13.11.1 Policy Responses, Options and Pathways

13.11.1.1 Progress on Adaptation Planning and Implementation

The solution space for climate change adaptation has expanded across European regions since AR5 (*high confidence*). European countries are increasingly planning to adapt to observed impacts and projected

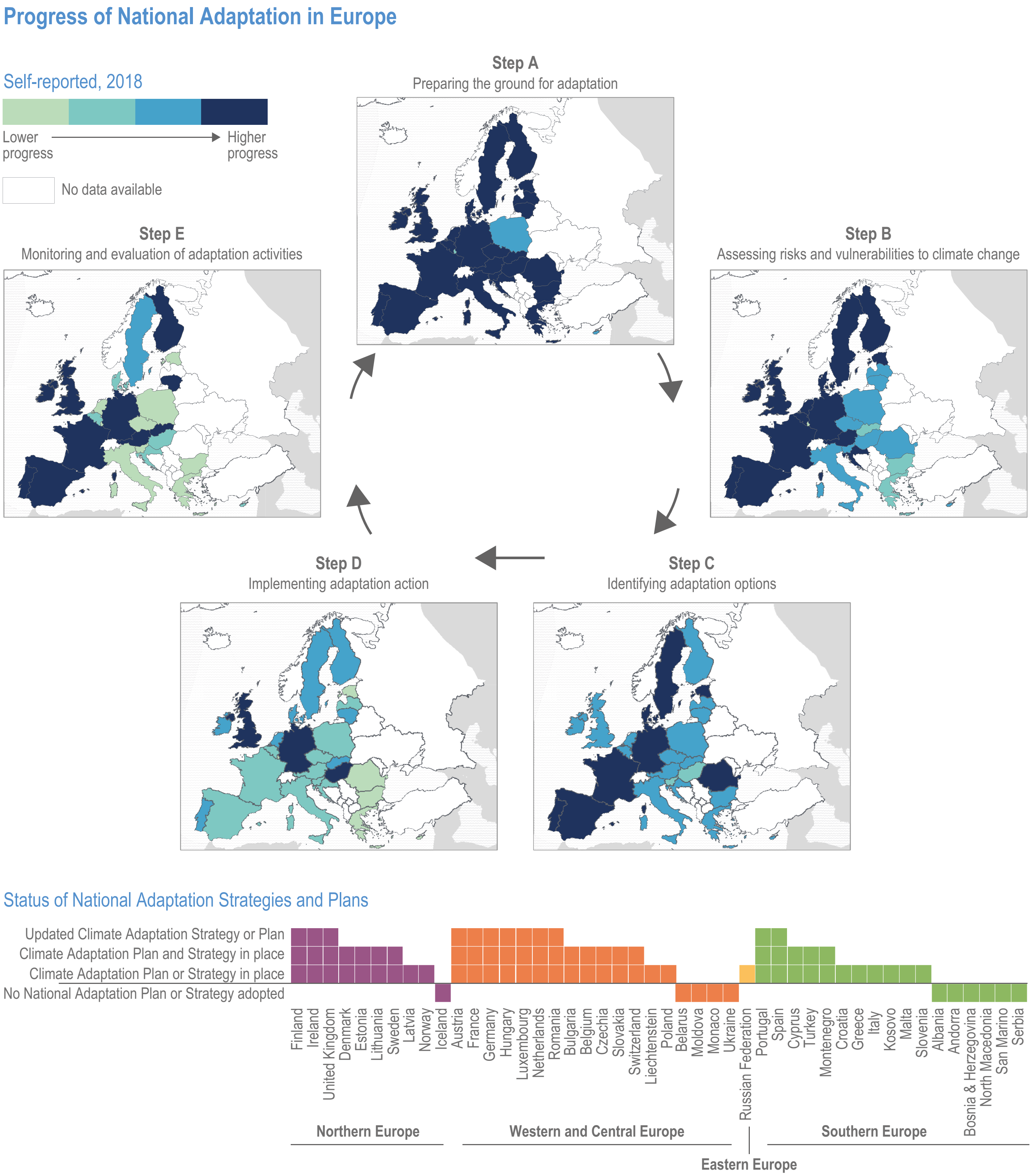

Figure 13.34 | Progress of national adaptation in Europe in 2018 and status of national adaptation plans and strategies in 2020. Data on the progress of national adaptation are from the self-reported status of EU member states, as documented in the Adaptation Scoreboard for Country fiches (SWD(2018)460). The status of national adaptation plans and strategies data are from EEA Report 6/2020 (EEA, 2020a), the ClimateADAPT portal (EEA, 2021a) and the Grantham Institute database 'Climate Change Laws of the World' (Grantham Research Institute, 2021).

Box 13.3 | Climate Resilient Development Pathways in European Cities

Climate resilient development (CRD) in European cities offers synergies and co-benefits from integrating adaptation and mitigation with environmental, social and economic sustainability (Geneletti and Zardo, 2016; Grafakos et al., 2020). Climate networks (e.g., Covenant of Mayors), funding (e.g., Climate-KIC), research programmes (e.g., Horizon Europe), European and national legislation, international treaties and the identification of co-benefits contribute to the prioritisation of climate action in European cities (Heidrich et al., 2016; Reckien et al., 2018; CDP, 2020). Still, mitigation and adaptation remain largely siloed and sectoral (Heidrich et al., 2016; Reckien et al., 2018; Grafakos et al., 2020). An assessment of the integration of mitigation and adaptation in urban climate-change action plans in Europe found only 147 cases in a representative sample of 885 cities (Reckien et al., 2018).

In European cities, CRD is most evident in the areas of green infrastructure, energy-efficient buildings and construction, and active and low-carbon transport (Pasimeni et al., 2019; Grafakos et al., 2020). Nature-based Solutions, such as urban greening, often integrate adaptation and mitigation in sustainable urban developments and are associated with increasing natural and social capital in urban communities, improving health and well-being, and raising property prices (Geneletti and Zardo, 2016; Pasimeni et al., 2019; Grafakos et al., 2020). Barriers to CRD in European cities include limitations in: funding, local capacity, guidance documents and quantified information on costs, co-benefits and trade-offs (Grafakos et al., 2020). Pilot projects are used to initiate CRD transitions (Nagorny-Koring and Nochta, 2018). Malmö (Sweden) and Milan (Italy) are two examples to illustrate the strategies and challenges of two European cities attempting to implement CRDP.

Malmö (population 300,000): Since the 1990s, Malmö has been transitioning towards an environmentally, economically and socially sustainable city, investing in eco-districts (redeveloped areas that integrate and showcase the city's sustainability strategies) and adopting ambitious adaptation and mitigation targets. The city has focused on energy-efficient buildings and construction, collective and low-carbon transportation, and green spaces and infrastructure (Anderson, 2014; Malmo Stad, 2018). Malmö has developed creative implementation mechanisms, including a 'climate contract' between the city, the energy distributor and the water and waste utility to co-develop the climate-smart district, Hyllie (Isaksson and Heikkinen, 2018; Kanters and Wall, 2018; Parks, 2019). Flagship eco-districts play a central role in the city's transition, in the wider adoption of CRD and in securing implementation partners (Isaksson and Heikkinen, 2018; Stripple and Bulkeley, 2019). The city has also leveraged its status as a CRD leader to attract investment. The private sector views CRD as profitable, due to the high demand and competitive value of these developments (Holgersen and Malm, 2015). Malmö adopted the SDGs as local goals and the city's Comprehensive Plan is evaluated based on them, for example, considering gender in the use, access and safety of public spaces, and emphasising development that facilitates climate-resilient lifestyles (Malmo Stad, 2018). Malmö also engages stakeholders via dialogue with residents, collaboration with universities and partnerships with industry and service providers (Kanters and Wall, 2018; Parks, 2019). Despite measurable and monitored targets, and supportive institutional arrangements, sustainability outcomes for the flagship districts have been tempered by developers' market-oriented demands (Holgersen and Malm, 2015; Isaksson and Heikkinen, 2018) and there is limited low-income housing in climate-resilient districts (Anderson, 2014; Holgersen and Malm, 2015).

Milan (population 1.4 million): Milan is taking a CRD approach to new developments (Comune di Milano, 2019). From 2020, new buildings must be carbon neutral and reconstructions must reduce the existing land footprint by at least 10%. The Climate and Air Plan (CAP) and the city's Master Plan (Comune di Milano, 2019) focus on low-carbon, inclusive and equitable development. The CAP is directed at municipal and private assets, and individual- to city-scale actions. In 2020, Milan released a revised Adaptation Plan and the Open Streets Project to ensure synergies between the COVID-19 response and longer-term CRD. Examples include strengthening neighbourhood-scale disaster response and reallocating street space for walking and cycling (Comune di Milano, 2020). Milan emphasises institutionalisation of CRD via a dedicated resilience department, and through active participation in climate networks and projects that support learning and exchange. Climate network commitments are cited in the city's Master Plan and CAP guidelines as driving more ambitious deadlines and emissions targets (Comune di Milano, 2019). Implementation of Milan's plans remains a challenge, despite dedicated resources and commitment.

climate risks across scales of government (*high confidence*) (Lesnikowski et al., 2016; Russel et al., 2020). Whereas in 2009, only nine EU countries had developed a National Adaptation Strategy (NAS) (Biesbroek et al., 2010; EEA, 2014), by mid-2020 all EU member states and several other European countries had adopted at least a NAS and/or revised and updated prior strategies (Figure 13.34, bottom; Klostermann et al., 2018; EEA, 2020a). Progress is also observed at the level of the EU with the adoption of the new EU strategy on adaptation to climate change in 2021 (European Comission, 2021a), and regionally, particularly in federalist and decentralised states (Steurer and Clar, 2018; EEA, 2020b; Pietrapertosa et al., 2021), and locally, with an increasing number of European cities planning for climate risks (*high confidence*) (Section 13.6.2.1; see Box 13.3; Chapter 6; Aguiar et al., 2018; Reckien et al., 2018; Grafakos et al., 2020). There is evidence of action across sectors and scales, even in European countries where national adaptation frameworks are absent (*medium confidence*) (Figure 13.34; De Gregorio

Hurtado et al., 2015; Pietrapertosa et al., 2018; Reckien et al., 2018). However, the implementation gap identified in AR5 (Chambwera et al., 2014), that is, the gap between defined goals and ambitions and actual implemented actions on the ground, persists in Europe (Aguiar et al., 2018; Russel et al., 2020; UNEP, 2021).

The drivers of adaptation progress in Europe differ across sectors and regions. Common drivers include: experienced climatic events, improved climatic information, societal pressures to act, projected economic and societal costs of climate change, participation in (city) networks, societal and political leadership, and changes in national and European policies and legislation (*medium evidence, high agreement*) (EEA, 2014; Massey et al., 2014; Reckien et al., 2018). The availability of knowledge, human and financial resources appears important for proactive adaptation (Termeer et al., 2012; Sanderson et al., 2018), while adaptation is also strongly dependent on economic and social development (*high confidence*) (Sanderson et al., 2018). How adaptation is governed differs substantially across Europe (Clar, 2019; Lesnikowski et al., 2021). Political commitment, persistence and consistent action across scales of government is critical to move beyond planning for adaptation (Steps A–C in Figure 13.34) and to ensure adequacy of implementation (Steps D and E in Figure 13.34) (Howlett and Kemmerling, 2017; Lesnikowski et al., 2021; Patterson, 2021).

The scope of climate risks included in European adaptation policies and plans (Step B in Figure 13.34) is generally broad (EEA, 2018a). Systemic and cascading risks (Section 13.10) are often recognised, but most conventional risk assessment methods that inform adaptation planning are ill-equipped to deal with these effects (Adger et al., 2018). For example, transboundary risks emerging in regions outside of Europe are considered only by a few countries such as the UK and Germany (Section 13.9.3). European climate change adaptation strategies and national policies are generally weak on gender, sexual orientation, as well as other social equality issues (Cross-Chapter Box GENDER in Chapter 18; Boeckmann and Zeeb, 2014; Allwood, 2020).

Many near-term investment decisions have long-term consequences, and planning and implementation (Steps C and D in Figure 13.34) can take decades, particularly for critical infrastructure planning in Europe (Zandvoort et al., 2017; Pot et al., 2018). Consequently, there are calls to expand planning horizons, to consider long-term uncertainties to prevent lock-in decision dependencies, to seize opportunities and synergies from other investments (e.g., socioeconomic developments and systems transitions) and to broaden the range of considered possible impacts (e.g., Frantzeskaki et al., 2019; Marchau, 2019; Oppenheimer et al., 2019; Haasnoot et al., 2020b). Yet, high GWL scenarios beyond 2100 are often not considered in climate-change adaptation planning due to a lack of perceived usability, missing socioeconomic information, constraining institutional settings and conflicting decision-making timeframes (*medium confidence*) (Lourenco et al., 2019; Taylor et al., 2020). High GWL scenarios are often seen as having a low probability of occurrence, resulting in inaction or incremental rather than transformative adaptation responses to projected climate risks (Dunn et al., 2017). Extending planning horizons to beyond 2100 increases deep uncertainties for decision makers as a result of unclear future socioeconomic and climatic changes. For adaptation to SLR along Europe's coast, for example, there are already considerable uncertainties during this century (Fox-Kemper et al., 2021).

Adaptive planning and decision making are still limited across Europe (*high confidence*). Prominent examples of adaptive plans include the flood defence systems for the City of London (Ranger et al., 2013; Kingsborough et al., 2016; Hall et al., 2019) and the Netherlands (Van Alphen, 2016; Bloemen et al., 2019). Adaptation pathways also have been developed for planning urban water supply (Kingsborough et al., 2016; Erfani et al., 2018), urban drainage (Babovic and Mijic, 2019) and wastewater systems (Cross-Chapter Box DEEP in Chapter 17; Sadr et al., 2020). Flexible strategies are increasingly considered by European countries (e.g., Stive et al., 2013; Kreibich et al., 2015; Bubeck et al., 2017; Haasnoot et al., 2019) but require appropriate design to be effective (Metzger et al., 2021).

Monitoring and evaluation of adaptation action is done only in some European countries (Step E in Figure 13.34) but is important for adjusting planning, if needed (Hermans et al., 2017; Haasnoot et al., 2018), and enhancing transparency and accountability of progress (Mees and Driessen, 2019). In the Netherlands, a comprehensive monitoring system has been put in place, including signals for adaptation that support decisions on when to implement adaptation options or to adjust plans (Hermans et al., 2017; Haasnoot et al., 2018; Bloemen et al., 2019).

13.11.1.2 Mainstreaming and Coordination

Coordinated responses are necessary to prevent inefficient and costly action (Biesbroek, 2021), balance under- and overreaction to climate risks (Peters et al., 2017; Biesbroek and Candel, 2019), prevent redistributing vulnerability and maladaptive actions (Atteridge and Remling, 2018; Albizua et al., 2019; Neset et al., 2019), and ensure timely implementation (*high confidence*) (Benson and Lorenzoni, 2017). Since AR5, progress has been made to increase coordinated adaptation actions, but so far this is limited to a few sectors (mostly water management and agriculture) and European countries and regions (mostly SEU, and WCE depending on impact) (*high confidence*) (Section 13.11.2; Lesnikowski et al., 2016; Biesbroek and Delaney, 2020; Booth et al., 2020). Despite evidence of emerging bottom-up (e.g., citizens and business) and top-down initiatives (e.g., governmental plans and instruments to ensure action), there are considerable barriers to mainstreaming adaptation (*high confidence*) (Runhaar et al., 2018).

While mainstreaming of adaptation into other policy domains has been advocated as an enabler for adaptation, it may have resulted in incremental rather than transformational adaptation, and may not be sufficient to close the adaptation gap (Andersson and Keskitalo, 2018; Remling, 2018; Scoville-Simonds et al., 2020).

13.11.1.3 Climate Services and Local Knowledge

Climate services to support adaptation decision making of governments and businesses across Europe have rapidly increased since AR5, partly as a result of national and EU investments such as the Copernicus C3S service (*high confidence*) (Street, 2016; Soares and Buontempo, 2019). These services are increasingly used in NEU, SEU and WCE, for example, in energy and risk prevention in coastal and riverine cities, stimulating regulations and bottom-up initiatives (Cavelier et al., 2017; Le Cozannet et al., 2017; Reckien et al., 2018; Howard et al., 2020). However, climate service efficacy is rarely systematically evaluated (Cortekar et al., 2020). Barriers to use include: lack of perceived usefulness of climate information to organisations and expertise to use the information, outdated statistics, mismatch between needs and type of information made available, insufficient effective engagement between providers and recipients of climate information and lack of business models to sustain climate services over time (*high evidence, medium agreement*) (Cavelier et al., 2017; Räsänen et al., 2017; Bruno Soares et al., 2018; Christel et al., 2018; Oberlack and Eisenack, 2018; Hewitt et al., 2020). Adaptation-decision support platforms also face challenges regarding updating, training and engagement with users (EEA, 2015; Palutikof et al., 2019).

In addition to scientific knowledge, traditional and local knowledge can enable adaptation action (Huntington et al., 2017) as is the case with indigenous-led ecosystem restoration in the European Arctic (Brattland and Mustonen, 2018). There is a need to draw on surviving Indigenous knowledge systems in Europe (Greenland, Nenets, Khanty, Sámi, Veps, Ingrian) as unique, endemic ways of knowing the world that can position present and historical change in context and offer unique reflections of change in the future (Ogar et al., 2020; Mustonen et al., 2021).

13.11.1.4 Financing Adaptation and Financial Stability

Dedicated financial resources for the implementation of NAS and plans are a key enabling factor for successful adaptation (*high confidence*) (Chapter 17; Russel et al., 2020). Yet, only 14 EU countries have announced such budget allocations in their plans and strategies; and even if budget numbers are available, they are difficult to compare (EEA, 2020a). Current adaptation spending varies greatly across and within European countries, partly reflecting (sub)national adaptation priorities or financing sources targeting investment projects (López-Dóriga et al., 2020; Russel et al., 2020) and competing statutory priorities (Porter et al., 2015). European government budgets are also burdened by climate-change damages today, particularly after huge flooding events, and austerity following financial crises, limiting anticipatory action (Penning-Rowsell and Priest, 2015; Miskic et al., 2017; Schinko et al., 2017; Slavíková et al., 2020). National adaptation funding in EU member states is complemented by EU funding (e.g., European Structural and Investment Funds, European Regional Development Funds, and LIFE program). While the EU spending target on climate action increased from 20% in 2016–2020 to 25% in 2021–2026, most spending is going into mitigation, not adaptation (Berkhout et al., 2015; Hanger et al., 2015; EEA, 2020a).

With higher warming levels, financing needs are *likely* to increase (*high confidence*) (Mochizuki et al., 2018; Bachner et al., 2019; Parrado et al., 2020), and governments can address this higher need by cutting other expenditures, increasing taxes or by increasing the fiscal deficit (Miskic et al., 2017; Mochizuki et al., 2018; Bachner et al., 2019). Yet, the requirement for fiscal consolidation that will be needed after the COVID-19 pandemic (Cross-Chapter Box COVID in Chapter 7) may also lead to a cessation of adaptation spending, as evidenced by the expenditure drop in coastal protection in Spain after the financial crisis in 2008 (López-Dóriga et al., 2020). Governments can shift the financial burden to beneficiaries of adaptation, as suggested, for example, for coastal protection and riverine flooding (Jongman et al., 2014; Penning-Rowsell and Priest, 2015; Bisaro and Hinkel, 2018). There is also an increase in financial mechanisms to accelerate private adaptation actions, including adaptation loans, subsidies, direct investments and novel public–private arrangements. For example, the European Investment Bank created a finance facility to support European regions through loans to implement adaptation projects (EEA, 2020a).

Since AR5, new evidence has emerged that climate change may deteriorate financial stability both at the global and European scales (Campiglio et al., 2018; Dafermos et al., 2018; Lamperti et al., 2019; ECB, 2021a). The European Central Bank, the European Systemic Risk Board, and several national central banks in NEU and WCE have started to systematically assess the consequences of climate risks for financial stability and plan to integrate climate stress testing into their supervisory tools (Batten et al., 2016; ECB, 2021a; ECB, 2021b).

13.11.2 Societal Responses, Options and Pathways

13.11.2.1 Private Sector

Within the private sector, there tends to be a preference for 'soft' (e.g., knowledge generation) than 'hard' (e.g., infrastructure) adaptation measures (Goldstein et al., 2019), in contrast to government-led responses typically favouring hard measures (Pranzini et al., 2015). However, there also remains diversity across sectors and organisations in the degree and type of adaptation response (Trawöger, 2014; Dannevig and Hovelsrud, 2016; Ray et al., 2017; Ricart et al., 2019). Whereas some sectors, such as flood management, banking and insurance, and energy (Bank of England, 2015; Gasbarro and Pinkse, 2016; Bank of England, 2019; Botzen et al., 2019), have generally made moderate progress on adaptation planning across Europe, there are key vulnerable economic sectors that are in earlier stages, including aviation (Burbidge, 2018), ports and shipping (Becker et al., 2018; Ng et al., 2018), and ICT (*high confidence*) (EEA, 2018b). There is also some evidence of 'short-sighted' adaptation or maladaptation; for example, in winter tourism there is a preference for technical and reactive solutions (e.g., artificial snow) that will not be sufficient under high levels of warming (Section 13.6.1.4).

Where adaptation is considered by companies, it is typically triggered either by the experience of extreme weather events that led to business disruptions (McKnight and Linnenluecke, 2019) or is included into corporate risk management in response to regulatory, shareholder or customer pressure (Averchenkova et al., 2016; Gasbarro et al., 2017). For instance, following the implementation of the recommendations of the Task Force on Climate-Related Financial Disclosure by the European Commission in 2019, 50 publicly listed companies revealed their exposure to their physical climate risks in 2020 (CDSB, 2020). But even if companies experience extreme weather events or stakeholder pressure, they may not adapt because they underestimate their vulnerability (Table 13.1; Pinkse and Gasbarro, 2019). For example, key barriers to adaptation among Greek firms include both external (e.g., lack of support and/or guidance) and internal factors (e.g.,

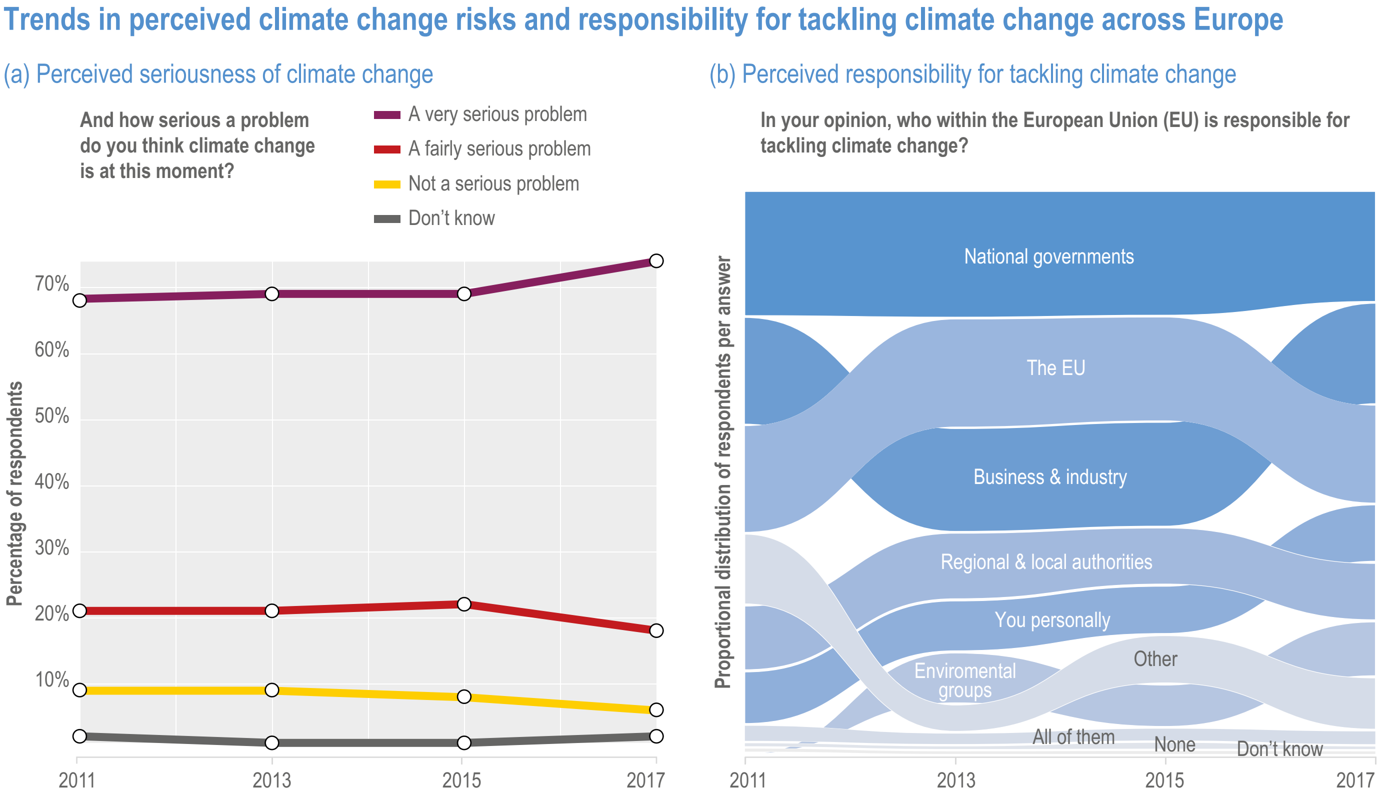

Figure 13.35 | Trends in perceived climate-change risks and responsibility for tackling climate change across EU-28; data collected from around 1000 respondents per country for each year surveyed (European Comission, 2017)

few resources, managerial perceptions) (Halkos et al., 2018). Lack of knowledge, feeling climate change is not a salient risk, and lack of social learning or collaboration appear to be key barriers to private-sector adaptation (Section 13.16.2.2; Dinca et al., 2014; André et al., 2017; Romagosa and Pons, 2017; Esteve et al., 2018; Luís et al., 2018; Ng et al., 2018). There remains little research on private-sector awareness of, or responses to, cascading or compound risks associated with climate change (Miller and Pescaroli, 2018; Pescaroli, 2018).

13.11.2.2 Communities, Households and Citizens

Planned behavioural adaptation remains limited among European households (*high confidence*), with few examples that can be considered transformative (e.g., structural, long-term, collective) (*medium confidence*) (Wilson et al., 2020). One Swedish survey of householders at risk of extreme weather events (e.g., floods, storms) found evidence of some organisational measures (e.g., bringing possessions inside prior to a storm, preparing for power cuts with candles, etc.), but very few households took any other (technical, social, nature-based, or economic) measures (Brink and Wamsler, 2019). Similarly, few at risk of flooding are taking action (Sections 13.2.1, 13.6.1; Stojanov et al., 2015); for example, there is little public take-up of available municipal support for individual adaptation in Germany (Wamsler, 2016). Water efficiency measures in anticipation of, or response to, drought are also limited (Bryan et al., 2019), although water reuse in Mediterranean and some other EU (e.g., the UK and the Netherlands) countries is increasing (Section 13.2; Aparicio, 2017). Among the adaptation responses recorded, few are perceived as opportunities (Taylor et al., 2014; Simonet and Fatorić, 2016). There is currently little European research on public responses to risks other than flooding, heat stress and drought, such as vector-borne disease, and to multiple and cascading risks (Section 13.7; van Valkengoed and Steg, 2019).

Perceived personal responsibility for tackling climate change remains low across the EU (Figure 13.35) and partly explains why household adaptation remains limited (*high confidence*) (Taylor et al., 2014; van Valkengoed and Steg, 2019), despite risk perception apparently growing (Figure Box 13.2.1; Capstick et al., 2015; Poppel et al., 2015; BEIS, 2019). Householders' risk perception and concern about climate change fluctuates in response to media coverage and significant weather or sociopolitical events (*high confidence*) (Capstick et al., 2015). On average across Europe, and particularly in relation to gradual change, compared with experts, non-experts continue to underestimate climate-change risks (*medium confidence*) (Taylor et al., 2014), have low awareness of adaptation options, and confuse adaptation and mitigation (Harcourt, 2019), suggesting a need for improved climate literacy among the public. Indeed, fostering learning and coping capacity supports robust adaptation pathways (Jäger et al., 2015).

There is strong public support for adaptation policy (e.g., building flood defences), particularly within the UK, France, Norway and Germany (Doran et al., 2018). Although, in some cases such public adaptation can undermine motivation for householders to take adaptation measures (Section 13.2), public adaptation can also increase householder motivations, with perceived efficacy of action a strong predictor of adaptation (*high confidence*) (Moser, 2014; van Valkengoed and Steg, 2019). However, there are also structural and economic barriers to household adaptation due to lack of policy incentives or regulations. For example, water-saving devices in homes could halve consumption, but lack of economic benefits to householders are barriers to adoption; and lack of standards as well as societal hesitation may explain low levels of water reuse in Europe (Section 13.2; EEA, 2017b). Conversely, water meters and higher tariffs have been found to reduce water consumption only in combination with other measures (EEA, 2017b; Bryan et al., 2019).

As well as temporal trends in climate-change risk perception, the literature since AR5 continues to show much heterogeneity (both within and between nations) among householders in respect of risk perception (*high confidence*). Higher climate-change risk perceptions have been observed in Spain, Portugal, Iceland and Germany (Figure 13.2); at the individual level, women, younger age groups, more educated, left-leaning and those with more 'self-transcendent' values perceive more negative impacts from climate change, although the strength of these relationships varies across European nations (Clayton et al., 2015; Doran et al., 2018; Poortinga et al., 2019; Duijndam and van Beukering, 2021). Stronger evidence exists since AR5 that experience of extreme weather events can shape climate-change risk perceptions, if these events are attributed to climate change or evoke negative emotions (*high confidence*) (Clayton et al., 2015; Demski et al., 2017; Ogunbode et al., 2019). Proximity to climate hazards does not predict adaptation responses in a straightforward way: in Portugal, those living by the coast were more *likely* to attribute local natural hazards to climate change and to take some adaptive measures (Luís et al., 2017); while waterside residents in flood-prone regions of France and Austria were more resistant to relocation, due to higher place attachment (Adger et al., 2013; Rey-Valette et al., 2019; van Valkengoed and Steg, 2019; Seebauer and Winkler, 2020). Migration from threatened regions is discussed in Section 13.8.1.3.

13.11.3 Adaptation, Transformation and Sustainable Development Goals

The implementation of far-reaching and rapid systemic changes, including both adaptation and mitigation options (de Coninck et al., 2018), remains less researched in societal systems than natural ones (Salomaa, 2020) that enhance multi-level governance and institutional capabilities, and enables lifestyle and behavioural change as well as technology innovation. Adaptation responses across European regions and sectors are more often incremental than transformative (*medium confidence*), with possible exceptions including water-related examples in, for example, the Netherlands (Section 13.2.2) and some cities (see Box 13.3). Transformative options may be better able to exploit new opportunities and co-benefits (see Box 13.3; Cross-Chapter Box HEALTH in Chapter 7; EEA, 2019a). Transitions towards more adaptive and climate-resilient systems are often the result of responses to crises which create windows of opportunity for systemic changes (Chapter 18; Johannessen et al., 2019). This includes extreme weather events, financial crises, for example in Malmö (Anderson, 2014; Isaksson and Heikkinen, 2018), and the COVID-19 pandemic (e.g., Milan), all of which have disrupted the status quo and accelerated innovation and implementation (e.g., Milan; see Box 13.3; Cross-Chapter Box COVID in Chapter 7).

Considerable barriers exist that prevent system transitions from taking place in Europe, including institutional and behavioural lock-ins such as administrative routines, certain types of legislation and dominant paradigms of problem solving (*high confidence*) (Johannessen et al., 2019; Roberts and Geels, 2019). For example, near-term and sectoral decision-making constrains transformative options for water-related risks (Section 13.2). Breaking through these lock-ins requires substantive (i.e., political) will, (un)learning of practices, resources, and evidence of what works. Trade-offs exist between the depth, scope and pace of change in transitioning from one system to another, suggesting that designing system transformations is a delicate balancing act (Termeer et al., 2017). Aspiring in-depth and comprehensive transformational changes might create a consensus framework to which to aspire, but it might not offer concrete perspectives to act on the ground. Taking small steps and quick wins offer an alternative pathway (Termeer and Dewulf, 2018).

Adaptation responses can also be understood in terms of their trade-offs and synergies with SDGs (Papadimitriou et al., 2019; Bogdanovich and Lipka, 2020). In terms of synergies, analysis of the Russian NAP found that successful completion of the NAP's first phase could lead to significant progress towards 15 of the 17 goals (Bogdanovich and Lipka, 2020). European water adaptation (e.g., flood protection) can similarly support freshwater provision; and water-secured environments support socioeconomic growth (Sadoff et al., 2015) since people and assets tend to accumulate in areas protected from flooding and supplied with water, reducing the incentive for autonomous adaptation (de Moel et al., 2011; Hartmann and Spit, 2016; Di Baldassarre et al., 2018). In health, behavioural measures to reduce mental health impacts (e.g., gardening, active travel) can have broader health benefits (SDG 3) as well as help reduce emissions (Section 13.7; SDGs 7 and 13). Conversely, growing use of air conditioning for humans and livestock represents a potential trade-off between adaptation and mitigation (Sections 13.5–13.7, 13.10). As noted in Section 13.8, addressing poverty (SDG 1)–including energy poverty (SDG 7) and hunger (SDG 2); and addressing inequalities (SDG 10), including gender inequality (SDG 5)–improves resilience to climate impacts for those groups that are disproportionately affected (women, low-income and marginalised groups). Also, more inclusive and fair decision making can enhance resilience (SDG 16; Section 13.4.4), although adaptation measures may also lead to resource conflicts (SDG 16; Section 13.7). Climate adaptation, particularly NbS, also supports ecosystem health (SDGs 14 and 15) (Dzebo et al., 2019).

Economic trade-offs appear to be more common across adaptation strategies, for example, reduced employment arising from land-use-change measures (Papadimitriou et al., 2019). There are also trade-offs between large-scale mitigation measures (e.g., wind farms) and adaptation options that rely on ecosystem services (e.g., water regulation) (Sections 13.3–13.4); and conversely, some adaptation options (e.g., air conditioning) may negatively impact mitigation. Figure 13.36 summarises the synergies between adaptation and SDGs as identified by 167 European cities in 2019; particularly prominent are reported biodiversity and health benefits most often arising from societal (e.g., informational) and structural (e.g., technological and/or engineering) measures. Beyond the urban context, biodiversity co-benefits from agroecology are also recognised (Section 13.5). Sustainable behaviour-change measures have been found to be particularly *likely* to lead to synergies with SDGs (Papadimitriou et al., 2019).

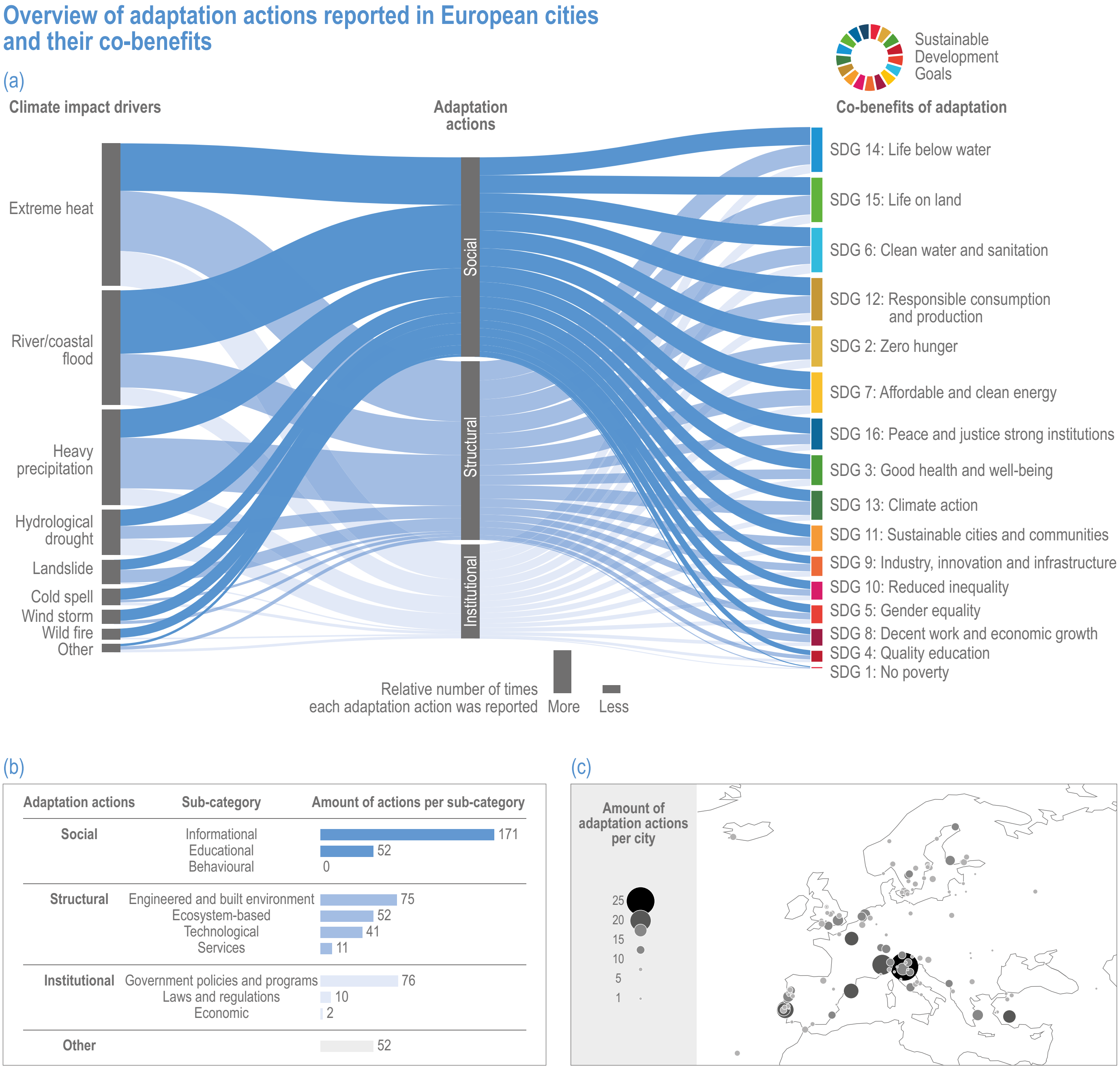

Figure 13.36 | Co-benefits for SDGs from adaptation actions. Shown is how European cities have assessed the sustainability co-benefits of taking adaptation actions. Data were extracted from the Carbon Disclosure Project (CDP) database using the 2019 dataset; of the 861 European cities submitting data, 167 provided data on their adaptation actions, and these data are shown here (CDP, 2019). The CDP categories of climate hazards were re-categorised into WGI Climate Impact Drivers (e.g., cold spell, heavy precipitation); CDP adaptation actions were re-classified into AR5 adaptation options ('social', 'structural' and 'institutional'; 'other' includes actions falling outside these AR5 categories); and CDP co-benefits were re-categorised as SDGs. The upper panel shows that all SDGs except one (SDG 17) were identified as a co-benefit of adaptation, although more environmental co-benefits were identified than social or economic ones. The lower left panel shows that societal actions were most common, followed by structural, then institutional. Informational measures were particularly common. The lower right panel shows how many actions were taken by different European cities.

Frequently Asked Questions

FAQ 13.1 | How can climate change affect social inequality in Europe?

The poor and those practising traditional livelihoods are particularly exposed and vulnerable to climate change. They rely more often on food self-provisioning and settle in flood-prone areas. They also often lack the financial resources or the rights to successfully adapt to climate-driven changes. Good practice examples demonstrate that adaptation can reduce inequalities.

Social inequalities in Europe arise from disparities in income, gender, ethnicity, age as well as other social categorisations. In the EU, about 20% of the population (109 million people) live under conditions of poverty or social exclusion. Moreover, poverty is unequally distributed across Europe, with higher poverty levels in EEU. The oldest and youngest in society are often most vulnerable.

The poor and those practising traditional livelihoods are particularly vulnerable and exposed to climate risks. Many depend on food self-provisioning from lakes, the sea and the land. With higher temperatures, the availability of these sources of food is *likely* to be reduced, particularly in SEU. Poorer households often settle in flood-prone areas and are therefore more exposed to flooding. Traditional pastoralist and fishing practices are also negatively affected by climate change across Europe. Semi-migratory reindeer herding, a way of life among Indigenous and traditional communities (i.e., Komi, Sámi, Nenets) in the European Arctic, is threatened by reduced ice and snow cover. Almost 15% of the EU population (in some countries more than 25%) already cannot meet their health care needs for financial reasons, while they are at risk of health impacts from warming.

In addition to being more exposed to climate risks, socially vulnerable groups are also less able to adapt to these risks, because of financial and institutional barriers. More than 20% of people in SEU and EEU live in dwellings that cannot be cooled to comfortable levels during summer. These people are particularly vulnerable to risks from increasing heatwave days in European cities (e.g., when they already face energy poverty). They may also lack the means to protect against flooding or heat (e.g., when they do not own the property). Risk-based insurance premiums, which are intended to help people reduce climate risks, are potentially unaffordable for poor households. The ability to adapt is also often limited for Indigenous people, as they often lack the rights and governance of resources, particularly when in competition with economic interests such as resource mining, oil and gas, forestry and expansion of bioenergy.

Adaptation actions by governments can both increase and decrease social inequality. The installation of new, or the restoration of existing, green spaces may increase land prices and rents due to a higher attractiveness of these areas, leading to potential displacement of population groups who cannot afford higher prices. On the other hand, rewilding and restoration of ecosystems can improve the access of less privileged people to ecosystem services and goods, such as the availability of freshwater. At city level, there are examples of good practice in CRD that consider social equity which integrate a gender-inclusive perspective in its sustainable urban planning, including designing public spaces and transit to ensure that women, persons with disabilities and other groups can access, and feel safe using, these public amenities.

Frequently Asked Questions

FAQ 13.2 | What are the limits of adaptation for ecosystems in Europe?

Land, freshwater and ocean organisms and ecosystems across Europe are facing increasing pressures from human activities. Climate change is rapidly becoming an additional and, in the future, a primary threat. Ongoing and projected future changes are too severe and happen too fast for many organisms and ecosystems to adapt. More expensive and better implemented environmental conservation and adaptation measures can slow down, halt, and potentially reverse biodiversity and ecosystem declines, but only at low or intermediate warming.

Ecosystem degradation and biodiversity loss have been evident across Europe since 1950, mainly due to land use and overfishing; however, climate change is becoming a key threat. The unprecedented pace of environmental change has already surpassed the natural adaptive capability of many species, communities and ecosystems in Europe. For instance, the space available for some land ecosystems has shrunk, especially in Europe's polar and mountain areas, due to warming and thawing of permafrost. Across Europe, heatwaves and droughts, and their impacts such as wildfires, add further acute pressures, as seen in the 2018 heatwave, which impacted forest ecosystems and their services. In the Mediterranean Sea, plants and animals cannot shift northward and are negatively affected by marine heatwaves. Food-web dynamics of European ecosystems are disrupted as climate change alters the timing of biological processes, such as spawning and migration of species, and ecosystem composition. Moreover, warming fosters the immigration of invasive species that compete with–and can even out-compete–the native flora and fauna.

In a future with further and even stronger warming, climate change and its many impacts will become increasingly more important threats. Several species and ecosystems are projected to be already at high risk at 2°C GWL, including fishes and lake and river ecosystems. At 3°C GWL, many European ecosystems, such as coastal wetlands, peatlands and forests, are projected to be at much higher risk of being severely disrupted than in a 2°C warmer world. For example, Mediterranean seagrass meadows will *very likely* become extinct due to more frequent, longer and more severe marine heatwaves by 2050. Several wetland and forest plants and animals will be at high risk to be replaced by invasive species that are better adapted to increasingly dry conditions, especially in boreal and Arctic ecosystems.

Current protection and adaptation measures, such as the Natura 2000 network of protected areas, have some positive effects for European ecosystems; however, these policies are not sufficient to effectively curb overall ecosystem decline, especially for the projected higher risks above 2°C GWL. NbS, such as the restoration of wetlands, peatlands and forests, can serve both ecosystem protection and climate-change mitigation through strengthening carbon sequestration. Some climate-change mitigation measures, such as reforestation and restoration of coastal ecosystems, can strengthen conservation measures. These approaches are projected to reduce risks for European ecosystems and biodiversity, especially when internationally coordinated.

Not all climate-change adaptation options are beneficial to ecosystems. When planning and implementing adaptation options and NbS, trade-offs and unintended side effects should be considered. On one hand, engineering coastal protection measures (seawalls, breakwaters and similar infrastructure) in response to SLR reduce the space available for coastal ecosystems. One the other hand, NbS can also have unintended side effects, such as increased methane release from larger wetland areas and large-scale tree planting changing the albedo of the surface.

Frequently Asked Questions

FAQ 13.3 | How can people adapt at individual and community level to heatwaves in Europe?

Heatwaves will become more frequent, more intense and will last longer. A range of adaptation measures are available for communities and individuals before, during and after a heatwave strikes. Implementing adaptation measures are important to reduce the risks of future heatwaves.

Heatwaves affect people in different ways; risks are higher for the elderly, pregnant women, small children, people with pre-existing health conditions and low-income groups. By 2050, about half of the European population may be exposed to high or very high risk of heat stress during summer, particularly in SEU and increasingly in EEU and WCE. The severity of heat-related risks will be highest in large cities, due to the UHI effect.

In SEU, people are already aware of the risks of heat extremes. Consequently, governments and citizens have implemented a range of adaptation responses to reduce the impacts of heatwaves; however, there are limits to how much adaptation can be implemented. At 3°C GWL, there will be substantial risks to human lives and productivity, which cannot be avoided. In the parts of Europe where heatwaves are a relatively new phenomenon, such as many parts of NEU and WCE, public awareness of heat extremes is increasing and institutional capacity to respond is growing.

Preparing for heatwaves is an important first step. Implementing and sustaining effective measures, such as national or regional early warning and information systems, heatwave plans and guidelines, and raising public awareness through campaigns, are successful responses. Evidence suggests that such measures have contributed to reduced mortality rates in SEU and WCE. At city level, preparing for heatwaves can sometimes require urban re-design. For example, green–blue spaces, such as recreational parks and ponds in cities, have been shown to reduce the average temperature in cities dramatically and to provide co-benefits, such as improved air quality and recreational space. The use of cool materials in asphalt, increasing reflectivity, green roofs and building construction measures are being considered in urban planning for reducing heat risks. Citizens can prepare themselves by using natural ventilation, using approaches to stay cool in heatwaves, green roofs and green façades on their buildings.

During heatwaves, public information that is targeted at people and social care providers is critical, particularly for the most vulnerable citizens. Governments and NGOs play an important role in informing people about how to prepare and what to do to avoid health impacts and reduce mortality. Coordination between vital emergency and health services is critical. Individuals can take several actions to effectively protect themselves from heat including (a) decrease exposure to high temperatures (e.g., avoid outdoor during hottest times of the day, access cool areas, wear protective and appropriate clothing), (b) keep hydrated (e.g., drink enough proper fluids, avoid alcohol, etc.) and (c) be sensitive to the symptoms of heat illness (dizziness, heavy sweating, fatigue, cool and moist skin with goosebumps when in heat, etc.).

Once the heatwave has ended, evaluation of what worked well and how improvements can be made is key to prepare for the *next* heatwave. Governments can, for example, evaluate whether the early warning systems provided timely and useful information, whether coordination went smoothly and assess the estimated number of lives saved, to determine the effectiveness of the measures implemented. Sharing these lessons learned is critical to allow other cities and regions to plan for heat extremes. After the heatwave, citizens can reflect if their responses were sufficient, whether investments are needed to be better prepared and draw key lessons about what (not) to do when the next heatwave strikes.

Frequently Asked Questions

FAQ 13.4 | What opportunities does climate change generate for human and natural systems in Europe?

Not all climate-change impacts across Europe pose challenges and threats to natural communities and human society. In some regions, and for some sectors, opportunities will emerge. Although these opportunities do not outweigh the negative impacts of climate change, considering these in adaptation planning and implementation is important to benefit from them. Nevertheless, Europe will face difficult decisions balancing the trade-offs between the adaptation needs of different sectors, regions and adaptation and mitigation actions.

Opportunities of climate change can be (a) positive effects of warming for specific sectors and regions, such as agriculture in NEU, and (b) co-benefits of transformation of cities or transport measures that reduce the speed and impact of climate change while improving air quality, mental health and well-being. Windows of action for transformation opportunities for large-scale transitions and transformation of our society may be accelerated through new policy initiatives in response to the COVID-19 crisis, such as the European New Green Deal and Building Back Better.

As warming and droughts impact SEU most strongly, direct opportunities from climate change are primarily in northern regions, thereby increasing existing inequalities across Europe. Across Europe, positive effects of climate change are fewer than negative impacts and are typically limited to some aspects of agriculture, forestry, tourism and energy sectors. In the food sector, opportunities emerge by the northward movement of food production zones, increases in plant growth due to CO_2 fertilisation and reduction of heating costs for livestock during cold winters. In the energy sector, positive effects include increased wind energy in the southwest Mediterranean and reduced energy demand for heating across Europe. While climatic conditions for tourist activities are projected to decrease for winter tourism (e.g., insufficient snow amount) and summer tourism in some parts of Europe (e.g., too much heat), conditions may improve during spring and autumn in many European locations. Fewer cold waves will reduce risks on transport infrastructure, such as cracking of road surface, in parts of NEU and EEU particularly by the end of the century.

Indirect opportunities emerge from the co-benefits of implementing adaptation actions. Some of these co-benefits are widespread but need careful consideration in order to be utilised. For example, an NbS approach to adaptation can make cities and settlements more liveable, increase the resilience of agriculture and protect biodiversity. Ecosystem-based adaptation can attract tourists and create recreational space. There are opportunities to mainstream adaptation into other developments and transitions, including the energy or agricultural transitions as well as COVID-19 recovery plans. Transformative solutions to achieve sustainability may be accelerated through larger changes of, for example, behaviour, energy, food or transport, to better exploit new opportunities and co-benefits. Implementation of adaptation actions can also help to make progress towards achieving the SDGs.

Inclusive, equitable and just adaptation is critical for CRD considering SDGs, gender as well as IKLK and practices. Implementation requires political commitment, persistence and consistent action across scales of government. Upfront mobilisation of political, human and financial capital in implementation of adaptation actions is key, even when the benefits are not immediately visible.

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