17. Responding to sustainability challenges

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Summary

- Responding to the persistent and emerging challenges facing Europe will require transitions in the production-consumption systems driving impacts on the environment and health.

- Sustainability transitions are highly complex and uncertain processes. Governments cannot simply plan and implement them. Yet, public policies and institutions are essential to catalyse and orient systemic changes in cooperation with businesses and civil society.

- Transitions involve the emergence and upscaling of diverse innovations. There is a need for more emphasis on social innovation, behavioural change and nature-based solutions.

- Public policies and institutions can promote system innovation, including by supporting experimentation, correcting market failures, facilitating the spread of new ideas and approaches, and helping ensure a just transition.

- Governments can accelerate systemic change by helping cities to innovate and network, by reorienting financial flows towards sustainable investments and by developing relevant knowledge systems and skills.

- Achieving sustainability transitions requires public engagement in defining visions and pathways, coherence across policy domains and scales, and use of foresight and adaptive approaches to navigate risks. Ecosystem-based approaches can help manage cross-system interactions within environmental boundaries.

17.

Responding to sustainability challenges

17.1 From challenges to responses

During the last two decades, the concepts of 'sustainability transitions' and 'transformations' have become increasingly prominent in the academic literature (Köhler et al., 2019). Since 2015, this trend has been matched by a growing uptake of the language and logic of sustainability transitions in European policy frameworks. As noted in Chapter 15, the EU's long-term strategy for a climate-neutral Europe and the European Commission's reflection paper on the 2030 agenda for sustainable development (EC, 2018b, 2019d) adopt the language of transitions systematically. Similarly, EU strategies such as the circular economy action plan, the Energy Union strategy and the 'Europe on the move' agenda embrace a systemic rather than a sectoral focus, emphasising economic transformation towards long-term targets (EC, 2015a, 2015b, 2017a). They are characterised by multidimensional goals, addressing themes such as jobs, competitiveness, fair access to resources and sustainability; a focus on diverse societal actors and creating stakeholder platforms; and increasing adoption of system transitions approaches, including particular emphasis on innovation.

Systemic change is necessary for the EU to achieve its sustainability objectives.

As discussed in Chapter 16, the many interlinkages in societal systems create a profoundly complex challenge for governance. Lock-ins, barriers and feedbacks mean that interventions may encounter resistance or produce unexpected outcomes, such as shifting problems to other locations, rather than tackling them. These interdependencies also mean that pursuing environmental goals is likely to produce synergies or trade-offs with other sustainability objectives.

Europe is not alone in needing to achieve systemic change. Indeed, Europe cannot achieve its sustainability objectives in isolation. The interconnection of the world's environmental, social and economic systems implies the need for concerted international efforts. These are global problems, requiring global responses.

In responding to these challenges, the EU's economic scale, diplomatic and trade links, and leadership in environmental governance confer significant influence. Beyond intergovernmental processes, the globalisation of supply chains mean that European product standards and business practices can have effects well beyond Europe's borders. Similarly, the consumption choices of Europeans also have implications for environmental and social outcomes across the world.

Nevertheless, there are clear constraints on Europe's ability to shape environmental outcomes in other

By embracing transitions, demonstrating solutions and seizing related opportunities Europe can lead the global effort for change.

regions. Decision-making processes at the global level are frequently slow and produce disappointing outcomes, and enforcement mechanisms are often lacking (EEA, 2015b). With this in mind, Europe's greatest potential influence may come from global leadership in embracing the need for transformation — demonstrating that there are solutions to the problems facing countries and regions across the world and seizing associated social and economic opportunities.

The EU's emerging strategic policy frameworks provide an essential foundation but in practice they are just a start. Major questions remain to be answered. How, for example, can the EU and its Members States translate their long-term ambitions into coherent and relevant actions? How can society-wide systemic change be catalysed and steered towards long-term goals? And what role do public policies and institutions at different levels have in such processes? This chapter begins to respond to those questions.

17.2 Understanding sustainability transitions

17.2.1 The multi-level perspective on transitions

The growing body of research into sustainability transitions and transformations has its roots in diverse research fields. Disciplines such as ecology, evolutionary economics, innovation theory and political economy each focus on different kinds of change processes and scales of activity. Yet, this diversity is increasingly coalescing into a broadly shared understanding of sustainability challenges, which emphasises the barriers to transforming complex systems and the role of drivers of change at the macro and micro levels in enabling the emergence of new ways of living, working and thinking (EEA, 2018).

The 'multi-level perspective' on transitions (Figure 17.1) is a useful model for understanding how these interactions shape the dynamics of change in production-consumption systems (Smith et al., 2010; Markard et al., 2012; Geels et al., 2017). It describes transition processes as arising from the interplay of developments at three levels: regime, niche and landscape.

The regime comprises the diverse factors that structure existing modes of producing and consuming. As discussed in Section 16.5, these include technologies, regulations, infrastructures, behaviours and cultural norms, which have co-evolved in ways that hinder the emergence of alternative technologies, business models and social practices. In terms of price and performance, for example, novel innovations are likely to struggle against established approaches that have benefited from decades of incremental improvements and investments.

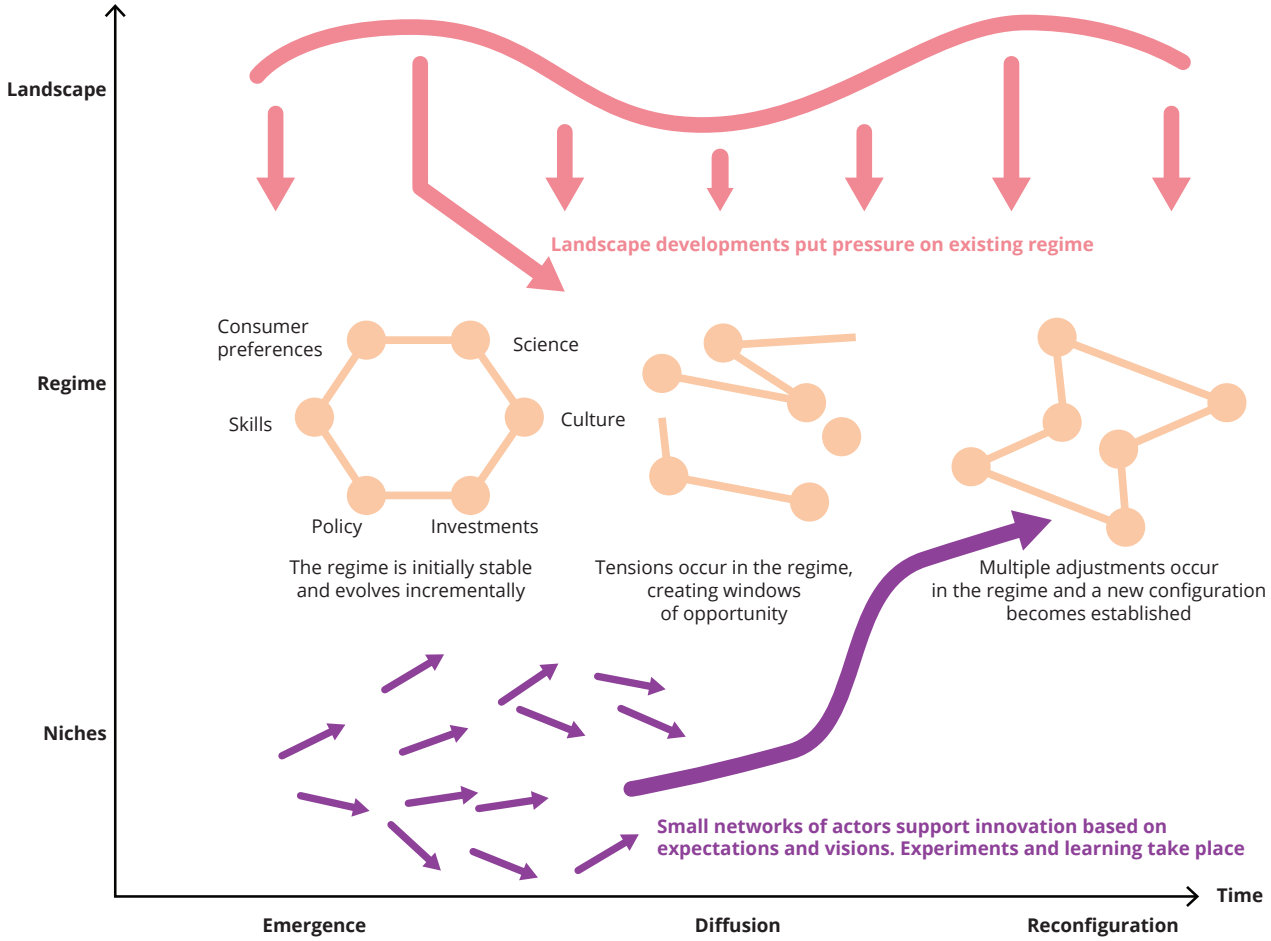
For innovations to alter the dominant system, three things are needed: niches, landscape developments, and cracks in existing regimes (Kemp et al., 1998). Niches are protected spaces, such as R&D (research and development) labs or demonstration projects, where entrepreneurs can experiment and develop radical innovations without direct exposure to market forces, consumer preferences, and so on (Smith and Raven, 2012). Landscape developments include long-term megatrends (e.g. social, economic, environmental) as described in Chapter 1, or more sudden shocks (e.g. a nuclear accident), which disrupt the regime. Cracks in existing regimes may arise from internal problems, external landscape pressures or bottom-up pressure from niche innovations (Turnheim and Geels, 2012). Collectively, this implies that transitions occur through dynamic, multi-level interactions between diverse actors, including businesses, users, researchers, policymakers, social movements and interest groups.

Figure 17.1 distinguishes three phases within transitions processes: the emergence of novel practices or technologies; their diffusion and uptake across society; and the disruption and reconfiguration of established systems. At each phase, innovations face major barriers, including inadequate funding, uncertainty about technical viability and consumer responses, incompatibility with established regulations or cultural norms, and active resistance from incumbent businesses.

Transitions are thus fundamentally uncertain processes, typified by setbacks and accelerations, surprises and unintended consequences. This makes it impossible to know in advance precisely what innovations will emerge, whether or how they will be integrated into lifestyles, and how they will affect sustainable outcomes.

Figure 17.2 presents an application of the multi-level perspective to the food system, including illustrative examples of landscape trends and important technological, social and organisational innovations. The multi-level perspective also provides a framework for integrating ideas from a range of transitions perspectives (e.g. Smith, 2012; Göpel, 2016). These include insights into how social practices change; the role of

FIGURE 17.1 The multilevel perspective on sustainability transitions



Source: Based on Geels (2002).

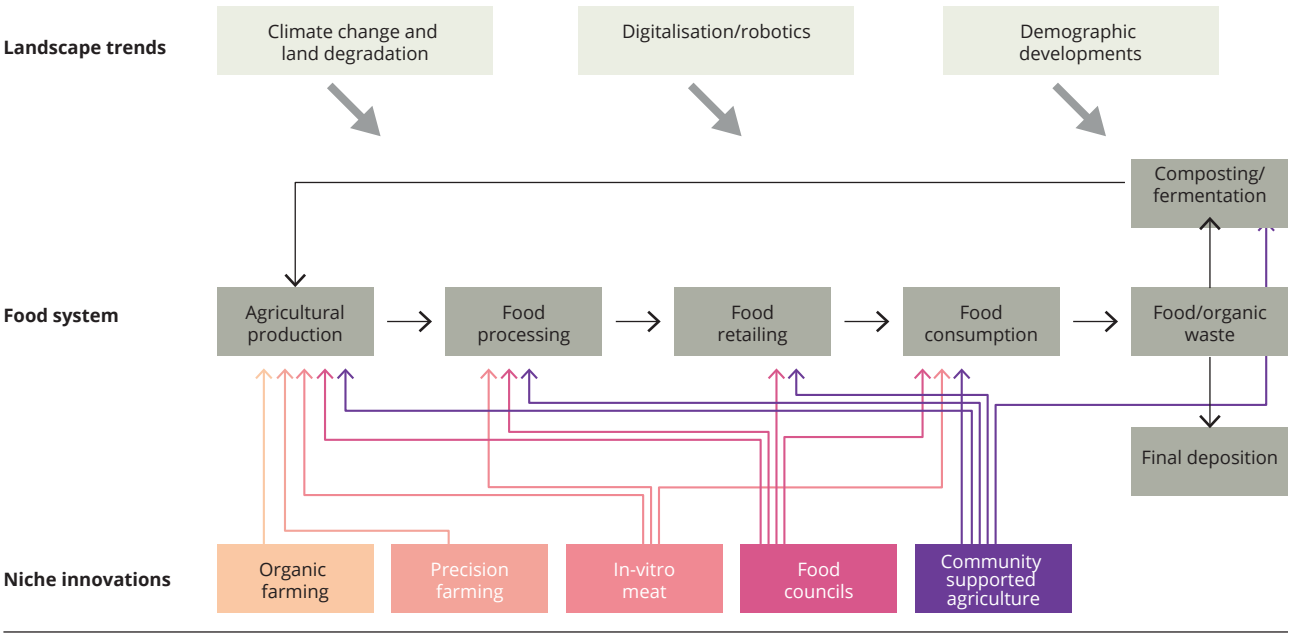
Sustainability transitions are non-linear, society-wide processes built on innovation and knowledge creation.

communities and cities in enabling more polycentric forms of governance, founded on bottom-up action by communities and other groups; the potential impacts of systemic change on society and the environment; and the importance of practices, values, worldviews and paradigms (EEA, 2018).

17.2.2 Implications for governance

The dynamics and interactions set out in the multi-level perspective point to the need for new governance approaches to support sustainability transitions. Historically, societies have relied on governments to manage the risks and harms associated with economic growth — primarily employing regulations and pricing instruments to correct market failures and using intergovernmental agreements to address transboundary issues and global collective action problems such as climate change. While these tools remain essential, they also face important constraints. For example, governments often face significant political barriers when seeking to introduce regulations and pricing instruments consistent with long-term sustainability goals. Equally, the deficiencies of global governance processes often mean that negotiated targets lack the necessary ambition and enforcement mechanisms.

FIGURE 17.2 Applying the multi-level perspective to the food system



Such realities imply that a purely hierarchical, top-down approach to achieving Europe's sustainability objectives will not achieve systemic change at the scale and pace needed. As Hajer at al. (2015) argue:

The SDGs [Sustainable Development Goals] … risk falling short of expectations because of what we call 'cockpit-ism': the illusion that top-down steering by governments and intergovernmental organisations alone can address global problems. In view of the limited effectiveness of intergovernmental efforts and questions about the capacity of national governments to affect change, the SDGs need to additionally mobilise new agents of change such as businesses, cities and civil society.

These observations have been associated with a shift in focus from government towards the broader concept of governance, which emphasises the complementary role of governments, markets and networks in organising society (Rhodes, 1997; van Heffen et al., 2000; EEA, 2015b). Such reasoning acknowledges the limitations of government power but also recognises that public authorities have unique capacities, resources and powers to identify and agree society-wide goals; to correct the operation of markets; and to stimulate and enable polycentric forms of governance, based on social interaction and information sharing.

For example, stringent environmental regulations and pricing instruments remain important, but promoting system innovation also requires a policy mix that supports the emergence and diffusion of new technologies and practices, helps phase out established systems and ensures a fair sharing of costs and benefits. Urban authorities and city networks have a key role. Public bodies are also vital in stimulating needed investment, developing necessary knowledge, providing directionality and coherence to activities across society, and creating mechanisms to anticipate and adapt to new risks and emerging issues. These issues are explored in detail in the remainder of this chapter.

17.3 Catalysing innovation and system change

Sustainability transitions are long-term processes, often extending over 25-50 years or more (Grin et al., 2010) and involving the emergence and upscaling of multiple innovations over shorter time scales. No single innovation

TABLE 17.1 Examples of sustainability innovations in the mobility, food and energy domains

	Mobility	Food	Energy
Incremental technical innovation	Fuel-efficient petrol or diesel cars	Precision farming, food waste valorisation, integrated pest management	Insulation, energy-efficient appliances, efficient gas or coal-fired power plants
Radical technical innovation	Battery electric vehicles, electric bikes, alternative fuels, autonomous vehicles	Permaculture, no-tillage farming, plant-based meat and dairy products, genetic modification	Renewable electricity, heat pumps, passive houses, whole-house retrofitting, smart meters
Social or behavioural innovation	Car sharing, modal shift, teleconferencing, teleworking, internet retail	Alternative food networks, organic food, dietary change, urban farming, food councils	Decentralised energy production ('prosumers'), community energy, energy cafes
Business model innovation	Mobility services, car sharing, remanufacturing vehicles, bike sharing	Alternative food networks, organic food	Energy service companies, back-up capacity, vehicle-to-grid electricity provision
Infrastructural innovation	Intermodal transport systems, compact cities, integrated transport and land use planning	Reforms to distribution systems, storage provision and better food waste management	District heating systems, smart grids, bio-methane in reconfigured gas grid

will hold the key to systemic change. Equally, the diversity of local contexts and challenges means that there are no single solutions applicable everywhere.

The electric motor, for example, will surely have a role in transforming the European mobility system, but it would still imply substantial resource demands, pollution and congestion (Section 16.4). The fundamental issue is not how to create a more sustainable car but rather how to meet society's need for point-to-point mobility and, perhaps more fundamentally, for social interaction and access to goods and services. As such, the transition to sustainable mobility will require numerous changes, ranging from car-sharing schemes, driverless cars and a shift to alternative modes of transport (e.g. walking, cycling) to improved spatial planning and novel communication technologies that can reduce the need for mobility. Such innovations will bring changes in social norms, values and lifestyles.

While transitions involve changes across society, governments have a key role in stimulating and orienting the direction of change and in reducing the many barriers to transitions. This section explores how public policies and institutions can provide support at each of the three phases identified in Figure 17.1 — emergence of innovations, their diffusion and subsequent reconfiguration of established systems.

17.3.1 Promoting sustainability innovation and experimentation

Novel social practices, technologies and business models are the core innovations that can drive systemic change. A diversity of ideas and approaches is important, because the viability and sustainability impacts of individual innovations are very hard to anticipate in advance and will often vary in different contexts. In the energy, food and mobility domains, multiple innovations are emerging that deviate in one or more dimensions from current modes of consuming and producing (Table 17.1). Sometimes these involve reviving or adapting older practices, for example initiatives that facilitate the reuse or repair of products. In addition, different forms of innovation often interact. Car sharing and bike sharing are not just about behavioural change, but they also represent new business models and new technologies (e.g. electronic booking systems, GPS — or global positioning systems, smart cars).

TABLE 17.2 Changing innovation policy framings

Overarching framing	Key features	Era	Policy rationale	Policy approaches (examples)
Innovation for growth	Science and technology for growth, promoting production and consumption	Since the 1950s	Responding to market failure: public good character of innovation necessitates state action	State financing of basic R&D, incentives for business R&D (e.g. tax breaks, subsidies)
National system of innovation	Importance of knowledge systems in development and uptake of innovations	Since the 1980s	Responding to system failure: maintaining competitiviness, coordinating system stakeholders	Promoting science hubs; incentivising coordination; SMEs; education and training
Transformative change	Alignment of social and environmental challenges with innovation objectives	Since the 2010s	Promoting transformation: pathways, coordination domains, experimentation, learning	Social challenges (H2020), SDGs, mission-oriented approaches to innovation (FP9)

Note: FP9, Framework Programme 9; H2020, Horizon 2020; SMEs, small and medium-sized enterprises.

Source: Based on Schot and Steinmueller (2018).

The character, rationale and extent of government interventions to support innovation has developed over time (Table 17.2). From the mid-20th century, policy interventions focused on addressing market failures, using state investments in R&D to compensate for inadequate private investment. Since the 1980s, governments have extended this focus to include promoting learning and knowledge circulation within innovation systems, comprising diverse actors including universities, businesses and government agencies. Both of these framings for innovation policy remain valid and important today. Europe could certainly do more to increase investments in basic research (Section 17.4.2) and to use education, science, business and tax policies to create an environment that enables and promotes innovation across society. But recent transitions research also points to the emergence of a third generation of innovation policy that focuses on enabling and promoting transformation towards long-term sustainability objectives, as exemplified by the SDGs (Schot and Steinmueller, 2018).

This emphasis on the directionality of innovation reflects a growing awareness that economic development approaches that promote all innovation and then seek to tackle harmful consequences through regulation and economic instruments are unsustainable. In practice, it implies the need not only to stimulate particular types of innovation (e.g. green technologies) but also for greater emphasis on real-world experimentation and learning, using pilots, demonstration projects and urban labs. These provide a means of exploring sustainability outcomes, identifying barriers, facilitating social acceptance and building coalitions of actors. Accepting and learning from failures is essential (Temmes et al., 2014).

Making innovations work in the real world requires inputs from diverse actors.

Making innovations work in the real world often requires input from a diverse range of actors with different kinds of resources, including researchers, businesses, investors, regulators and users. This point is integral to the EU's concept of Responsible Research and Innovation (EC, 2014b). Its importance is also expressed clearly in the EU's 'Lamy report' on maximising the impact of EU research and innovation programmes (EC, 2017d):

Fully mobilising and involving stakeholders, end-users and citizens in the post-2020 EU R&I programme, for instance in defining its missions, will not only increase the degree of co-creation, it will also maximise its impact and stimulate a stronger demand

for innovative products and services as well as a better grasp of social changes. This will bring open science and open innovation to the next level and turn Europe into a continental living innovation lab.

In recent years, European innovation policy has broadened its focus to RD&D (research, development and demonstration). It could continue further towards promoting real-world demonstrations and experiments, for example by providing additional financial support for social and grassroots innovations. In the EU context, the establishment of an Innovation Fund, to distribute financial resources collected under the EU Emissions Trading System, is a useful step. The new fund will support, on a competitive basis, the demonstration of innovative technologies and breakthrough innovations in areas such as renewables, carbon capture and utilisation (CCU) and energy storage (EC, 2018j).

Public authorities can also assist local projects by facilitating networking and knowledge exchange through workshops, innovation or implementation agencies, or by establishing (digital) platforms. Another option is to provide exemptions from regulations that hinder particular innovations or entrepreneurship. For example, emulating a government programme in the Netherlands, the EU's circular economy action plan applied the concept of 'innovation deals', which identify and address potential regulatory obstacles for innovators (EC, 2018h). Such measures would align with the EU's ambition to 'stimulate a culture of experimentation and risk taking' (EC, 2018d), while respecting environmental standards and the precautionary principle.

Engaging and mobilising society

Citizens, communities and civil society groups represent important sources of creativity and innovation. Indeed, as Stirling (2015) notes, 'It is remarkable how many current major global industries are building around once-marginal technologies like wind turbines, ecological farming, super energy-efficient buildings, or green chemistry. All of these owe key elements in their pioneering origins to early development by grassroots social movements.' As such, transitions policy should build on the groundswell of bottom-up sustainability initiatives and further mobilise the 'energetic society' of engaged citizens, professional non-governmental organisations (NGOs) and motivated communities (Hajer, 2011).

Social innovations and grassroots innovations tend to be more radical than business-driven greening efforts, for example in questioning conventional consumerism and advocating change in user practices and lifestyles. They are often more oriented towards social justice or alternative economic rationales (e.g. community ownership, self-sufficiency). They are also highly contextual and often developed in response to real local problems (Seyfang and Smith, 2007).

In recent years, many European countries have experienced a surge of bottom-up social and grassroots innovations. Several of the promising innovations highlighted in Table 17.1 started as grassroots initiatives. For example, alternative food networks (AFNs) are food provisioning practices based on shorter supply chains and direct producer-consumer interactions (e.g. farmers markets, direct farm sale, weekly box schemes). In addition to reducing transport-related pollution, AFNs entail more direct interactions with food producers, potentially fostering a better understanding of environmental and social impacts of food choices and influencing consumer expectations and food system norms (Forssell, 2017).

Social innovations and grassroots innovations are often more radical than business-driven 'greening' efforts.

There are now thousands of community energy initiatives across Europe (Hossain, 2018), some benefiting directly from EU support. Such initiatives are decentralised, small-scale forms of energy production (often solar photovoltaic (PV) or wind turbines) that are locally owned and operated, often engaging civil society groups, such as social enterprises, schools, businesses, faith groups, local government or utility companies (Seyfang et al., 2014). In Germany, more than 700 community energy initiatives (mostly citizens in cooperatives) account for about 40 % of renewable energy capacity (DECC, 2014; de Vries et al., 2016).

Similarly, there are several hundred 'transition town' initiatives in Europe. Transition towns are community projects that aim to increase self-sufficiency to reduce the potential effects of climate change and economic instability. They do this by stimulating renewable energy production, lifestyle change, community housing, alternative local currencies, repair cafes and community cafes using food that would otherwise go to waste. There are many similar networking initiatives at international and national levels, for example Global Action Plan and Switzerland's 'Les artisans de la transition' (ADLT, 2019; GAP, 2019).

National and European monitoring of social and grassroots innovations is difficult and underdeveloped, but the total number of initiatives across

BOX 17.1
Climathon: transformative approaches to flood risk adaptation

To support transformative adaptation, the city of Vejle, Denmark, co-organised with Climate-KIC a 24-hour Climathon event, to develop innovative ways to adapt to river and coastal flooding in Vejle. The event was open to those with a desire to create new solutions, including engineers, designers, business people, software developers, social scientists and legal or financial experts. The attendees pitched their solution to a panel of experts, including city representatives. The winning idea addressed surface flooding by replacing a standard pavement with a partly glass-covered underground concrete stream: a 'transparent urban waterway'. The winning team established the company Climate Change Consulting DK, meaning that the event produced both innovative solutions and entrepreneurial activity. ■

Source: ETC/CCA et al. (2018).

In addition to generating financial returns, nature-based solutions can deliver substantial non-market benefits.

Europe is likely to number in the tens of thousands. Cumulatively they represent a substantial amount of societal energy that policymakers could engage with more strategically (e.g. Box 17.1). Although social and grassroots innovations sometimes receive some short-term seed money, they are rarely the focus of dedicated policy attention and sustained support.

Governments could offer more support for civil society innovations, for example by funding citizens' groups and projects; providing privileged access to public infrastructure (e.g. vacant land or offices); facilitating the circulation of knowledge about grassroots projects; stimulating experimental partnerships with public services (e.g. schools, hospitals); and more publicly displaying support for citizen-led sustainability projects and their positive contribution to public life locally. This may require some institutional change to overcome the potential mismatch between informal grassroots innovations and formal procedures for policy support (e.g. proposal writing, organisational structures, accountability, budgetary reporting). Intermediary organisations that connect and support multiple initiatives (Section 17.3.2) also play a valuable role in this area.

Nature-based solutions

The EU's Seventh Environment Action Programme, the biodiversity strategy to 2020 and the EU's Horizon 2020 research and innovation programme each promote the use of 'green infrastructure' and 'nature-based solutions' as responses to sustainability problems and as an alternative to 'grey infrastructure' (i.e. human-engineered solutions, often employing concrete and steel). Green infrastructure and nature-based solutions make use of the capacity of ecosystems to deliver highly valuable regulating services — such as capturing carbon, regulating water flows or moderating extreme events — while also providing cultural benefits (Raymond et al., 2017).

Compared with grey infrastructure, nature-based solutions can perform well in financial terms, as well as providing substantial non-market co-benefits (Box 17.2). For example, restoring or creating wetlands on the banks of rivers upstream can function as watersheds that can concurrently mitigate flooding downstream, filter contaminated water, increase biodiversity and enhance recreation opportunities. Landscape conservation and restoration measures can function as natural water filtration plants, replacing conventional water treatment technologies. Forests can reduce or even prevent pollutants from entering streams that supply fresh water to downstream urban areas. Man-made features such as green walls, green roofs and sustainable urban drainage systems can mitigate the impacts of storm water by slowing the rate of run-off through retention, as well as decreasing urban heat effects, improving insulation and providing habitat for a variety of species.

Green infrastructure can be implemented either standalone or in integrated solutions that combine both green and grey infrastructure. Integrating green infrastructure into spatial planning can capitalise on the strengths of both grey and green infrastructure to foster resilient results (Browder et al., 2019). Green infrastructure can also be applied on different scales — from green walls and roofs on buildings, to green belts through industrial complexes, to large-scale watershed restoration and reforestation, in urban, peri-urban, rural and marine areas. The co-benefits are diverse. For example, evidence from 18 'urban labs' across Europe shows that high-quality, biodiversity-rich areas of urban green infrastructure can help address air pollution, noise, climate change impacts, heat waves, floods and public health problems (Maes et al., 2017). Investments can also provide more direct economic benefits, such as increasing property

values. In designing initiatives and policy interventions, it is important to ensure that such benefits are distributed fairly, including across localities, regions and income groups.

The relative novelty of nature-based solutions can mean that they are sometimes expensive in financial terms when compared with grey infrastructure alternatives, which have benefited from decades of investments and efficiency improvements. As with other innovations, however, wider use of nature-based solutions is likely to produce economies of scale and learning, leading to cost reductions. For example, the cost of green roofs has fallen substantially in several countries during recent years (Nurmi et al., 2013).

17.3.2 Supporting diffusion of promising innovations

For many innovations, moving beyond experimentation towards wider adoption occurs via market diffusion, as learning and expanding production enable a new product or business model to become more competitive. In other cases, such as local initiatives and social innovations, the diffusion process may occur through replication or adaptation of an idea in a new location. In either case, innovations often face major barriers to upscaling, ranging from upfront costs of switching to a new technology and consumer uncertainties to the absence of necessary infrastructure or mechanisms for sharing knowledge. Perhaps most fundamentally, incumbents often enjoy a competitive advantage because the social and environmental costs of production are not fully represented in market prices.

'Levelling the playing field' by fixing market failures

Governments have a variety of tools available to help innovations to become mainstream. Economists often favour the use of economy-wide instruments, such as environmental taxes or cap-and-trade policies, which internalise the social and environmental costs of production in market prices. Models suggest that 'technology-neutral' instruments of this sort are cost-effective because they enable market forces to direct investments towards the most efficient technologies, and avoid errors when public authorities seek to pick winners.

In addition to shaping the selection environment for new technologies and supporting their diffusion, broadly focused instruments such as taxes and regulations can also stimulate innovation. Although it runs counter to common perceptions, there is much evidence to support the 'Porter hypothesis' that strict environmental policy can stimulate innovation and job creation, rather than hindering them (Rayment et al., 2009; OECD, 2010; EEA, 2014, 2016c). The European countries with the most stringent environmental policies are generally characterised by high levels of eco-innovation and economic competitiveness (Figure 17.3; EEA, 2016b).

Economic instruments also have some important limitations. First, efforts to tax activities in one location may not have the desired effect if they cause production to shift to other countries or incentivise businesses to use substitute resources (ETC/SCP et al., 2015). Second, introducing general economic instruments (e.g. a carbon tax) faces major political obstacles because the benefits are diffuse, hard to measure, and lie in the future, whereas the costs are concentrated and immediate (Hughes and Urpelainen, 2015). Powerful industries (oil, cars, utilities, retail) tend to resist their introduction and consumers may also raise opposition, particularly because the costs of environmental taxes may fall disproportionately on lower income

BOX 17.2
Non-market benefits of Lisbon's street trees

A cost-benefit analysis of street trees in Lisbon (Soares et al., 2011) showed that for every EUR 1 invested annually by the municipality in tree management, residents receive benefits valued at EUR 3.11. Each of Lisbon's trees is estimated to provide annual benefits of EUR 4.27 in energy savings, EUR 0.23 in reduced CO_2 emissions, EUR 3.75 in reduced air pollutant deposition, EUR 33.18 in reduced storm water run-off and as much as EUR 100.40 in increased real estate values. In total, Lisbon's 41 247 street trees are calculated to provide services valued at EUR 5.8 million annually, while EUR 1.3 million is spent maintaining them.

Further city case studies can be found at the Oppla platform: https://oppla.eu/nbs/case-studies. ■

Environmental policy can often drive innovation and job creation, rather than hindering them.

FIGURE 17.3 Demanding environmental policy is associated with greater competitiveness and more eco-innovation

Notes: The figure includes all EEA member countries for which data are available on stringency of environmental policy.
OECD, Organisation for Economic Co-operation and Development.

Source: EEA (2016b).

Environmental tax reforms need to ensure a socially fair distribution of costs and benefits.

groups (Chapter 16). This often leads to defeat or watering down of the instrument. It is notable, for example, that, despite years of advocacy for a shift towards increasing taxation of environmental harms, as well as their administrative cost-effectiveness, environmental tax revenues in the 28 EU Member States (EU-28) decreased from 2.6 % to 2.4 % of gross domestic product (GDP) between 1995 and 2017. Nevertheless, revenues from environmental taxes amounted to some EUR 370 billion in 2017 — funds that could be more clearly directed in support of sustainability transitions.

These challenges also point to the benefits of coordinating environmental taxation across countries to limit burden shifting. They also highlight the need to design and communicate environmental taxes as part of broader packages of environmental fiscal reform that ensure a socially fair distribution of costs and benefits. This can include offsetting new taxes with reduced taxation of other activities (e.g. labour or sustainable consumption), as well as direct support for the groups or regions affected.

A third concern with general economic instruments is that empirical studies suggest that purportedly neutral policy tools inevitably involve an element of selection, as they steer resources to technologies that are currently cheapest

but not necessarily those that are most promising or potentially disruptive. For this reason, technology-specific instruments may also be needed to drive the development and deployment of radically new technologies (Bergek and Berggren, 2014).

Promoting specific innovations

Diffusion of innovations often requires targeted measures that reduce the costs and uncertainties of switching to new technologies and practices. For example, financial instruments such as purchase subsidies, low-interest loans or feed-in-tariffs can help offset price differentials with established products. Non-financial incentives (including removing legal barriers, e.g. for food donations) can further increase the appeal of initiatives. Public procurement can create a market for sustainable goods and services (e.g. Copenhagen's public sector canteens and food services served 88 % organic food in 2015 (KK, 2016)). Investments in necessary infrastructure are often essential for diffusion of technologies (e.g. distributed energy production). And safety regulations and standardisation can generate trust and confidence in novel technologies.

Standards can also influence the diffusion of innovations, including beyond Europe's borders. Standards, certification schemes and labels often emerge through an interaction of different stakeholders, with civil society organisations proposing new benchmarks, and companies promoting their harmonisation and enforcement in different regions as a means of reducing production costs or achieving a level playing field with competitors.

Diffusion also involves changing user practices, norms and business processes. In part, this is about developing positive narratives. Uptake of renewable technologies in Germany, for example, was initially underpinned by positive stories about renewable energy and green growth and jobs related to German manufacturers of wind turbines and solar panels (Geels et al., 2016). This narrative was promoted by a green advocacy coalition, which included not just environmental groups, solar PV and wind associations but also metal and machine workers, farmer groups and church groups. Governments and other actors can shape narratives by disseminating information (e.g. via labelling or media campaigns) and framing it in ways that positively affect attitudes, beliefs and norms (e.g. social marketing or 'nudging'). Insights from behavioural sciences are increasingly applied to policy initiatives across Europe (EC, 2016a).

> Knowledge sharing is particularly important to enable the diffusion of grassroots initiatives and social innovations.

In view of the recent proliferation of initiatives and labels related to environmental and sustainability information, it is essential to develop standards to increase consumer trust. In 2013, the European Commission published a recommendation on the use of the product and organisation environmental footprint (PEF and OEF) methods (EC, 2013a). This was followed by collaboration with industry to develop and apply methods and develop approaches to verification and communication aimed at building a single market for green products.

Integration of innovations into the business environment often represents a challenge, as incumbent businesses are often geared towards established technologies and practices — in terms of investments, skills, knowledge, organisational structures and revenue flows. In some instances, the emergence of innovations may lead to the collapse of incumbents; in others, established firms may hinder the diffusion of an innovation or shift their business model towards embracing it. Policies influence this process of integration in the business environment both by stimulating consumer demand and by facilitating or mandating changes in production. Box 17.3 illustrates the broad range of measures that are contributing to diffusion of electric vehicles.

Upscaling local projects and grassroots innovations

The upscaling of sustainability innovations also depends critically on sharing knowledge and insights gained from experimentation and demonstration projects. In practice, lessons and insights are seldom shared widely, which often leads local innovators to 'reinvent the wheel'. The impact of Europe's many bottom-up initiatives will be less as long as they remain fragmented and short lived (Turnheim et al., 2018).

Knowledge sharing is particularly important for grassroots initiatives and social innovations, which rely less on market forces to drive diffusion. In these cases, scaling can take the form of 'scaling out' — replicating a social innovation in a different location; 'scaling up' — influencing laws and policies at higher levels; or 'scaling deep' — developing narratives that resonate with cultural values (Moore et al., 2015). All types of scaling rely on knowledge transmission.

Governments can stimulate the circulation of knowledge and lessons learned between social innovation projects and pilots, for example by standardising information and

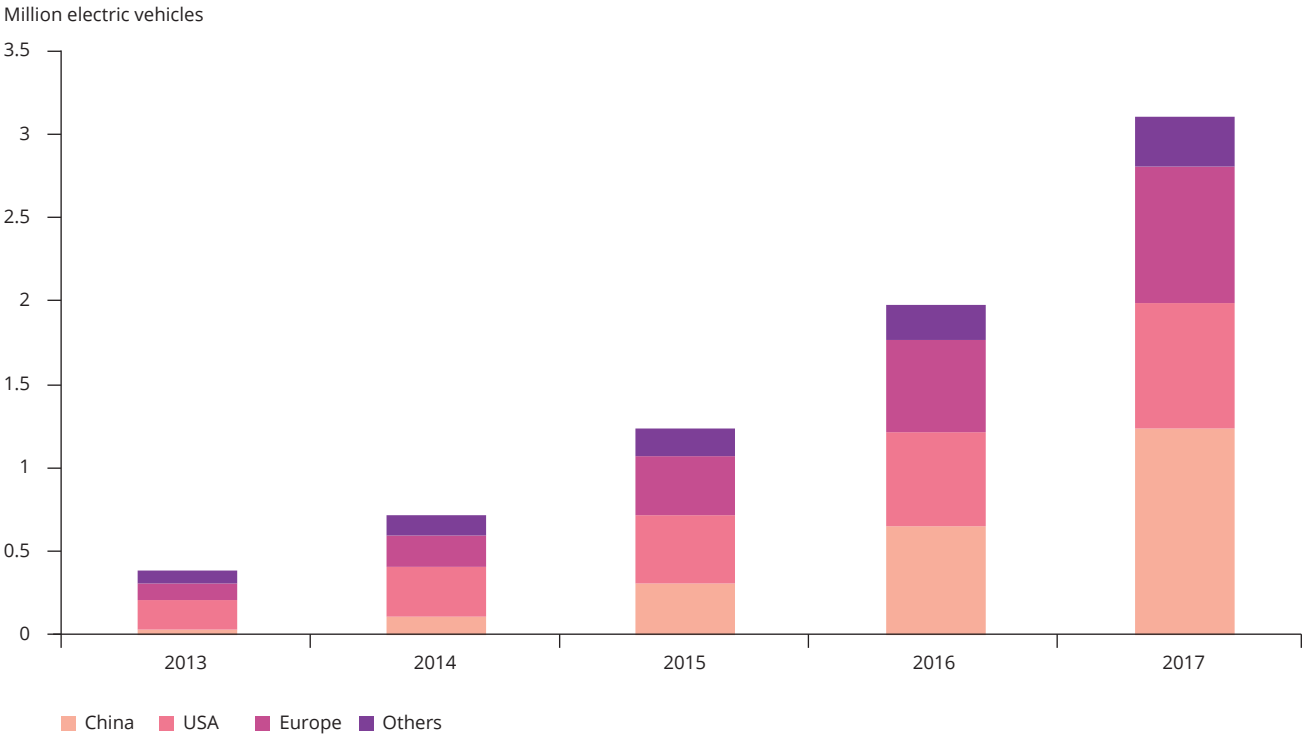
BOX 17.3 Electric vehicle diffusion

Electric vehicles have started diffusing, and the total global stock passed 3 million in 2017 (Figure 17.4). Annual sales in 2017 were 54 % higher than in 2016, surpassing 1 million units, with more than half of those global sales in China (IEA, 2018b). Only a few countries have fairly high market shares: Norway (39.2 %), Iceland (12 %) and Sweden (6.3 %). The remainder have shares under 3 %. In 2017, members of the International Energy Agency's Electric Vehicles Initiative (EVI) set the aspirational goal of achieving a 30 % market share for electric vehicles in each country by 2030. The EVI members comprise Canada, China, Finland, France, Germany, India, Japan, Mexico, the Netherlands, Norway, Sweden, the United Kingdom and the United States.

In all of the countries that are pioneering the diffusion of electric vehicles, public policies at national and local levels are playing a major role. The most prominent are direct consumer incentives such as vehicle purchase subsidies or tax exemptions. There is a clear correlation between the strength of financial incentives and the speed of diffusion (Wesseling, 2016). Even with grants, however, the up-front costs of electric vehicles remain higher than those of other cars. Early adopters are often middle-aged, well-educated, affluent, urban men, who are motivated by pro-environmental attitudes, a desire to save on fuel costs and an active interest in new technology (Nilsson and Nykvist, 2016). These factors point to the importance of complementary measures that can shift public perceptions and drive changes in business practice, as well as the value of policy support for electrifying public transport.

Measures used across Europe include financial support to the electric vehicle industry; public investments in charging infrastructure or subsidies for home chargers; public procurement of electric vehicles (e.g. for municipal vehicle fleets); state aid for electric public transport; indirect consumer incentives such as preferential access to bus lanes, free or preferential parking, access to low-emission zones, free charging at public stations and road toll exemptions; consumer outreach and education policies; and regulatory incentives such as sales targets for electric vehicle manufacturers or bans on sales of internal combustion engine vehicles (EEA, 2016a; CCC, 2018; EC, 2018i). ■

FIGURE 17.4 Cumulative global fleet of electric vehicles



Source: IEA (2018a).

BOX 17.4 Austrian biomass district heating systems

Biomass district heating (BMDH) systems (which use pellets and waste wood from Austria's forests) emerged in the late 1970s in rural villages. They were pioneered by new entrants to the market, such as sawmill owners, carpenters and monasteries, who sold heating services to nearby houses. From the mid-1980s, these small- to medium-scale village heat-only systems started to diffuse more widely. At this time, farmers, who in Austria often own forests, started building more local BMDH plants to develop the market for wood products.

Recognising opportunities for rural revitalisation, public authorities began to provide support. Dedicated intermediary organisations, such as the Austrian Biomass Association, were created to compare experiences, formulate lessons and share insights. Pioneering provinces launched energy agencies that provided training, technical advice and financial support for BMDH developers. These activities substantially improved technical and economic performance in the 1980s and early 1990s. Collectively, these changes resulted in a 10-fold increase in the total number of BMDH systems in Austria between the mid-1980s and the end of the 1990s.

At the national level, the federal Environmental Promotion Fund streamlined the complex policy environment by harmonising the eligibility, application and payment procedures for capital grants for BMDH systems in 1995. In 2000, technical performance guidelines were introduced and disseminated through seminars and training courses. Stable rules enabled more reliable calculation of cost-benefits, which in the early 2000s stimulated the involvement of energy utilities and the National Forestry Agency, which constructed large-scale BMDH systems to co-generate heat and power. This produced exponential growth in the period 2000-2010. By 2010, Austria had approximately 3 100 BMDH systems, of which about 2 500 were village heating systems. ■

Source: Based on Geels and Johnson (2018).

organising workshops. Implementation agencies (e.g. energy agencies or innovation agencies) can play a valuable role as intermediaries, because they engage with multiple projects, enabling them to compare them and extract and codify general lessons, so that these can provide insights for new projects or policymaking (Geels and Deuten, 2006; Kivimaa, 2014). Box 17.4 illustrates the role of intermediaries in knowledge circulation and aggregation in the diffusion of biomass district heating systems in Austria.

Social and grassroots initiatives are often diverse in character and context specific, which can make it difficult to extract lessons and disseminate good practice. Nevertheless, intermediary organisations or social networks can play a useful role (EEA, 2018). The Transition Network, for instance, encompasses more than a thousand local transition initiatives in 43 countries and has developed a guide that articulates core values and operational principles for setting new initiatives (TN, 2018). Similarly, Community Power, a network established by Friends of the Earth Europe to support community energy, engages in knowledge sharing and political lobbying for legislative change (EEA, 2018).

Grassroots innovations can take several decades to reach scale (e.g. Box 17.5). They can be nurtured through dedicated efforts such as providing local finance (e.g. public banks), community building, political lobbying, professionalisation, engaging with incumbent actors and providing policy support. Mainstreaming may also involve a degree of co-option (e.g. by big businesses) and divergence from their initial grassroots visions and values (Berkhout, 2006; von Oelreich and Milestad, 2017).

Public institutions and social networks have key roles in sharing knowledge and lessons learned.

17.3.3 Managing phase-out, disruption and structural change

Deliberate phase-out actions that target the decline of existing technologies and practices are necessary to accelerate sustainability transitions. Such actions are still quite rare, but they are gaining political salience and include bans

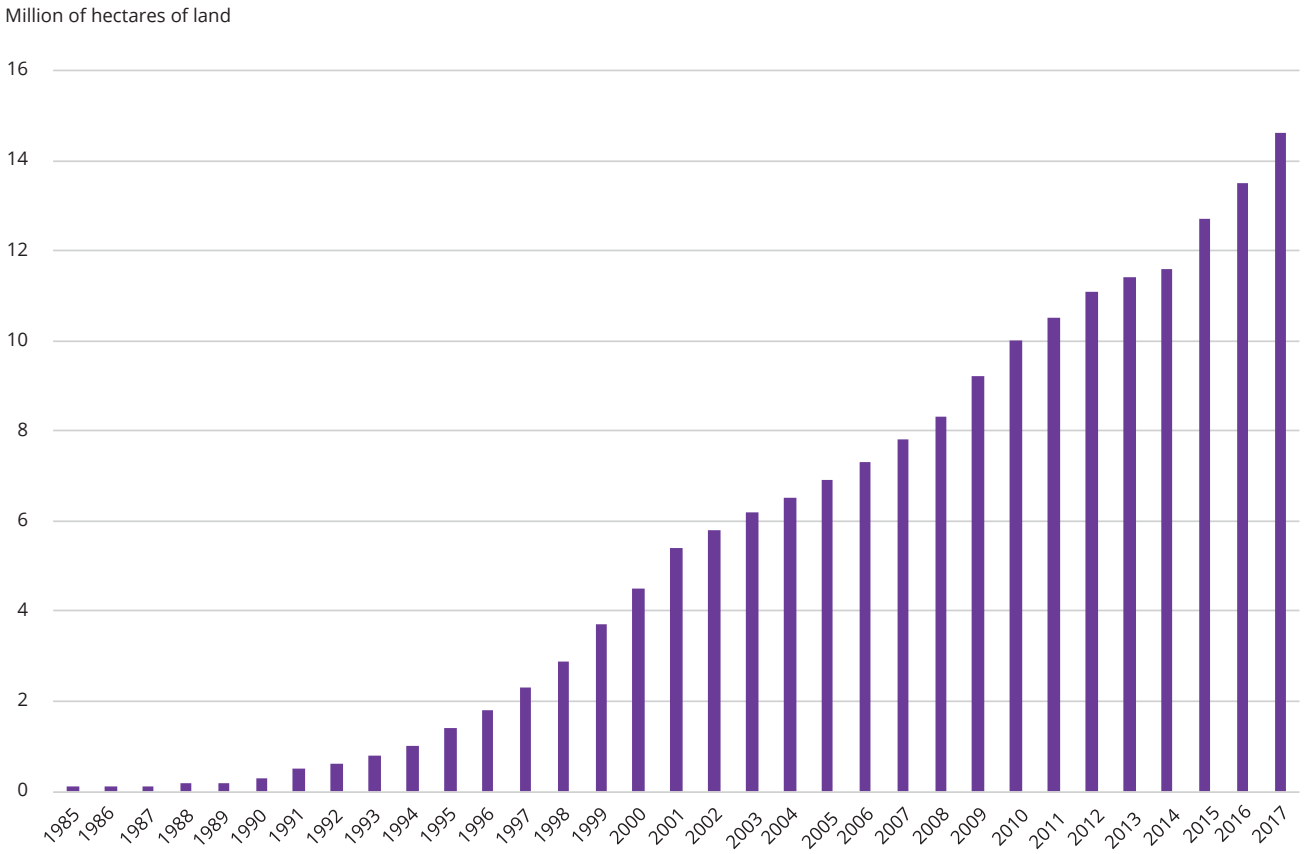
BOX 17.5 Mainstreaming organic food

Organic food was pioneered in the 1930s by activist farmers and scientists as a means of recycling nutrients and organic matter and improving human and animal health. Between 1970 and 1990, a more organised organic food movement emerged, advocating small-scale production and localism. Gradually, associations were created that developed organic standards to build consumer trust and engaged in political advocacy to gain policy support (Smith, 2006; von Oelreich and Milestad, 2017).

In the 1990s and early 2000s, market demand for organic food grew (Figure 17.5), partly in response to food scandals. Supermarkets became interested, encouraging farmers to convert to organic production, and policymakers introduced organic farming policies and supported research and technical training.

As big farming businesses entered the market, greater pressure to standardise production and provide predictable outputs drove small farmers out of business. Organic farming moved from niche to mainstream and, in the process, diverged from some of its initial grassroots values such as local production and broader sustainability values (Smith, 2006). Although organic food has become a profitable and fast-growing market, it remains more expensive than mainstream food, which means that wider diffusion beyond affluent consumers or those simply willing to pay extra may require continued policy support (Aschemann-Witzel and Zielke, 2017). ■

FIGURE 17.5 Organic agricultural land coverage in Europe, 1985-2015



Sources: FIBL and IFOAM (2016); FIBL (2019).

TABLE 17.3 Policy approaches for addressing the negative socio-economic consequences of transitions for workers, regions and firms

	Compensation (defensive, reactive)	Structural reorientation (active)
Workers	Compensation for losses, e.g. redundancy payments, early retirement benefits	Skill upgrading and retraining programmes, financial assistance to relocate, wage subsidies, assistance in finding new jobs
Regions, communities	Compensation for losses (e.g. increased transfer of resources to local policymakers or regions), relocating public agencies to particular regions	Regional assistance for economic diversification, e.g. direct investments in public goods (e.g. infrastructure), regional innovation policies, subsidies or tax incentives to new businesses in growth sectors, technical assistance
Firms	Compensation for lost asset values or 'grandfathering' of existing assets, state subsidy of company liabilities (e.g. pension or site remediation liabilities)	Grants or in-kind assistance to (1) upgrade existing technologies or practices, (2) stimulate reorientation towards new technologies and markets

Source: Adapted from Spencer et al. (2018).

or regulations, removal of implicit or explicit subsidies, and targeted financial incentives, which make a technology less attractive (Kivimaa and Kern, 2016). For example, the European Commission's 2009 phase-out of incandescent light-bulbs accelerated the transition towards compact fluorescent lights (CFLs) and light emitting diodes (LEDs). In 2015, Finland, the Netherlands and the United Kingdom decided to phase out coal use and in 2017 joined 16 other countries in creating the Powering Past Coal Alliance. Bans on sales of internal combustion engine vehicles have been announced for 2025 (Norway), for 2030 (Ireland, the Netherlands, Austria), and for 2040 (France, United Kingdom) (CCC, 2018). And the EU's Energy Union calls for the removal of all environmentally harmful subsidies (EC, 2015b).

Governments have an essential role in supporting the 'losers' from transition processes and addressing inequities. While the 'creative destruction' associated with structural economic change always creates hardship for those in declining sectors, the impacts can be particularly acute in regions where particular sectors dominate the local economy and are closely tied to the local culture and identity. The historical decline of the old industrial regions, dependent on coal, steel or bulk chemicals (e.g. Lorraine in France, Limburg in Belgium and the Midlands in the United Kingdom), disrupted entire communities, creating unemployment and other social problems (Baeten et al., 1999; Campbell and Coenen, 2017). Coal and lignite extraction and support services still account for more than 5 % of employment in the Polish part of Silesia (EC, 2018g). Rural economies may likewise be strongly intertwined with established systems of agricultural production (Chapter 13).

Such concerns are increasingly reflected in policymaking. For example, the Paris Agreement includes a call for a 'just transition of the workforce and the creation of decent work and quality jobs'. The renewed EU industrial policy strategy (EC, 2017c) likewise emphasises that 'The benefits of industrial transformation need to be widely spread and those who lose out must be able to find opportunities and support to adapt. Lifelong learning, equal opportunities and fair access to education, training and technological skills are at the heart of building such resilience.' The most recent update of the EU Emissions Trading System specifies that revenues from auctioning allowances and from a new Modernisation Fund should be used to support a just transition, for example through retraining and supporting new employment opportunities.

Governments can alleviate negative consequences through compensation measures or actions aimed at reorientation, innovation and developing skills, as outlined in Table 17.3. The relatively successful reorientation of the German Ruhr region in the 1980s and 1990s involved both kinds of policies (Box 17.6).

EU cohesion policy has already moved from a focus on social welfare (transferring funds to less developed regions) to more active, restructuring approaches. For example, the EU's flagship regional innovation approach 'smart specialisation' is increasingly supporting regions in industrial transition, which can face particular challenges in accessing regional support mechanisms (EC, 2017b).

BOX 17.6
Restructuring the German Ruhr coal region

Coal, steel and related industries in the Ruhr region, which employed more than half a million people, faced economic decline in the 1970s and 1980s because of cheaper imports. Initial efforts aimed to improve competitiveness (e.g. subsidies, mergers) but, when this proved insufficient, controlled mine and plant closures provided compensation payments, early retirement packages and wage subsidies. By the mid-1980s, the region was also engaged in a proactive industrial policy, aiming to stimulate 'sunrise technologies' such as environmental technologies (e.g. energy efficiency, renewable energy, recycling and waste combustion), which could build on the region's existing engineering capabilities. Regional diversification succeeded in making the Ruhr a key centre for environmental industry, technology and research. It also focused on its 'industrial culture', turning former mines and steel factories into tourist destinations.

In contrast to the traditional top-down industrial policy, the reorientation strategy was implemented in partnership with municipalities, universities and private actors. Although policymakers were important for providing strategic direction, quality control and funding, their role was also to facilitate 'dialogue and collaboration between stakeholders that led to the inception of 'regional development coalitions', i.e. bottom-up co-operation between different actors in a local or regional setting based on a socially broad mobilisation and participation' (Campbell and Coenen, 2017). ■

The European Commission has established a smart specialisation pilot to help regions in acute crisis or falling into decline to transform and diversify into new, sustainable economic sectors. It also supports coal regions in transition, and it has established thematic platforms on industrial modernisation, energy and agri-food, enabling policymakers, researchers, business and civil society to pool experience.

17.4 Key enablers of change: cities, finance and knowledge

Three cross-cutting themes stand out as having particular importance in enabling change:

- Cities are crucial for transitions. They are hubs of creativity, innovation and learning, with the capacity to effect systemic change at local scales and to share ideas through city networks. Urban areas also face particular vulnerabilities that necessitate transformative adaptation.

- Finance has a key role in either impeding or enabling sustainability transitions. Today it tends to do more of the former. As the United Nations Environment Programme (UNEP, 2018) notes, 'Clearly, some capital is flowing to the new economy that we need. But far more is continuing to support the old economy.'

- Knowledge is essential for understanding challenges and designing responses. The EU has developed an unrivalled knowledge system to support the design and implementation of established environmental policies, but the emergence of systemic and transformative policy frameworks creates the need for new knowledge and competencies.

17.4.1 Leveraging the potential of cities and city networks

Almost three quarters of the EU's population live in cities, meaning that much of the production-consumption dynamics in European society also resides there. The density of urban populations also creates opportunities for resource-efficient ways of living and means that sustainability initiatives can have considerable impact. The United Nations affirms the role of cities with its New Urban Agenda and through SDG 11 — 'Make cities inclusive, safe, resilient and sustainable'.

In Europe, the EU's 2016 Pact of Amsterdam (establishing the EU urban agenda) arguably marked the start of 'a new role-redefining phase for cities: one in which cities are no longer only the object of EU policymaking, but now also become part of policymaking itself. Since then, cities got a 'seat at the table' of EU governance.' (Potjer and Hajer, 2017).

Transformative adaptation is particularly urgent in cities. This is due to both their physical characteristics (e.g. the heightened impacts of heat waves and flooding) and their concentration of population and economic/cultural assets, which often intensifies economic losses and vulnerabilities, especially for those residents with low incomes or poor health. The dependence of cities on their hinterlands and wider areas for food, water, energy and other essential supplies means that they are vulnerable to climate-related impacts both within the city borders and beyond.

Supporting urban innovation

Cities also provide good settings for engaging citizens, businesses and local governments in innovating and co-creating knowledge and in enabling experimentation and learning. For example, local authorities can trial

solutions on a relatively small scale before rolling them out more widely, or they can experiment with different options in various districts (Heiskanen and Matchoss, 2018). Cities can support social innovation and grassroots initiatives by providing institutional support and resources (e.g. facilitation, access to unused urban space). Stakeholder engagement is often easy to achieve because of the proximity of public authorities, businesses and users. For instance, deploying modern tramways in French cities involved stakeholder consultations and learning processes, leading to ways of handling grievances about disruptions during construction (e.g. through compensation, dialogue, re-routing) (Turnheim and Geels, 2019).

European and national authorities can reinforce urban experimentation by providing additional resources, increasing local powers, and developing criteria and standards for urban sustainability. Maximising the impact of individual initiatives requires sequences of urban projects to build on each other's experience. This can involve intra-city learning — sharing knowledge among initiatives within a city or region, for example through workshops or working groups. It can also take the form of inter-city learning, with flows of knowledge between cities mediated by national, regional or global networks (e.g. Box 17.7). For example, the C40 Climate Leadership Group is a network of global megacities that increasingly sees itself as a key global actor on climate change rather than just a collection of pilot projects. The International Council for Local Environmental Initiatives (ICLEI) increasingly engages with systemic local sustainability transformations (ICLEI, 2015). And the Global Covenant of Mayors for Energy and Climate Change facilitates monitoring and sharing of best practices among more than 7 000 cities worldwide (primarily European) that commit to reducing CO_2 emissions by at least 40 % by 2030 and increasing resilience to climate change.

Public policies are essential to offset inequities and facilitate structural change.

Transitions at city scale

Cities themselves also represent distinct systems that can be transformed. Urban authorities have strategic agency, dedicated budgets and responsibilities for providing local services such as water and sanitation, mobility, energy and waste disposal, particularly in countries benefitting from political decentralisation (e.g. Sweden) or federalism with municipal autonomy (e.g. Germany) (Ehnert et al., 2018). These characteristics create opportunities to stimulate transitions in close interaction with citizens and other actors.

Cities such as Birmingham, Castellón, Frankfurt, Valencia and Wrocław have begun to implement comprehensive urban transition programmes that promote 'stakeholder partnerships to maximise the learning and economies of scale that arise from a focused, concentrated approach' (Climate KIC, 2015). Some large cities are actively reconfiguring local transport systems (tram, bus, cycling, car sharing), district heating or housing, or developing experimental neighbourhoods and urban living labs. Pioneering cities are also setting new targets that sometimes exceed national targets. Table 17.4 shows European city targets for renewable energy. Similar urban targets have been set for heat supply (e.g. renewable heat, district heating or solar thermal heating) and transport (e.g. bans on petrol and diesel cars in Athens, Madrid or Paris) (IRENA, 2018).

At the same time, other cities, towns and regions are trailing behind for a variety of reasons. Larger cities tend to benefit from scale and special institutional and regulatory powers compared with smaller cities. Some may be reluctant to promote transitions because of the economic importance of local (polluting) industries, while others may face challenges in accessing city networks (e.g. because of language barriers). Perhaps most fundamentally, urban authorities may lack the competency, resources or responsibility to pursue transformational approaches. European and national policymakers can help address these disparities by offering financial, technical and administrative support, for example through the EU's URBACT programme.

75 %

of Europeans live in cities — meaning that much of the production-consumption dynamics in European society also reside there.

17.4.2 Financing innovation and investment

Ensuring that public and private investments support sustainability goals is arguably the single most important challenge. Barriers exist at each stage of innovation — from invention through to broad diffusion of technologies, practices and business models. In the earliest stages, the public good characteristics of basic research and uncertainty about

BOX 17.7 HINKU: towards carbon-neutral municipalities

In Finland, municipalities are collaborating to curb their greenhouse gas emissions beyond the requirements of EU targets and schedules. The project 'HINKU: towards carbon-neutral municipalities' brings together local authorities, businesses, experts and citizens to find cost-effective ways of reducing emissions, especially in the transport, housing and food sectors. By 2030, the participants hope to have reduced emissions by 80 % compared with 2007 levels.

HINKU started in 2008 as a network of five small municipalities with 36 000 inhabitants. By 2018, it had expanded to 42 municipalities totalling more than 750 000. The results are positive. HINKU municipalities have already reduced greenhouse gas emissions by 30 %, while creating jobs and improving energy self-sufficiency. Finland's climate and energy legislation, based on international and EU laws, has provided a key driver for the HINKU process. The programme also enjoys support from across the political spectrum and at different levels of government. At the national level, the Finnish Environment Institute (SYKE) coordinates and facilitates the HINKU process, for example by calculating annual greenhouse gas emission inventories for each HINKU municipality, supporting public relations and helping municipalities to access external research funding.

Communication and sharing information and ideas through a common platform are central to the HINKU process. A network for frontrunners — the HINKU forum — helps create innovative solutions and distribute data, experiences and good practices to other localities and stakeholders. Experimentation in municipalities is helping to identify ways of engaging residents and overcoming barriers to the uptake of new technologies. For example, joint procurement of solar panels enables municipalities and households to combine their purchasing power and secure lower costs. First carried out in 2014, joint procurement is now expanding in Finland. ■

Sources: FIBL and IFOAM (2016); FIBL (2019).

TABLE 17.4 Selected European city-wide renewable energy targets

Target	Year	City (country)
100 % renewable energy in total energy mix	2029	Sønderborg (DK)
	2030	Frederikshavn (DK), Malmö (SE), Växjö (SE)
	2040	The Hague (NL)
	2050	Copenhagen (DK), Frankfurt (DE), Hamburg (DE)
100 % renewable energy in electricity mix	2020	Skellefteå (SE)
	2025	Munich (DE)
	2030	Osnabrück (DE)
	2035	Groningen (NL)

Source: IRENA (2018).

returns can deter private firms from investing in R&D, implying an important role for public spending. As innovations move towards commercialisation they may struggle to cross the 'valley of death' — the funding gap that arises as public grants decline, the need for private finance increases, and commercial returns remain low. Finally, the sheer scale of financial resources needed to effect broad diffusion of innovations — in particular, the costs of necessary investments in infrastructure (e.g. housing retrofits, electricity grids, transport systems) — are especially daunting. At each stage, market failures (e.g. environmental externalities) and policy failures (e.g. erratic shifts in incentive structures) deter investment in sustainability innovations and perpetuate the flow of financial resources towards unsustainable modes of production and consumption.

Like other regions, Europe faces problems in each of these areas. In the research domain, in its Europe 2020 strategy (EC, 2010) the EU committed to raise R&D spending to 3 % of GDP by 2020. Despite improving from 1.76 % since 2008, total R&D investment stood well below the target at 2.03 % in 2016. This was substantially below investment in the United States (2.79 %), Japan (3.29 %) and South Korea (4.23 %). In 2015, China also surpassed the EU's investment in R&D (Eurostat, 2018).

R&D investments in sustainability-related domains have fluctuated. Energy R&D more than doubled between 2001 and 2010 (Figure 17.6), benefiting significantly from the stimulus package expenditure in 2009, which aimed to prevent economic collapse after the financial crisis (Grubb et al., 2014). Spending has also diversified significantly, shifting from a heavy (and arguably wasteful) focus on nuclear energy in the 1980s towards a much broader portfolio of low-carbon technologies. Overall, however, spending has not recovered to its peak in the 1980s, and since 2010 it has declined.

Achieving sustainability transitions will require much more ambitious public investment in innovation.

Similar trends are apparent in other important sustainability-related domains. Government spending on R&D in the agriculture, environment and transport areas has increased significantly since the early 2000s in EU countries, with transport in particular receiving a boost after the financial crisis. However, investment has declined in all three areas during recent years (Eurostat, 2019; OECD, 2019), potentially weakening European competitiveness and opportunities for a broad transition.

At the same time, there appears to be growing recognition of the need for much greater public investment in sustainability-oriented R&D. For example, the EU and 24 countries (including some EU Member States), which together account for 80 % of global investment in clean energy R&D, have pledged to double that spending to approximately USD 30 billion annually by 2021 as part of the Mission Innovation initiative. This increase is intended to accelerate significantly the availability of affordable clean energy (Mission Innovation, 2018). There is a strong case for extending this level of ambition beyond a narrow focus on clean energy technologies towards supporting diverse forms of innovation in other domains such as sustainable food and mobility and non-toxic chemicals.

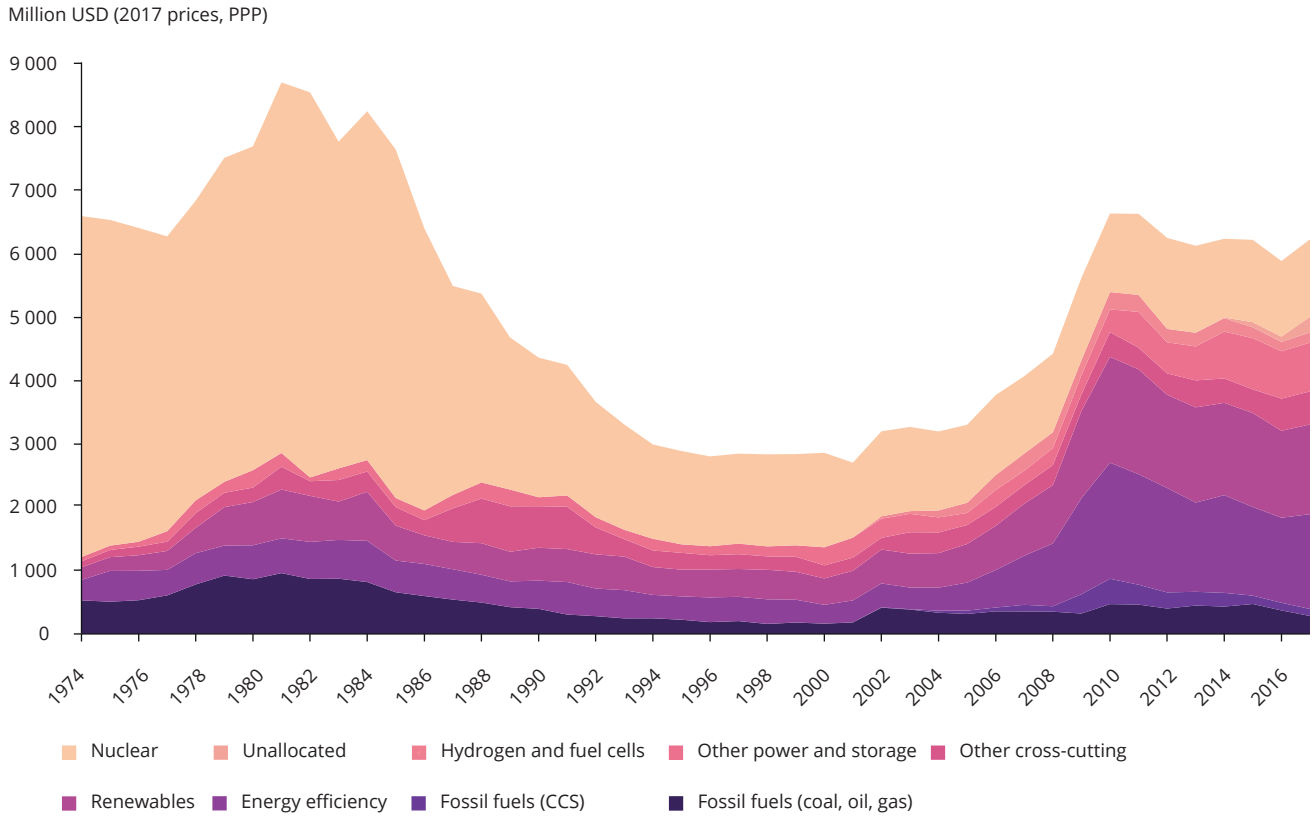
Beyond research, there are concerns about the availability of finance in Europe to support progress towards commercialisation and bridge the 'valley of death'. A variety of private sources of finance can support the commercialisation of innovations, including venture capital, business angels (wealthy entrepreneurs or philanthropists), crowdfunding and blockchain funding. Yet, it is doubtful that these sources alone will ensure the large-scale, long-term and targeted investments needed to address the urgent sustainability challenges facing Europe today (EEA, 2019). This implies a key role for governments in stimulating, orienting and complementing private investments (Saha and Muro, 2017; Sopher, 2017).

Such a role is not without controversy, as it runs counter to prevailing reasoning, which promotes markets as the primary engine of innovation and recommends that public policy focus on correcting market failures. Yet, ambitious public investments played foundational roles in many of the most transformative innovations during the 20th century (Auerswald and Branscomb, 2003; Mazzucato, 2015). Achieving sustainability transitions is likely to require even greater levels of ambition, engagement and risk-taking from the state, accompanied by a willingness to accept failures alongside successes (Mazzucato and Perez, 2015).

Financing diffusion and fixed capital formation

Broader diffusion of innovations and development of related infrastructure will require huge investments. For example, the United Nations Conference on Trade and Development (UNCTAD, 2014) estimates that achieving the SDGs will require global investments of USD 5-7 trillion annually. Simply meeting Europe's 2030 climate change targets will require additional funding

FIGURE 17.6 Trends in energy R&D spending in Europe by technology (based on IEA estimates)



Note: CCS, carbon capture and storage; PPP, purchasing power parity.

Source: IEA (2018c).

Diffusion of clean technologies and the transformation of whole production-consumption systems will require huge investments.

of EUR 180 billion annually (EC, 2018e). These vast sums appear broadly attainable when seen in the context of total investment (gross capital formation) in the global economy (USD 20.0 trillion in 2017) and in Europe (USD 3.5 trillion) (World Bank, 2018). But they will evidently entail a significant reorientation of public and private spending across society.

Financing socio-technical transitions will necessarily draw on a diverse array of interacting funding sources, including institutional investors. As noted in the European Commission's sustainable finance action plan, 'Banks, insurance companies and pension funds are the main source of external finance for the European economy and … could provide the critical mass of investments needed to close the gap for the transition to a more sustainable economy' (EC, 2018f). At present, however, financial resources primarily consolidate established modes of production and consumption. For example, pension funds and insurance companies allocate just 1-2 % of their assets to 'green sectors' compared with the 5-10 % distributed to 'brown' sectors, such as oil, gas and coal, and the 20-25 % put into other high-carbon sectors, such as metals, chemicals, transport and automobiles (Rademaekers et al., 2017).

Public authorities, households and end-users (e.g. vehicle owners) also have a central role in financing transitions, reflecting the investments needed in demand-side sectors, notably buildings and transport. Rademaekers et al. (2017) estimate, for example, that achieving the EU's 2030 climate and energy targets will require more than EUR 1 trillion of investments in transport and buildings in the period 2021-2030 compared with less than EUR 80 billion for power generation and the electricity grid.

Collectively, these different public and private actors arguably have the resources to finance transitions, yet a variety of barriers and market failures deter such investments. For example, many sustainability innovations have unattractive risk/return profiles. Concerns about stranded assets may encourage investors to lobby against policies promoting systemic change. Public investments are constrained by weak economic growth and a continued focus on fiscal consolidation. Many end-users are prevented from investing in cost-saving efficiency improvements by often daunting upfront costs.

Public policy tools can help create markets for sustainability innovations by clearly signalling the intended development pathways, thereby reducing risks and stimulating investment. For example, the EU is broadly on track to achieve its target of allocating 20 % of its budget to climate action under the Multiannual Financial Framework 2014-2020. The European Commission proposes to increase this to 25 % in the 2021-2027 time frame (EC, 2018c). Furthermore, public procurement of goods and services amounts to 16 % of GDP in the EU (EC, 2017e), implying that it can also provide a major stimulus for innovation and diffusion. Other tools include taxes and subsidies, feed-in tariffs, tradable permits and obligations to use energy from renewable sources. For such interventions to be effective, however, it is essential that the policy signals are robust and stable. Sudden shifts in policy represent an important source of risk that can significantly undermine investor confidence.

Combining investment sources through 'blended finance' mechanisms can also increase financial flows (OECD, 2018b). For example, investments by development banks or government agencies that cover the high-risk tranches of investments can stimulate private investment. This is the logic behind the EU's European Fund for Strategic Investments, which aims to catalyse investment of at least EUR 0.5 trillion, with 40 % targeting innovation and infrastructure projects that contribute to climate action.

Another important barrier to investment by banks and institutional investors is a reported shortage of high-quality and sizeable projects that promise stable investment returns (Rademaekers et al., 2017). Energy efficiency investments, for example, are often small and distributed across numerous households and businesses, implying high transaction costs. Responding to this challenge is likely to involve developing technical and knowledge capacity — for example at city level — to help ensure a steady flow of good-quality projects (OECD, 2018a). Another useful approach involves aggregating small projects into a larger pool to attract investment, for example by securitising green mortgages used to finance residential retrofits. As households will need to provide a substantial proportion of the investment to achieve Europe's climate targets, it will be particularly important to find ways to help them meet these costs (e.g. Box 17.8). Elaborating government guidelines on green securitisation could support the development of this market (Aldersgate Group, 2018).

Green bonds provide another mechanism to increase large-scale institutional investments. The green bond market has expanded very rapidly, rising from a global issuance of USD 3.4 billion in 2012 to USD 161 billion in 2017, in part because of the availability of secondary markets for investments. However, optimism about the rapid growth of green bonds needs to be tempered. First, increased transparency is needed to ensure that they are not used for 'greenwashing' (Aldersgate Group, 2018). Second, despite rapid growth, green bonds account for less than 1 % of the global bond market. The flow of investment into fossil fuel exploitation continues to dwarf global investments in renewables (OECD, 2018a).

Additional measures could seek to reformulate institutional rules and formal expectations of financial actors. For instance, pursuant to its action plan on financing sustainable growth, the European Commission plans to develop a unified classification system (to better define what counts as sustainable finance); develop standards and labels for sustainable financial products (including green bonds); better integrate sustainability in ratings and research by credit-rating agencies; change the fiduciary duties of institutional investors and asset managers, so that they more systematically consider sustainability factors and risks in investment processes; strengthen disclosure responsibilities and accounting rules, so that companies are required to inform investors about sustainability performance and risks; and assess the possible negative impact of the Basel III regulatory framework on European bank lending, investment and other activities, which are critical for sustainable finance.

By signalling intended development pathways, public policies can reduce risks and stimulate investment.

BOX 17.8 Energiesprong

Shifting to energy-efficient buildings is a huge challenge. The EU requires all new houses to be 'zero energy' by 2021, meaning that they produce as much energy as they use on heating, lighting, and so on. However, new houses represent only a tiny proportion of the continent's total housing stock. As about 40 % of Europe's CO_2 emissions come from heating and lighting in buildings, retrofitting existing buildings is crucial for climate change mitigation. Unfortunately, this requires a substantial investment from homeowners.

Launched in 2010, the Dutch initiative Energiesprong — later expanded to France, the United Kingdom, Germany and North America — tackles this financial obstacle with a clever shift in perspective. Dutch households spend about EUR 13 billion on energy each year. If, instead, they were to use the same money to repay a long-term loan, then it would effectively free up about EUR 225 million today to invest in the housing stock, which is equivalent to between EUR 30 000 and EUR 40 000 per household.

Energiesprong succeeds by coordinating relevant sectors and identifying 'win-win' solutions. Banks were persuaded to finance energy refurbishments because Energiesprong secured a 30-year energy performance warranty on refurbished homes and brokered a deal to refurbish 111 000 housing association properties. The building sector and the economy as a whole also stand to gain from these big investments, and households benefit from better insulated homes, higher property values and more spending power once loans are repaid.

Experimentation and learning have played an important role in upscaling the programme. A focus on reducing costs in the initial phase resulted in a 30 % improvement in the price-performance ratio, greatly improving the initiative's financial viability. Reducing the renovation time to 1 week per dwelling likewise made the process more appealing to homeowners. As the programme extends into other countries, economies of scale and continued innovation should drive further improvements in performance.■

Sources: FIBL and IFOAM (2016); FIBL (2019).

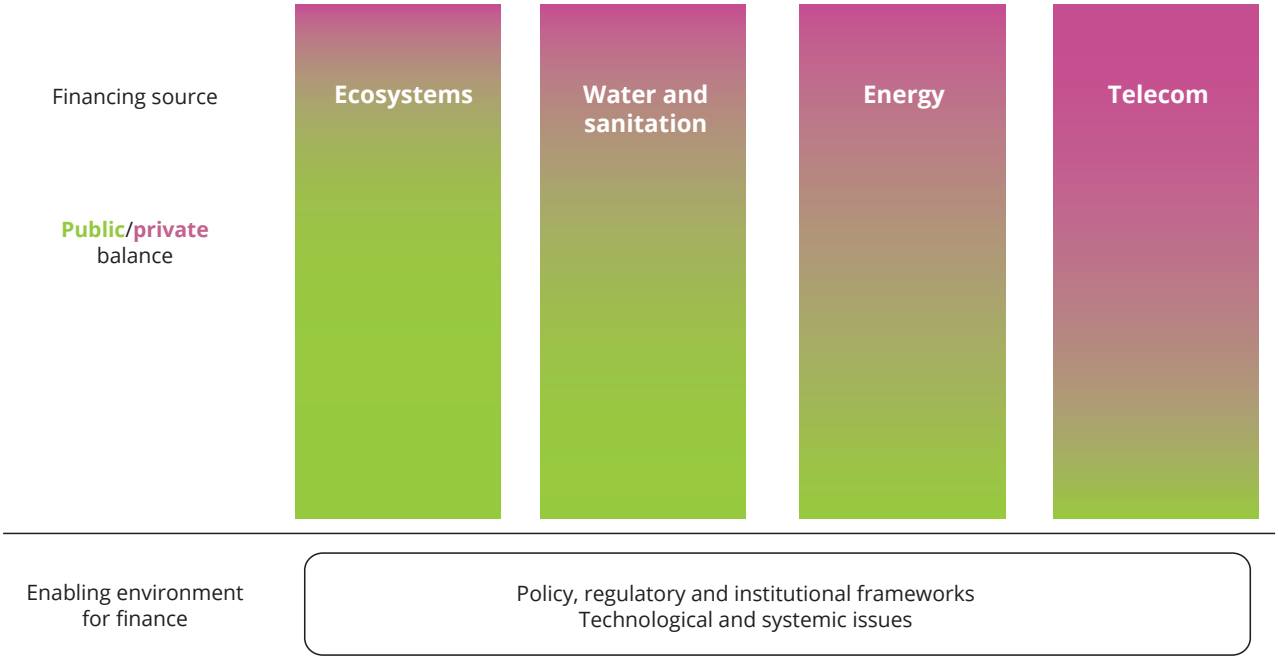
Investing in natural capital

Investments in green infrastructure and nature-based solutions enhance ecological resilience and society's capacity to transform and adapt, often delivering benefits that far exceed their costs. In its landmark study on land degradation, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2018) found that timely action to avoid, reduce and reverse land degradation is essential for achieving the majority of the SDGs and would deliver co-benefits for nearly all of them. In addition to enhancing biodiversity and ecosystem services, the benefits of restoration include increased employment, increased business spending, improved gender equity, increased local investment in education and improved livelihoods. Moreover, the value of these benefits is, on average, 10 times the cost.

Nevertheless such investments often face major barriers. These include a lack of awareness about potential benefits, limited design and implementation capacities, and strong vested interests in developing grey infrastructure. Whereas grey infrastructure investments often deliver immediate returns, benefits from green solutions can take 10-15 years to realise. Perhaps most importantly, the benefits of investments in nature often have public good characteristics, meaning that they accrue to society generally rather than to private actors. As private actors often have weak incentives to invest, there is often a significant role for the public sector (UN, 2018; Figure 17.7), either as the sole source of finance or in motivating private spending (e.g. through co-financing or planning requirements). The European Investment Bank's Natural Capital Financing Facility exemplifies this approach, providing funding to projects that promote conservation, restoration, management and enhancement of natural capital, including ecosystem-based solutions (EIB, 2019).

Bottom-up innovations in finance provide another potential source of funding for green infrastructure and nature-based solutions (Toxopeus

FIGURE 17.7 The continuum of public and private finance in achieving the SDGs



Source: UN (2018).

and Polzin, 2017). For example, crowdfunding provides a mechanism for spreading the costs of investments across a large group of people, which corresponds well with the dispersed benefits arising from environmental public goods (see also Box 17.9).

17.4.3 Knowledge and skills to support transformative policy

The knowledge systems that developed to support environmental governance during the 20th century were well adapted to the challenges and thinking of that time. Confidence in the capacities of governments to plan and steer societal development using regulations and economic instruments underpinned the widespread use of rational analytical approaches, such as modelling, grounded in assumptions of mainstream economics about how people respond to incentives, individually and collectively. These analytical approaches remain essential, but it is increasingly clear that they are not sufficient.

Investing in natural capital often delivers benefits that far exceed costs.

Integrated assessment modelling, for example, provides many valuable insights — helping to set agendas and long-term targets; identify lowest cost pathways and optimal configurations of technologies; communicate urgency and costs of delay; and map out trade-offs and distributional impacts associated with systemic change (van Vuuren and Hof, 2018). Like all analytical perspectives, however, it has important limitations and blind spots, which can lead to it providing misleading guidance if used in isolation. In particular, it neglects many of the fundamental characteristics of transitions, such as the role of shocks, non-linearities, resistance, radical

BOX 17.9
Crowdfunding bottom-up initiatives in Ghent

To moderate climate change impacts, Ghent is seeking to create more green areas in the city. In keeping with the city's reputation for being social and creative, local authorities are seeking to actively engage citizens in developing bottom-up initiatives. Since many of these small-scale projects face difficulties securing finance, Ghent has developed a crowdfunding platform that allows citizens to propose and finance their ideas for the city. Two projects addressing climate adaptation have been successfully realised with the support of the crowdfunding. gent platform. Both promote creating green spaces and food production in the city, one by creating mini-gardens on balconies in social housing and the other by transforming stone facades into vertical gardens. In addition to providing food, these initiatives support biodiversity, mitigate extreme temperatures and reduce greenhouse gas emissions. The projects are small compared with global climate change challenges. However, the crowdfunding platform has proved to be an excellent instrument for realising small drops of climate mitigation and adaptation measures that have the opportunity to generate larger ripple effects. ■

innovation, actors and institutions, social practices and behavioural shifts.

The inherently uncertain, exploratory and open-ended character of transitions creates the need for a much broader range of knowledge to support governance. This includes a need for much better understanding about complex societal systems, including the interactions, lock-ins and feedbacks that influence sustainability outcomes, social acceptance and political feasibility. Identifying the opportunities and risks associated with systemic change also requires better information about the impacts of drivers of change and cross-system interactions.

Ecosystem-based management requires accounting systems that monitor and assess the cumulative impacts of environmental pressures from multiple sectors. This can support assessment of the economic and social risks and costs that arise from continued degradation of ecosystems. The globalised character of modern production-consumption systems implies a need for a better understanding of Europe's environmental and social footprint to help inform the governance of transitions.

The importance of innovation for transitions necessitates a knowledge system that enables society to learn from successes and failures, replicate and upscale promising initiatives, identify unexpected consequences, and avoid lock-ins to unsustainable innovation pathways. Identifying goals and pathways requires information about the interests and preferences of different groups and their visions for the future. And the viability and credibility of polycentric governance hinges on the presence of robust monitoring and reporting systems that meet user needs.

To the extent that it is currently available, knowledge about these themes resides in multiple disciplines

Enabling sustainability transitions will require a transformation of the knowledge system supporting governance.

and with diverse actors across society, making only a limited contribution to policy and governance. As stated in the Amsterdam Declaration on global change (IGBP et al., 2001), 'A new system of global environmental science is required. … It will draw strongly on the existing and expanding disciplinary base of global change science; integrate across disciplines, environment and development issues and the natural and social sciences; collaborate across national boundaries on the basis of shared and secure infrastructure.'

Supporting sustainability transitions will therefore require actions such as pluralising evaluations — combining multiple analytical approaches and engaging with different research communities; engaging with societal concerns — recognising different viewpoints and preferences through interactions with diverse social actors and stakeholders; attending to real-world complexities — tracking developments in existing systems and abstracting lessons from (local) initiatives; and co-creating knowledge — ensuring that the knowledge is relevant, actionable and understandable by engaging decision-makers and other stakeholders in knowledge co-production. The last point especially is much easier said than done.

Developing and using new forms of knowledge often requires that policymakers and other actors have access to relevant concepts, competencies and institutional mechanisms. These include, for example, the need to develop

an understanding of system and transitions concepts; the need to develop skills in participatory foresight techniques that enable different actors to explore possible futures; the need for stakeholder engagement skills and platforms that enable policymakers to engage with business, NGOs, citizens, researchers and others; and the need for a governance culture that promotes experimentation and acknowledges the need to accept and learn from failures.

More broadly, there is a need to create networks that can tap into, organise and communicate the knowledge dispersed across society. Intermediary organisations that bridge between science, policy and society will have an important role. Similarly, the emergence of 'platforms of action' (e.g. under the Paris Agreement and the EU's circular economy action plan) provide a novel means of collating and sharing practice-based evidence among non-state and public actors. Making the most of their potential will require developing new methods to categorise and use this kind of knowledge (Steward, 2018).

17.5 Governance of innovation, innovations in governance

In combining state actions across multiple policy domains with bottom-up innovation and experimentation, sustainability transitions involve difficult governance challenges. How, for example, can such complex, dispersed and emergent processes be steered towards multiple, long-term sustainability goals? How can societies achieve coherence across policy domains and levels of governance? How can the inevitable risks and uncertainties associated with systemic change be managed? This section explores these questions. It concludes with reflections on how regions can combine different approaches to governance to manage nature-society interactions within environmental limits.

Developing shared visions for long-term development can inspire and guide action at different scales of governance.

17.5.1 Setting the direction for transitions

Unlike most past transformations of production-consumption systems, sustainability transitions are purposeful and directional. Although the future of society cannot be known in advance, the desired outcomes are reasonably clearly defined — most prominently in the SDGs but also in the growing body of long-term visions and targets in instruments such as the Paris Agreement and the EU's long-term framework policies addressing themes such as climate, energy, mobility and biodiversity.

Developing ambitious macro-level visions and goals is an important first step in guiding transitions in desirable directions. Visions can help in identifying possible alternative ways to meet social needs, tackle the problems that need to be solved and define the roles of different actors. Perhaps most importantly, they provide a shared narrative for actors across society, extending beyond electoral cycles and short-term objectives. This can help in coordinating activities and steering innovation, learning processes and investments (Smith et al., 2005; Hekkert et al., 2007).

In an increasingly complex and fragmented governance context, such visions and associated narratives can have a powerful influence on both state and non-state actors. For example, many EU Member States have responded to the EU circular economy strategy by voluntarily preparing national circular economy plans (see Chapter 9). At the sub-national level, regional governments and cities are committing to reductions in greenhouse gas emissions that often exceed national targets (Averchenkova et al., 2017; see also Chapter 7). In the United States, withdrawal from the Paris Agreement has prompted more than 2 000 American businesses, 280 cities and counties, and 340 colleges and universities to announce that they are still in the Agreement and determined to achieve the United States' commitment on emissions (Watts, 2017).

Visions and associated pathways are inherently normative, as they involve choices, trade-offs and prioritisation of certain goals and values over others. Societal actors are likely to have very different perspectives on how to move forwards, even if they agree on the overarching sustainability goals. This underlines the need to develop visions through collaborative processes that involve state, business and civil society actors. Achieving this is often difficult because stakeholders vary greatly in their priorities, resources, values and discourses.

Visioning and other foresight approaches can help actors to explore alternative futures systematically and collectively. As noted in the EU's better regulation toolbox (EC, 2018a), 'Foresight and other forward-looking tools complement quantitative modelling with a system thinking and long-term approach. … They facilitate thinking out-of-the-box. The objective is to engage with different possible futures (e.g. providing alternative futures) and challenge present assumptions thereby broadening the policy horizon.' Such approaches are not only about cognitive outcomes (based on expert judgements), but also

about using creative and participatory processes to foster communication, learning, agreement and commitment.

Visions count for little if they are not translated into actions. It is therefore important to involve political actors (or those with political influence) in developing them. There is also a need to translate visions and goals into concrete policies and projects, backed up by specific targets, implementing agencies and monitoring frameworks. Backcasting is often used to translate future goals into a range of transition pathways, which can then be used to develop policy strategies and programmes (Figure 17.8).

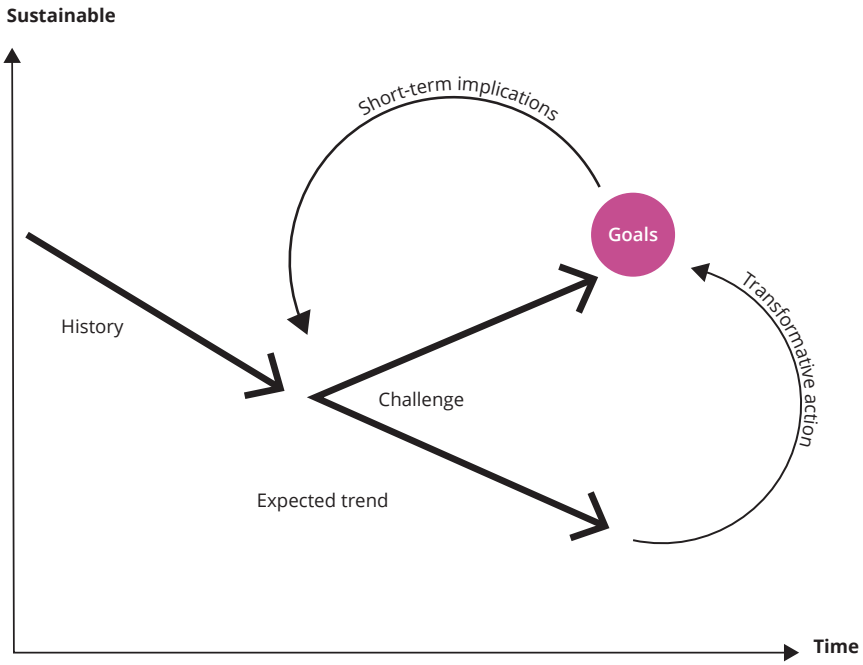
Within Europe, the process of translating visions into targets is well advanced in some policy areas. For example, the EU's 2011 *Roadmap for moving to a competitive low carbon economy in 2050* (EC, 2011) used modelling and scenario analysis to map out milestones and sectoral reductions needed to achieve the EU's 2050 target of reducing greenhouse gas emissions by 80-95 %. Subsequent frameworks have elaborated much more detailed targets and measures to achieve the long-term goal.

Similarly, the EU's circular economy action plan (EC, 2015a) articulates a vision and breaks it down into more concrete sub-goals and focus areas addressing topics such as plastics, waste and critical raw materials. In contrast, the food domain lacks an overarching sustainability vision and long-term goals, making it hard to develop policies and targets to support food system transitions. The SDGs and existing EU strategies can provide a foundation for engaging stakeholders and developing a shared vision for the food system.

Another mechanism for translating broad visions into concrete actions comes in the form of missions that convey a sense of urgency and common purpose, thereby stimulating innovation and investments. As outlined by Mazzucato (2018), targeted missions provide a means of bridging between macro-level goals or challenges and micro-level projects and experimentation (Figure 17.9).

Like broader visions, missions are intended to be motivational and foster bottom-up activity, as well as creating a frame for target setting and monitoring. However, by shifting the focus from broad challenges to more specific and ambitious but achievable problems (e.g. achieving 100 carbon-neutral cities in Europe by 2030) they provide a more specific focus for research, investment and economic growth. In this way, they aim to promote collaboration between all actors in the innovation ecosystem, including corporations and disruptive start-ups, public institutions and users (RISE, 2018).

FIGURE 17.8 Backcasting analysis

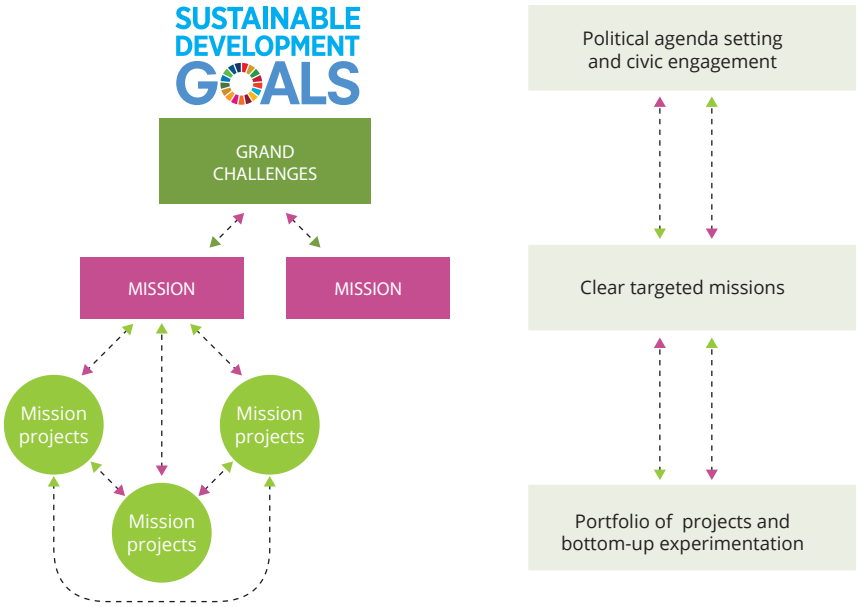


Source: van Vuuren and Hof (2018).

17.5.2 Coherence across policy domains and levels of governance

Systemic changes necessarily link to a broad range of policy domains, extending well beyond environment and sectoral policies, such as energy and agriculture, to embrace cross-cutting areas such as innovation, competition, tax, industry, education and welfare (Figure 17.10). Actions in each of these areas contribute to stimulating, orienting and facilitating systemic change. In practice, however, the fact that policies — at all levels of governance — are often developed in departmental silos with contrasting objectives and expertise means that misalignments and conflicts are inevitable (Section 16.6). This incoherence can slow down transition processes, creating contradictory signals about the direction of travel and deterring investments (OECD, 2015).

FIGURE 17.9 From challenges to missions



Source: Mazzucato (2018).

Actions to improve coherence are therefore important.

At the EU level, measures to enhance coordination include the better regulation agenda and the European Semester process (EC, 2019a, 2019c). Both contribute to improved environmental governance, for example through fitness checks of environmental legislation and the greening of the European Semester (EC, 2019b).

While EU policies can provide an important impetus for sustainability transitions across Europe, transitions are reliant to a very large degree on policy decisions and activities at Member State, regional or local levels. These different governance levels vary not only in their capacities but also in the barriers that they face, implying that they each contribute in different ways to transition processes. It is therefore important to achieve effective multi-level and multi-actor governance, with policy actions at each level reinforcing each other, exploiting opportunities and overcoming barriers.

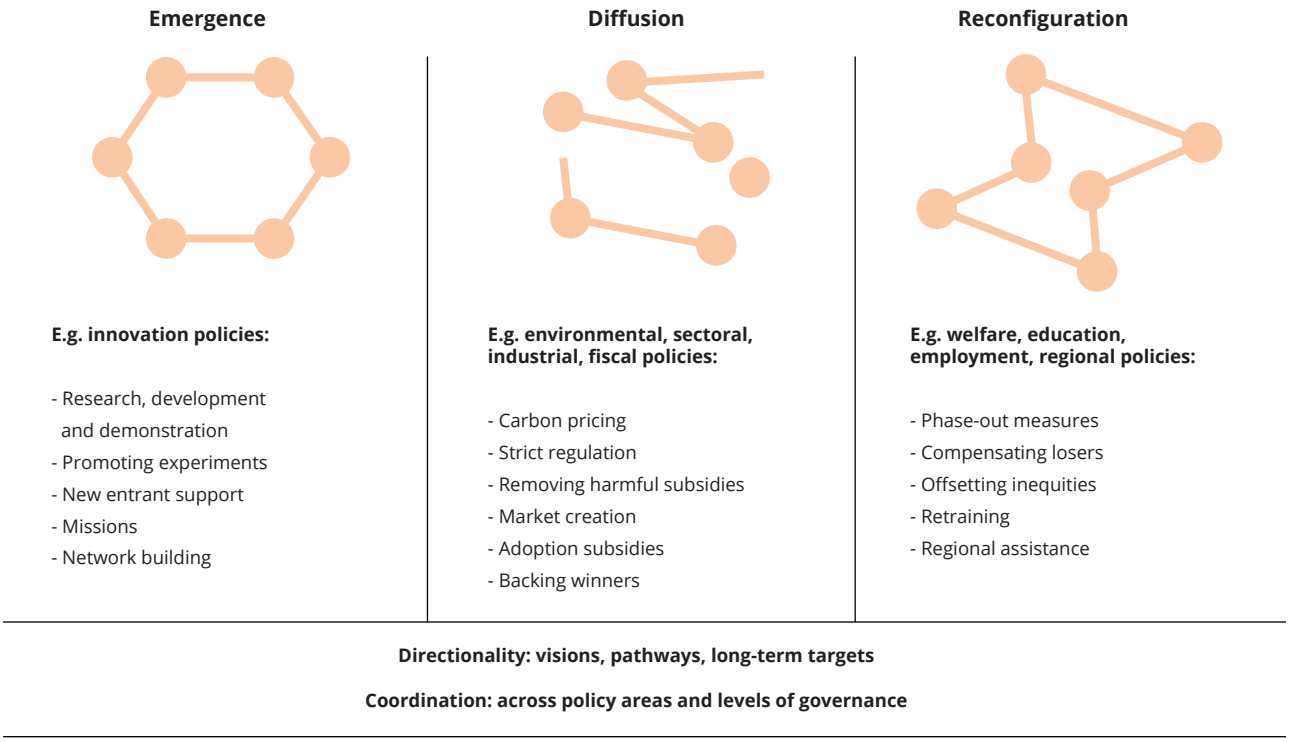
Misalignments can take a variety of forms. At the broadest level, policymakers may be pursuing inherently inconsistent policy goals (Rogge and Reichardt, 2016; Kern et al., 2017). For example, policies that subsidise renewables to make them more competitive may coexist with subsidies to fossil fuel-based industries that aim to support employment. In other instances, incoherent instruments can create barriers to change. In Finland, for example, operators of some new transport services found it extremely difficult to get the necessary permits to operate, as they could not be classified as taxis or goods transport (Temmes et al., 2014).

At the EU level, the European Commission has identified a variety of barriers that hinder the emergence and diffusion of innovation, including product market regulation, competition rules, market fragmentation, risk aversion and access to seed and start-up capital (EC, 2016b, 2017d, 2018d). As a result, 'Disruptive and breakthrough innovations are still too rare in Europe' (EC, 2018d). More generally, existing policies and rules are often geared towards established ways of meeting needs and may actively support them through subsidies or public procurement. As such, mapping and reducing barriers — temporarily or permanently — is an important step in creating niches for innovation.

Coordination can be further enhanced by organisational innovations, such as super-ministries that combine policy domains, political advisers with cross-departmental remits, inter-ministerial committees or independent units (OECD, 2015), such as a transitions unit in the prime minister's office. Many examples of such innovations exist in relation to climate and energy policy, and new initiatives are also emerging in some areas, for example Spain's Circular Economy Inter-ministerial Committee. There would be benefits in developing such mechanisms to address sustainability transitions, building on the experience of national sustainable development committees and ministries.

City networks represent another useful institutional mechanism to coordinate actions across levels of governance. For example, the Eurocities network specifically aims to reinforce the role of local governments in multi-level governance by helping enable cities to deliver on the EU's strategic priorities. As well as connecting cities directly to EU-level policymaking, it provides a platform for knowledge sharing among the local governments of more

FIGURE 17.10 Policy mixes for sustainability transitions



Source: Adapted from Geels (2006).

Systemic changes link to a broad range of policies including energy, agriculture, innovation, competition, tax, industry, education and welfare.

than 140 of Europe's largest cities, accounting for 130 million citizens.

The EU's strategic policies relating to the circular economy, the low-carbon economy and the bioeconomy represent key frameworks for coordinating the diverse actions needed to achieve economic transformation (EC, 2011, 2015a, 2018b). As the European Commission has noted in its reflection paper on the 2030 sustainability agenda (EC, 2019d), 'If we are to succeed, we must pull in the same direction at all levels. It is therefore of the utmost importance that all actors in the EU prioritise the sustainability transition. They must further develop the cross-cutting policy agendas that have been adopted at the EU level in recent years.'

While developing more cross-cutting frameworks would certainly be valuable, it is important to stress that such frameworks are likely to be misaligned. As emphasised in Section 16.6, this underlines the need for careful assessment of synergies and trade-offs, including those resulting from shared reliance on a limited natural resource base.

17.5.3 Avoiding potential harms in transition processes

From a risk management perspective, it is essential that societies promote innovations that contribute to sustainability goals and constrain those that are harmful. In practice, however, the impacts of new technologies and ideas are very hard to anticipate because they depend to a large degree on how innovations are used and integrated into ways of living and how they interact with other complex systems and drivers of change.

Novel chemicals, for example, can present direct threats to human and environmental health, and the accumulation and interaction of such substances in the environment

or within organisms can amplify uncertainties. Similarly, the interplay of innovations and social responses may produce counter-productive outcomes, for example if car-sharing schemes cause people to cycle or walk less (Rademaekers et al., 2018). Interdependencies between systems can produce unexpected harms, such as the deforestation and food price increases that accompanied expanded biofuel production in the early 2000s. Structural economic change is sure to create winners and losers, potentially affecting whole regions.

These realities create difficult dilemmas. In many cases, the social and environmental consequences of innovations cannot be anticipated; by the time they do become apparent, widespread diffusion and associated lock-ins may make the innovation very difficult to remove (Collingridge, 1980). Yet, Europe cannot afford not to innovate. Inaction greatly increases environmental risks and has severe human and financial consequences.

Research and practice point to a variety of strategies for responding to these dilemmas. First, governments and other actors can certainly do better at exploring and identifying potential risks *ex ante*, building on existing impact assessment approaches and employing a variety of tools and analytical approaches. Such approaches must go well beyond simple forecasting exercises, based on historical data. Instead, the International Risk Governance Council (IRGC, 2018) recommends combining foresight approaches (which employ participatory approaches to map out possible futures, risks and opportunities) with 'broadsight' approaches that explore outcomes in horizontally interconnected systems.

The 'resource nexus' perspective employed to explore cross-system interactions in Chapter 16 exemplifies the latter approach. Other valuable

Promoting diversity in innovation is vital to increase creativity, mitigate lock-ins, hedge against surprises and enable learning.

techniques include horizon scanning to identify and interpret weak signals of potentially important developments (Box 17.10); developing scenarios for possible future changes in systems as a means of identifying potential risks or windows or opportunity; modelling of pathways to explore impacts and trade-offs, or using agent-based or system dynamics models to explore potential changes in systems (EEA, 2018).

Although potential hazards must be identified as early and accurately as possible, the non-linear and open-ended nature of systemic change (as well as the pace and scale of technological innovation) mean that assessing and mitigating all risks in advance is impossible. Societies do not know what innovations will emerge, how they will influence and co-evolve with social practices, and what environmental and social impacts will emerge. These are 'unknown unknowns' — issues of fundamental uncertainty, rather than risks that can be assessed and balanced. In such situations, the precautionary principle provides a useful tool to support decision-making.

The precautionary principle stipulates that, where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. Although this is sometimes interpreted as a barrier to technological progress, a more nuanced understanding casts the precautionary principle as a source of guidance in situations in which risk assessment tools are inadequate. Rather than automatically requiring bans on potentially harmful innovation, it opens up a range of response strategies centred on acknowledging ignorance and uncertainty. These include the need to need to 'consider alternatives, explore uncertainties, maximise learning and promote adaptability in careful, reversible, step-by-step implementation' (Stirling, 2015).

Promoting diversity in innovation is essential because it nurtures creativity, mitigates lock-ins, hedges against surprises, enables learning and increases tolerance of failure of individual innovations. It provides the foundation for shifting to alternative innovation pathways in the event of surprises or unexpected consequences. But achieving this goal requires that diversity be complemented with real-world pilots and trialling, monitoring and evaluation, learning and communication.

These themes come together in adaptive governance approaches such as 'transitions management', which addresses change in socio-technical systems such as energy and mobility, and 'adaptive management', which focuses on nature-society interactions. Both acknowledge the risks and uncertainties inherent in transforming complex systems and seek to navigate these processes through iterative cycles of vision setting, experimentation, monitoring and evaluation. They put particular emphasis on the importance of social learning and stakeholder participation, reflecting the uncertain and pluralistic nature of knowledge (Foxon et al., 2008).

Applying a precautionary approach ultimately raises questions about the purpose and direction of innovation — questions that fall outside the focus of narrow forms of risk assessment and are often brushed

BOX 17.10 Identifying emerging risks and opportunities for Europe's environment and policies

Even when successful in its original intended use, innovation can result in unexpected and harmful consequences for the environment and human health. As numerous historical examples illustrate, mitigating harmful impacts requires identifying potential hazards as early and accurately as possible (EEA, 2001, 2013). In addition to enabling interventions to limit impacts, early warning can help stimulate the development of substitutes, hence contributing to sustainable innovation.

The increasing rate and complexity of technological and societal change (Chapters 1 and 15) means that early warning systems need to anticipate risks and opportunities that are not yet observable (Science for Environment Policy, 2016). Emerging risks can result from the introduction of radically new products or technologies (e.g. synthetic biology, artificial meat), the changing context in which they operate (e.g. climate change) or systemic effects related to radical transformations (e.g. energy systems). Another kind of challenge is associated with the public's risk perception, as some technological innovations can be met with more societal protest or controversy than expected (e.g. first-generation biofuels, wind turbines, nanotechnologies, genetically modified organisms), especially in times of decreasing trust in institutions and experts.

Against this backdrop, the Seventh Environment Action Programme calls for improvements in 'the understanding of, and the ability to evaluate and manage, emerging environmental and climate risks' (EC, 2013b). In 2017, the Environment Knowledge Community (EKC) ([1]) established the EU foresight system for the systematic identification of emerging environmental issues (FORENV) 'to identify, characterise and assess emerging issues that may represent risks or opportunities to Europe's environment'. FORENV adopts a systematic and participatory approach to risk management, building on methodologies such as horizon scanning, text mining or media monitoring (EC, 2017f) and on relevant expertise. In particular, it links with the Scientific Committee on Health, Environmental and Emerging Risks (SCHEER) and the Eionet Forward-Looking Information and Services (FLIS) representatives from EEA member countries. The first 2018-2019 annual cycle is focusing on identifying key emerging issues at the environment-social interface and communicating them to policymakers and the public at large, encouraging appropriate and timely action. ■

aside by popular discourses about the value of innovation. For example, Genus and Stirling (2018) argue that 'Taken as a whole, EU initiatives and policies tend to characterise innovation in an undifferentiated way — as a self-evidently generally 'good thing' irrespective of the specific kind of innovation involved or the alternatives that might thereby be foreclosed.' A more precautionary approach — including open, participatory approaches to define directionality — is in tune with the EU's concept of Responsible Research and Innovation (EC, 2014a), and very much at the heart of the shift to mission-oriented and transformative innovation policy.

17.5.4 Managing system interactions within environmental limits

As discussed in Section 16.5, production-consumption systems interact in many ways — both with each other and with ecosystems, for example through the resource nexus. Achieving Europe's long-term sustainability goals will therefore depend on governance approaches that reflect these interactions and help ensure that systems operate together within environmental limits.

Ecosystem-based management has emerged as a key governance approach for addressing the many interactions within and between society and nature. Ecosystem-based management aims to coordinate the interactions between multiple actors and sustainability outcomes in ways that preserve ecosystem services and ensure that society operates within environmental limits.

([1]) The Environment Knowledge Community is an informal platform of five Commission Directorates-General (for Environment, Climate Action and Research and Innovation, the Joint Research Centre, Eurostat) and the EEA that was set up in 2015 with the objective of improving the generation and sharing of environmental knowledge for EU policies.

In practice, ecosystem-based management brings together many of the features of innovative governance already highlighted in this section. In addition to being a distinctively 'place-based' governance approach, ecosystem-based management involves (McLeod and Leslie, 2009; NOAA, 2018):

- Engaging multiple actors: Rather than addressing individual sectors, ecosystem-based management highlights the importance of interactions between stakeholders in a socio-ecological system and their cumulative impacts on the environment. This includes engaging actors at different levels — from local to global — in coordinating actions and sharing data.

- Actions towards shared targets: Engaging sectors, public authorities and other actors is achieved by defining shared targets linked to ecosystem functioning. For example, the Water Framework Directive requires that water bodies achieve good ecological status across a variety of biological, hydromorphological and physico-chemical characteristics.

- Focusing on diverse sustainability outcomes: Ecosystem-based management captures the full range of benefits associated with maintaining ecosystem service flows, as well as the trade-offs inherent in reconciling the activities of multiple sectors and other actors at a particular spatial scale.

- Monitoring and adaptive governance: Recognising that complex systems are constantly changing in ways that cannot be predicted or controlled, ecosystem-based management embraces an adaptive governance style, grounded in flexible and innovative institutions that are highly responsive to new information and experiences.

- Multidisciplinarity: Understanding the interactions of multiple societal and ecological systems requires broad knowledge, including 'synthesizing and applying knowledge from across social and natural sciences, as well as the humanities' (Leslie and McLeod, 2007).

Ecosystem-based approaches help in understanding environmental trends and coordinating collective action to preserve natural capital.

Within EU governance, ecosystem-based management underpins some of the key environmental policies that together contribute to implementing the EU biodiversity strategy, notably the Water Framework Directive and the Marine Strategy Framework Directive. Since their introduction, these tools have enabled a shift in governance, bringing together sectors and Member States to consider and balance their collective interests and assess the cumulative pressures that they are placing on particular regions (EEA, 2015a).

The shift to a systems approach in EU environmental governance is not simple, because it challenges established knowledge, skills, decision making processes and structures (Voulvoulis et al., 2017). Perhaps, partly for these reasons, Europe still has a long way to go to achieve good status in its freshwater and marine ecosystems (as discussed in Part 2 of this report). Nevertheless, adopting ecosystem-based approaches provides an essential starting point for understanding the links between ecological status and the diverse pressures imposed by society and for coordinating collective action in ways that preserve Europe's natural capital. As such, there could be significant value in strengthening the implementation of ecosystem-based management and extending its use in EU environmental policy.

Overall, ecosystem-based management provides a natural complement to the transitions frameworks described in this chapter. Whereas the multi-level perspective is much stronger than ecosystem-based management in explaining the dynamics of change in production-consumption systems, it gives limited consideration to cross-system interactions and environmental impacts and thresholds. In contrast, ecosystem-based management addresses precisely these kinds of interlinkages and effects, using ecological criteria, and exploring them at the spatial scales most appropriate for managing nature-society interactions, such as a river catchment area or a regional sea spanning multiple administrative boundaries. Considering the multi-level perspective and ecosystem-based management together in future policy design could help accelerate sustainability transitions in line with the 2050 vision of the Seventh Environment Action Programme.