollution already exist and progress is being made to collect and harmonise noise information and assess noise impacts on health across Europe. However, the current monitoring framework has yet to reflect the wider, progressive policy agenda for zero pollution. Areas requiring more attention include sources, exposure to and health risks from

emerging pollutants, including chemicals, pharmaceuticals and chemicals in (consumer) products, as well as soil contamination, indoor air pollution and how quiet and green areas contribute to citizens' well-being. Europe is investing in advancing air-pollution monitoring by using satellite data and investigating the potential of such data for improving emission inventories or information on air quality. The European Climate and Health Observatory (Chapter 3) is an example of collaboration across different institutions to create knowledge, supporting climate adaptation policies with relevant information and tools. The EGD and the Zero Pollution Action Plan foresee the development of a monitoring and outlook tool that builds on both existing and new data sources and models, with an important role for the EEA. However, as it will not be possible to monitor all sources and substances of concern, monitoring must also be complemented by acting on early warnings.

'There is sufficient evidence available to support policy actions to improve the environment, health and well-being. A lack of knowledge should not be used to justify inaction.' (EEA, 2020e)

One of the key knowledge requirements regarding environment and health relates to the huge amount of synthetic chemicals entering the environment, including exposure citizens and related health impacts — the unknown territory of chemical risks (EEA, 2019f). A comprehensive knowledge base on chemicals is needed to inform policy development and implementation. The Chemicals Strategy for Sustainability includes initiatives to improve both the availability of chemical data and understanding the impacts of chemicals. It also aims to develop alternative risk-governance methods to deal with chemicals and mixtures of chemicals for which there is limited data. Achieving this would be key to strengthening the science-policy interface. Key performance indicators will be developed in collaboration with stakeholders and the use of strategic foresight on chemicals will be enhanced.

The new safe- and sustainable-by-design paradigm requires the development of harmonised methodologies and minimum performance requirements that define the dimensions of both safety and sustainability. Knowledge and experience on how to implement this approach in practice must be developed by multiple actors, including business, education and research, both in Europe and internationally, given that many products are imported into Europe. Activities fostering such knowledge may include developing and validating guidance materials, cross-disciplinary exchanges of good practice, and establishing pilot projects in key industrial sectors (EEA, 2020c). The strategy will also support further development of human and environmental biomonitoring. The Human Biomonitoring Initiative (HBM4EU) is an example of how new knowledge can be developed through collaborative approaches (Box 5.1).

Many people are exposed to multiple environmental stressors, including air pollution, chemicals, noise, heatwaves and limited access to green spaces. Knowledge of their combined health impacts is necessary to protect the most vulnerable and affected citizens. Consideration of distributional effects plays an important role in the planning of effective measures. A better understanding of the linkages between the environment, social and health dimensions — for example, through the integration of environmental data and data on socio-economic status — would help in designing measures that have the greatest effect on the total burden of disease, and in identifying which groups benefit from mitigation measures, in terms of both health and economic impacts.

'...data and indicators that capture the intersectionality of environmental and social challenges are needed such as more accurate and timely information on how different demographic groups, workers and territories are affected by the environmental degradation.' (OECD, 2021)

Box 5.1 Human biomonitoring — a new way of collaborating on knowledge

HBM4EU is a joint effort by 30 countries, the EEA and the European Commission (www.hbm4eu.eu) to coordinate and advance the human biomonitoring of synthetic chemicals in Europe. The HBM4EU initiative represents a novel collaboration between scientists, chemical-risk assessors and risk managers and policymakers at both the European and national level.

HBM4EU has built bridges between the research and policy worlds to provide a coherent and robust knowledge base for chemical-risk assessment and management and thus deliver benefits to society in terms of enhanced chemical safety. The Initiative is generating evidence of citizens' actual exposure to chemicals, identifying exposure pathways and upstream sources of chemicals, and linking exposure to health outcomes.

Building on the knowledge and networks developed in the HBM4EU project, the Partnership for the Assessment of Risks from Chemicals (PARC) (ANSES, 2020) will take this collaborate approach further. It aims to create a sound knowledge base for risk assessment and risk management in different contexts. It will build new data and innovative methods creating a sound knowledge base for taking regulatory decisions on chemicals.

Knowledge to support the transition to a sustainable mobility system is required across different scales — European, national and local — including how these can best work together to maximise synergies. There is a considerable body of evidence on the positive health effects of active modes of mobility (walking and cycling) and the environmental benefits of public transport, and how these can be fostered in cities. Opportunities for similar change in rural areas are less well understood, and demand and behavioural aspects generally need more attention. Recently, the COVID-19 pandemic has strongly reduced passenger rail travel, the most sustainable mode of travel apart from walking and cycling (EEA, 2021c). Understanding these effects and how to rebuild confidence in public transport will be crucial for the transformation to a sustainable mobility system.

COVID-19 has also provided some insights into the relationship between knowledge and action. It was a novel and visible threat to which society responded with alarm and a sense of urgency. Strong responses were implemented with the prospects of easing them once the risk was under control. In contrast, despite detailed knowledge of the scale of deaths and disease from air pollution, this is not considered in the same way. It has become normalised and does not lead to responses at the scale and speed required to reduce the risks to health.


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6 Sustainability trends, prospects and responses

Is Europe making progress towards sustainability?

Despite some success in reducing environment and climate pressures, Europe's overall progress to overcome the four interrelated crises — biodiversity loss, climate change, resource overconsumption and pollution — is both slow and insufficient. Environmental pressures associated with production and consumption remain high. Beyond widely acknowledged pressures on climate and biodiversity, a recent analysis suggests that Europe is also significantly transgressing its safe operating space for issues such as nitrogen and phosphorus losses, and land-system change (EEA and FOEN, 2020). European consumption of resources is still higher than in many other global regions and contributes significantly to environmental harm outside Europe (Sala et al., 2019; EEA, 2019f).

Europe must transform its economy and society to protect ecosystems, deliver carbon neutrality and achieve a circular economy, while ensuring prosperity and social justice. This requires rethinking production and consumption patterns and ways of living. Several core societal systems have been identified that drive environment and climate pressures and related health impacts, particularly energy, mobility and food. Recently, some signs of change have been observed across these systems, such as an increasing share of renewable energy (Chapter 3), the expansion of electric mobility, and developments in precision agriculture. However, these mainly incremental changes do not match the scale and urgency demanded by long-term environmental and sustainability goals, and the root causes of unsustainability and associated social practices and lifestyles prevail. For example, while a large-scale uptake of electric cars is now emerging, a truly systemic shift towards a fundamentally different mobility system (e.g. modal shifts away from car ownership, changing infrastructures and pricing, smart mobility, sustainable tourism) is still far from being realised. Likewise, there is no indication that the environmental harm caused in regions outside Europe by European lifestyle choices is declining.

Progress towards sustainability in Europe is influenced by multiple drivers of change at different scales, such as accelerating technological change, the increasing scarcity of and competition for resources, and diversifying values, lifestyles and governance approaches (EEA, 2020d). Many global megatrends — such as global population growth or power shifts in the global economy — continue to intensify persistent environmental problems, while emerging trends such as digitalisation and artificial intelligence are becoming increasingly influential in shaping sustainability outcomes. Ultimately, Europe's persistent environmental and sustainability challenges are inextricably linked to economic growth, lifestyles, jobs and earnings. This makes the transformation of core societal systems complex and highly uncertain. The co-evolution of system elements — technologies, regulations, infrastructures, behaviours, etc., as well as vested interests — create lock-ins and barriers to change. Links between production-consumption systems create additional challenges, such as the risk of burden shifting when addressing a problem in one system in isolation.

Looking ahead, the prospects for achieving Europe's sustainability goals are uncertain. Systemic transformations can be achieved but are complex and cannot be simply planned and implemented. Yet, public policies and institutions are essential to catalyse and steer such changes. Beyond setting environment and climate targets, they are needed to promote system innovation, correct market failures, reorient financial flows, help cities innovate and network, and ensure a just transition. Europe must find ways to leverage the power of citizens, communities and businesses to find new ways of producing and consuming and trigger new ways of thinking and living.

What are Europe's ambitions for sustainability?

The EGD and the 8th EAP proposal are the most important strategic policy frameworks setting out comprehensive European sustainability ambitions. They are complementary but share the same long-term vision and environmental priority objectives (Chapter 1), with the goal to guide and coordinate action. In addition, the European Commission has signalled commitment to implementing the UN Agenda 2030 and its 17 SDGs through a new 'whole of government approach' which comprises a range of strands, such as 'applying deeply transformative policies', 'EU engagement in the world' and 'policy coherence for sustainable development'.

The EGD, the 8th EAP, plus the commitment to the SDGs, reflect a much more holistic ambition around sustainability and societal transformations than previous policy frameworks. Together, the frameworks articulate a clear time horizon with the need for immediate action and progress towards 2030, which is considered a stepping stone on Europe's transformation pathway towards fully achieving sustainability by 2050. Underlying this long-term perspective is the ambition to fundamentally transform the European economy for a sustainable future. This is underpinned by a range of headline strategic goals and visions, such as climate neutrality by 2050 (EGD), a circular economy, a regenerative growth model, and living within planetary boundaries.

'The 8th EAP has the long-term priority objective for 2050 that citizens live well, within the planetary boundaries in a regenerative economy where nothing is wasted, no net emissions of greenhouse gases are produced and economic growth is decoupled from resource use and environmental degradation.' (EC, 2020q)

To guide and operationalise action, the frameworks describe several key dimensions that require attention. For example, the need for far-reaching systemic transformations of key societal systems (especially energy, mobility, food) as well as reducing Europe's consumption footprint. In this context, mainstreaming sustainability into all EU policies is now a priority objective of the EGD. That means, for example, that sectors and subsectors — such as transport, aviation, textiles, construction, plastics, gas, power, etc. — are now explicitly part of the systemic transformation ambition and agenda. The 8th EAP proposal lists some enablers to achieve this, such as phasing out harmful subsidies, mobilising sustainable investments, making full use of nature-based solutions, and harnessing the potential of the digital transformation.

The 8th EAP proposal also builds on the EGD's mainstreaming sustainability goal with the ambition of 'strengthening the integrated approach to policy development and implementation, notably by mainstreaming sustainability in all relevant initiatives and projects at national and EU level'. The proposal aims to improve integration by focusing on exploiting 'the synergies between economic, environmental and social objectives, while paying careful attention to potential trade-offs and to the needs of vulnerable groups'.

To track Europe's progress towards systemic transformations, the EGD and the 8th EAP proposal aim to measure progress against their objectives in the wider context of sustainability, well-being and resilience. This should be achieved through a combination of complementary initiatives, such as Eurostat's SDG monitoring, monitoring tools under specific EGD initiatives (such as zero pollution and the Circular Economy Action Plan), the European Commission's Strategic Foresight Report, tools under the European Semester and the Environmental Implementation Review, as well as a new 8th EAP monitoring mechanism.

Beyond Europe's borders, the frameworks also set out an ambition for Europe to provide global leadership towards sustainability. There is recognition in the EGD that the current existential crises (climate, biodiversity, resources, pollution) require strong global responses towards systemic transformations while simultaneously addressing social justice concerns. In that context, full commitment to existing multilateral agreements (such as the Paris Agreement), stepping up bilateral engagements with partner countries, as well as support to its immediate neighbours are mentioned as some of the actions Europe envisages for the coming years.

How do current policy developments respond to the need for systemic transformation?

The arguably strong and holistic sustainability objectives of the EGD and 8th EAP proposal are mainly at the level of visions and aspirations. To be actionable, the broad objectives must be translated into a set of tangible and measurable targets and policy instruments at clearly defined geographical scales, with clear time horizons and responsibilities for implementation and cross-coordination. Many open questions remain in this respect, such as how 'living well, within planetary boundaries' could be defined, measured and operationalised, or what is meant by a 'regenerative growth model that gives back to the planet more than it takes'.

The 8th EAP proposal calls for an integrated approach to policy development and implementation. The proposal has the ambition of mainstreaming sustainability criteria into all relevant strategies, legislative and non-legislative initiatives, programmes, investments and projects not only at the EU level

but also to foster sustainability mainstreaming at national, regional and local levels. However, such policy coherence across different geographical scales requires well-functioning multilevel governance mechanisms between actors at the EU, national governments, and regional and local authorities, both from the public and private sectors. In practice, many barriers and obstacles remain, such as diverging interests and priorities across different parts of Europe, or vested interests wanting to preserve unsustainable structures and practices.

The holistic nature of the sustainability aspirations of both the EGD and 8th EAP proposal also calls for full coherence of policies and actions across many different domains. In the past, isolated, piecemeal approaches have proved ineffective. Chapters 2 to 5 highlight the need to understand and better address interlinkages, synergies, trade-offs and co-benefits across many areas. This is a major challenge: for example, priorities linked to protecting natural capital and managing agriculture are still poorly aligned; far-reaching measures for energy and climate mitigation are being challenged by negative effects on biodiversity or producing socially unfair outcomes; and an integrated framework for environment and health is still lacking. Overall, the risk of siloed policy implementation remains with action poorly aligned across different areas.

The EGD and the 8th EAP proposal emphasise the need to engage all areas of policy in enabling fundamental structural transformation of the societal systems driving sustainability challenges. This focus on the policy mix is needed to trigger, guide and manage the impacts of socio-economic change. It marks a clear shift from the neoclassical framing of sustainable development that emerged in the 1980s and 1990s, which contended that sustainability could be achieved most effectively and efficiently by using economic instruments to correct price incentives. In practice, efforts to 'get the prices right' have made limited progress. Facing resistance from businesses and consumers, as well as concerns about driving production overseas and disproportionate impacts on low-income groups, governments have been reluctant to introduce taxes or similar instruments at sufficiently stringent levels. There has been little progress in shifting taxes from labour to resources or environmental pressures. Indeed, environmental tax revenues in the EU fell between 2002 and 2019 from 6.6 % to 5.9 % of total tax revenues (Eurostat, 2021b).

Economic instruments such as environmental taxes certainly have an essential role to play in delivering on the ambitions of the EGD and 8th EAP proposal. They will need to be used more effectively and forcefully to redirect public investment and shape economic activity and consumption choices. Yet the EGD rightly situates these tools within a broader set of policies aimed at enabling systemic change, from promoting innovation and experimentation, through facilitating the diffusion of sustainable modes of producing and consuming, phasing out harmful economic activities and ensuring that structural economic change produces beneficial and fair outcomes.

Innovation and experimentation to reduce environmental pressures in key societal systems will also have to go beyond a focus on economic and fiscal structures, and technical solutions. Social innovation, behavioural changes, as well as new business models are needed across society to stimulate the emergence and spread of new ways of thinking, living and consuming. This requires the engagement of a diverse range of actors, including policymakers, researchers, businesses, investors, regulators and citizens. Several promising initiatives at the EU level are underway, like partnership approaches aimed at supporting implementation under policy frameworks, such as the Biodiversity Strategy (Chapter 2), the Climate Pact (Chapter 3) and chemical risk assessment (Chapter 5). There is also the partnership approach of the Horizon Europe programme, which aims to streamline public-private partnerships towards achieving Europe's sustainability goals. The New European Bauhaus is meant to act as an incubator for experimentation and innovation in order to reshape thinking, behaviours, and markets around new ways of sustainable living and building (EC, 2021i). However, these are small initiatives compared to the challenge at hand, and their successful implementation remains to be seen. In general, European and national monitoring of social innovations and new business models remains difficult and underdeveloped.

How can knowledge support action to achieve change?

Chapters 2 to 5 identify the need for better knowledge and understanding around key environmental and climate problems, especially for solutions and potential responses. However, this will need to be complemented with new types of knowledge. Achieving Europe's sustainability visions and ambitions requires alignment across diverse policy mixes, including fiscal, sectoral, industrial, welfare, education, employment, regional, innovation and research policies. Equally important, such a transformation will critically depend on broader societal engagement, including the private sector, civil society and citizens. Therefore, knowledge requirements to support this transformation encompass the environmental, economic, social, behavioural and governance aspects of sustainability. Some initial reflections are set out below on a few selected topics, including systems and systemic challenges, foresight, macroeconomic insights, and measurement and assessment of progress towards sustainability.

An integrated approach to policy development and implementation requires better knowledge on the functions and effectiveness of different policies and instruments and how they can be used in conjunction to maximise potential synergies while avoiding problem-shifting from one policy area to another. This is of particular importance given the need to simultaneously transform key societal systems. There must be a better understanding of the dynamics within these systems, feedback

loops and interactions across systems, and the cumulative effects of transitions in terms of socio-economic and environmental outcomes. Although the current knowledge base on such systemic challenges is growing quickly it is still relatively partial.

'President von der Leyen has mandated Vice-President Šefčovič to lead the Commission's efforts to embed strategic foresight into its work by ensuring that the Commission makes full use of the knowledge, information, and research to future-proof our policies, as well as strengthen our culture of preparedness and evidence-based anticipatory policy-making.' (EC, 2021k)

An illustrative example of well-understood cross-system dynamics is the use of biomass and biofuels to reduce GHG emissions in the energy system against land-use demands, on the one hand, and food security, biodiversity and ecosystem health considerations, on the other hand (Chapter 3). Likewise, risks associated with policy choices and how to manage or potentially mitigate them must be better understood. For example, a socially fair and just transition that avoids disproportionate economic and social impacts on certain groups in society, as well as on geographical regions in Europe, will need to be underpinned with detailed and spatially disaggregated information on social vulnerabilities, local economic impacts, and options for facilitating the education and retraining of those workers affected by phase-out measures.

In the context of highly complex, non-linear and uncertain processes, such as systemic transformations of key societal systems, foresight can be a useful tool. Foresight — the discipline used to explore and anticipate the future — helps build and use collective intelligence in a structured and systematic way. Plausible futures and associated opportunities and risks can be explored through vision and pathway exercises, which can also involve identifying trends and emerging issues. Recently, the European Commission has embedded strategic foresight more centrally in EU policymaking, aiming to 'improve policy design, develop future-proof strategies and ensure that short-term actions are coherent with long-term objectives' (EC, 2021k). Annual foresight reports, the first of which focused around resilience as a compass for EU policies (EC, 2020a), and the annual EU Environmental Foresight System (FORENV) cycle (EC, 2021l) have been initiated. Additional action-oriented outcomes, such as an EU-wide foresight network and the European Commission Competence Centre on Foresight, aim to operationalise these foresight ambitions. The full engagement of decision-makers with this strategic foresight agenda will be crucial to ensure that the different foresight actions reap the full benefits of participatory processes. For example, foresight could be used to explore how Europe's broad sustainability visions ('living well within planetary boundaries' and 'regenerative economy') can be understood and operationalised. Likewise, it should also be employed more systematically for other scales of decision-making, such as at the national and local levels.

There are major economic and social barriers to transforming Europe's systems of production and consumption. Governments urgently need to upscale investments in systemic transformations, especially for infrastructures (e.g. transport systems, electricity grids, housing retrofitting), innovations, skills, and natural capital. The EGD investment plan and subsequent initiatives (EU taxonomy regulation, etc.) are a good starting point, but many issues must be better understood. A critical question is how governments, in partnership with the private sector, can finance the massive investments needed while, at the same time, financing public debt and maintaining the welfare state (EEA, 2020l). At the macroeconomic scale, there are questions and uncertainties about the aggregate impacts of transforming Europe's core socio-economic systems in ways that enable them to operate within environmental limits. For example, what will these transformations mean for gross domestic product and employment across the economy as a whole? Creating an economic model that sustains growth while preserving and restoring natural capital will require unprecedented improvements in environmental efficiency, which might not be technically feasible. 'Degrowth' is sometimes proposed as a better way to achieve sustainable development but it would also create major challenges, for example in terms of how to finance the welfare state and needed investments in economic transformation. Indeed, the fact that GDP growth has been harmful for the environment in recent decades does not necessarily mean that degrowth will be good for the environment (EEA, 2021b). These are fundamental questions that need to be explored.

Another crucial area for knowledge to support action relates to measuring and monitoring progress. In relation to the EGD and 8th EAP proposal objectives, the European Commission intends to achieve this through a range of monitoring tools, mainly dashboards based on established quantitative indicators. It is also foreseen that these will also contribute to the EU's overall efforts to measure progress towards sustainability, well-being and resilience to inform Europe is on track to achieve systemic transformation. Transformational change towards sustainability, well-being and resilience is complex, multidimensional, co-evolutionary and non-linear. Established indicators alone — even when combined into composite 'super aggregate' indicators, accounting frameworks or sophisticated dashboards to ensure complementarity and coherence — will fall short in capturing the multidimensional outcomes and dynamics inherent in the transformation processes they are attempting to monitor. Therefore, these indicator-based approaches will need to be complemented with systemic knowledge and quantitative and qualitative sustainability assessments. In addition, the predominant approach to knowledge development, uptake and use must be improved through more participatory, interdisciplinary and transdisciplinary approaches. Ultimately, there is a question about whether a transformation of the knowledge system is needed.

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7 Strengthening knowledge for action

Recent years have seen a change in understanding of environmental challenges which has informed European policy and knowledge responses to varying degrees. The concept of paradigm change was popularised by Thomas Kuhn in The Structure of Scientific Revolutions (Kuhn, 1962). This provides a useful framework with which to illustrate these changes in understanding, policy and knowledge and to explore the implications of strengthening knowledge for action. In essence, progress takes place within a dominant paradigm, then serious anomalies occur leading to a crisis which is resolved through a change in world view and the adoption of a new paradigm (Figure 7.1).

A fundamental change in understanding of environmental challenges

SOER 2020 highlighted how a fundamental change in understanding of environmental challenges has evolved from a focus on specific issues to a more systemic perspective and the recognition that environmental issues are inseparable from broader sustainability issues (Table 7.1). This change in understanding is now well established and reflects a paradigm change from environment to sustainability.

A fundamental change in policy

Applying this framework to policy, it can be stated that the dominant paradigm has been in place since the 1970s. A policy paradigm sets out the framework of ideas and standards that specify the nature of the problems addressed as well as the policy goals and the types of instruments that can be used to reach them (Hall, 1993). This has evolved over time as, in the 1970s, European environmental policy comprised mainly regulatory interventions focusing on specific issues. It was based on the premise that targeted environmental legislation could lead to improvements in a range of environmental issues with relatively direct, cause-effect relationships.

Table 7.1 Changing understanding of environmental challenges and the evolution of approaches to policy and assessment

Characterisation of key challenges	Key features	In policy since	Policy approaches (examples)	Assessment approaches and tools (examples)
Specific	Linear cause-effect, point source, local	1970s	Targeted policies and single-use instruments	Data sets, indicators
Diffuse	Cumulative causes, multiple sources	1990s	Policy integration, market-based instruments, raising public awareness	DPSIR, data sets, indicators, environmental accounts, outlooks
Systemic	Systemic causes, interlinked sources	2010s	Policy coherence, systemic focus (e.g. mobility system), long-term and multidimensional goals (e.g. SDGs)	DPSIR, STEEPV, data sets, indicators, accounts, practice-based knowledge, systems assessment, stakeholder participation, foresight
Sustainability	As above; Volatile, uncertain, complex, ambiguous (VUCA); Urgent and large scale	1990s and in focus today	As above; Open governance, participative, innovation, experimentation	As above; Post-normal science, response orientated, collaborative

Note: DPSIR = drivers, pressures, state, impacts and responses; STEEPV = social, technological, economic, environmental, political and values.

However, by the 1980s, it had become increasingly clear that such targeted policies were insufficient to address environmental problems resulting from diffuse pressures from various sources. Policy responses included the integration of environmental concerns into sectoral policies, an increasing use of non-legislative instruments, and greater coordination with stakeholders. This led to mixed results as environmental considerations were insufficiently integrated into sectoral policies or policy instruments failed to deliver outcomes that matched the scale and urgency of the challenges. Since the late 1990s, more attention has been paid to better understanding the interlinkages between the environment, economy and society. Policy responses have included a greater focus on sustainability and coherence among EU policies.

However, despite the successes of European environmental governance, problems persist and the outlook for Europe's environment in the coming decades is discouraging (EEA, 2019f). This anomaly reflects both the systemic nature of environmental challenges and policy responses that have largely resulted in incremental improvements and marginal efficiency gains. Kuhn highlights how a paradigm can make it difficult to identify important problems because they cannot be stated in terms of the conceptual and instrumental tools of the paradigm.

In the last decade, major global scientific reports from the IPCC, IPBES, International Resource Panel (IRP) and UNEP have spelt out the gravity of multiple crises — climate, biodiversity loss, resource overconsumption and pollution — and that current trajectories are unsustainable. Kuhn characterised a crisis in science as a period where there is debate about fundamentals, competing concepts, development of new ideas and methods, and finally a new theory. A crisis results in a different understanding and new ways of seeing problems and solutions — a change in world view. In line with Kuhn's pre-paradigm phase, this change in world view saw a proliferation of new concepts in policy linking the environment and the economy — for example, green, low-carbon, circular, blue and bio economies and natural capital as well as the transitions agenda. SOER 2020 emphasised that these crises are interconnected and that policy responses, such as focusing on improving efficiencies and decoupling, fall short of the systemic solutions needed. In terms of the policy landscape, the response culminated in a change in the policy paradigm to one which puts sustainability goals and the need for transformative change to address systemic challenges at the heart of European policy, as reflected in the EGD and 8th EAP proposal. The overview of current policy ambitions and objectives in preceding chapters and an initial analysis of how they have responded to the need for systemic transformation provide a baseline against which to assess progress in the coming years.

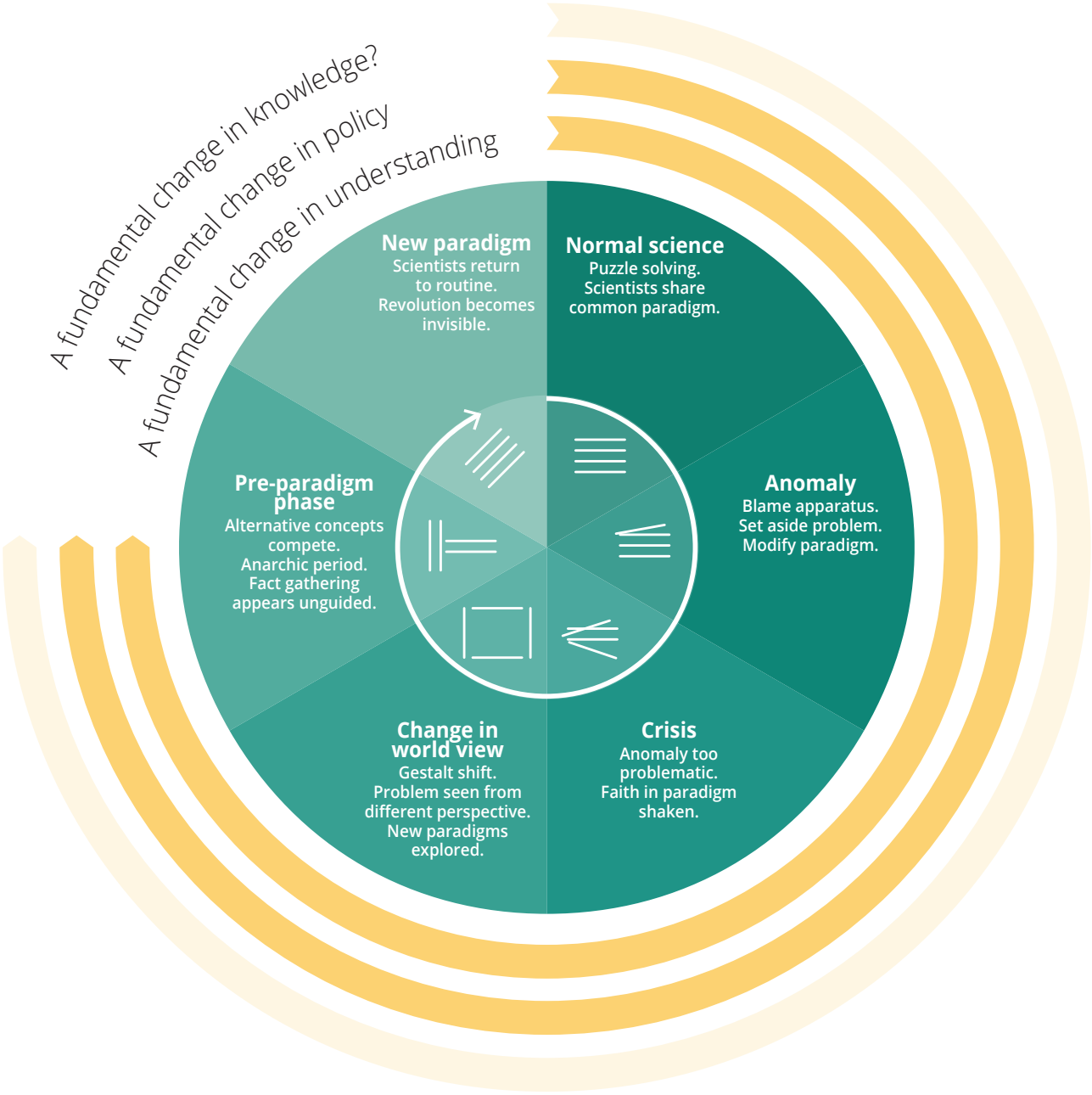
A fundamental change in knowledge?

Turning to the knowledge base that supports policy, the dominant paradigm can also be said to have been in place since the 1970s. It has also evolved over time with knowledge development primarily based on environmental monitoring, data, indicators and assessments linked to the implementation of legislation, as well as scientific research and citizen science initiatives. In parallel with policy developments, the change in world view and understanding of sustainability challenges has also been reflected to some extent in the type of knowledge that has been developed and approaches to doing so. The preceding chapters identify such knowledge needs which include addressing data gaps, improving monitoring, indicator development and the need for monitoring frameworks and measurements of progress that capture sustainability, well-being and resilience. In addition, a wide range of specific knowledge needs have been specified related to existing societal systems, lock-ins and barriers, enablers of change, along with the knowledge needed to develop pathways of transformative change and inform and support effective responses.

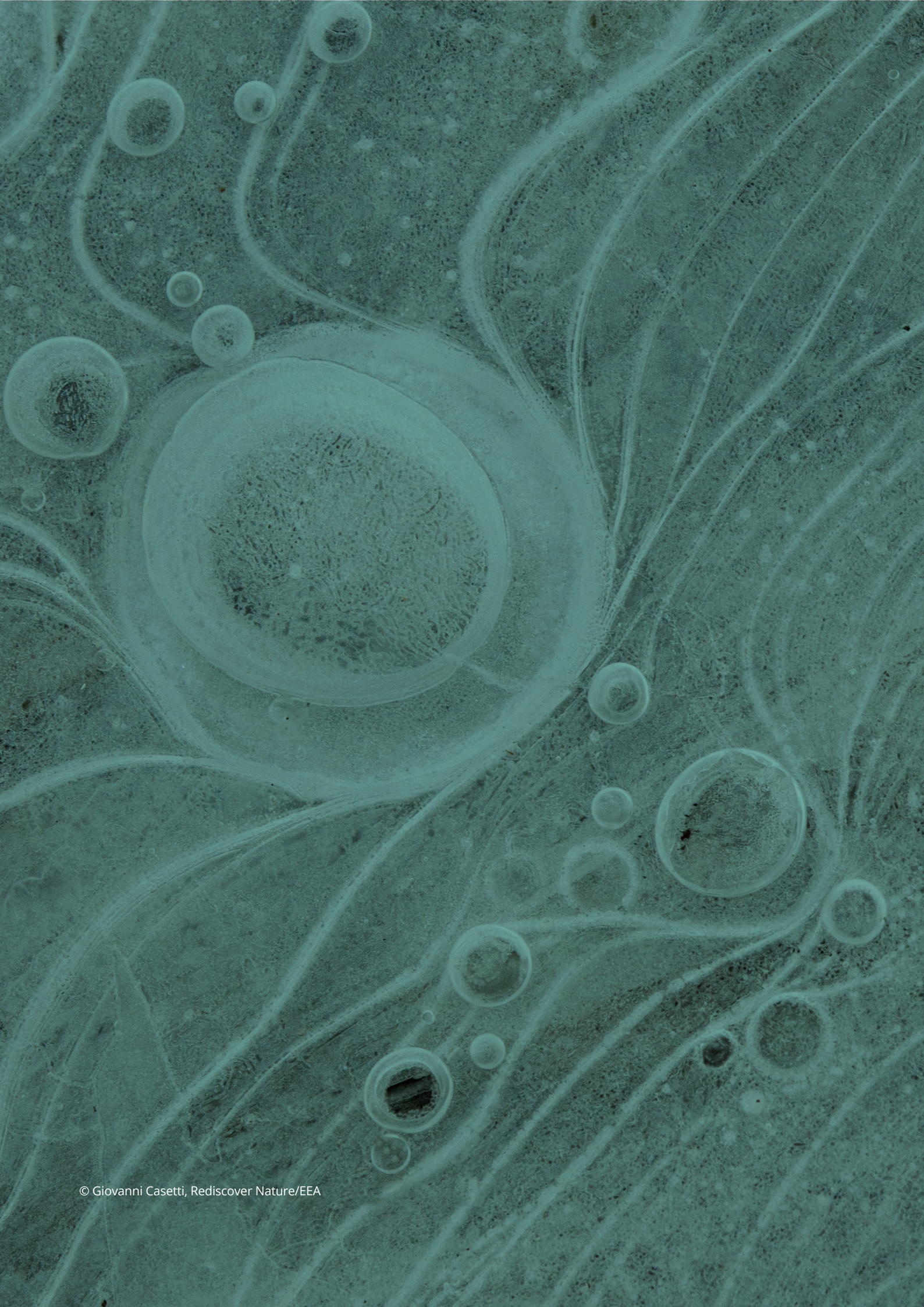
However, Kuhn highlights that since in reality it is challenging to both see and date scientific revolutions, they tend to be viewed not as revolutions but as additions to scientific knowledge. This may reflect the fact that while a new paradigm must be seen to resolve some outstanding and generally recognised problems, it must also preserve a relatively large part of the problem-solving activity as its predecessors. This results in a large but incomplete overlap between problems that can be solved by the old and new paradigms.

Improving the knowledge base and science-policy interface was part of the enabling framework of the 7th EAP, with a similar objective now appearing in the 8th EAP proposal. Therefore, current monitoring, data, indicators and assessments and approaches to developing knowledge are still needed although, in relation to sustainability challenges and supporting transformational change, they have important limitations and blind spots. Looking ahead, the context for addressing systemic environmental challenges of unprecedented scale and urgency is one of volatility, uncertainty, complexity and ambiguity — a VUCA world. The term post-normal science describes a situation where facts are uncertain, values are in dispute, stakes are high, and decisions are urgent, and where an approach which seeks to manage uncertainties rather than pursue certainty may be more appropriate. This raises the question of whether strengthening knowledge for action can be achieved by addressing existing knowledge gaps, complementing them with additional knowledge and more participatory, interdisciplinary and transdisciplinary approaches or is a new paradigm needed? A paradigm change to knowledge for systemic transformation would complement those observed in understanding and policy in recent years.

Figure 7.1 **The structure of scientific revolutions**



Source: EEA, adapted from Kuhn (1962).



8
A knowledge system for systemic transformation

Knowledge as an enabler of systemic transformation

Sustainability challenges and increasingly systemic and transformative policy responses, coupled with the desire to promote and navigate transition processes across society, create substantially new opportunities and demands for knowledge (EEA, 2019f). Responses include addressing knowledge gaps and the use of more participatory approaches, but will these really deliver what is needed or is a new paradigm of knowledge for systemic transformation what is required?

Knowledge needs to be trusted, actionable and integrated. While the current knowledge system has established approaches addressing the quality and credibility of knowledge, ways to ensure knowledge is actionable are less well developed. Actionable knowledge needs to be relevant, understandable, link to sustainability challenges and policy ambitions, and incorporate an understanding of political decision-making. This means going beyond producing knowledge for experts to generating wisdom on how to act. Knowledge also needs to be integrated, spanning policy domains, disciplines, types of knowledge and different ways of framing problems and possible solutions.

In the 8th EAP proposal, knowledge is identified as a key enabler for achieving sustainability objectives. The aim is that policy and action are based on the best-available scientific knowledge and that the environmental knowledge base and its uptake are strengthened by research, innovation, education, fostering green skills and further building up environmental and ecosystem accounting (EC, 2020q). As part of its goal to mainstream sustainability in all EU policies, the EGD aims to mobilise research, foster innovation and activate education and training to support the transition (EC, 2019).

The Horizon Europe Strategic Plan (2021-2024), which was developed through a co-design approach, highlights how achieving the objectives of the green and digital transitions will only be possible through collective action at a systems level, in line with the SDGs, with more ambitious investments in knowledge and its diffusion (EC, 2021f). As well as identifying key areas for knowledge development, Horizon Europe also has a strong focus on building capacities and partnerships in European policy ambitions. The Horizon Europe solution-orientated missions and European partnerships aim to promote societal, ecological and economic transformations by involving, collaborating with and building consensus among citizens and practitioners on research and innovation roadmaps and priorities (EC, 2021f). The new European Research Area states that the engagement of citizens, local communities and civil society will be at the core of achieving greater societal impact and greater trust in science (EC, 2020e).

Policy developments have clearly recognised the role that knowledge will play in systemic transformation. However, it is not enough just to focus on developing the knowledge base. SOER 2020 highlighted how generating, sharing and using relevant knowledge to the full will require fundamental changes in the knowledge system linking science with policy and action.

What is a knowledge system?

Knowledge systems include the practices, routines, structures, mindsets, values and cultures affecting what and how knowledge is produced and by whom and how it is communicated (Fazey et al., 2020). Key actors include universities, research institutes, and non-government and government organisations. A critical question is whether current knowledge systems are adequate to address the environmental and societal challenges and support transition processes. This question also needs to be considered in the context of wider societal developments. More people are questioning the value of established institutions, public policy, expertise and scientific evidence in ways that undermine confidence in such structures and the value of the knowledge supporting them (ESPAS, 2019).

However, scientific evidence is only one input in the policy process, so use of the term 'evidence-informed policy' rather than 'evidence-based policy' makes it clear that while all evidence is considered, it does not become the sole basis for decision-making. Therefore, scientific advice for policy must be based on the best-available evidence and communicated in a transparent and accountable way that explicitly and honestly assesses uncertainties, ambiguities and tensions (SAPEA, 2019).

The policy system also has a responsibility to consider how it works in terms of accessing and using knowledge and its own role in the knowledge system.

Effective partnerships between scientists, policymakers and those who implement policy decisions help build trust and credibility (SAPEA, 2019). The Joint Research Centre (JRC) has several initiatives that provide relevant insights: for example, the Knowledge Management for Policy initiative (Topp et al., 2018) and the Enlightenment 2.0 research programme that seeks to understand the different drivers that influence political decision-making (Mair et al., 2019). In addition, citizen science can play a role in strengthening trust in public institutions as well as engaging people in knowledge development.

Although current knowledge systems have delivered important benefits and major advances in learning, they also have limitations. These include being fragmented (providing only a partial understanding of reality); compartmentalised (organised into disconnected disciplines or government departments and agencies); elitist (producing highly specialised, self-referential research with little focus on communication); exclusive (marginalising important voices such as the poor, women, ethnic minorities); hegemonic (reproducing existing structures and power dynamics); and disconnected from action (focusing on problems rather than solutions and how to implement them) (EEA, 2019d). They have primarily supported incremental change rather than the systemic transformations required to address sustainability challenges (Fazey et al., 2020).

Knowledge systems are always evolving and visions of systems that link knowledge with action for effective societal responses to sustainability challenges have been developed. The RESCUE foresight initiative developed a vision of an open knowledge system which included societal agenda setting, collective problem framing, a plurality of perspectives, integrative research processes, new norms for handling dissent and controversy, better treatment of uncertainty and of diversity of values, extended peer review, broader and more transparent metrics for evaluation, effective dialogue processes and stakeholder participation. It involved an iterative loop of learning, doing and reflection and would be supported by formal and informal education and capacity building (European Science Foundation and European Cooperation in Science and Technology, 2012; Cornell et al., 2013).

More recently, a vision of a future knowledge system was developed in a foresight exercise undertaken by researchers, which involved over 340 participants from diverse backgrounds, relating to social and environmental change and sustainability (Fazey et al., 2020). The future system envisaged was much more collaborative, open, diverse, egalitarian and able to work with values and systemic issues. Its goal also changed from creating knowledge about the world to rapidly creating the wisdom about how to act appropriately. This would also need to occur rapidly and at scale if knowledge systems are to keep pace with the scale and speed of planetary change (Fazey et al., 2020).

These visioning exercises provide a useful foundation on which to further develop thinking about the type of knowledge system that can effectively contribute to achieving Europe's sustainability objectives. They identified the need for more integrated knowledge, collaborative practices and effective science-society-policy interfaces. Some initial reflections are given below on these few selected areas in relation to strengthening knowledge development, uptake and use.

How to produce knowledge for systemic transformation?

Addressing sustainability challenges requires knowledge that is integrated and spans policy domains, disciplines, types of knowledge and different perspectives. This means complementing still essential single-discipline research with more interdisciplinary and transdisciplinary approaches. While cooperation and integration efforts are not new and are supported by funding mechanisms, the current incentive and reward structure in academia and the higher education sector does not support interdisciplinary and transdisciplinary research to the degree required. Transdisciplinary approaches are particularly important for sustainability challenges and transitions as they overcome disciplinary boundaries for a more complete understanding.

More collaborative practices are also gaining prominence. When stakeholders are involved in knowledge creation, they are more likely to make use of the knowledge, therefore knowledge co-production or co-creation has been explored as a way of addressing the gap between knowledge production and its use in decision-making. Knowledge co-production is defined and put into practice in diverse ways. Norström et al., 2020 define knowledge co-production for sustainability research as iterative and collaborative processes involving diverse types of expertise, knowledge and actors to produce context-specific knowledge and pathways towards a sustainable future. They identify four general principles that underly high-quality knowledge co-production and offer practical guidance about engaging in co-production processes as well as evaluating their success.

In summary, the principles suggest that processes should be context-based, pluralistic, goal-oriented and interactive. Being context-based means understanding how a challenge emerged, how it is affected by its particular social, economic, and ecological contexts, and the different beliefs and needs of those affected by it. Being pluralistic means the process should explicitly recognise a range of potentially contrasting perspectives, knowledge and expertise and consider factors such as gender, ethnicity and age. Being goal-orientated means

articulating clearly defined, shared and meaningful goals that are related to the challenge in hand. While being interactive means it is critical to facilitate ongoing learning among actors, active engagement, and frequent interactions.

While there is no one model for designing and conducting successful knowledge co-production processes, most guidance suggests taking a phased approach to structure engagement, reflection and assessment. Important stages include an initial framing of the problem, developing response options, then implementing and evaluating them.

However, such processes can also be resource and time intensive which creates challenges if the intention is to inform and support policy processes that often move at a fast pace. Other barriers include difficulties in contextualising processes, the incommensurability of world views, and a lack of trust, leading to limited commitment and openness on the part of decision-makers and practitioners. These factors are particularly challenging in the context of systemic transformations as sustainability challenges are often characterised by diverse views, competing and vested interests, multidimensional objectives and multiple desired outcomes. This means that while such collaborative approaches would play an important role in a future knowledge system, they are not a panacea for addressing the gap between knowledge production and its use in decision-making.

How to strengthen knowledge uptake and use?

Strengthening knowledge uptake and use requires effective science-policy-society interfaces. These come in a range of forms — current policy developments are supporting the development of networks, platforms, knowledge centres and partnerships where policymakers and stakeholders engage with each other to develop, organise and share knowledge. Recent initiatives include the partnership approach of the EU Bioeconomy and Biodiversity Strategies for 2030 and the establishment of Knowledge Centres for Bioeconomy and Biodiversity (Chapter 2), the EEA's Climate-ADAPT platform (Chapter 3), the European Circular Economy Stakeholder Platform (Chapter 4), the Partnership for the Assessment of Risks from Chemicals (Chapter 5) and the New European Bauhaus (Chapter 6).

In a knowledge system, boundary organisations such as the EEA have a particularly important role to play in bridging the gap between policy and science as well as with other stakeholders and practitioners. This is reflected in the 8th EAP proposal which specifically identifies a role for the EEA in 'helping civil society, public authorities, citizens, social partners and the private sector identify climate and environmental risks and take action to prevent, mitigate and adapt to them, and fostering their engagement in closing knowledge gaps'.

'The knowledge landscape is becoming very fluid and incredibly rich. It is as though we are sailing on a sea of knowledge and finding it difficult to navigate. There is an urgent need for organisations that can help policy makers and others make sense of the deluge.' (Šucha and Dewar, 2020)

Box 8.1 Eight skills to address eight challenges in knowledge management for policy

Synthesising research: employ methods to make better sense of the wealth of knowledge available on a given topic, particularly when driven by a research question co-produced with policymakers.

Managing expert communities: communities of experts, sharing a common language or understanding, are fundamental to applying knowledge to complex problems. Effective teams develop facilitation skills to reduce disciplinary and policy divides.

Understanding policy and science: seek to better understand the policy process, which can never be as simple as a policy cycle with linear stages. Effective teams adapt their strategies to a messier context.

Interpersonal skills: effective actors are able to interact well with others in teams to help solve problems.

Engaging with citizens and stakeholders: well-planned engagement with stakeholders, including citizens, can help combine scientific expertise with other types of knowledge to increase their relevance and impact.

Communicating scientific knowledge: impact requires effective communication skills, from content-related tools like infographic design and data visualisation, to listening and understanding your audience.

Monitoring and evaluation: monitoring and evaluating the impact of research evidence on policymaking helps improve the influence of evidence on policymaking.

Advising policymakers: effective knowledge brokerage goes beyond simply communicating research evidence, towards identifying options, helping policymakers understand the likely impact of choices, and providing policy advice from a scientific viewpoint.

Source: Topp at al. (2018).

The objectives of the EEA-Eionet Strategy 2021-2030 reflect this, aiming to enable a sustainable Europe by providing trusted and actionable knowledge for informed decision-making on priorities and solutions, in line with Europe's policy ambitions. As well as producing such knowledge, this also involves active engagement with policymakers, co-creation approaches and investing in building stronger networks and partnerships.

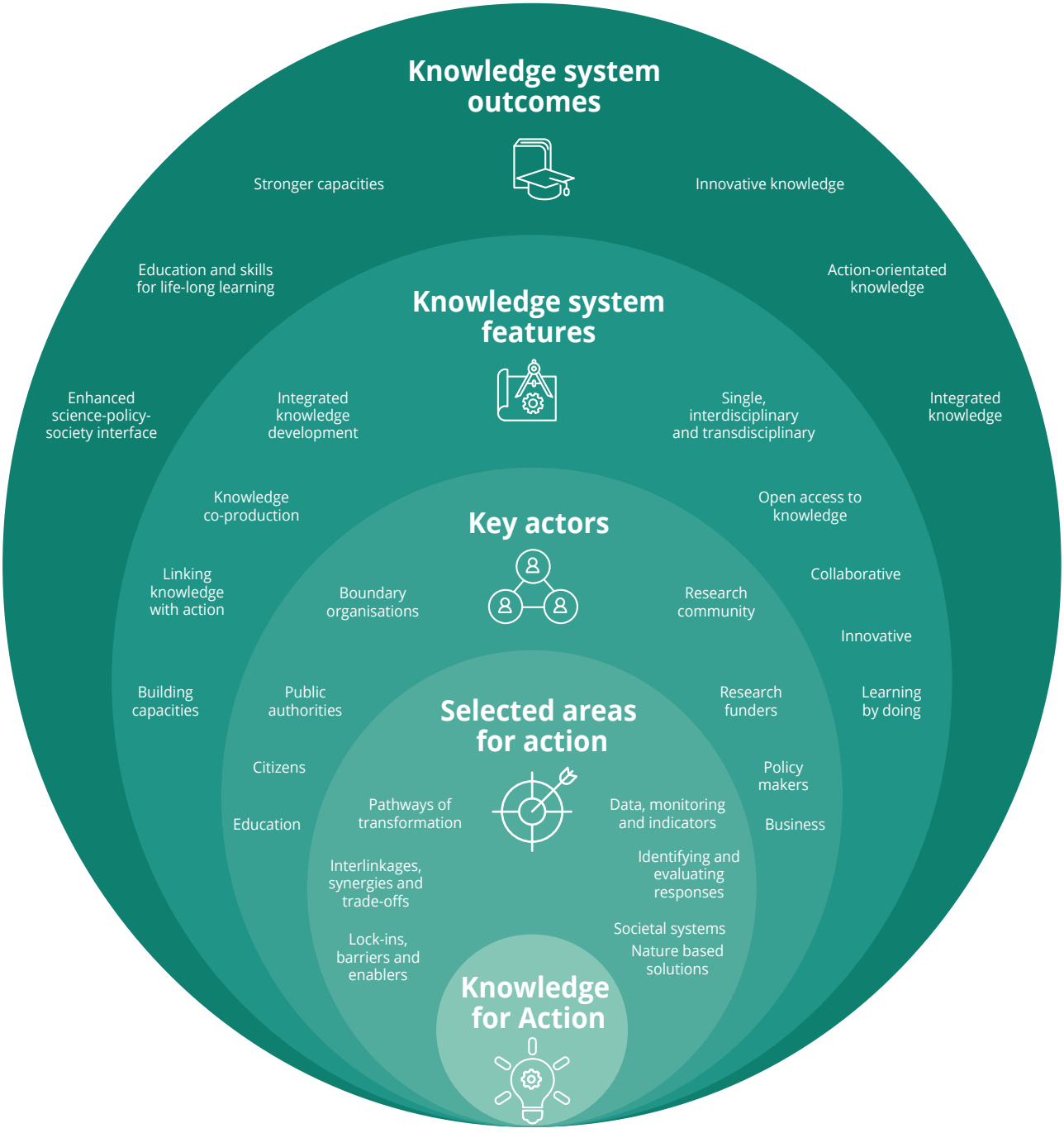
Thinking about how changes in knowledge systems can support systemic transformations also involves reflecting on the type of competencies needed. The JRC Knowledge Management for Policy initiative synthesised insights from interdisciplinary work on the science-policy interface to inform a skills and training agenda (Box 8.1). Development of such skills by those engaged in the science-policy-society interface would contribute to enhancing the effectiveness of activities.

8.5 Elements of a knowledge system for systemic transformation

In summary, in the context of sustainability ambitions aiming for transformational change in society, a knowledge system that supports the capacity for wise decision-making is essential. This means going beyond creating knowledge about the world to rapidly creating the wisdom about how to act appropriately. Such a knowledge system would guide knowledge development, uptake and use as an iterative and holistic process (Figure 8.1). Knowledge production is often disconnected from action limiting learning from practice and innovation on how to achieve change. Current developments and previous visioning exercises provide a solid foundation to build on when developing a more comprehensive picture of such a knowledge system for Europe and how it could be achieved at the required scale and pace.

The coming years provide an opportunity to develop such a knowledge system. In the same way as Europe has started to develop a series of systemic, long-term policy frameworks that address multidimensional sustainability challenges and seek to stimulate and guide coherent action, a similar approach will be needed for knowledge. Development of a European knowledge strategy would determine what knowledge is needed and provide direction that would shape new practices and the knowledge system. Therefore, it has an important framing role and should be developed with stakeholders to ensure that it reflects different principles, views, values and policy ambitions. Such a knowledge strategy could underpin the transformation of the current knowledge system to one that reflects the changing relationship between science, policy and society and creates, organises and uses diverse knowledge to empower the transition to a sustainable Europe.

Figure 8.1 **Elements of a knowledge system for systemic transformation**



Source: EEA.

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