European Environment Agency

Urban adaptation in Europe: what works?

Implementing climate action in European cities

EEA Report 14/2023

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Executive summary

Cities on the frontline of climate change: the need for urban adaptation

Average temperatures across Europe are rising faster than the global average, and Europe's cities are feeling the impacts of climate change more regularly and more severely. With the summer of 2023 breaking temperature records, the case for investing in societal resilience to climate change has never been clearer.

The impacts of climate change can be even more intensely felt in urban areas due to their morphology and their dense infrastructure and population. Increased surface run-off during storms and heavy precipitation events makes urban areas particularly vulnerable to flooding. The urban heat island effect can also cause surface temperatures to be up to 10-15°C warmer in urban areas than their surroundings. Additional and growing risks in urban areas include water scarcity and reductions in water quality, the spread of infectious disease-carrying vectors, storms, wildfires, landslides, and coastal flooding due to sea level rise. The sectors reported to be most impacted by climate change in larger urban areas are water, buildings, health and transport. If smaller municipalities are taken into account, then there are also major impacts reported in the agriculture and forestry, environment and biodiversity, and civil protection and emergency sectors.

There are clear indications that these impacts may increase in the future. Artificial or sealed surfaces are widespread in urban areas and can exacerbate the risk of localised flooding. The overall proportion of sealed land in Europe has already increased by over 6% since 2000. Meanwhile, an estimated 26.9% of urban areas saw a significant (>10%) increase in population living within existing floodplains between 2011 and 2021. The urgency to take action will only increase, and there is a need to rapidly upscale what is already seen to work in cities. Importantly, this means that adaptation actions undertaken now will need to not only address the local impacts of climate change which are already happening, but they will also have to protect against the additional, greater impacts foreseen in the future.

The need for urban adaptation aligns with the equally urgent need to shift to more sustainable ways of living. The triple crises of climate change, biodiversity loss and pollution are interlinked and reinforcing, and largely driven by our currently unsustainable production and consumption systems. As such, there is much that can already be done to transition to more sustainable practices, and this is a call to action. With three quarters of Europe's population estimated to live in urban areas, cities have the responsibility, but also the capacity, to be true drivers of change.

Local adaptation actions aim to increase the overall resilience of urban systems, taking into account that there are inequalities both in the way that different population groups are affected by climate change and also in how they may benefit from any adaptation actions taken. Adaptation is required across all sectors and at all governance levels, with upscaling of local action urgently needed.

Implementing adaptation: what actions are being taken?

So, what can actually be done to be better prepared in the future? What are cities already doing, and is it working? While there are still many unknowns, especially on the effectiveness of specific measures, cities are already taking action across Europe, and much can be learned from existing approaches and projects.

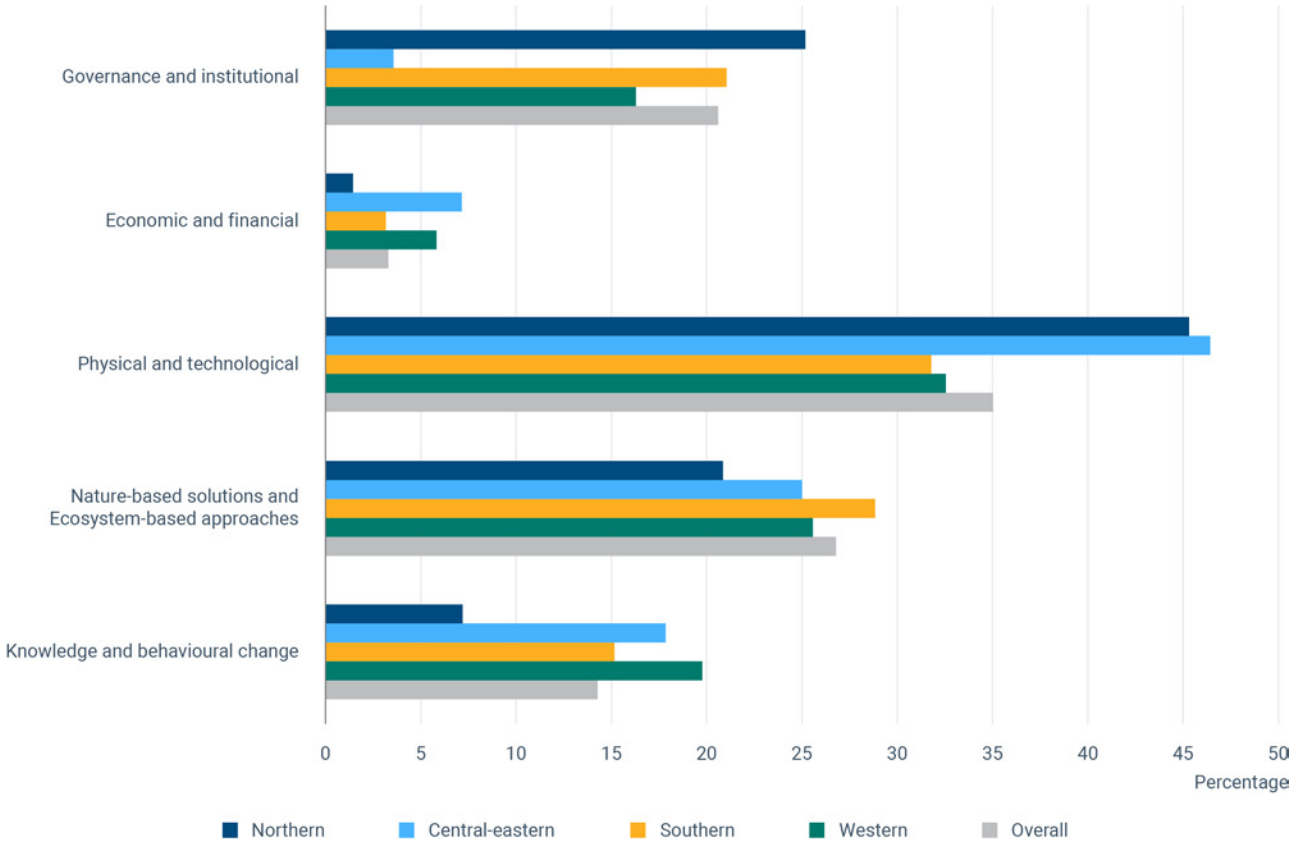
Adaptation policies and measures aim to reduce the exposure and/or vulnerability of a population, its assets and the surrounding ecosystem to the impacts of specific climate-related hazards. For example, in urban areas measures may include actions to increase infiltration of excess rainwater, to provide cooling, to avoid construction in high-risk areas, or to inform the population and provide insurance measures and social support networks (reducing vulnerability). In extreme cases, they may even include relocation of at-risk populations to reduce exposure.

Cities across Europe have highly diverse contexts, capacities and experiences, and are at very different stages of adaptation readiness, but all are taking some form of action. Good practices are being tested and shared, although they are not being scaled up quickly enough to keep pace with climate change. In 2022, over 19,000 adaptation actions were reported by local authorities signatory to the Covenant of Mayors, mainly addressing adaptation needs in the water (17%), buildings (13.6%), environment (11.7%), land (10.8%), agriculture (9.3%) and health (7.6%) sectors.

This report uses the Key Type Measure classification, which changes the focus from hazard-specific approaches to approaches that emphasise the importance of building overall resilience. Ideally, this can result in a society able to withstand the impacts of multi-hazard events and other potential economic or political shocks. The classification can also be used to facilitate the reporting and monitoring of progress on adaptation actions. Physical and technological measures are the most frequently reported actions taken by cities across Europe, followed by nature-based solutions and governance measures. However, the interconnectedness between different adaptation measures is especially important, and they usually need to be used in combination to maximise the effectiveness of any specific adaptation initiative. This is not only because limited financial resources need to be used to address as many challenges as possible, but also because in any one activity there are social, natural, technological and financial dimensions that interact.

Nature-based solutions and ecosystem-based approaches promote the maintenance and re-integration of nature into our urban areas. Given that they provide a multitude of co-benefits, space should be prioritised for green (vegetation) and blue (water) elements in dense urban areas. The importance of nature-based solutions is recognised, and 91% of local climate action plans across Europe already include them in their planned adaptation measures. However, due to the magnitude of current and expected future climate impacts, it may still be necessary to combine these approaches with complementary types of adaptation actions, including physical infrastructure, to ensure they can meet urban adaptation needs. In fact, physical infrastructure, including levees, sea walls and shading, continue to be widely used adaptation measures, although they are increasingly combined with nature-based solutions in their implementation. Water recycling, separation of rain and greywater and climate-resilient building design are physical measures with multiple additional co-benefits. Technological adaptation measures include several effective measures such as risk mapping and early warning systems. This is also a growing area where there is much future potential.

Figure ES.1 **Share of adaptation actions reported to CDP by European cities by type of action and region**



Notes: This analysis is based on an interpretation of the action descriptions in the CDP database. Where an action involved several categories of measures, the main one was used in the classification.

Source: CDP, 2022.

Governance and institutional measures include policies and regulations that can assist in increasing overall climate resilience. A comprehensive local climate action plan is key to achieving adaptation goals. Targeted spatial planning and building regulations can also be used to restrict urban expansion, especially in high-risk areas, as well as to maintain and create new space for green infrastructure. Updating specific building codes and design regulations can also promote circularity in material use and efficiency in energy and water use. Economic instruments and finance can encourage the uptake of adaptation options, including, for example, the creation of green roofs, rainwater collection tanks or energy efficiency renovations. They can also be used to assist in enforcing specific climate-related policies and regulations. Affordable insurance measures that take into account the need for further climate resilience are also essential to help reduce the impact of climate-related economic losses.

Measures relating to increased knowledge and behavioural change, including information campaigns and awareness raising, can lead to higher individual and overall societal resilience. They can also be fundamental to the implementation of further, much-needed change amongst broader stakeholders, including the private sector and major industries. Training and capacity building on climate resilience is also essential to ensure that relevant stakeholders have the knowledge and ability to take effective action.

Urban agriculture, placemaking and preservation of cultural heritage can help drive integrated climate adaptation in the urban setting. Urban agriculture builds resilience locally by helping reduce flood risk and the impacts of high temperatures, while also building social cohesion and strengthening local food systems. The practice of placemaking, in all its diverse forms, is gaining popularity, allowing people to collectively reimagine the public spaces at the centre of their communities. Placemaking can strengthen individual and community resilience through a co-creation process that builds cohesion and social capital. Attractive public spaces can contribute further to climate resilience through the incorporation of green and blue infrastructure in their designs. Cultural heritage, meanwhile, is particularly vulnerable to the impacts of climate change. Suitable approaches to its protection need to be integrated into adaptation and risk management strategies. It can also be an important asset for climate adaptation in its own right, as cultural heritage sometimes encapsulates historical knowledge about how extreme climatic conditions have been managed in the past, providing ideas about how to efficiently adapt in the future. Meanwhile, revitalising and conserving historic buildings not only preserves cultural heritage but also helps to mitigate the additional carbon emissions associated with new construction.

Implementing adaptation: what works?

There are several enabling factors that can help to streamline and scale up the implementation of different types of adaptation actions. These are also in line with enabling factors for transitions to more sustainable urban living in general, and it is important to keep in mind the overall goal of increased societal resilience and preparedness to the effects of climate change.

Citizen engagement is the most reported enabling factor for the implementation of adaptation actions. It is critical to involve citizens in planning, implementation and maintenance of actions as they can provide important information about local impacts of climate change and the appropriateness of specific adaptation measures. Citizens' resources and motivation to participate in climate adaptation planning varies significantly, so it is essential to offer different venues for participation as well as different forms of engagement. It is particularly important to engage vulnerable groups to ensure that outcomes of climate adaptation activities are equitable.

The availability of sustained funding and sufficient budgetary capacity are the most reported barriers to the implementation of adaptation actions in cities. Ensuring sufficient financial resources are available in the longer term is essential, as is ensuring the technical capacity to access resources and use them effectively. The availability of sustained funding is often closely linked to long-term political commitment from relevant governance structures, along with a clear overall long-term vision and goals. Actions need to be well organised and communicated across all governance levels, sectors and stakeholders.

The effective use of knowledge and data is essential to ensure that the right adaptation actions are selected and then implemented in the right way, in the right place, and with the desired effect. More effective, comprehensive monitoring and evaluation of adaptation measures is also needed. This is essential to ensure that any necessary adjustments can be made in a timely manner, and that specific targets can be met. It is also essential in order to provide further evidence of which specific adaptation options may be the most effective under different conditions. The sharing of good practices can allow faster implementation and scaling up of what is already proven to be effective. Participation in relevant networks related to climate action and involvement in twinning and peer-learning initiatives are seen as particularly valuable.

A landscape of increased ambition

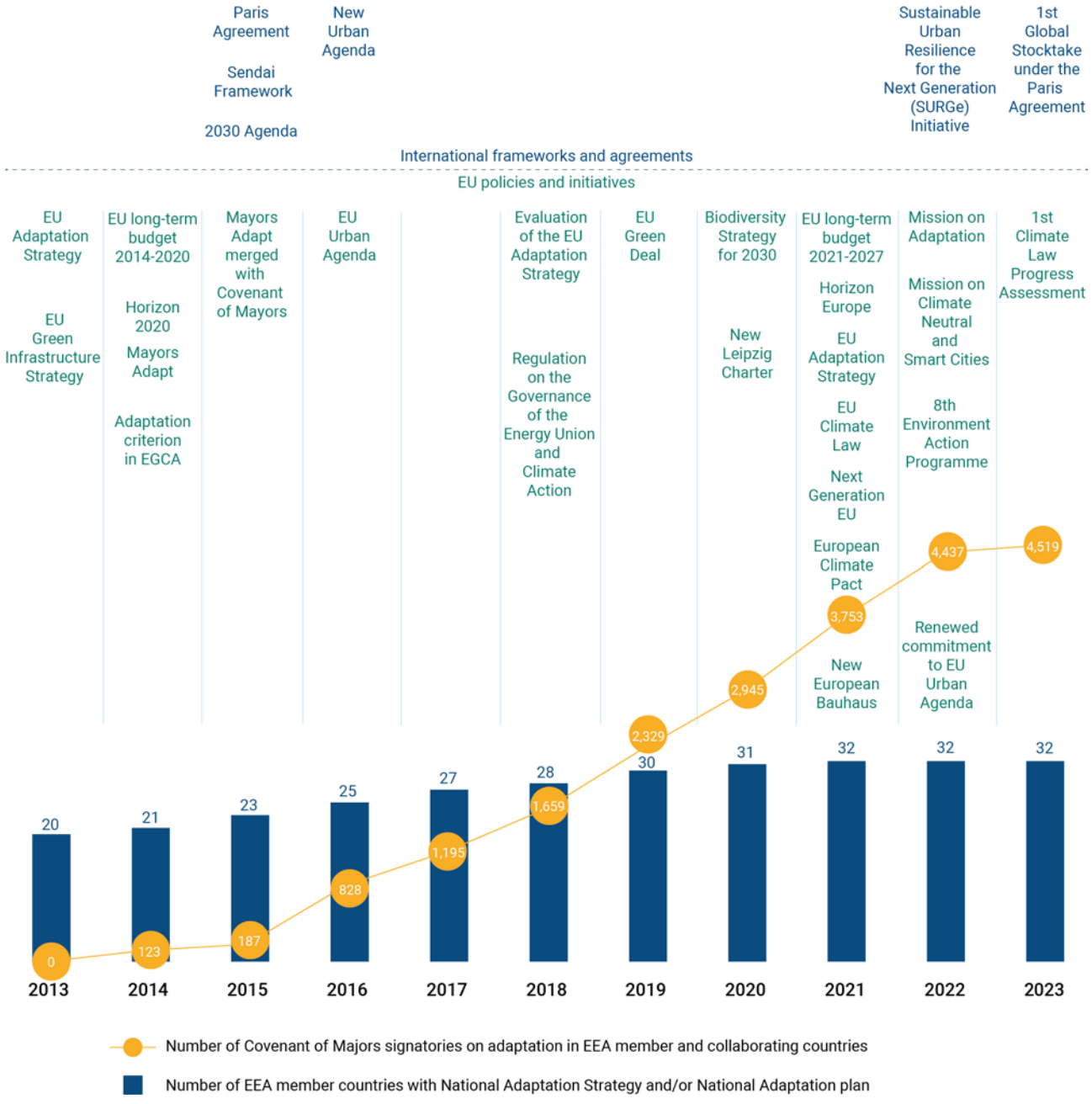
The importance of supporting and facilitating sub-national adaptation to climate change is increasingly acknowledged in policies at both national and European level, and cities are already playing a key implementation role. Local authorities are well positioned to put adaptation strategies and plans into practice and increasingly they are legally mandated to do so. Adaptation projects implemented at the municipal level can be tailored to the climate impacts observed locally as well as to the specific stakeholders involved, including citizens themselves.

European institutions have stepped up their ambitions over recent years, creating enabling policies designed to accelerate action at local level. The 2021 EU adaptation strategy aims to ensure resilience, with the European Climate Law setting the climate neutrality target for 2050 into a binding legal obligation. These policy and legal directives are, in turn, supported with increased sources of funding to co-finance the adaptation actions needed. New implementation mechanisms such as the 2023 Mission on Adaptation have been established to support the scaling of actions. EU action is further reinforced by action in Member States, be it at the level of national, regional or local governance. In many cases, local authorities are increasingly being given a seat at the decision-making table, informing regional, national and European governments of what their citizens need in order to be resilient.

Adaptation planning is becoming more mainstream. An estimated 51% of European cities now have dedicated adaptation plans, marking significant progress from the 2018 figure of 26%. Different factors influence the formulation and development of local climate and energy plans, including city size (linked to technical and resource capacity), national legislation on local climate planning, and participation in city networks/initiatives. Back in 2020, an estimated 123 million people in the EEA-38 countries were living in local authorities with an adaptation commitment under the Covenant of Mayors. That figure now stands at 202.5 million.

The European Green Deal commitment to leave nobody behind becomes increasingly tangible within an urban context. There may be significant inequalities in impacts of climate change in urban areas, with those most affected already at a disadvantage, because of their age, health or socio-economic status. Inequality and unequal levels of vulnerability to climate change impacts highlight the need for 'just resilience', meaning that equity must be taken into account in the design, implementation and monitoring of adaptation measures.

Figure ES.2 **Evolution of European policy relevant to adaptation, national adaptation plans and strategies, and number of signatories to the Covenant of Mayors with adaptation commitments for 2013-2023**



Note: Major international and European milestones defining the adaptation policy landscape, trends in the number of countries having national adaptation policies and the number of local authorities signatory to the CoM with an adaptation commitment from 2013-2023.

Sources: EEA, 2020b. Updated by authors with information from the 2023 adaptation reporting (EEA, 2023a) and the Covenant of Mayors.

Towards societal resilience: what does success look like?

Examples of good practices and signs of progress can be found across the board, in the types of actions taken, and in the many enabling conditions that cities are actively working on. Progress is being made, but it is clearly not yet enough. But how do you measure 'enough'? What is still needed to turn individual actions taken by local authorities into widespread initiatives that really make an impact at European scale?

While the importance of adaptation is increasingly recognised in Europe, it still needs to be embraced across all sectors and all governance levels. The mainstreaming of adaptation needs, especially across the most affected sectors, would be a significant step forward. The involvement of citizen groups and the private sector in enabling more widespread investment in adaptation and maintenance of adaptation projects could also prove pivotal. Ultimately, adaptation is needed across all sectors and governance levels to prepare our societies to face current and future climate-related impacts while minimising fatalities, loss of quality of life, economic losses and further environmental degradation.

A much more tangible target around adaptation in Europe needs to be established as a means of pulling everyone in the same direction, and to help signal whether Europe is on or off track. Only an estimated 55% of European local climate action plans analysed defined metrics which could be used to measure progress. Of the indicators included in these plans, 72% related only to the output of the actual action taken, rather than the targets set or outcomes expected. In fact, only 2% of indicators were linked to a specific target. There is still a need for better monitoring and evaluation in local adaptation plans, as well as the definition of agreed specific local targets on adaptation. This report includes several examples of indicators already used by cities to measure progress in the implementation of adaptation actions.

A first step towards more tangible agreed adaptation targets is to establish a common vision for what a resilient urban future looks like. That vision should prioritise the integration of nature in increasing the overall well-being of the community, while ensuring basic needs and nurturing a sense of belonging, trust, equity, inclusiveness and hope.

Section I

Setting the scene

1 Introduction

1.1 Why do we need to adapt our cities?

Our climate is changing. It can no longer be ignored. Temperatures across Europe are rising even faster than the global average. The direct and indirect effects of this can be potentially devastating to the environment and our quality of life (EEA, 2024a). Mitigating the further impacts of climate change by limiting greenhouse gas emissions and reducing resource use will not be enough: we need to adapt to the changes already seen in our climate and prepare our society for further expected changes in the near future.

Adapting to climate hazards is not new, with measures such as relocation or the installation of sea walls having been used for centuries. However, today's climate is changing at an accelerated rate, compounded by megatrends such as urbanisation, biodiversity loss, pollution and unsustainable consumerism. Effective adaptation actions and policies can and should be tailored to simultaneously address these additional trends. The benefits of action in cities go beyond reducing the direct impacts of climate change and bring a multitude of additional positives, such as health and well-being, quality of life and social sustainability.

Almost three quarters (74.8%) of the European population is estimated to have lived in urban areas in 2021 (EUROSTAT), and the overall share of artificial (sealed) surface increased by over 6% between 2000 and 2018 (EEA, 2019). High population density, combined with high degrees of soil sealing and compounding factors, such as high pollution and inequality, can lead to urban populations being more exposed and vulnerable to the impacts of a warming climate.

Europe has some of the oldest city centres in the world, with 42% of all buildings built before 1950. Europe's renovation rate lies at around 1% of buildings per year (Economidou et al., 2019). This means that infrastructures are usually old and are not easily and frequently maintained. Buildings are not necessarily adapted to the current climate conditions or to future climate conditions. Life expectancy in Europe is increasing and birth rates are decreasing. This means that we will have an increasingly older population which may be more vulnerable to climate change. On average, people in Europe now live 5 years longer than they did in 1995 (EC-DG ECFIN, 2018). While urbanisation and urban sprawl remain an issue, almost half of Europe's cities are actually shrinking in terms of losing population. This brings additional concerns on retrofitting and adjusting infrastructures to the changing needs of the population, compounded by the need to adapt the built environment to future climate conditions.

However, cities are often very progressive in taking climate action. For example, European cities' signatory to the Covenant of Mayors (CoM) signed an overall commitment to reduce their emissions of 27% by 2020 (Kona et al., 2018), which was well above the minimum requested EU target at the time (20%). Moreover, the implementation of specific known climate adaptation measures, experimentation and innovation are often done at the local level, meaning that this is where real change can happen.

Cities are well-positioned to develop tailored responses to climate change, and consider local needs and vulnerabilities (Fuhr et al., 2018). They are also increasingly legally mandated to do so. Local governments govern urban planning and develop and

maintain urban infrastructure. They also have a variety of means through which they can influence the actions of their residents and businesses (Karhinen et al., 2021).

While there is still discussion on which climate scenario may be closest to our actual future, we do know the general trends we can expect. This means we have enough evidence of occurring changes in our climate and environmental system to know what needs to be addressed. In many cases, we also know how to address the changes already experienced and those foreseen. Particularly at the local level, many specific actions have already been taken to adapt to climate change. While many are still in pilot phases, we do start to see results that can be replicated.

1.2 Sustainability transitions and the place for adaptation

Sustainability transitions refer to the profound changes needed to shift society towards more sustainable modes of living. Transformative adaptation involves fundamental changes in systems (e.g. mobility, energy, food and construction) to address these shifts, and minimise impacts and vulnerabilities. Achieving sustainability transitions will depend on coherent contributions across the policy domains, embracing the Sustainable Development Goals (SDGs) as an overarching framework for policy making and action (EEA, 2019). These will require a full and detailed understanding of the systems driving environmental challenges and potential pathways for sustainability across society. They will require a fundamental shift in Europe's responses on a backdrop of concerted international actions.

Responding to sustainability challenges requires transitions in production and consumption systems, though these transitions are highly complex and uncertain processes if seen at a broader scale. Clearly, public policies and institutions are playing a major role in catalysing transformational processes. They bring different governance levels, businesses, people and their local community-based organisations into systemic innovations based on clear visions and pathways that are meaningful to the individual.

The EEA urban sustainability report referred to the need to respect every city's own specific cultural and historical settings. Actions to achieve urban environmental sustainability need to recognise, adapt to, or draw on culture to improve the design and implementation of new policy measures. Research and innovation, as well as capacity building, enables local authorities and municipalities, service and infrastructure providers, and the public to translate global and European policy-driven strategies into concrete local action.

The ultimate goal of urban sustainability transitions is to create a Europe that is environmentally sound and resilient to climate change impacts through comprehensive interconnected solutions that address various aspects of urban life and infrastructure. The logic of urban transitions relies on a 'transfer-replicate-scale-up' perspective.

1.3 Taking climate action: how do adaptation measures fit in?

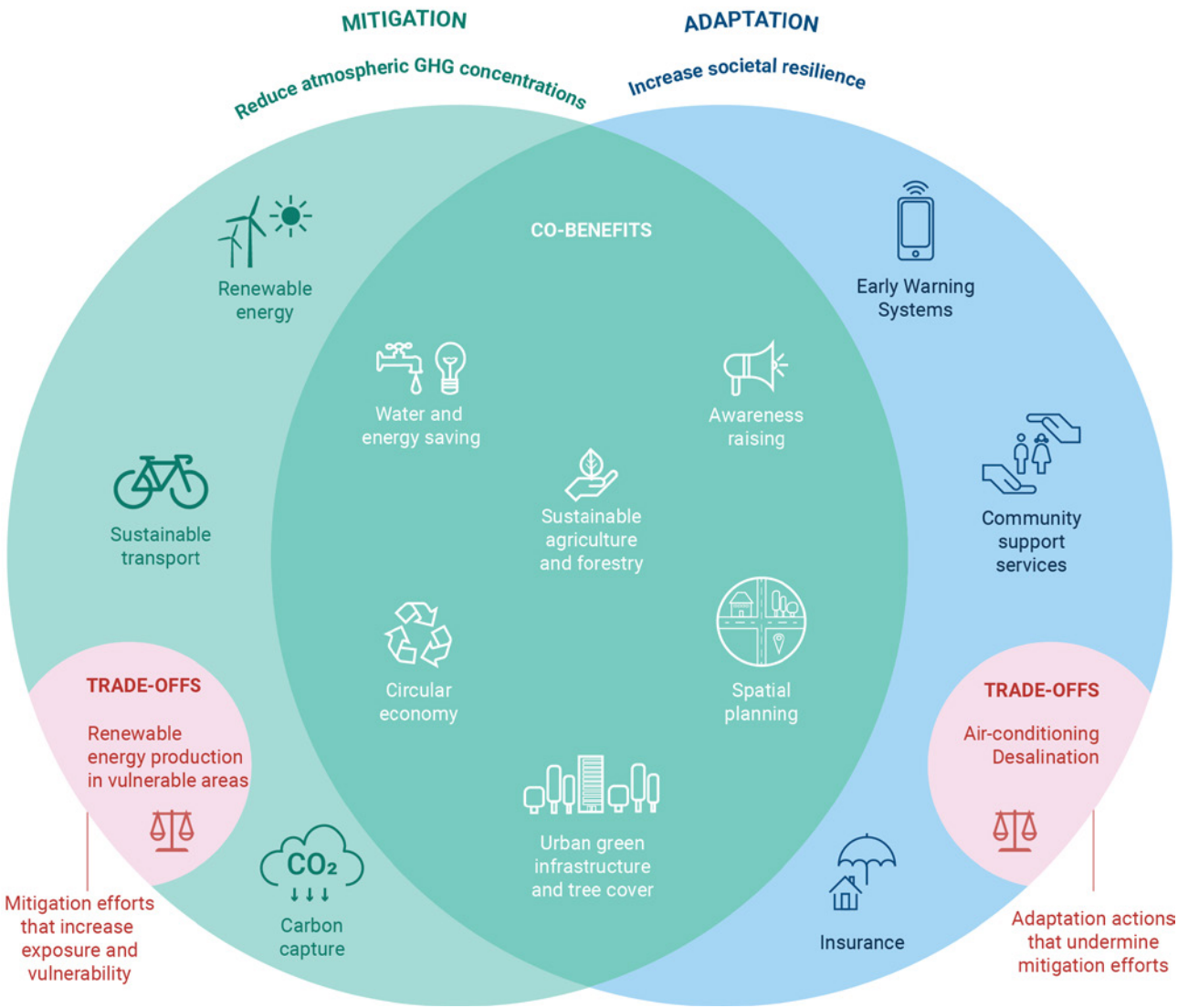
This report takes stock of where we currently stand in implementing actions to adapt to climate change at the local level. It aims to open a discussion around why we are not yet further along and what it would take to build a truly climate-resilient society that is prepared for the impacts of climate change, now and in the future.

Building on previous EEA Urban Adaptation reports (EEA, 2012, 2016, 2020b), we emphasise the need for transformative adaptation. That is, systematic adaptation transcending specific hazards and sectors, with a long-term vision to build strong

overall societal resilience. Rather than addressing adaptation as the implementation of specific measures to reduce the impacts of a specific climatic hazard, we emphasise actions that can reduce the overall risk associated with climate change.

Throughout this report, we recognise the need to maintain strong efforts to reduce emissions and shift towards climate neutrality. However, climate action needs to simultaneously prepare our society for the projected changes that will occur even if mitigation targets are met (IPCC, 2022). A study with data up to March 2022 of climate action plans amongst signatories of the CoM showed that 82% of these plans only address the mitigation pillar. Just 18% of them simultaneously address mitigation and adaptation (EC-JRC, 2022). With this in mind, we try to emphasise examples of adaptation measures that have mitigation co-benefits rather than trade-offs. These include, for example, increasing green spaces in urban areas for cooling (Figure 1.1) as opposed to actions such as desalination or installing air conditioning systems. Other measures that are beneficial to both types of climate action include spatial planning and increasing energy efficiency and circularity in the construction sector since it is one of the main emitters of greenhouse gases (GHGs) (EEA, 2024b).

Figure 1.1 **Overview of the synergies and trade-offs between climate mitigation and adaptation actions**



Source: Adapted from UNEP, 2022.

1.4 About this report

This report recognises that cities are essential in the implementation of effective adaptation measures. It gives an overview of the main types of measures already taken by cities, and the main enabling factors for the implementation of these measures at the local level. Real-world examples and case studies are used throughout to illustrate the measures presented and provide inspiration. The report aims to provide a rich source of information to support EU policy makers, municipal leaders and officials. In support of the EU ambition of truly engaging its people, it is also written for the general public.

The topics covered and the format of this report are strongly influenced by a survey completed in May 2022 by EEA member states and supported by further interviews with Amsterdam, Athens, Cascais, Ghent, Košice, Madrid, Nicosia and Poznan. In addition, representatives in the field of adaptation were asked to identify challenges faced in implementing adaptation and the issues they would like to see addressed in this report. Most EEA member states asked for examples of adaptation actions from cities, together with their best practices and shared experiences of implementation. A request was also made for insight on barriers and obstacles, and how to overcome them.

The analyses and data shown and discussed in this report cover the EEA's 38 member countries and cooperating countries ([1]). Case studies and examples have also been included from outside the European continent if considered potentially inspirational and replicable within Europe.

The main data sources analysed throughout the report are the:

- Global Covenant of Mayors signatories database: reported adaptation actions by the signatories to the CoM for Climate and Energy (EC-JRC, 2023). The climate action plans of 1,151 cities addressing adaptation were included in the analysis, covering Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden and Türkiye.

- Carbon Disclosure Project (CDP) database on city actions on adaptation to climate change: the global disclosure system for investors, companies, cities, states and regions to measure and manage their environmental impacts, risks and opportunities of climate change for water security and deforestation (2022 Cities Database, CDP 2022). The database includes 739 reported actions from 29 European countries covering the Netherlands, Greece, Sweden, Denmark, Finland, France, Italy, Portugal, Spain, Albania, Germany, Norway, Belgium, Bulgaria, Croatia, Iceland, Lithuania, Monaco, Switzerland, Türkiye, Latvia, Poland, Montenegro, Czechia, Slovenia, Greenland, Ireland, Hungary, and Bosnia and Herzegovina.

- European local climate action plans: the database and analysis of local climate action plans (Reckien et al., 2022). The analysis includes 297 European cities within the EU-27 countries, of which 137 had local climate action plans. A further analysis of 76 plans containing indicators for monitoring and evaluation was done, with relevant indicators detailed for each type of adaptation action for reference and potential inspiration for cities (Ramboll, 2024).

([1]) Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye, Albania, Bosnia and Herzegovina, Kosovo, Montenegro, North Macedonia and Serbia.

Where relevant throughout this report, we present analyses for the EEA member and cooperating countries using the following groupings, consistent with the European Climate Risk Assessment:

- northern: Denmark, Estonia, Finland, Iceland, Ireland, Latvia, Lithuania, Norway and Sweden;
- southern: Cyprus, Croatia, Greece, Italy, Malta, Portugal, Slovenia, Spain, Türkiye, Albania, Bosnia and Herzegovina, Kosovo ([2]), Montenegro, North Macedonia and Serbia;
- western: Austria, Belgium, France, Germany, Liechtenstein, Luxembourg, the Netherlands and Switzerland;
- central-eastern: Bulgaria, Czechia, Hungary, Poland, Romania and Slovakia.

Building on other EEA efforts in support of the EU Adaptation Strategy

This report builds on a series of previous and complimentary EEA work on climate impacts, vulnerability and adaptation. The most important ones are:

- Previous EEA urban adaptation reports, all of which have provided extensive overviews of the impacts of climate change in cities, and have presented and evaluated adaptation actions. In particular, the 2016 report focused on the need for Transformative Adaptation and the 2020 report included an overview of the effectiveness of adaptation measures. Inspired by and following on these previous reports, this report provides an update of existing knowledge on the topic and emphasises the implementation stage of adaptation actions.
- European Climate Risk Assessment (EUCRA): gives an overview of the climate risks currently experienced in Europe and their future trends. EUCRA looks at the available historic and modelled climate data, but also assesses multiplying factors which may lead to greater overall risks and cascading impacts.
- European Climate Change Adaptation Platform (Climate-ADAPT): includes up-to-date information on expected climate trends, adaptation policies, case studies and adaptation options. Climate-ADAPT is continuously updated in line with the EU Adaptation Strategy and the European Climate Law. It aims to become the main European reference information system and provider of adaptation knowledge. The following tools and initiatives of relevance to the sub-national level are hosted on the platform:
    - Urban Adaptation Support Tool: maintained in collaboration with the CoM, this guidance tool details the main considerations for each step of the adaptation cycle, from planning through to the implementation and monitoring of adaptation actions.
    - EU Mission on Adaptation to Climate Change: Climate-ADAPT acts as a key 'mission knowledge hub' providing new services at local and regional levels to promote adaptation, increase preparedness and share experiences and potential solutions. The Mission's Adaptation Dashboard provides an overview of indicators that can be used to measure vulnerability, exposure and adaptation action at the local level.

(2) Under UNSCR 1244/99.

- European Climate Data Explorer (ECDE): provides interactive access to past, present and future climate hazards and impacts on the European, national, subnational and transnational levels from the Copernicus Climate Change Service. It reflects the priority sectors of the EEA, namely health, agriculture, forestry, energy, tourism, water and coastal regions.

- European Climate and Health Observatory: launched in 2021 in partnership with the Directorate-General for Climate Action (DG CLIMA) to better understand, anticipate and minimise the health threats caused by climate change.

2 Climate risk in urban areas

Key messages

- Climate change is felt even more intensively in urban areas due to their morphology, dense infrastructure and high population densities, which increase exposure and vulnerability to climate-related risks.
- Temperature and precipitation variability are the most frequently identified climate-related hazards addressed in local climate action plans across Europe. In urban areas, surface temperatures can be up to 10-15°C warmer than their surrounding areas. More frequent, highly variable rainfall can quickly lead to flooding in urban areas, with on average 10.6% of urban areas in Europe at risk of flood.
- There are clear indications that these impacts may increase in the future. For example, an estimated 26.9% of urban areas saw a significant (>10%) increase in population living within existing floodplains between 2011 and 2021.
- Water, buildings, health and transport are the sectors reported to be most impacted by climate change in urban areas. Water scarcity, reductions in water quality, the spread of infectious disease-carrying vectors, storms, wildfires, landslides and coastal flooding due to sea-level rise are increasing in urban areas.
- Adaptive capacity in cities varies greatly across Europe. In addition to adapting cities to current and expected future climate risks, adaptation actions will have to comprehensively address and increase all aspects of adaptive capacity to reduce overall exposure and vulnerability.

2.1 Identified climate risks

What are the current and potential future impacts of climate change in urban areas? Climate change will have varied impacts across Europe. The European Climate Data Explorer gives a dynamic overview of time series on climate indicators, including temperature and precipitation patterns. For overall trends and projections on current and future climate conditions, the European Climate Risk Assessment should be consulted, which also further analyses the main cascading impacts of climate change.

In this chapter we focus on the main hazards identified by cities, and the aspects of exposure and vulnerability that will specifically lead to higher overall risk (following the risk concept as described in Box 2.1). Where relevant, compounding factors which may exacerbate the occurrence of these hazards within an urban context are also described.

Box 2.1

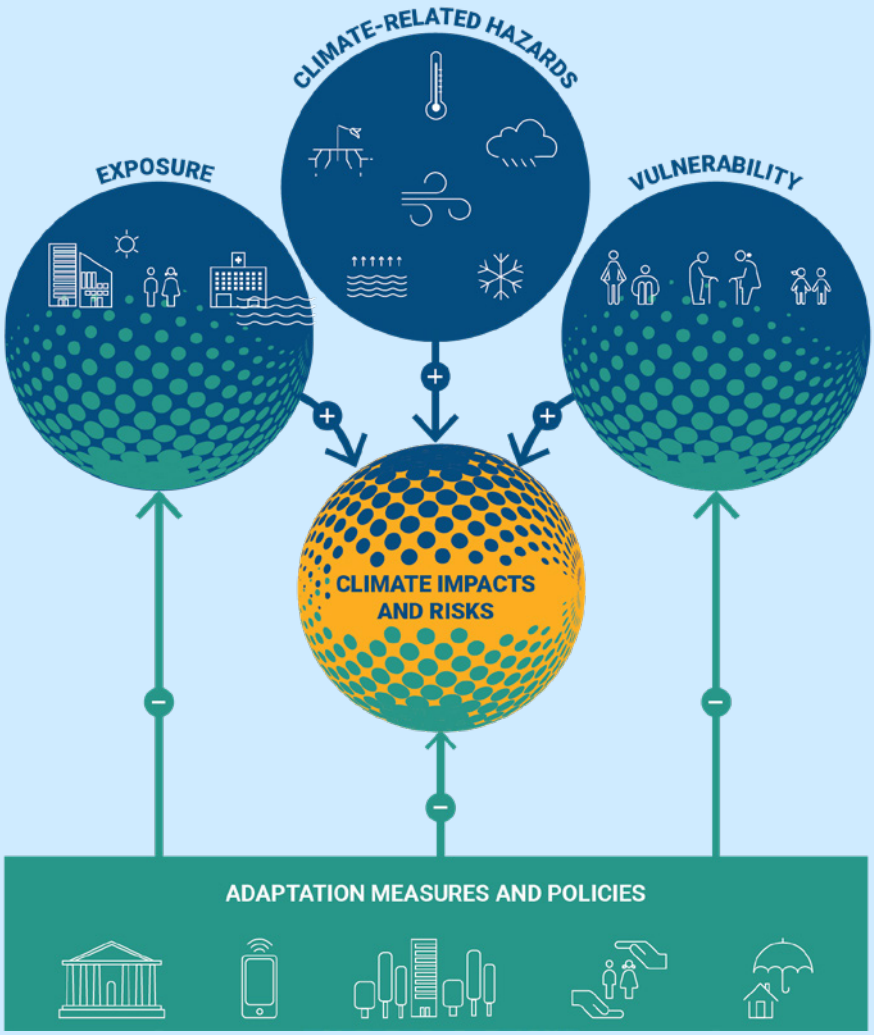
Components of climate risk

The current climate conditions and how they will change in the future determine the likelihood of an area being affected by climate-related hazards, such as heatwaves, or slow onset events such as sea-level rise. The overall risk, however, will be increased also by the presence of people, livelihoods, infrastructure and assets, or species and ecosystems in places and settings that could be adversely affected (exposure), and the overall tendency of the exposed system and its components to be adversely affected (vulnerability). Vulnerability is often described by the degree to which a system or species is affected, either adversely or beneficially, by climate variability or change (sensitivity) and the ability of people, sectors or systems to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (adaptive capacity).

The combination of local conditions, with respect to the actual climate hazard, exposure and vulnerability, will result in the overall risk experienced. Adaptation measures and policies aim to reduce this overall risk by:

- reducing the exposure of people, assets and environment to expected hazards (e.g. via levees to control frequently flooded areas, building restrictions within known floodplains and increased green spaces for cooling);
- reducing vulnerability by increasing adaptive capacity with measures which increase a population's overall resilience and capability to recover from a shock (e.g. awareness campaigns, improving overall health infrastructure and employment levels, and investment in research and development).

Figure 2.1 Components of climate risk



Notes: This figure shows where adaptation policies and measures fit in. They aim to increase overall climate resilience by reducing exposure or vulnerability.

Source: Adapted from IPCC, 2023.

The level of exposure and vulnerability differs widely across regions, depending on location and their economic and social conditions. Overall, 94% of the local climate action plans analysed identified specific hazards, with the frequency of reported hazards differing across Europe (Figure 2.2).

Figure 2.2 **Overview of hazards identified in local climate action plans for a selection of European cities, by region**

Source: Local climate action plan datasets (Reckien et al., 2022).

2.1.1 Urban temperature variation

Temperatures across Europe are rising - heatwaves caused more than 85% of fatalities from climate-related hazards in the period 1981-2020 (EEA 2022h). Of the local climate action plans analysed (Reckien et al., 2022), 85% mentioned 'urban temperature variation' as a specific hazard experienced and addressed in the plan. Cities in southern countries indicate this hazard to a slightly greater extent (94%), but it is also of great concern to central and eastern countries (91%). Urban temperature variation features to a lesser extent, but still significantly, for cities in the western (85%) and northern (78%) countries.

In addition, in dense urban areas, where there is a high concentration of people, activities and sealed surfaces with high heat retention, the urban heat island (UHI) effect can lead to higher average temperatures. In fact, surface temperatures can be 10-15°C warmer in local hotspots within cities than their surrounding areas

(Mentaschi et al., 2022). Night-time temperatures are also increasing: in France, some all-time records were exceeded in 2023. Heatwaves are also occurring later than usual in the year (Box 2.2), putting different population groups at risk, e.g. children at school in September.

Box 2.2

Heatwave Cerberus: temperature extremes in summer 2023

The summer of 2023 was the fifth warmest on record for Europe, with heatwave conditions persistent across large areas in July and August.

23 Italian cities issued 'red alerts' advising everyone to avoid direct sunlight between 11.00 and 18.00. In Athens, Greece, the Acropolis site was closed from 12.00 to 17.00 on several days to protect its visitors. The situation was so extreme that the first in the series of 2023 heatwaves was nicknamed 'Cerberus' after the three-headed dog that guards the gates of the underworld in Greek mythology.

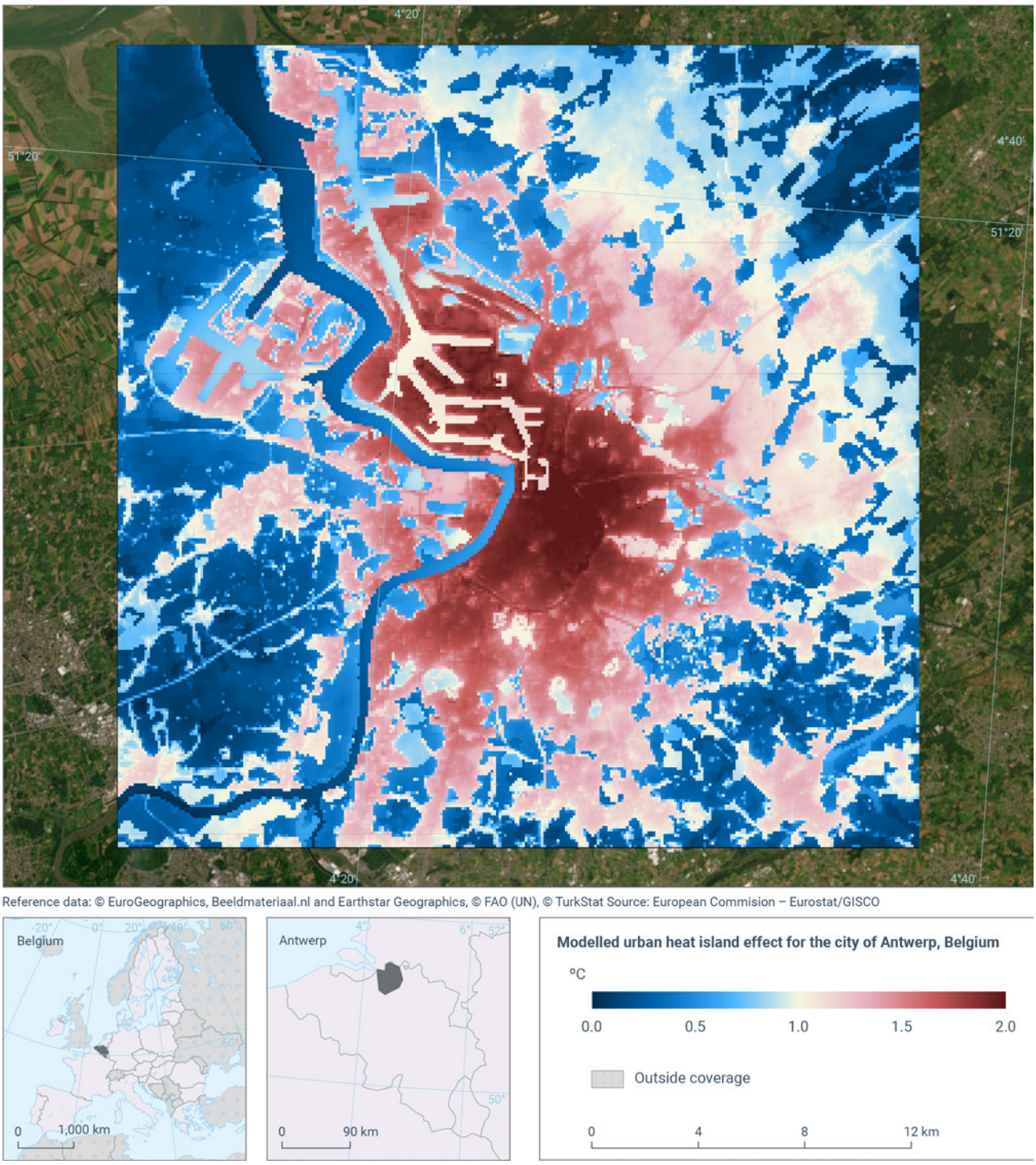
The naming and ranking of heatwaves is intended to increase public awareness of the dangers of extreme heat: 'Zoe' was the world's first named heat wave reaching category 3 (most severe) in 2022 in Seville, Spain.

In mid-July 2023, a 'heat dome' sat over the southern half of the continent creating stable and dry conditions, which led to parts of Greece, Spain and Italy experiencing temperatures over 45°C. Resulting from the dome's high pressure system, the spread of wildfires intensified. This caused the ground to warm up and lose moisture since little rain fell and high winds persisted.

The extreme heat-sustained drought conditions, particularly severe in Southern Europe, resulted in the Fire Weather Index indicating 'very extreme' fire danger in mid-July. Wildfires forced numerous evacuations in Albania, France, Italy, Portugal, Spain, and Greece, including 20,000 tourists and residents from the island of Rhodes.

Map 2.1 details the UHI effect for Antwerp, Belgium, showing that the densest part of the city centre is on average 2°C warmer than the surrounding peri-urban areas.

Map 2.1 **Detailed modelling of the urban heat island (UHI) effect for the city of Antwerp**



Notes: The map shows the 10-year average temperature at 2m height (2008-2017), modelled by the UrbClim model within the framework of the Copernicus Health Service. The map gives the relative difference in temperature from the lowest value in the area, in this way mapping the urban heat island, with higher temperatures towards the city centre as compared to the surrounding areas.

Source: Copernicus Health Service/VITO.

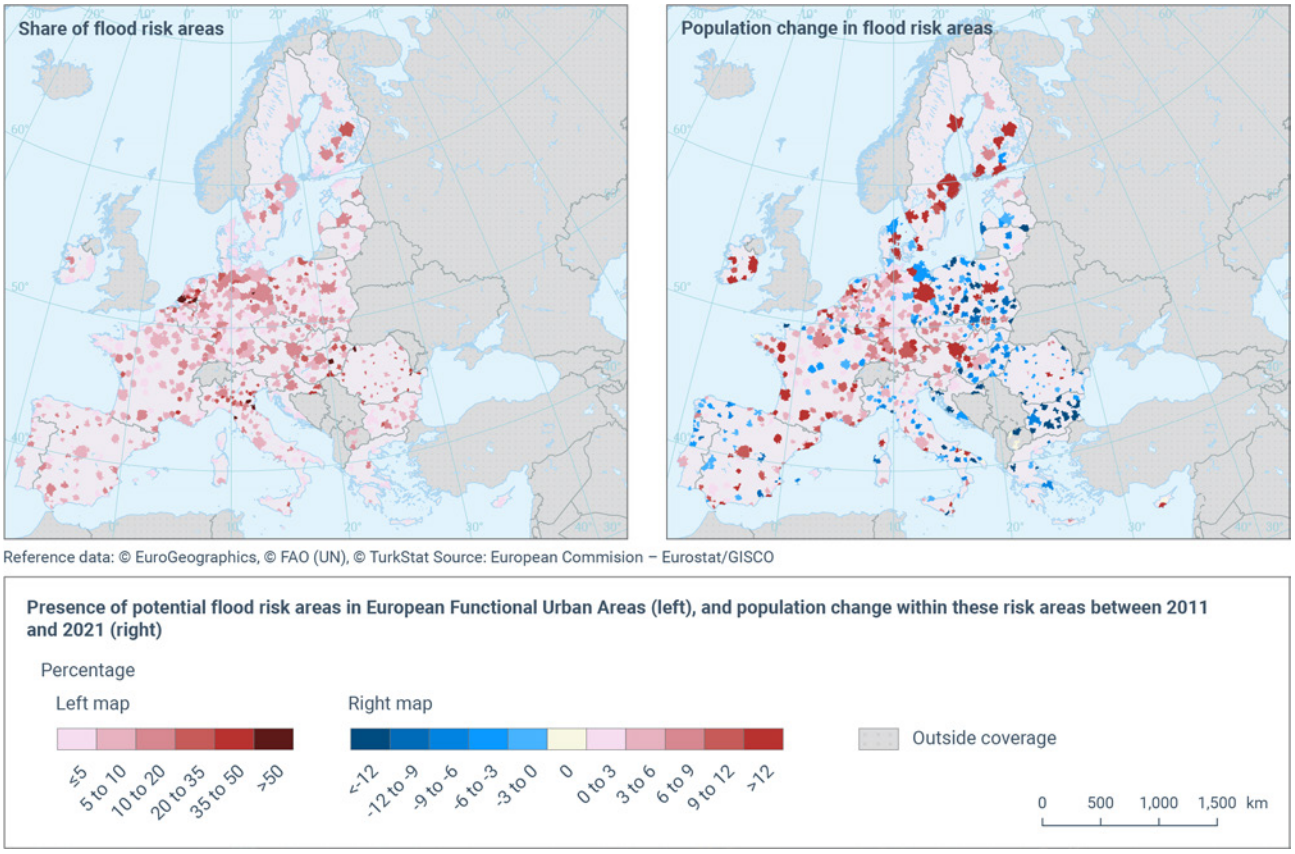
Europe's population is ageing and in the future, there will be a higher proportion of elderly people who are particularly vulnerable to heat. It was estimated, that the population aged older than 85 years contributed to around 60% of total deaths in the period 2000-2019 (Masselot et al. 2023). The very low renovation rate of buildings means that residential and commercial spaces are often not adapted to higher temperatures, which lead to thermal discomfort and lower productivity. Extreme heat also exacerbates existing air quality issues, impacts biodiversity and affects the functioning of transport and distribution systems. In particular, the combination of urban air pollution and excessive heat can greatly impact human health and wellbeing (EEA, 2022b).

2.1.2 Flooding and water scarcity

Most plans (84%) mentioned precipitation variability with 54% specifically addressing inland flooding and 54% addressing droughts and water scarcity. Rainfall is expected to become less predictable and high variation will lead to higher risks of both droughts and flooding. Extended dry periods leave the ground compacted and less able to absorb and retain water. Thus, short, heavy rainfall episodes are more likely to cause a high amount of surface run-off and flash flooding. Importantly, the high share of sealed areas in cities greatly increases the risk of both flooding and water scarcity, with roads, infrastructure and buildings blocking the natural infiltration of rainfall into the ground. A recent example of wide-spread flooding, in the summer of 2023, was in Emiglia Romagnia, Italy. The impacts of climate change on water quantity and quality and the related impacts on human health are explored in detail in EEA, 2024c.

On average, 10.6% of the area within cities and their surrounding commuting zones (i.e. functional urban areas) in Europe consist of floodplains, meaning they are potential flood risk areas. Map 2.2 (left) shows the share of floodplains within these functional urban areas across Europe, which ranges from 0% (no presence of floodplains) up to over 60% (mostly in urban areas in the Netherlands). Map 2.2 (right) shows that the average population increase within floodplains per urban area was 1.6%. More than half of urban areas (57.9%) saw an increase in population within floodplains over those ten years, with 26.9% of urban areas seeing an increase of over 10% in population within floodplains. So, for a majority of cities, an increasing number of people and assets are within flood prone areas and exposed to a potentially increasing flood hazard.

Map 2.2 **Presence of potential flood risk areas in European functional urban areas (left), and population change within these risk areas 2011-2021 (right)**



Source: EEA analysis, based on potential flood risk areas and GEOSTAT population grids 2011 and 2021.

Water use is particularly high in cities, with overexploitation of natural water sources adding to the impacts of increasingly unpredictable rainfall. The Water Exploitation Index indicates to what extent water resources are exploited compared to the water available. In some regions in Türkiye, Spain, Cyprus, Italy and Malta, the seasonal water exploitation index is well above 40%. A threshold above 40% is classified as a region being under 'severe water scarcity'.

2.1.3 Sea-level rise, coastal flooding and erosion

Almost a third (29%) of local climate plans specifically address sea-level rise, coastal flooding and storm surges. In northern countries up to 79% of cities identify these risks. Uncontrolled building within coastal zones also increases the risk of coastal erosion and a collaborative paper by CoCliCo and PROTECT warns that adaptation to multi-metre sea-level rise should start now (Cozannet et al., 2023).

2.1.4 Mass movements

Mass movements include rockfalls, landslides and avalanches, all of which are expected to occur more frequently in the future, with greater fluctuations in permafrost areas and general soil moisture content as rising temperatures destabilise ice and snowfall. Where urban areas are forced to expand on steeper slopes, this may become a higher risk for loss of property and fatalities. Over half (56%) of local climate action plans in southern European cities identify landslides as a hazard already experienced, compared to only 23% overall in Europe (Figure 2.2).

2.1.5 Storms and high wind

Nearly three-quarters (74%) of local climate action plans in northern European cities identify storms as a hazard already experienced, compared to only 29% overall for Europe. While the number of reported windstorms significantly increased over the last decades there is no consensus regarding a climate-induced trend in windstorms over Europe (EC-JRC, 2020). There is growing confidence in projections that foresee the frequency and intensity of storms increasing in northern and central Europe. For southern Europe, storm intensity is expected to increase, but with a decrease in their frequency (EEA, 2021a). The variability in high winds and storms will need to be addressed, especially in cities where the morphology of the built environment can influence and reinforce strong winds.

2.1.6 Wildfires

During 2017-2019, on average, almost 2% of the European population was directly affected by wildfires (EEA unpublished analysis based on EFFIS data). Poor air conditions, often associated with urban areas, increase considerably with the indirect air quality effects of the proximity of wildfires.

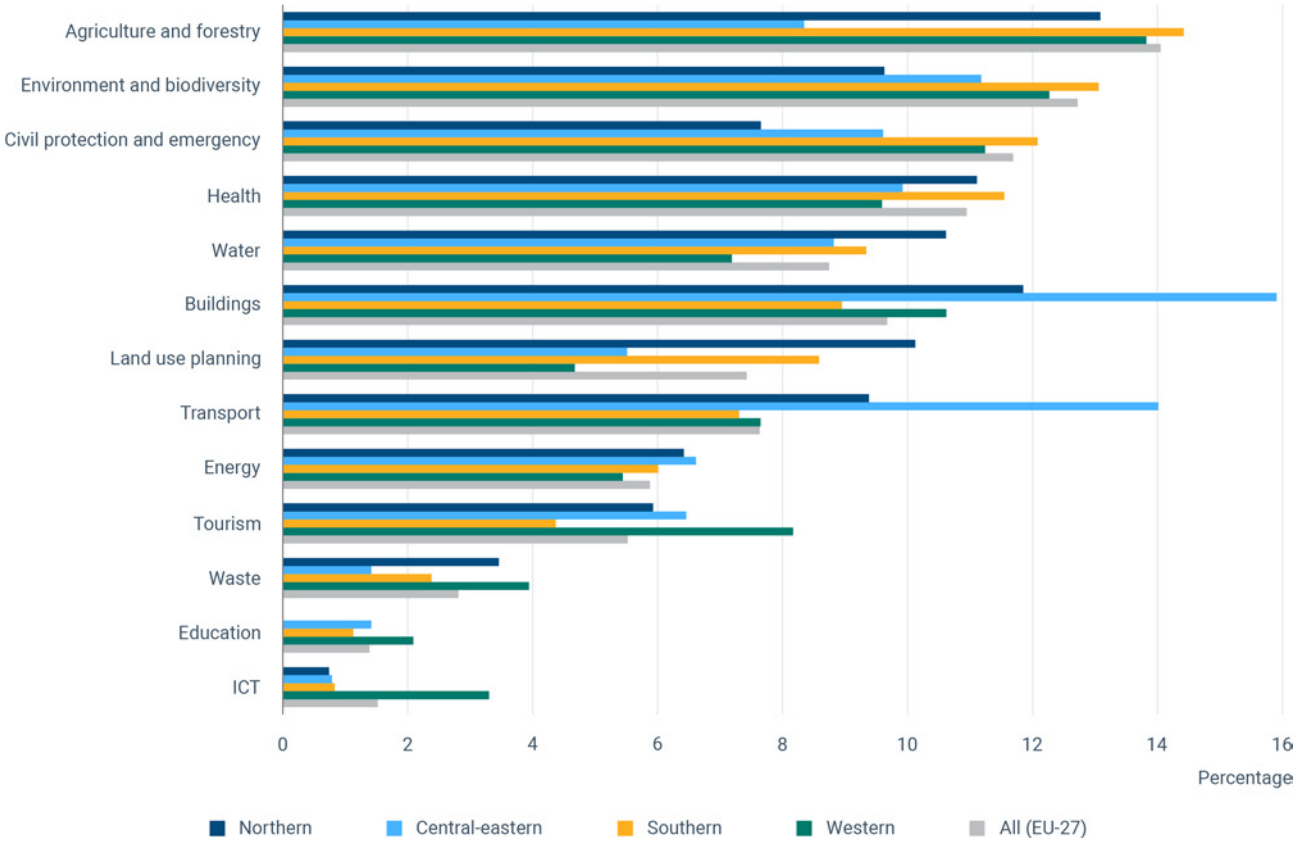
2.2 Sectors particularly impacted

The sectors reported to be most impacted by climate change in larger urban areas are water, buildings, health and transport (Reckien et al, 2022). If smaller municipalities are taken into account, then there are also major impacts reported in the agriculture and forestry, environment and biodiversity, and civil protection and emergency sectors (Figure 2.3, based on reporting to the Covenant of Mayors).

Agriculture and forestry is the sector most often reported as vulnerable to the impacts of climate change, based on 1,123 local authorities reporting to the CoM in 2022. Climatic changes will cause adverse weather and extreme events that can negatively affect crop and livestock production in Europe and globally. In Europe, local impacts on production are currently compensated by intra-European trade, which in the mid-term impacts food availability, affordability and the dietary choices of urban and rural populations in Europe. This puts population groups with a lower socio-economic status at risk of consuming food of lower nutritional value or even food insecurity (EEA, 2024a).

Environment and biodiversity is the second most-reported vulnerable sector. There will also be diverse and mostly negative impacts on biodiversity with a shift in species suitability under changing climatic conditions, which will also affect urban biodiversity. In fact, with rising temperatures, an increasing area of Europe

Figure 2.3 **Sectors identified as vulnerable to the impacts of climate change, as reported by local authorities signatory to the Covenant of Mayors (CoM) by European region**



Note: The figure shows the number of times vulnerable sectors were reported as a share of all reported sectors (%) per European region.

Source: EC-JRC, 2023.

is now becoming suitable to potential carriers of infectious diseases such as the tiger mosquito, which can carry the Dengue, Chikungunya and Zika viruses. This is particularly impactful in urban areas where the high density of people can accelerate the spread of such diseases (EEA, 2022b).

In Paris, health authorities fumigated areas of the city this year for the first time to control the spread of tiger mosquitos. The species was first spotted in France in 2004 and is now present throughout most of the country, having been responsible for cases of Dengue in the south of continental France in previous years, and now a first case in Paris in 2023.

Civil protection and emergency, health, water and buildings are also frequently reported as vulnerable. Flooding in urban areas can cause significant direct and indirect damages to critical infrastructure, according to a recent study which looked into the cascade effects of flood damages and the critical sectors addressed in 26 European cities.

Tourism, often a major source of income in cities, will also be adversely affected by changing weather conditions such as heat extremes (especially in southern Europe), water scarcity and less snow in more northern cities reliant on ski tourism.

3 The policy setting for adaptation action

Key messages

- European climate policy under the Green Deal largely reflects and localises international policies and initiatives on mitigation and adaptation in cities.
- The importance of supporting and facilitating urban adaptation to climate change is increasingly acknowledged in policies and initiatives at the European level.
- Climate adaptation strategies and plans at all levels tend to have a strong urban dimension and cities are already playing a key implementation role.
- Transformational urban adaptation processes align with the goal to boost resilience to climate change through comprehensive, interconnected solutions that address various aspects of urban life and infrastructure.

3.1 The European landscape of increased ambition

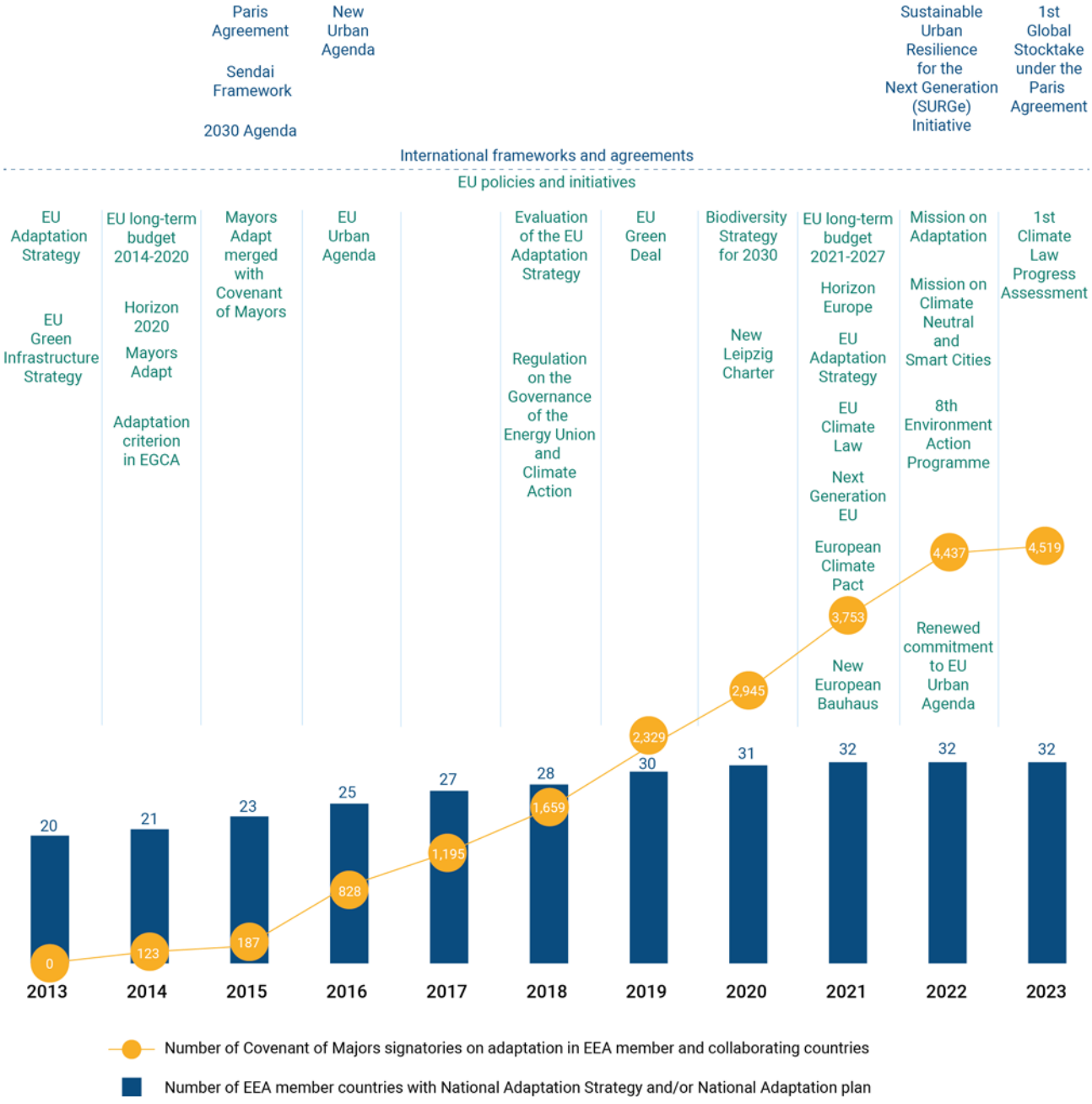
There has been a significant increase in ambition regarding climate change adaptation action across Europe and within EU Member States at both national and subnational levels over the past several years (Figure 3.1). These joint European efforts have been informed by, and are a response to, global level commitments such as the 2030 Agenda for Sustainable Development and the UNFCCC Paris Agreement.

European efforts also localise international urban focused initiatives, such as the Sustainable Urban Resilience for the Next Generation (SURGe) Initiative launched under COP27, with the objective to enhance and accelerate local and urban climate action through multi-level governance, engagement and delivery through five integrated tracks (buildings and housing, urban water, urban mobility, urban waste/consumption and urban energy)

The European Commission adopted its EU Strategy on Adaptation to Climate Change in February 2021, building on its 2013 predecessor. This strategy aims to make Europe climate-resilient by 2050, fully adapted to the unavoidable impacts of climate change and establishing an interim goal of embedding awareness of adaptation and planning in 'every single local authority, company and household' by 2030. It seeks to increase and accelerate the EU's efforts to protect nature, people and livelihoods against the unavoidable impacts of climate change.

The EU Adaptation Strategy is one of the main actions taken under the European Green Deal. Adopted in December 2019, the Green Deal is a strategy to make energy production and the way of life in Europe more sustainable and less harmful to the environment (EC 2021b). It is the blueprint for the transformational change required to achieve the international goals for emissions reductions and climate resilience set by the Paris Agreement.

Figure 3.1 Evolution of the adaptation policy landscape over the past 10 years



Note: Major international and European milestones defining the adaptation policy landscape, trends in the number of countries having national adaptation policies and the number of local authorities signatory to the CoM with an adaptation commitment from 2013-2023.

Sources: EEA, 2020b. Updated by authors with information from the 2023 adaptation reporting (EEA, 2023a) and the Covenant of Mayors.

The European Climate Law is a foundational and legally-enforceable element consisting of a series of measures including new legislation and investments, which entered into force in July 2021. It sets a legal objective of climate neutrality, a binding target of net zero greenhouse gas emissions by 2050 and an intermediate target of reducing net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. EU Institutions and Member States are bound to take the necessary measures at EU and national levels to meet the target while promoting fairness and solidarity among EU Member States. The Climate Law, regarding adaptation, requires 'continuous progress in enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change' (EU, 2021b).

3.1.1 Complementary and reinforcing policies and regulations

Other European policies and regulations with objectives complementary to societal resilience, environment and climate change, reinforce efforts being untaken in relation to the Green Deal and the Strategy on Adaptation to Climate Change. Several examples are provided here:

- The EU cohesion policy aims to strengthen social, economic and territorial cohesion across the EU regions. Several of the thematic areas supported by cohesion policy funds in the 2021-2027 period are directly linked to the goals of the Green Deal, including climate action. The Sustainable Europe Investment Plan (the European Green Deal Investment Plan) mentions cohesion policy as one of the EU's budget sources that can help fund investments in climate and environment-related projects. Projects funded earlier by the Urban Innovative Actions (UIA) and URBACT have been incorporated under cohesion policy. This overarching instrument provides a mosaic of expertise and support to both research and practice and ultimately to policy-in closer cooperation between cities and EU Member States;

- The Urban Agenda for the EU is a multi-level working method for urban policy and practice, which promotes cooperation between EU Member States, cities, the European Commission and other stakeholders (EUI, 2023). It decentralises and embeds the vision of the UN New Urban Agenda within Europe, focusing on better funding, regulation and knowledge for EU policymaking and implementation.

- The New Leipzig Charter provides a key policy framework document for sustainable urban development in Europe (EPRS, 2020). It highlights the need for cities to establish integrated and sustainable urban development strategies and to ensure their implementation in each city as a whole, i.e. from its functional areas to its neighbourhoods. The Charter is strongly aligned with cohesion policy and its framework for sustainable urban development. EU Member States have agreed to implement the Charter in their national or regional urban policies.

- The 8th Environment Action Programme is the EU's common agenda for environment policy until 2030, setting out priority objectives and the conditions needed to achieve them. It aims to speed up the transition to a climate-neutral, resource-efficient economy while acknowledging the importance of healthy ecosystems. A set of indicators is used to monitor progress towards the EU's environment and climate goals outlined in the 8th Environment Action Programme (EEA, 2023b).

- The Regulation on the Governance of the Energy Union and Climate Action establishes reporting requirements on adaptation for EU Member States (EU, 2018). EU Member States must report on national adaptation actions to the European Commission biannually. A review of the reported information (EEA, 2022b) provides insight on how countries are planning, implementing, monitoring and evaluating adaptation policies and actions, including at the subnational level.

- The EU Biodiversity Strategy for 2030 includes a focus on promoting healthy and vibrant urban ecosystems (EC, 2020a). It aims to stop the loss of green urban spaces and to steadily increase them. It also calls for all cities and towns with over 20,000 inhabitants to develop urban greening plans that systematically integrate green infrastructures and nature-based solutions (NBS) into urban planning processes.

- Zero Pollution Action Plan which can also support adaptation measures in areas such as just transition.

Box 3.1

Support for urban adaptation at the national level

The European Climate Law (EU, 2021b) requires EU Member States to adopt, implement and regularly update national adaptation strategies and plans and biannually report on adaptation actions.

All 32 EEA member states have had a national adaptation policy framework in place since 2019. Currently 31 countries have a National Adaptation Strategy (NAS), 18 have a National Adaptation Plan (NAP) and 17 have both. Some countries have begun to introduce legally-binding obligations to address climate change, several of which include specific provisions for adaptation.

As reported in 2023, 10 countries have an adopted national climate law with adaptation relevance: Croatia, Finland, Greece, Hungary, Iceland, Ireland, Luxembourg, Portugal, Spain and Switzerland. Each of these countries, with a legal obligation for adaptation, has a set adaptation policy framework. All 10 countries have a NAS and five have both NAS and NAP (EEA, 2023a).

National adaptation reporting also provides insight on impacts and adaptation at the subnational level, including the urban level. 10 countries specifically identified the urban sector as a key sector affected by climate change in 2023 (Austria, Bulgaria, Czechia, Hungary, Italy, Portugal, Romania, Slovakia, Spain and Switzerland), rating the risk of potential future impacts as medium or high. This indicates that increasing risk due to climate change is anticipated for the sector in the future.

Five of these 10 countries, plus 10 other countries (15 in total), refer to buildings as a key affected sector. 20 countries refer to urban and/or buildings. Nine countries also gave specific consideration to urban areas within the summary of their national strategies (Austria, Bulgaria, Hungary, Italy, Luxembourg, Poland, Portugal, Slovenia and Spain).

3.1.2 Financing mechanisms

Two main financing sources provide critical EU funding for implementing the EU Adaptation Strategy:

- The Next Generation EU Recovery plan (EC, 2020b) complements funding already allocated/earmarked in the EU's seven-year budget, contributing one-third of its EUR 1.8 trillion budget towards EU Green Deal activities.

- The European Regional Development Fund (EU, 2021a) is one of the main financial instruments of EU cohesion policy (along with the Cohesion Fund (CF), the European Social Fund Plus (ESF+) and the Just Transition Fund (JTF)). It aims 'to reinforce economic, social and territorial cohesion by redressing the main regional imbalances in the Union'. A minimum of 8% of the ERDF resources in each Member State must be invested in priorities and projects selected by the cities themselves and based on their own sustainable urban development strategies.

These sources of funding are further complemented by national and subnational sources along with private and philanthropic contributions.

3.1.3 Implementation mechanisms

Policies and regulations require robust implementation mechanisms to result in the desired impacts. Given the centrality of the EU Adaptation Strategy in this report, a few initiatives and programmes supporting its implementation are presented here. Arguably the most central is the Mission on Adaptation to Climate Change. The EU framework on missions was established in 2021 under Horizon Europe with the aim of solving the greatest European challenges by 2030. One of the five initial missions, the Mission on Adaptation to Climate Change, 'focuses on supporting EU regions, cities and local authorities in their efforts to build resilience against the impacts of climate change'. The Mission on Adaptation's objective is to support at least 150 European regions and communities towards climate resilience by 2030. As of September 2023, 308 regional and local government authorities have been formally accepted as mission charter signatories.

Other complementary initiatives also contribute to adaptation and resilience goals:

- The Mission on Climate Neutral and Smart Cities is a mitigation-focused mission which aims to deliver 100 climate-neutral, smart cities by 2030. It also aims to showcase these cities as experimentation and innovation hubs to enable all European cities to follow suit by 2050. This mission is a vehicle to deploy concrete solutions in already selected cities, transforming current research and innovation into actionable knowledge to support local climate change strategies while testing new forms of collaboration. A 2023 joint funding opportunity between this Mission and the Mission on Adaptation, with an indicative budget of EUR 40 million, covers urban greening and re-naturing for urban regeneration, resilience and climate neutrality.

- The European Climate Pact seeks to build a greener Europe by providing a platform for all facets of European society to work and learn together, develop solutions and achieve real change at all governance levels, including local authorities.

- The New European Bauhaus is an interdisciplinary initiative connecting the European Green Deal to living spaces and experiences with the goal to make Europe climate-neutral by 2050.

- The European Urban Initiative (EUI) aims to translate the NEB core values and deliver tangible, real-life examples. Its main objectives are to strengthen integrated and participatory approaches to sustainable urban development and to provide a stronger link to EU policies. The EUI supports urban areas with innovative actions, capacity and knowledge-building, as well as policy development and communication on sustainable urban development. The EUI also promotes the multi-level working of the Urban Agenda for the EU and intergovernmental cooperation on urban matters.

- The Covenant of Mayors (CoM) brings together over 10,000 local governments, each of which has committed to actions around three key pillars. These are reducing greenhouse gas emissions on their territory; increasing resilience and preparing for the adverse impacts of climate change; and tackling energy poverty as one key action to ensure a just transition.

- The URBACT IV programme facilitates knowledge sharing and good practice between cities and other levels of government. The purpose is to promote integrated sustainable development in cities, improve city policies and improve the effectiveness of the cohesion policy in cities. URBACT IV will complement the actions being delivered by the European Urban Initiative. A key aim of URBACT IV is to 'enhance the institutional capacity of public authorities'. URBACT contributes to the partnerships of the Urban Agenda for the EU and the renewal of the Leipzig Charter with the concepts of green, just and productive cities, adopted in 2020.

- The European Commission's Green Capital Award (and Green Leaf Award) aims to promote sharing of good practices by recognising and rewarding local action towards a greener, more sustainable future. Winning cities are actively working together with their citizens on improving the urban environment, including reducing pollution and becoming more climate resilient.

4 Just resilience

Key messages

- Climate change affects all European residents, but not everyone is impacted to the same extent. Those most impacted are typically those who are already disadvantaged due to factors such as age, health, or socio-economic status.
- At the urban scale, some injustices are particularly present because of the interaction between the physical characteristics of the built environment and the often-large proportion of socially vulnerable residents. If they are not addressed, these existing injustices may be reinforced or new ones may develop.
- The implementation of climate adaptation measures may not benefit all members of society evenly. For instance, marginalized communities often have les access to green spaces and face higher financial barriers in obtaining flood insurance or implementing flood-proofing strategies.
- A 'just resilience' approach takes into consideration injustices in both the process and outcomes of the development of adaptation actions. It requires meaningful and inclusive participation, as well as regular monitoring, reporting and evaluation of the outcomes of the adaptation process.

4.1 The need for justice in adaptation

The term 'just resilience' is introduced in the EU Adaptation Strategy and refers to climate change adaptation measures carried out in a just and fair manner, forming the equivalent of 'just transition' in climate change mitigation (EC, 2021a). It addresses two distinct phenomena of injustice in climate change adaptation:

1. with respect to climate impacts and risk: 'unequal burdens', which recognises the unequal distribution of climate impacts and risks due to unequal exposure to hazards, pre-existing inequalities, and differences in adaptive capacities and capabilities resulting in exacerbated impacts and increased vulnerabilities;

2. with respect to adaptation action: 'leaving no one behind'. This entails striving for a just distribution of the benefits and burdens of adaptation responses among social groups, and ensuring fair and transparent processes with a fair distribution of political power and participation in policymaking. Avoiding maladaptive behaviour and targeting the underlying causes of pre-existing inequalities are also key here (Lager et al., 2023).

A 'just resilience' approach ensures these aspects are considered and taken into account in local level adaptation planning, implementation and monitoring. To do this, decision makers need to consider three dimensions of justice (IPCC, 2022), namely:

1. distributive justice, i.e. the allocation of burdens and benefits among individuals, nations and generations;

2. procedural justice, which refers to who decides and participates in decision-making;

3. recognition, which refers to respect for engagement with and fair consideration of diverse cultures and perspectives.

This chapter explores what a 'just resilience' approach means in practice and particularly within an urban context.

4.2 Injustice at the urban scale

4.2.1 Injustice in impacts and exposure

In many European countries, vulnerable communities tend to live in dense, urban environments. The physical characteristics of these urban environments often coincide with an increased level of social vulnerability, reinforcing the uneven distribution of climate impacts and risks.

Factors such as age, gender, household composition, income or level of education, medical conditions or ethnicity may affect someone's sensitivity to climate change impacts, meaning that they are less able to prepare for, resist and/or recover from climate change impacts. They may also have fewer resources available to adapt, or less access to essential public services (transport, health, education) (Breil et al., 2018). Those living in high-risk areas or places with poor environmental qualities will also be more exposed to the impacts of climate change. Examples include those living in low-lying areas prone to frequent flooding or in low-quality housing that is poorly adapted to increasing temperatures. Some areas at higher risk of flooding are inhabited by populations who may not be able to afford moving to safer locations as areas at higher risk of flooding often contain cheaper housing (EEA, 2020b).

Cities such as Rennes, France and Birmingham, UK see a very high heat health risk in their central urban areas. These areas, which in both cities have the highest intensity of Urban Heat Island (UHI) effects, show a combination of increased exposure and high levels of vulnerability leading to a high health risk in cases of high temperatures (Buscail et al., 2012 and Tomlinson et al., 2011). An analysis of how hospitals and schools were distributed in relation to UHI effects in 100 European cities found that almost half of hospitals and schools are in areas at least 2°C warmer than the regional average. In some European countries, local administrative units with higher unemployment rates also tend to have larger areas at risk of flooding. In addition, approximately 10% of educational facilities and 11% of healthcare facilities across Europe are located in potential flood-prone areas (European Climate and Health Observatory, 2022).

4.2.2 Injustice in urban adaptation actions

As the need for climate adaptation is increasingly recognised (EEA, 2020b and 2020c), ensuring that adaptation measures reduce the impacts of climate change on vulnerable groups is vital. Yet, the benefits and burdens of these adaptation measures are often not evenly distributed (EEA, 2022f; Breil et al., 2021). In urban areas across the EU, neighbourhoods with low-income residents tend to have less green space, which is usually of poorer quality. They are also likely to have lower quality housing that is poorly-adapted to increasing temperatures. As a result, they are likely to be more impacted by climate change than residents of wealthier neighbourhoods (EEA, 2022e). If justice is not considered in adaptation implementation, actions may lead to new inequalities or worsen existing ones.

There are three aspects of responses which may lead to situations in which 'winners and losers of adaptation projects' arise (Sovacool et al., 2015):

1. Positive effects: access to the benefits of an adaptation action. This may include primary benefits of the adaptation actions, such as reduction in flood risk, as well as secondary benefits such as increased biodiversity or recreational space that the flood risk reduction measures bring. However, these positive effects may have a social bias, disproportionately benefitting certain more advantaged groups over others.

2. Negative effects: how the costs or burdens from the implementation of adaptation policies and actions (increased costs or a decrease in quality of the living environment) are imposed on communities unevenly. Negative effects of adaptation actions may also disproportionately affect socially vulnerable groups and lead to a greater share of the potential burden of adaptation actions being shared by them, resulting in more vulnerability. In particular, this latter phenomenon is closely related to the notion of 'maladaptation', which is elaborated upon below in Box 4.1.

3. Procedures: some individuals or groups may be excluded or are unable to meaningfully participate in the decision-making process (Breil et al., 2021).

Box 4.1

Maladaptation

Maladaptation poses a growing concern for adaptation planners. This concept refers to actions taken in one location or sector that inadvertently heighten the vulnerability of another location, sector, or group to future climate change. Measures that may initially benefit a specific group or sector could ultimately prove maladaptive under future climate conditions, affecting either the same groups or sectors or others.

Another dimension of maladaptation involves prioritizing short-term gains over long-term resilience, potentially leading to resource depletion and increased vulnerability over time. For instance, certain development policies and actions may yield immediate economic benefits but result in heightened vulnerability in the medium to long term. This occurs, for example, when the construction of “hard” infrastructure limits future adaptation options. (Breil et al., 2021)

If adaptation efforts merely shift risk or vulnerability without addressing underlying issues, marginalized communities are likely to bear the brunt of the consequences. This is because they often have minimal involvement in decision-making processes and limited capacity to mitigate risks and vulnerabilities (Atteridge and Remling, 2018). An example of a response to a specific manifestation of maladaptation, namely gentrification, is provided in Box 4.4.

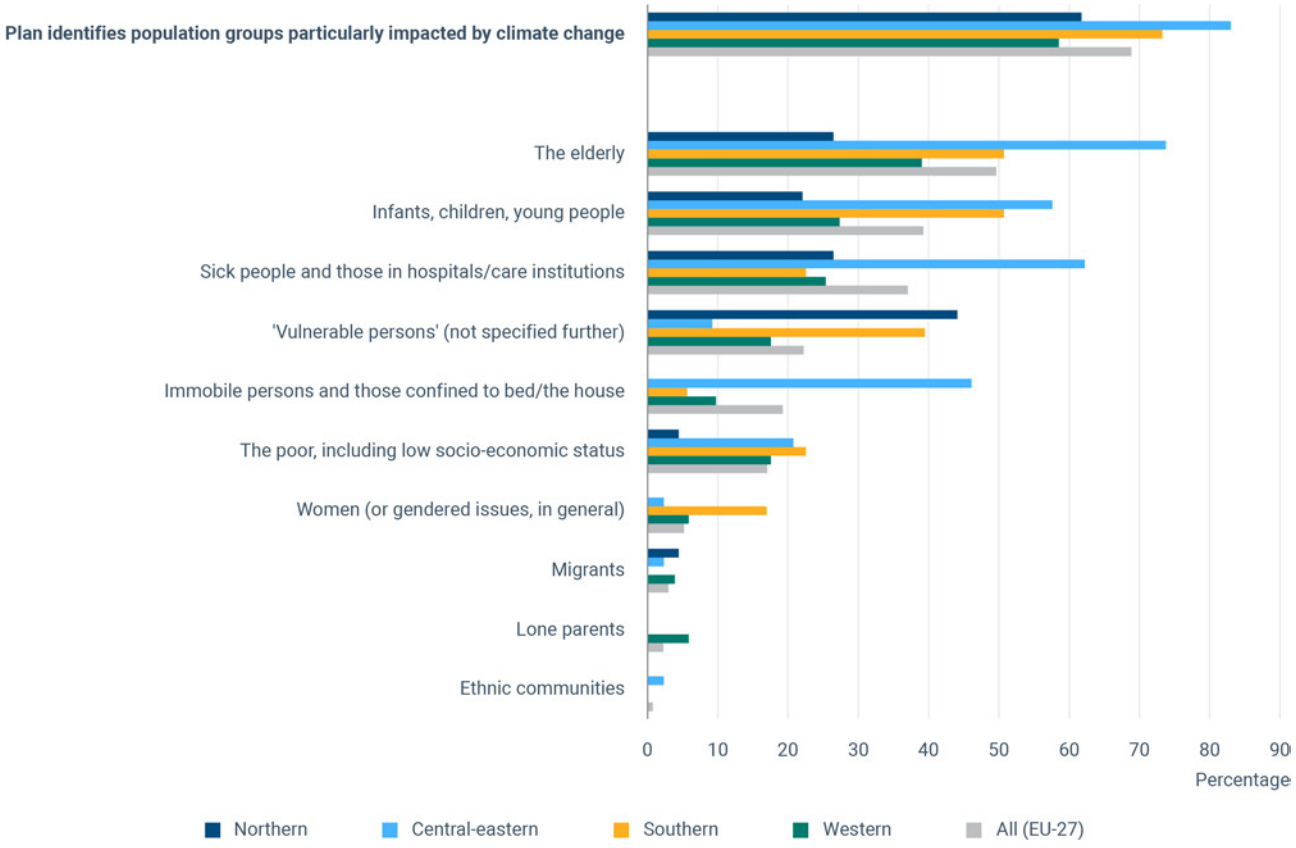
4.3 Putting 'just resilience' into practice

Enabling 'just' adaptation means shifting the benefits of adaptation actions and reducing their associated burdens in favour of the most vulnerable groups. Adaptation planned and implemented at the local scale plays a particularly important role in achieving this. This is because local authorities generally have the best knowledge of local population characteristics, local climate-related hazards and opportunities for community participation. Thus, considering justice in planning and implementing adaptation actions is most important at the subnational level, local level and at city scale (EEA, 2022e). To achieve this, all dimensions of justice need to be included throughout the adaptation policymaking or planning process (Lager et al., 2023).

4.3.1 Identifying and engaging vulnerable groups

While practical guidance for local authorities on how to identify and involve vulnerable groups in their adaptation efforts remains somewhat sparse, a review of local climate action plans (Reckien et al., 2022) shows that across the EU, many local authorities recognise the importance of identifying these population groups. A majority (68%) of these reviewed local climate action plans identified certain population groups that are, or will be, particularly impacted by climate change. The majority of local climate action plans recognised the disproportionate impact of climate change particularly on the elderly, children, sick people or those in hospitals/care institutions (Figure 4.1).

Figure 4.1 **Share of plans (%) identifying specific groups as being particularly impacted by climate change by European region**



Source: Reckien et al., 2022.

Once socially vulnerable groups have been identified and mapped, decision-makers need to ensure their meaningful and inclusive participation. As the outcomes of planning processes are influenced by who is involved, enabling participation of vulnerable social groups is a particularly important aspect to ensure increased justice in climate change adaptation (Breil et al., 2021). This requires a good understanding of who is affected and what is at stake for each of the social groups. Engagement and agreements of diverse stakeholders in design and implementation can further increase the overall acceptance and support for the resulting measures.

However, participation does not automatically lead to better outcomes for social justice (Lioubimtseva and da Cunha, 2020; Planas Carbonell, 2021). Simply reaching out to disadvantaged groups is not enough, participation processes must also address the differential capacities of the stakeholders taking part (Breil et al., 2021). The most vulnerable groups need to be empowered to understand the issues at stake and share their insights on the most appropriate adaptation actions. Furthermore, power structures that may determine access and active participation in the planning and decision-making need to be recognised. Perceptions of vulnerability may also differ, and those who may be classified as socially vulnerable may not perceive themselves as such.

The cities of Dresden and Prague are two examples where vulnerable groups were involved in making decisions about types of adaptation options and where they should be implemented. In the relatively disadvantaged neighbourhood of Gorbitz in Dresden, Germany, consultation with residents on the ways to improve thermal comfort in homes and the neighbourhood, as part of the HeatResilientCity project, led to plans to plant more trees, install window shutters and boost ventilation in apartment blocks. Participatory mapping by residents of District 6 in Prague identified that bus shelters were particularly hot and uncomfortable, leading to the installation of green roofs (EEA, 2020b).

Box 4.2

Engaging socially vulnerable groups in adaptation policy planning across the EU

Vulnerable communities are increasingly being integrated into participatory stakeholder engagement processes during the formulation of national adaptation policies. During the preparation of Finland's National Adaptation Plan (NAP) 2030, consultations were held with stakeholder representatives for vulnerable groups such as the youth, elderly, disabled and the indigenous Sami people, whereas the most vulnerable populations were included in the development of France's second NAP, represented through state services or via their representatives within associations. Climate Conversation events in Ireland were used to co-create the Climate Action Plan and included people in hard-to-reach areas of the country and members of disadvantaged communities, amongst others.

Furthermore, vulnerable groups are being taken into account when prioritizing adaptation measures. Finland's Climate Act and the climate policy planning system under the Act aim to ensure justice and fairness in the context of climate measures. All 80 measures in Latvia's NAP2023 intend to address vulnerable stakeholders. Similarly in the Netherlands, the interest of the most vulnerable groups are paramount when prioritizing actions, and in Sweden priority areas for adaptation in the National Adaptation Strategy have been identified based on their impact on society, including the effects on vulnerable groups. Policy-making in countries such as the Netherlands and Spain is also informed by research on social equity and fairness (EEA, 2022a; EEA 2023b).

At the sub-national level, vulnerable groups are also being included in the development of regional adaptation policy. This is mandatory in Greece, where stakeholder engagement and public consultation, especially with stakeholder groups whose activities are more vulnerable to climate change, is required in the development of regional adaptation action plans. Representatives for the most vulnerable populations in national, regional and local associations are involved in the development of regional climate policies in France.

4.3.2 Implementing adaptation with equity in mind

The implementation of adaptation measures can positively or negatively address inequities in two main ways. The first is related to the process of implementation itself: it can either engage with particularly vulnerable populations or exclude them, their life experiences and their perspectives. Strategies and plans should provide practical ways to engage these groups (with accompanying capacity-building activities if necessary). The second relates to the actual choice of adaptation measures, though more research is needed on their potential justice implications.

There are exemplar cities, such as Barcelona and Berlin, that allocated significant resources towards advancing their understanding, mapping and integration of vulnerable and marginalised groups in both planning and implementation (Lager et al., 2023). An example of an adaptation project of this being done successfully is OASIS (Openness, Adaptation, Sensitisation, Innovation and Social Ties), a schoolyard greening programme in Paris. The programme aimed to transform schoolyards in Paris into green oases accessible to both school pupils and local communities.

While not yet conclusive, there may be a link between the implementation of green spaces and gentrification or displacement (due to rising property prices). A recent study of 28 cities in North America and Europe concluded that there was a strong positive relationship between greening in the period 1990-2000 and the gentrification that occurred between 2000-2016 in 17 of them (Anguelovski et al., 2022). In addition, a study in Minneapolis concluded that green stormwater infrastructure may deepen environmental inequalities (Walker, 2021).

In many cases, NBS implementation itself has only a limited role to play in gentrification. For example, in the case of Dublin, it was the high technology investment and related real estate development that were the primary drivers (Anguelovski et al., 2022). Regardless, adaptation policies must proactively mitigate potential gentrification risks of NBS implementation. Collaborations between local officials implementing these projects, other government departments holding other policy levers and local communities are critical for identifying displacement mitigation strategies. For example, in creating or enhancing affordable housing and rights policies in cities - these exist in Amsterdam and Lyon, where 30% or more of the housing stock is allocated to social housing.

The 2021 Barcelona Laboratory for Urban Environmental Justice and Sustainability report showcasing over 50 tools and policies to prevent displacement and gentrification, while also improving the accessibility and inclusiveness of green amenities and spaces in urban contexts (BCNUEJ, 2021). Additional good practice examples from Europe and beyond are found below in Boxes 4.3 and 4.4.

Box 4.3

Nantes, France: green and affordable

Nantes has been making great strides in achieving the status of being one of the greenest cities in Europe while remaining affordable (BCNUEJ, 2021). It invests around EUR 30 million per year to bring nature back into the city landscape, guaranteeing that all inhabitants live within 300m of one of the city's 100+ municipal parks and green areas. To meet this ambitious commitment, the city carefully oversees the equitable distribution of green amenities across its neighbourhoods. Integrated development zones (ZAC) play an important role in enabling strong oversight by planners of the city's large project developments. Strict municipal guidelines requiring 56% of new housing stock construction to be designated as public and social housing ensures less affluent community members have equal access to new, desirable developments or can afford to stay in upgraded neighbourhoods. The city has also established clear guidelines around community participation in all development projects. This results in equitable regreening and greening without affordability-related displacements or barriers.

Box 4.4

Looking beyond Europe: tackling NBS-related displacement in Washington, D.C.

The 11th Street Bridge Park project in Washington, D.C. was the city's first elevated public park, positioned over the Anacostia River. It was a green infrastructure partnership between Ward 8's non-profit Building Bridges Across the River and the District Department of Transportation. Having faced strong community pushback in the early stages of the project's development on the grounds of potential gentrification-related impacts, project managers invested significant resources into collaborating with community leaders to develop equity-focused development strategies. Such strategies included the establishment of community land trusts, safeguarding affordable housing investments, investment in small businesses, and the provision of skills training and jobs for local residents (Cartier, 2021).

4.3.3 Measuring progress on just resilience

The number of local adaptation plans which include equity aspects is increasing (Reckien et al., 2022). However, guidance documents for local just resilience often lack specific methods for monitoring the status of vulnerable groups, their involvement in adaptation decision-making or the social outcomes of adaptation measures implemented over time. An operational set of just resilience indicators at EU levels, which could serve as a reference for the development of such indicators at national and local levels, is not yet available.

Lager et al. (2023) offers systematic overviews on climate change impacts and risks with an uneven burden, including an overview of adaptation policies and measures (policy interventions) that are currently known for having justice implications. The report identifies three critical elements that should guide the development of an effective just resilience monitoring and progress reporting scheme:

1. Policy relevance: local policy can be informed by EU and national just resilience policy priorities. At EU level, the priority lies on employment and worker wellbeing, as well as on the international dimension of EU adaptation policies. Several policy initiatives inform and support European cities in shaping their just resilience policies, such as the New Leipzig Charter and the Covenant of Mayors;

2. Sound scientific basis: a full assessment of just resilience aspects needs to be made, including areas where knowledge and data may be scarce. The uneven burden of climate change impacts and the risk for potential unjust policy interventions occurs across a wide range of sectors, including agriculture, biodiversity, buildings, energy, health, transport, and water management.

3. Practical applicability: indicator proposals need to build on data that is continuously updated and accessible to allow progress monitoring over time.

Box 4.5

Examples of monitoring initiatives at the urban scale

While there are still only limited datasets with sufficient level of detail to cover subnational justice-related aspects, there are a number of indicators already in use (or being developed) to measure progress in just resilience.

Glasgow city region has based its adaptation strategy on the ambition of achieving a socially just adaptation process by co-creating a qualitative vision for the area. This draft strategy has undergone a Social Impact Assessment acknowledging the more complex and systemic issues associated with long-term climate adaptation in the participatory processes put in place. Recently, an interactive vulnerability map was published to monitor progress towards just resilience and decision-making for action plans, and to understand how adaptation measures are impacting different groups. The indicators for social disadvantages, used to identify disadvantaged populations, are based on the Scottish Index of Multiple Deprivation.

Another example is the development of subnational indicators for the metropolitan area of Helsinki to understand adaptation needs and evaluate the effectiveness of measures (Lager et al., 2023). The city of Helsinki is currently building further on this work.

Section II

Implementing adaptation: what works?

This section explores five clusters of adaptation actions that aim to build our resilience to a climatically unstable world and contribute to creating cities where people, nature and the economy can thrive. Adaptation actions aim to reduce the impacts of climate-related hazards by reducing overall exposure, reducing overall vulnerability to climate change or increasing adaptive capacity. The types of actions taken will vary in effectiveness depending on local conditions, possibilities and requirements. The right combination of measures, but also their specific design and implementation, will have to be defined by each municipality individually. This is to ensure the best adaptation outcomes to reduce the risk of maladaptation, and to include and address the most vulnerable groups. While not exhaustive, we aim to give an overview of the options available and highlight examples of specific actions implemented by cities in Europe. Where relevant, international examples are also provided.

The key type measures (KTMs) for adaptation to climate change were established to respond to the shortage of standardised reporting requirements or indicators, which is often cited as a limitation to monitoring progress on adaptation. The full overview of the KTMs (Leitner et al., 2021) is given in Annex 1, which includes the following general categories, upon which the following chapters are based:

- governance and institutional: policy instruments, regulations and mechanisms to support and streamline adaptation;
- economic and finance: insurance, economic incentives and innovative financing mechanisms;
- physical and technological: early warning systems (EWS), mapping, physical infrastructure and other sector-specific innovations;
- nature-based solutions (NBS) and ecosystem-based approaches: measures integrating nature, including green infrastructure, tree cover, water and soil regeneration;
- knowledge and behavioural change: awareness raising, knowledge sharing and actions encouraging changes in consumption and lifestyle patterns.

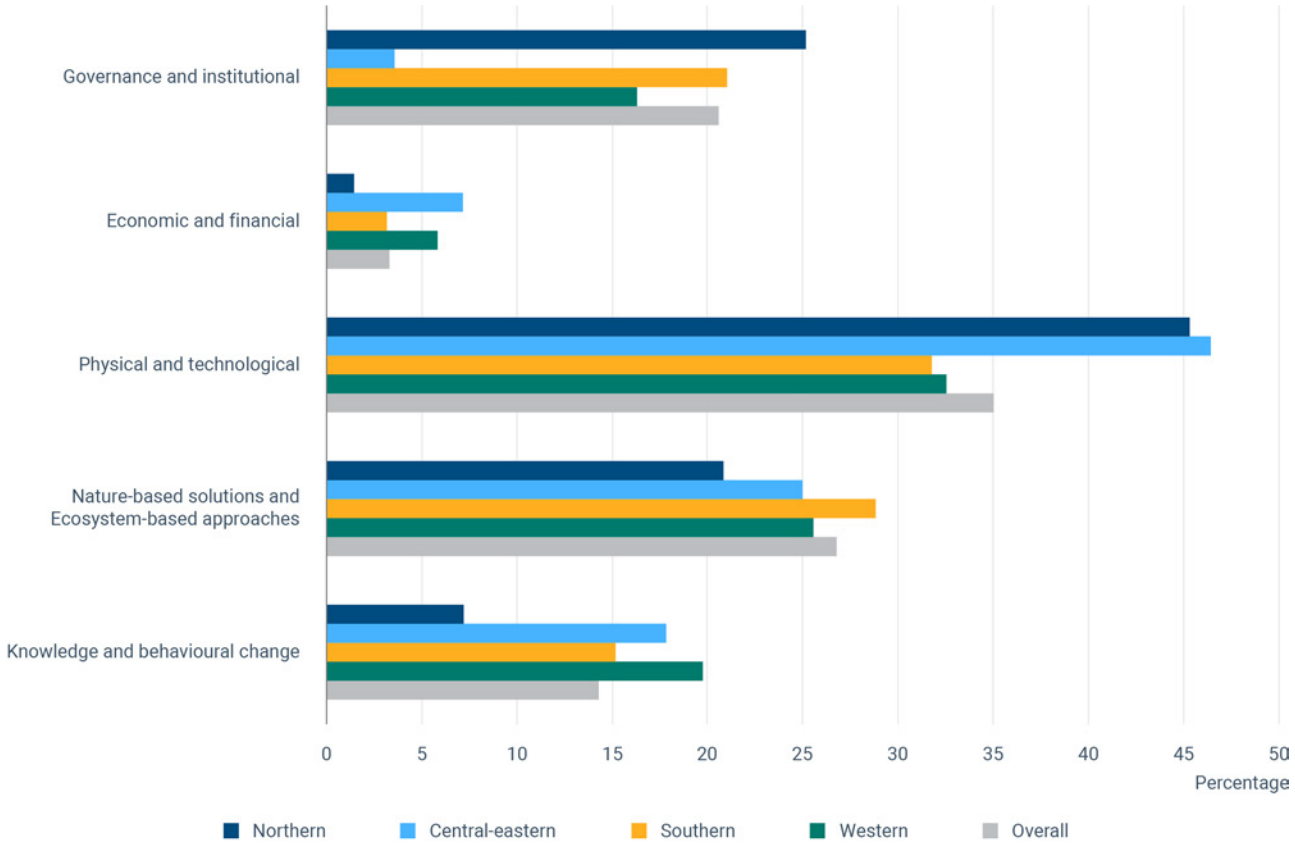
The KTMs were first developed in 2012 to simplify reporting under the Water Framework Directive following the 2010 reporting by EU Member States where there were varying interpretations of the requirements (EEA, 2020a). The goal of using this type of approach is to have clear and consistent outputs from reporting to better support adaptation planning, monitoring and evaluation (Leitner et al., 2020). In fact, Members States are now asked to report on these voluntarily under GovReg Art 19 (EEA, 2022a). The use of KTMs for adaptation to climate change is, however, still a relatively new concept, and there will still be room for improvements or refinements over time.

While separated into five main clusters, there is significant and necessary overlap between the groups of measures. Additionally, there is increasing evidence that developing interventions that bring together a number of cluster strategies (e.g. grey infrastructures, NBS and governance/institutional strategies) result in better adaptation outcomes (UNEP, 2022). Some examples of adaptation actions that include different elements include:

- technological solutions that engage the public, such as water demand management through the use of water meters, which naturally overlap with behavioural change;
- planning and zoning activities, such as land-use and zoning restrictions identified in the institutional and governance measure, which may complement physical measures in relation to managing floods and infrastructures on flood zones.

Figure S2.1. gives an overview of the relative share of actions taken, as reported by cities to the Carbon Disclosure Project (CDP, 2022).

Figure S2.1 **Share of actions taken by main Key Type Measures (KTMs) by European region**



Notes: This analysis is based on an interpretation of the action descriptions in the CDP database. Where an action involved several categories of measures, the main one was used in the classification.

Source: CDP, 2022.

Physical and technological measures were reported the most frequently across Europe, covering 35.4% of all actions, followed by NBS (26.6%) and governance (20.3%). Knowledge-based actions accounted for only 14.3% of actions and economic measures were the least reported (3.4%). While there is similarity in the general preferences towards certain kinds of measures, there are some differences across Europe. For example, central and eastern countries report more economic measures, southern countries report using more NBS, northern countries report using more governance measures than NBS and western countries report with slightly higher emphasis on knowledge-sharing measures than other regions of Europe.

Within each KTM, actions can address one or several specific hazards and tackle issues within a wide variety of sectors. Figure S2.2 gives an overview of the sectors in which adaptation actions are most commonly reported by the signatories of the CoM. In 2022, over 19,000 adaptation actions were reported, with the majority addressing adaptation needs in the water (17%), buildings (13.6%), environment (11.7%), land (10.8%), agriculture (9.3%) and health (7.6%) sectors.

Figure S2.2 **Adaptation actions planned and reported by the CoM signatories in 2022, by sector**

Note: In total, 19,124 planned adaptation actions were reported.

Sources: EEA analysis of EC-JRC, 2023.

Several cities have suggested indicators which may be used to monitor progress in the implementation of adaptation measures. Some examples, based on an unpublished EEA analysis of 76 local climate action plans across Europe, are given at the end of each chapter within this section. These are meant only to serve as potential inspiration as to how the various actions (only in terms of actual output) can be measured.

Additionally, detailed descriptions of adaptation options falling under each of the KTMs and further extended case studies on their implementation can be found on Climate-ADAPT.

5 Governance and institutional measures

Key messages

- Local authorities play a vital role in enhancing communities' adaptative capacities by establishing or improving policies, regulations, financial incentives and guidance.
- European cities have advanced in adopting local adaptation plans, mainly relying on national climate laws and international climate networks. However, more efforts are needed to showcase the effectiveness of adaptation measures and their integration with mitigation goals.
- Mainstreaming adaptation in cross-sectoral policies and regulations plays a vital role in achieving multiple benefits, especially in long-term urban developments. Meanwhile, sectoral plans provide focused and effective solutions.
- Despite advancements in governance and institutional measures, cities still need to focus on public engagement, participation, involvement of vulnerable groups and aligning risks with goals.

5.1 What are governance and institutional measures?

Depending on a country's governance system and decentralisation level, cities have the authority to establish binding laws and policies across various sectors that can address local adaptation needs. Governance and institutional measures are legal, policy, management and social instruments that can include both formal (e.g. laws, policies and procedures) and informal aspects (e.g. routines, beliefs, and norms shaping social practices and human behaviour). They can play a pivotal role at the city level (Patterson, 2021; Noble et al., 2014).

Table 5.1 gives an overview of the various institutional and governance measures relevant at the city level. Across the EU in 2022, governance and institutional measures made up 20.3% of the 711 reported adaptation actions. Within this category, 11% were policy instruments, 5.1% pertained to management and planning actions, and 4.2% were associated with activities focused on coordination, cooperation and networks (CDP, 2022). Northern EU countries are leading in reporting governance measures, followed by southern, western and central/eastern countries.

Table 5.1 Overview of the governance and institutional measures included in this chapter, following the KTM classification

Sub-measures	Elements	Urban examples
Policy instruments	Creation/ revision of policies	• Local climate adaptation strategies and plans • Sustainable energy and climate action plans.
Management and planning	Mainstreaming adaptation Creation/revision of technical rules, codes and standards Adopting building certification design standards	• Mainstreaming into sectoral plans, or long-term cross-sectoral plans • Urban planning • Climate proofing measures for buildings, e.g. optimising energy efficiency, using sustainable materials, green infrastructure and sustainable urban drainage systems.
Coordination, cooperation and networks	Creation/ revision of coordination arrangements Creation/ revision of stakeholder networks	• Creation of regional coordination boards • Creation of new organisational structures in local authorities. • Creation of local partnerships; • Enhancing existing local networks into multi-level, multi-stakeholder collaboration spaces.

5.2 Policy instruments

An increasing number of cities in Europe integrate climate adaptation into their planning instruments and decision-making processes (EEA, 2020b). Local climate action plans are dedicated city level planning documents addressing climate change adaptation and/or mitigation. The adoption of local adaptation policy documents is increasing in European cities, mainly driven by national climate governance, as in Croatia, Denmark, Poland and Ireland or through increasing commitment of local authorities to the Covenant of Mayors, as in Italy, Latvia, Romania and Slovakia (EEA, 2022a).

In 2018, an evaluation of 885 EU and UK cities showed that only 26% had standalone adaptation plans, while 17% had combined adaptation and mitigation plans (Reckien et al., 2018). It was further indicated that factors, such as city size, national legislation regarding local climate and energy planning and participation in city networks/initiatives (e.g. CoM), can have a positive impact on the formulation and development of local climate and energy plans. However, there has been significant progress since then, with 51% of European cities now having dedicated adaptation plans (Reckien et al., 2023).

Although these plans may vary in specific details, they generally follow a similar structure. Great examples include those of Sofia (Bulgaria), Galway and Dublin (Ireland). Galway's adaptation plan stands out for its comprehensive risk assessment, detailed action plan, integration of adaptation into planning decisions, infrastructure improvements, public awareness campaigns and ongoing monitoring. This approach has been driven, in part, by the Irish government's requirement for cities to develop high-quality plans, including climate risk assessments. Galway is also set to release a new joint Climate Action Plan in 2024, further highlighting its commitment to climate resilience.

In a recent study, local climate action plans were assessed based on an evaluation of the impacts and risks, establishment of adaptation goals, identification of adaptation measures, implementation strategies, monitoring and evaluation practices, and the involvement of society. While the quality of plans has improved in recent years, the average quality score remains at approximately one-third of the maximum possible score. This highlights the need for enhanced public participation, better alignment of risks with goals and addressing the specific adaptation requirements of vulnerable groups (Reckien et al., 2023).

5.3 Management and planning: mainstreaming adaptation

Mainstreaming involves the integration of adaptation aspects into broader planning frameworks, such as sustainability, resilience plans, urban/development plans and integration to other sectoral policies and plans, like local flood and heatwave plans (Reckien et al., 2019). It entails a cross-sectoral approach aimed at achieving broader goals that address climate change impacts across various policy fields. While it may result in slower policy development, it can help significantly increase resilience in the long-term (Rauken et al., 2015).

Box 5.1

Mainstreaming adaptation into other sectoral plans

Flood risk management plans

In several European countries, such as Slovakia, Ireland and Poland, municipal flood plans considering climate change have been established, as mandated by the EU Floods Directive. However, only a fraction of cities at larger rivers have addressed the challenge of climate change in their flood risk plans, with flood protection often treated separately from climate considerations (Reckien et al., 2019). The Floods Directive emphasises the importance of integrating land use and spatial planning in flood risk management plans (FRMPs). Some EU Member States have implemented regulations to restrict activities in flood-prone areas and integrate spatial planning policies within flood risk management. However, challenges remain in defining flood-prone areas and linking them to flood hazard maps in certain countries. The legal means for asset relocation exist, but enforcement is rare due to legal complexities and the high costs associated with moving assets and people (European Court of Auditors, 2018)

Heat health action plans

Municipal heat health action plans (HHAPs) can help address the health impacts of climate change and are recorded in some cities in Austria, Croatia and Slovakia. However, they are relatively rare and often not the sole adaptation-related plan of a city (Reckien et al., 2019). HHAPs provide short-term responses, which include early-warning meteorological systems, institutional responsibilities and the measures to be deployed. Well-designed and wel-implemented HHAPs could assist in reducing mortality from extreme temperatures (EEA, 2020b). They can be applied in urban and other settings to target the general population and, in particular, vulnerable groups such as the elderly or outdoor workers (IPCC, 2022). Specific HHAPs are listed in ten countries: Austria, Belgium, France, Germany, Italy, North Macedonia, Portugal, Spain, Sweden and Switzerland.

Mainstreaming applies to all levels of governance from EU to local level. The strategic significance of multi-level and cross-sectoral mainstreaming in the implementation of adaptation is highlighted in the EU Adaptation Strategy.

Europe has made continuous progress in mainstreaming climate change adaptation at the national level. Several countries, including Belgium, Denmark, Estonia, Malta, Poland, Portugal, Romania and Slovakia, are increasingly incorporating climate change impacts into their national Disaster Risk Management (DRM) frameworks and sectoral planning (EEA, 2022a; Leitner et al., 2023). This integration extends to areas such as national civil protection plans, disaster risk management plans, national risk assessments, drought management plans, flood risk management plans and river basin management plans. Notably, EU Member States have advanced their efforts in integrating climate change adaptation into sectors that were previously less explored, including urban planning, buildings and transport (EEA, 2022a). Examples include Latvia's integration of climate change adaptation into the architecture strategy and France's incorporation of adaptation into various plans and documents related to territorial coherence, urban planning, natural risk prevention and marine environments. Portugal is actively engaged in mainstreaming climate change adaptation into coastal management, with plans to integrate the national Coastal Risk Assessment (CRA) into local master plans (Leitner et al., 2023)

5.3.1 Adaptation through urban planning

The integration of climate adaptation policies into urban planning processes can help to address both climate change mitigation and adaptation effectively and simultaneously. Urban planning processes can effectively address climate adaptation objectives by incorporating a multi-scale, multi-sectoral approach. They can link adaptation and mitigation policies with local transport, biodiversity and health-related policies to determine the scale, mix and design of development to ensure resilience to climate impacts (Reckien et al., 2019).

More than three-quarters (82%) of local action plans include measures related to buildings and land use planning, 42% of plans focus on changing building codes (52% for plans in central and eastern countries), 35% on improving insulation and 10% on compact development (Reckien et al., 2022). Notably, 22% of plans in northern countries included measures related to the mixed use of land.

The Basque government, in its KLIMA 2050 strategy, considers urban plans to be crucial in implementing adaptation objectives. As an example, the Urban Development Master Plan (PGOU) of Bilbao requires development proposals to have specific climate risk studies and the city is developing a Green Infrastructure Plan.

5.3.2 Planning measures addressing both adaptation and mitigation

Urban planning can promote the efficient use of urban space and discourage urban sprawl. There are several planning concepts supporting climate change mitigation and sustainability, such as 'compact cities', 'complete neighbourhoods', '15-minute cities' (Box 5.2), '20-minute neighbourhoods' and 'superblocks' (TCPA, 2021). Their focus is on ensuring that the local community's needs are met within a short distance, reducing car dependency and improving infrastructure. Implementing such policies brings adaptation co-benefits by efficiently using urban space, preventing urban sprawl in vulnerable areas, transforming public space through brownfield land reuse and making room to integrate NBS (e.g. by reducing the need for parking).

Box 5.2

Paris' 15-minute city policy

Paris has embraced the concept of the '15-minute city' as a central strategy to address climate and social challenges in the city. The vision is to create a city that allows residents to meet their daily needs closer to home within 15 minutes on foot or by bicycle. The concept identifies six essential social functions for sustaining urban life: working, living, healthcare, education, commerce, and entertainment.

Since 2014, actions have been taken to realise this concept and enhance living standards in neighbourhoods across the city. The Paris Resilience Strategy focuses on tackling climate change, air pollution, inequalities and social cohesion through cross-cutting collaboration between departments. Efforts include transforming the motorway network and the ring road to support active mobility, reducing traffic lanes and speed limits, and enhancing the bus and cycle network. The plan revolves around repurposing existing places for multiple uses instead of building new facilities. The objective is to offer all residents a 'common base' within their neighbourhood. Paris showcases this transformation by emphasising schools as neighbourhood hubs. Additionally, the city is bolstering its network of local shops, supporting small independent businesses and promoting locally-sourced products and services under the 'Made in Paris' label.

Participatory democracy plays a crucial role in the vision, with 'citizen kiosks' providing residents with one-stop shops for inquiries and advice in their neighbourhoods. Paris has one of the largest participatory budgets globally, allowing residents to develop proposals and vote for projects, fostering trust and active engagement in shaping their neighbourhoods.

Actions towards sustainable mobility work towards both adaptation and mitigation targets, as do those increasing the efficient use of energy and water.

More than half (63%) of local adaptation plans incorporate at least one measure on transport, with 47% on improving public transport, 39% on cycling facilities and 25% on walking infrastructure. Notably, cities in central and eastern Europe have the highest share of plans including measures on all three of these priorities (Reckien et al., 2022).

Urban plans can support climate resilience in building design, including considering building orientation, internal layout, insulation, ventilation, green roofs, walls and passive cooling strategies. Sweden's Planning and Building Act 2010, for example, emphasises maximising natural advantages when arranging buildings (UN Habitat, 2022). Planning policy requirements can also promote the use of sustainable urban drainage systems (SUDS) in new developments. These include rainwater harvesting, stormwater retention ponds, and the integration of green infrastructures to manage water runoff and reduce pressure on drainage systems.

Eco-district zoning, characterised by neighbourhood-scale developments, incorporates principles such as efficient street networks, mixed land use and social diversity to address climate challenges. The Luciline eco-district in Rouen, France, is a sustainable mixed-use community in a former industrial area. It includes a water management system with canals, green roofs and tree corridors to combat urban heat. The area offers low-carbon transport options and involves stakeholders through public consultations.

5.3.3 Safeguarding and designating space for nature

Local plans can both safeguard and designate new space for climate adaptation measures, including green infrastructure. In some cases, there may also be policies in place to limit urban sprawl, as is the case in Flanders, Belgium. Gent, a city in east Flanders, already requires that an equal area of paved surface is removed and replaced with natural area when expanding built areas; see the city's 'Ruimte voor Gent' strategy. New constructions are also required to meet specific requirements, including adding green roofs and not producing surface runoff from rainwater, which should be collected or infiltrated into the ground and drained separately to the sewage system. The collection and infiltration of rainwater is already required and supported by subsidies throughout the region for new construction or renovations. The city also has a specific green spatial plan that safeguards 257ha of green areas and sets aside 113ha of building ground purely for natural areas, forests and parks.

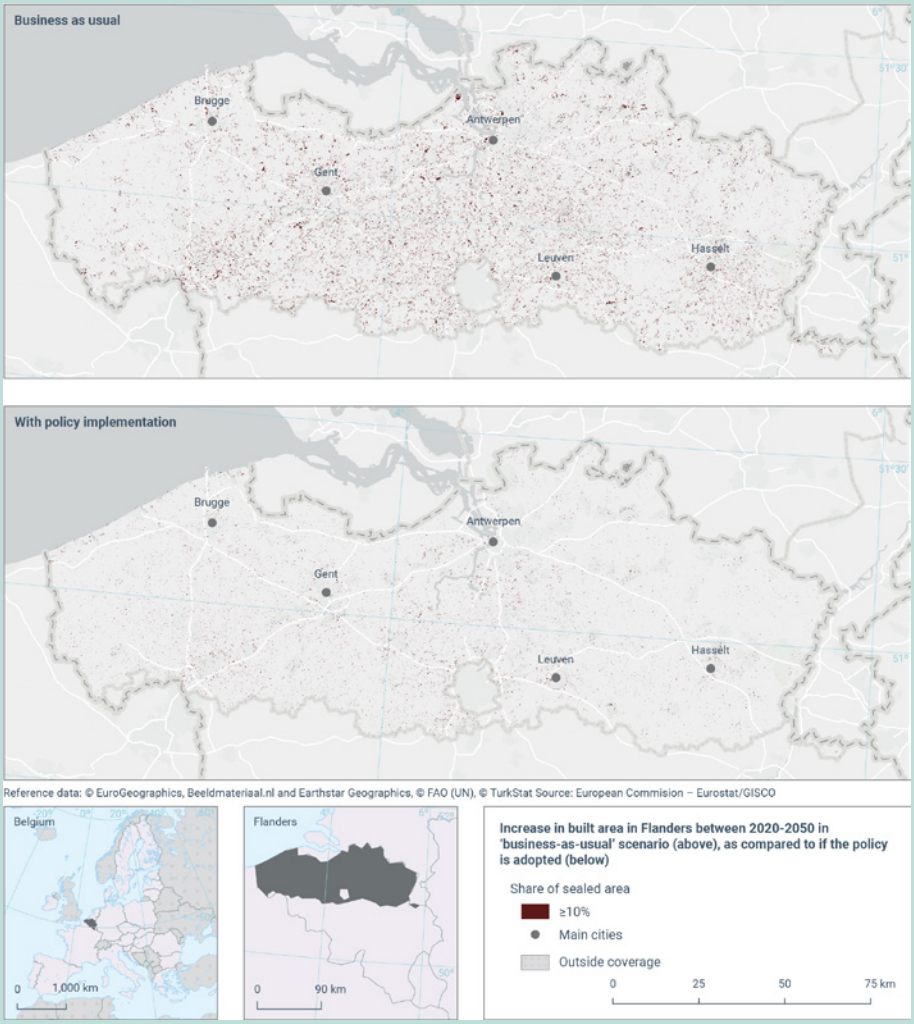
Box 5.3

No more concrete: the 'building shift' in Flanders, Belgium

Flanders is one of the most densely-populated regions in Europe, with 28.7% of the region's land surface made up of built-up or sealed areas. With a higher share of sealed area, the risk of flooding due to high surface run-off is greater, and the higher the potential UHI effect, the greater the risk of heatwaves in cities. The so-called 'bouwshift' or 'betonstop' has been proposed in Flanders. It promotes the renovation of existing sealed areas instead of allowing new construction and limits the use of impermeable materials for driveways and terraces.

In the Flemish Spatial Plan, the target limit is set allowing 4.5ha of additional construction area per day up to 2025. This should be reduced to 3ha per day and by 2040, no new areas are to be constructed at all. According to a recent study, some 40,000ha of open space could be conserved with this policy by 2050. There are concerns on how such a law would be enforced and monitored, and where the responsibility for compensation should lie. However, the hope is that further negative impacts of such a high share of built-up land can be limited and more space given to natural areas that can help mitigate the increasingly severe impacts of climate change. The southern Belgian region of Wallonia is also expected to adopt a similar regulation in the future.

Map 5.1 **Increase in built area in Flanders between 2020-2050 in 'business-as-usual' scenario (above), as compared to if the policy is adopted (below)**



Source: VITO, HOGENT (Poelmans et al., 2023).

Similar initiatives are seen in other countries. One example is the policy on 'No more concrete in city centres', indicated in the Polish Deal and coordinated by the Polish Ministry of Climate and Environment. The initiative aims to increase micro and small water retention and all green areas in their cities, creating financial and legal solutions to support this and establishing a required minimum (%) of biologically active space in cities.

Cities can also have specific plans to increase green infrastructure. Barcelona's Tree Master Plan for example, aims to exceed minimum EU standards for per capita green space access. Copenhagen strives to be Europe's first carbon-neutral city through its Urban Nature Strategy, which prioritises community-led greening projects such as urban gardens in areas lacking green spaces. Lyon's Local Urbanism and Housing plan mandates minimum open space and specific greening measures for each plot of land. The Biotope Area Factor (BAF) is a pioneering regulation addressing the UHI effect in inner city Berlin. It is used by authorities to calculate the proportion of developed land that can, or should, be green infrastructure. Targets vary for each site or land use.

To guide effective urban forestry programmes, the '3-30-300 rule' has been proposed, drawing from existing local policies in European cities (Konijnendijk, 2022). This rule centres on three key components:

1. ensuring that every resident can view a minimum of three substantial trees from their home (inspired by the Tree Policy in Frederiksberg Commune, Copenhagen);

2. striving for at least 30% tree canopy cover in all neighbourhoods (e.g. Bristol and Barcelona);

3. ensuring that individuals have access to a green space within 300m of their location.

The 'Sponge City' approach, originating in China, addresses urban design policies to combat climate-induced flooding and drought. It involves integrating green spaces and permeable surfaces, such as green roofs and swales to absorb rainwater and cool the city during high temperatures. This cost-effective strategy, also known as sustainable urban drainage systems (SuDS) in the UK, provides benefits such as enhanced air quality, reduced emissions and expanded green spaces, making it a promising urban climate adaptation solution.

5.3.4 Location of new development away from areas of risk

Due to its long-term strategic nature, urban planning has leverage in addressing climate impacts, such as sea-level rise, coastal erosion and flooding, by formulating policies that steer new developments away from high-risk areas (TCPA and RTPI, 2023).

In Denmark, local plans can include provisions that keep certain areas free from new construction if such exposed buildings might be susceptible to risks e.g. floods or other threats to life, health or property. Development in Denmark's coastal areas is also limited unless it is deemed necessary. Finland's National Land-Use Guidelines recognise the need to adapt to climate change risks and direct new developments away from flood risk zones (UN Habitat, 2022). Portugal has banned new permanent buildings in areas with 'high' and 'very high' wildfire risk, with exceptions allowed only if specific risk reduction measures such as buffer zones are implemented (OECD, 2023). Similarly, France's wildfire risk prevention plans manage developments carefully, banning construction in areas where property protection is not feasible,

but allowing it with wildfire risk reduction measures such as non-flammable building materials and fire walls (Kocher and Butsic, 2017).

Additional zoning measures aim to restrict development in ecologically sensitive and vulnerable areas. Examples include establishing public land buffers and designating riparian or coastal setbacks. Integrated coastal zone management plans also help to coordinate and manage various activities in coastal zones, while considering the ecological and environmental impact to ensure long-term preservation (UN Habitat, 2022). In Finland, building is explicitly prohibited in shoreline areas near the sea or bodies of water without specific building permit provisions.

In some cases, specific adaptation measures may not be feasible and managed retreats or planned relocations may be necessary, involving the permanent relocation of settlements, households, infrastructures and activities from high-risk areas. Managed retreats are closely tied to private property rights and necessitate coordination at various spatial scales, aligning with national and subnational regulations and land use planning. This requires early engagement and transparent discourses with local communities to ensure that decision-making adheres to their needs. An example is Dorset County Council in the UK, which is proactively addressing planned relocation. Within its local plan renewal, the council introduces criteria for relocating existing highly vulnerable developments in coastal areas and essential infrastructures susceptible to flooding. The criteria involve ensuring the lawfulness of existing developments relocating to areas with lower flood risk, maintaining the size of existing buildings, that the replacement dwellings are compliant with relevant planning policies for new developments and that appropriate restoration is conducted on the original site (TCPA and RTPI, 2023).

5.3.5 Integrating adaptation in building codes and design standards

Updating building codes and design standards can optimise construction, material energy and building energy demands, making the building sector more resilient (Adriadapt, 2022).

Bolzano, Bologna and Reggio Emilia in Italy adopted the Reduction of the building impact index (RIE) to evaluate the effect of building interventions on permeability, encouraging green roofs and other greening measures to promote water infiltration and rainwater retention (Bertocchi et al., 2011). It is applicable to all new constructions and major renovations, with specific target values depending on performance levels and land use type. The General Urban Plan for Bologna is supported by the municipal Building Regulations, approved independently and featuring the RIE index (Comune di Bologna, 2020). Basel in Switzerland has successfully made green solutions mandatory through legislative changes in the building code, leading to a substantial increase in green roofing areas per inhabitant. The greening of all new and renovated flat roofs is obligatory, and specific design directives are given.

Sustainability reporting and certification programs for buildings include initiatives such as the Building Research Establishment Environmental Assessment Method (BREEAM), Passivhaus standards, and Leadership in Energy and Environmental Design (LEED). BREEAM encompass a wide range of climate change considerations, including energy efficiency, carbon reduction, water conservation, flooding and mitigation of overheating risks (TCPA and RTPI, 2023). Rotterdam's climate adaptation plans envision a 'waterproof' and 'heatproof' city by transforming the built environment to capture and store rainwater effectively. Building codes mandate the replacement of hard standing surfaces with greenery or permeable materials. They also require large developments to construct underground water

storage infrastructures for rainfall capture and release the water to ditches, canals, waterways and lakes (Van Der Berg, 2022).

Legislation in countries where wildfires are frequent (e.g. Greece and Portugal) mandate structural protection measures and fire-proof building designs, including the use of non-flammable materials and roofs in high-risk areas (OECD, 2023). For instance, in the case of fires in Attica, Greece, a village built with high-quality materials suffered limited damage, while a neighbouring village with inadequate building standards experienced significant destruction (Hellenic Republic, 2021).

Box 5.5

Reusing Posidonia: promoting eco-friendly local materials in the Balearic Islands, Spain

The successful implementation of the LIFE Reusing Posidonia project by the Balearic government has led to the promotion of over 900 social housing units. The project prioritises the use of local traditional materials, such as reusable waste materials (e.g. dried posidonia, straw and reused doors) and eco-friendly local products (e.g. Mares sandstone, clay and adobe). The prototype building, consisting of 14 public protection dwellings, was constructed using these sustainable materials to reduce emissions from manufacturing and support local artisan industries. The main objective of the project was to provide regulators and authorities in the building sector with data and reference values. The project achieved a significant reduction (about 61%) in CO_2 emissions during the construction process compared to conventional building methods, highlighting the positive environmental impact of the sustainable building approach.

Figure 5.1 Posidonia project, Balearic Islands, Spain

5.4 Coordination, cooperation and networks

Measures under this sub-category refer to multi-level governance arrangements, including networks and collaborative mechanisms. Such measures create supportive governance frameworks that are necessary for city governments to ensure coordinated and coherent action from multiple actors involved in local adaptation policy development and implementation (EEA, 2020b).

Multi-level coordination mechanisms involving cities are increasing in several countries. Cities and local authorities may participate in the development of national adaptation strategies and actively engage also with regional authorities. Multi-level networks also often involve public and private organisations and sometimes universities, research institutions, NGOs and grassroots groups.

Cities are also establishing new organisational structures dealing with adaptation implementation to foster inter-departmental collaboration. Antwerp's climate plan introduces a new climate governance model that serves as the system within which decision-making for climate policies must take place. A climate committee, led by a climate director, is responsible for initiating and facilitating public engagement and debates related to climate policy development. The climate director, on the other hand, manages climate projects, advises the city mayor on policy development and ensures a unified approach to climate adaptation planning. The goal of this new system is to prioritise climate change adaptation and resilience in policy development, fostering an integrated and cohesive approach to climate planning (Van der Berg, 2022).

Urban adaptation is complex and affects multiple stakeholders. In the adaptation policy cycle, an initial step is to identify impacted stakeholders and actively involve them in the adaptation process. Multi-stakeholder engagement is a common procedure for cities and local authorities offering a wide range of key services. Currently, stakeholder engagement is more prevalent in larger cities, with southern, central and eastern European cities lagging behind (EEA, 2020b).

Box 5.6

Urban governance for social justice in Barcelona

In Barcelona, the local government has taken significant steps to become a 'hub of social innovation and science' by embracing social-based partnerships and participatory approaches (Olazabal and Castán Broto, 2022). The city has established a new interdisciplinary department to work towards climate resilience. It brings together ecology specialists, the sustainability culture and strategy office, the city Energy Agency and the social rights and resilience department, ensuring multiple perspectives and direct communication with governmental commissioners and the city leader.

Barcelona's approach to climate planning is socially-informed and integrated with climate justice. The action plan CLIMA 2018-30 uses technical assessments to prioritise actions based on social vulnerability (energy poverty in marginalised neighbourhoods) and opportunity (e.g. greening or social measures). It is exceptional in actively engaging local communities in knowledge co-creation. Approximately 85% of the actions were developed through participatory processes, as documented by the municipality.

5.5 Limitations and outlook

Reported limitations to the implementation of governance and institutional measures include inadequate resources and capacities, the lack of political commitment and support, and the lack of expertise or interdisciplinary knowledge (Birchall et al., 2021). In particular, smaller and economically disadvantaged European cities may need assistance to develop and implement local climate adaptation plans (Reckien et al., 2018). Lack of institutional capacity leads to difficulties in coordination across different departments and stakeholders, as regulative requirements of different departments may clash. For example, Copenhagen faces challenges in transforming its streets into cloudburst boulevards due to conflicting road design regulations at national and local levels (SWECO, 2022).

Resistance to government-imposed regulations and municipality plans by relevant stakeholders and residents may disrupt political support for the adoption and success of these measures. To tackle these concerns, municipalities should develop policies that mitigate potential unequal effects, adopt a phased approach to implementation for efficiency and acceptance, and prioritise effective communication with diverse stakeholders (C40, 2019). The EIB Climate Survey 2022 revealed that the majority of respondents in Europe (66%) actually supported stricter government measures imposing changes in people's behaviour to address climate change (Map 5.2). The breakdown of support for these measures varied across regions with the highest support in western Europe (66%), followed by eastern Europe (64%) and the Nordic countries (58%). Interestingly, 34% of the surveyed population expressed opposition to these measures.

Climate-induced community resettlement, in particular, is often highly sensitive, with cities either avoiding or overlooking it because of its immediate, irreversible impact on people's livelihoods and cultural identity. Regrettably though, unplanned relocations are already more prevalent compared to planned ones, which incur major and inequitable costs (Norman, 2022). This is despite the increasing acceptance of the possibility of planned relocation for certain coastal communities (IPCC, 2022). This emphasises the urgency for policymakers to address planned resettlement in a just and inclusive manner since it is currently a significantly under-addressed policy area in Europe (Glavovic et al., 2022). Moreover, it calls for proactive strategic planning to avoid developments, in the first instance, in high-risk locations.

The landscape of governance and institutional measures and their implementation in European cities is highly diverse and still evolving. Improvements can be made in aligning adaptation plans with broader social and economic strategies, such as poverty reduction, and significantly improving participatory processes and public engagement. Significant mainstreaming in continuously revising urban strategies and planning instruments to address longer-term climate risks for urban communities is necessary (Norman, 2022). This means calling for robust regulations on the strategic location of developments and substantial investments in developing climate-resilient plans for future development. Identifying and including all vulnerable groups in the planning and implementation processes is also essential for successful adaptation efforts (Reckien et al., 2023).

Map 5.2 **EIB Climate Survey 2022, share of respondents in European countries that support stricter government measures imposing changes in people's behaviour to address climate change**

Source: Adapted from EIB, 2022a.

Box 5.7

How do cities measure governance and institutional actions?

- **Number of successful legislative amendments** — Hamburg, Germany. (Amendments to the water act, waste water act, possibly charging schemes. Determination of the need for amendments to other legal provisions (e.g. building regulation))
- **Application of guidelines to new planning and renovation of green spaces** — Munich, Germany (Guidelines for climate-sensitive planning of public green spaces)
- **Number of risky development projects avoided, reconsidered and redirected** — Marseille, France (Anticipating the impact of natural hazards on urban development)
- **Number of information meetings with partners held on thermal comfort and urban heat effect** — Montpellier, France (Anticipate climate change adaptation, improve thermal comfort in the city and in buildings)
- **Budget for international cooperation projects aimed at improving climate justice** — Barcelona, Spain (Developing climate solidarity, cooperation between cities and people, a strategy for reducing environmental debt and preparing to accept climate refugees)
- **Number of strategic and planning documents updated taking into account adaptation to climate change** — Gorzów Wielkopolski, Poland (Creating a decision support system and increasing the city's adaptive potential)
- **Number adaptation projects in the participatory budget in relation to the number of all projects** — Częstochowa, Poland (Increasing the city's resistance to hazards and pollution)
- **Area (percentage of the city's area) covered by forms of legal nature protection** — Olsztyn, Poland (Adaptation to threats related to rainfall and floods)
- **Share of the city budget allocated to environmental research and development (especially eco-innovation) by public and private institutions** – Pécs, Hungary (Precipitation retention, complex utilization of collected rainwater and waste water)
- **Membership in a cooperation network related to adaptation to climate change** — Katowice, Poland (Implementation of adaptation activities)

6 Economic instruments and Finance

Key messages

- There is a steady stream of innovative financing mechanisms, insurance and risk-sharing products being developed, tested and refined. Many are demonstrating their potential to place new, adaptation-focused financial resources at the disposal of Europe's urban municipalities.
- The uptake of these measures in Europe remains uneven and still somewhat limited. This is mostly due to the highly technical nature of measures that require very high levels of municipal authority financial literacy and capacity to oversee their development, implementation and monitoring.
- Overcoming a range of additional barriers, including legislative restrictions and under-developed legal frameworks for engaging with the private sector, will require concerted efforts by all actors to allow this type of measure to fulfil its full potential.

6.1 What are economic instruments and finance measures?

Economic instruments and finance measures include incentive mechanisms and funding schemes that can encourage the implementation of adaptation actions, and insurance and risk-sharing mechanisms that can help to reduce the potential economic impacts of climate change. Novel forms of economic instruments and financing measures also have the potential to place new financial resources at the disposal of local authorities. In many cases, these are ways of unlocking new forms of investment, often private (IISD, 2023).

Table 6.1 provides an overview of what some of these measures look like within an urban setting. Local authorities indicated that only 3.4% of all actions they were undertaking to support their adaptation ambitions were classified as financing and incentive instruments (2.1%) and insurance and risk-sharing instruments (1.3%) (CDP, 2022). The results are not surprising given the often highly technical nature of these measures that require very developed levels of financial literacy and capacity to develop and implement them.

Table 6.1 Overview of the economic and financial measures included in this chapter, following the KTM classification

Sub-measures	Elements	Urban examples
Financial and incentive mechanisms	Incentive mechanisms Funding schemes	• mechanisms related to taxes such as exemptions, reductions • tariffs • transfer payments, grants • credit trading • sectoral/adaptation funding schemes • crisis preparedness funding schemes • crowdfunding • bonds • public private partnerships
Insurance and risk-sharing mechanisms	Insurance schemes and products Contingency funds for emergencies	• preparedness • response • disaster relief • recovery products

6.2 How are these measures being implemented?

6.2.1 Financial and incentive mechanisms

There is constant innovation in the development of alternative financing mechanisms capable of providing new revenues for climate adaptation measure implementation. However, many are still only in use by larger urban municipalities with deeper financial expertise.

Debt instruments include, among others, green bonds, sustainability bonds, social bonds and resilience bonds. What differentiates these types of bonds from regular bonds is that the lender of the bond makes a commitment to using the repaid interest towards implementing environmental projects and sustainability or resilience related investments or projects. Some resilience bonds are part of a subset of what is known as catastrophe bonds that link insurance premiums to resilience projects in order to monetise avoided losses through a rebate structure (Martin-Moreau and Ménascé, 2018). Once again, the interest repaid on these bonds is directed towards projects that improve infrastructure and increase the resilience of communities to natural disasters.

Local governments in Europe make up a very marginal share of green bond issuers despite green bonds being a well-utilised financial instrument across all sectors. Between 2014-2022, municipal-issued bonds accounted for only 1.4% of the total number of green bonds issued (Climate Bonds Initiative, 2023). European countries issuing the greatest number of municipal bonds were Sweden, Germany, Switzerland, France, Iceland, Spain, Norway and Finland. The City of Paris was the first European municipality to issue a green bond, with its experience elaborated on in Box 6.1.

Box 6.1

City of Paris: the first municipal issuer of a green bond

In 2015, the City of Paris, France issued a EUR 300 million green bond to finance a number of projects to improve the city's resilience to climate change (Climate-ADAPT, 2016a). 20% of the expected 1.75% annual profit rate has been assigned to climate adaptation-related projects (e.g. water use demand management and the reduction of the UHI effect), with the overall aim of reducing greenhouse gases in the city by 75% by 2030.

The first of its kind to be issued by a municipality, the green bond was initially oversubscribed with applications by investors valued at EUR 475 million, reflecting strong investor interest in financing projects with environmental benefits. Eventually more than 30 investors were involved, mainly comprising of domestic investors (83%), but also a few international institutions from Benelux (9%), Switzerland (3%) and the Nordic countries (3%). Insurers and pension funds bought the majority of the trade (51%), with asset managers making up the rest (49%).

There is an increasing number of cities issuing green bonds around the world including Vancouver, Canada, Johannesburg, South Africa and Mexico City, Mexico.

The capacity of less well-resourced and/or smaller municipalities to utilise and benefit from complex financing instruments, such as different forms of bonds, have resulted in relatively modest uptake. The size of their proposed investment projects is often too small to be attractive to outside investors, particularly for smaller urban municipalities, but approaches are being developed to overcome capacity constraints and project size barriers. Kommunivest, Sweden's largest municipal funding agency, has created a portfolio of smaller projects from a wide number of municipalities to attract green loans and to issue green bonds. The projects cover mitigation and adaptation, with over 130 investment projects across more than 75 Swedish municipalities, counties and regions now engaged. Similar local government debt offices have also been set up in Denmark and Finland, showing the replicability of the model.

Results-based financing instruments are methods of funding where the lender/funder provides capital that is contingent on successful results (IISD, 2023). Key drivers for taking this approach are enhancing accountability, efficiency and innovation. 'Stormwater markets' are one of the most-used forms, incentivising property owners to implement measures that reduce runoff from their properties into public storm or sewer systems. Reducing private stormwater runoff into these public systems can in turn reduce operational and infrastructure costs related to stormwater capture, conveyance and treatment. One approach for doing this is the provision of grants to property owners that undertake actions to reduce the amount of impervious surfaces on their property through the installation of green infrastructures or other forms of water capture and retention (e.g. rain barrels). The City of Bratislava provides an example of one such successful approach (Box 6.2).

Box 6.2

City of Bratislava subsidy programme to reduce flooding damage

Since 2016, the city of Bratislava in the Slovakia has been providing private businesses and residences with a 50% subsidy (EUR 1,000 maximum per application) to implement measures that increase city resilience to heavy precipitation events that result in flooding and property damage. With a range of Sustainable Urban Drainage System (SUDS) approaches eligible for the subsidy, over 1,000 projects comprising of water reservoirs, rainwater gardens and green roofs have been funded to date, with interest continuing to grow. This subsidy scheme is an important part of the city's climate adaptation strategy (Interlace Hub, 2022).

A more systematic approach being deployed in municipalities in numerous European countries is the charging of a form of stormwater or rainwater fee to all property owners. Since regulations for stormwater management are generally set at municipal levels, there is great potential for further expanding this approach across Europe. In Germany, since the 1980s, many municipalities and/or water utilities have been implementing programmes whereby property owners are charged stormwater fees based on impervious surfaces, using a polluter-pays principle. These fees then finance new stormwater-related city investments. Where property owners implement private measures to reduce their reliance on public storm or sewer water systems, they receive fee reductions or exemptions, as in Berlin.

Importantly though, more research is required to better determine the exact fee level that offers sufficient incentives for this approach to be truly effective. An estimated 3-5% of municipalities in Poland have also established stormwater fee programmes. In most of these cases the fee is calculated for 1m^3 of discharged rainwater, or for a measurement unit of impervious surface, with opportunities for fee reductions based on the implementation of rainwater retention measures. Fees vary widely across these municipalities, from EUR 0.38-2.31 per m^3 (Godyń et al., 2020). Charging too high a fee can make such a measure highly unpopular with residents and, at times, with politicians. However, charging too low a fee can reduce the incentive for individuals to reduce their use of public storm and sewer systems.

A study exploring approaches to integrated stormwater management revealed that 60% of surveyed cities had some kind of stormwater fee (Kondratekno et al., 2021). There may be several different approaches used for generating these fees. Examples include: a connection fee in Aalborg and Copenhagen (Denmark), Helsinki (Finland) and Stockholm (Sweden); a fee per m^3 of discharge to a combined sewer or separate sewer in Liepaja, Daugavpils and Riga (Latvia), and Kaunas (Lithuania) respectively; a variable annual fee per m^2 of surface area, which may be differentiated by the type of property, in Elblag (Poland), Helsinki, Lahti and Kuopio (Finland), and Stockholm (Sweden), and a fixed annual fee per type and size of property in Stockholm (Sweden) and Turku (Finland). Some cities applied fee discounts for disconnection from the city's stormwater management system or Sustainable Urban Drainage System (SUDS) on site (e.g. Stockholm).

Looking abroad to a country with a highly developed stormwater market, the US provides a noteworthy example of how stormwater fees can evolve into a more programmatic approach with the ambition of using solely private sector funding to implement a city's green infrastructure ambitions (Box 6.3).

Box 6.3

Looking beyond Europe: Washington D.C.'s Stormwater Retention Credit (SRC) trading programme

Established in 2013, Washington D.C.'s Department of Environment (DDOE) launched the world's first Stormwater Retention Credit (SRC). Through this programme, private developers generate and sell SRCs to earn revenue for projects that reduce harmful stormwater runoff. This can be done through the installation of green infrastructures and/or removal of impervious surfaces. As with all market-based approaches, the market determines the variable value of the SRCs, with each SRC corresponding to one gallon (4.5 litres) of stormwater retention for one year. Any developer interested in being part of the programme, as a means of meeting the increasingly stringent stormwater reduction obligations, can buy credits directly from sellers that have generated them by installing green infrastructures. Sellers include other private sector actors as well as non-profit organisations and businesses. The allure of engagement comes from the fact that the only alternative is to pay a fee that is almost twice the price directly to the DDOE.

The role of the DDOE goes beyond setting the rules and managing compliance. It maintains a real-time market registry that lists all of the SRCs available for sale at any point in time. The DDOE strives to reduce participant transaction costs by providing sample contracts and financial return calculators, supporting those businesses wanting to begin engagement by providing grants to offset the costs of the technical design work and their outreach efforts. Ultimately, the DDOE aims to completely remove itself from funding green infrastructure projects, with funding covered completely by private sectors efforts.

In addition to encouraging the public to co-fund the implementation of adaptation measures on their own properties, many urban municipalities are now engaging the public and private organisations to contribute to the decision-making, financing and project implementation on public lands. An example of this is the AdaptCascais Fund (Box 6.4).

Box 6.4

AdaptCascais: an inclusive mechanism to fund local action

Established by the Municipality of Cascais, Portugal in 2021, the AdaptCascais Fund addresses the challenges faced by vulnerable communities, particularly those with limited resources, to protect themselves from the impacts of climate change. The fund promotes adaptation-focused projects that increase the resilience of these communities and reduce inequalities in the long-term. Fundable projects include NBS, infrastructure improvements and awareness campaigns. Additionally, the fund provides technical resources to interested parties.

In a transparent process run by the town hall, local stakeholders have the opportunity to submit their ideas on adaptation measures. In the first edition held in 2021, EUR 24,000 was allocated, with nine projects judged eligible for funding (EUR 3,000 maximum per project). Projects covered diverse areas including riverbed restoration, reforestation, water conservation and waste reduction. In the second edition in 2023, eight projects were awarded funding. The costs and benefits of the fund are carefully monitored to ensure proper use of funds.

The project's success lies in its transparency, inclusivity and the ability for organisations to present their climate solutions based on their experience. The implementation time is expected to be relatively quick and that the project can be replicated indefinitely, focusing on long-term climate change adaptation measures.

Source: João Denis, 2022, personal communication.

6.3 Insurance and risk-sharing mechanisms

During the period 1980-2020, the total economic losses from weather and climate-related events in EEA member states amounted to a total of EUR 450-520 billion. Less than one third of these losses were insured. The EU Adaptation Strategy aims to build resilience and ensure that the EU is well prepared to manage climate change-related risks, and adapt to their impacts. One way to do this is by reducing the overall monetary losses from weather and climate-related events through the use of insurance mechanisms.

The primary aim of insurance is to deliver financial and fiscal resilience by addressing the residual risks associated with the impacts of shocks and stressors that go beyond a specific system's existing capacity to absorb them. Yet to date, insurance in the public sector is still not widely used, with the exception of insurance against flooding in Czechia, Ireland, Latvia, Hungary, Poland, France, Sweden, UK, Finland, Denmark and Norway (Hudson et al. 2020). To date, there is little to no use of insurance for other climate hazards such as wind, snow/ice or landslides.

Recognising the limited public sector use of insurance mechanisms, the European Commission (DG CLIMA and DG FISMA) established the Climate Resilient Dialogue Working Group. Its aim is to explore ways to reduce the climate protection gap as well as stimulate investments in good adaptation actions (EC, 2023b). A diverse group of organisations is involved in the dialogue, including insurers, reinsurers, risk managers, public authorities, regional authorities, representatives of consumers and the Covenant of Mayors – Europe and the EEA. It is important to follow what emerges from these dialogues in terms of concrete next steps for boosting the capacity of insurance mechanisms to support local climate adaptation ambitions.

In its interim report, the Working Group summarises three principal ways that insurance products may be able to improve the attractiveness of adaptation investments:

1. Adaptation investments/general risk reduction: offering wider insurance coverage or better terms where adaptation measures are included. This will incentivise the demand for adaptive measures and products, stimulating investment.

2. Adaptation investments/insuring adaptation projects: offering more insurance coverage for adaptation-related projects, e.g. construction to install flood barriers. Insurance coverage can make the investment more attractive to lenders or investors by reducing financial risks, thus stabilising the profit margins of projects. Additionally, insurance might support ecosystem-based adaptation projects through covering the time until ecosystems fully grow their risk protection benefits.

3. Adaptation-enabling investments/insuring companies with their core business in adaptation: offering insurance coverage for companies that operate in adaptation products and in adaptation technological innovation.

An important related risk-sharing mechanism is reserve funds. Municipal budgeting is complex because towns can face unexpected and unpredictable financial hurdles that arise from natural disasters. To help manage financial uncertainty, reserve funds can help ensure good financial and cash management. These funds can be 'dedicated' or 'designated' and include money that is set aside for specific purposes (e.g. natural catastrophe recovery).

The Local Disaster Risk Reduction and Management Fund is a unique program in the Philippines that encourages local government investment in disaster risk reduction. It builds on a long-standing directive from the national government to local governments to set aside 5% of their budgets as a local calamity fund. Starting in 2012, the government introduced new legislation to authorise local governments to use up to 70% of these funds to support pre-disaster preparedness and risk reduction measures.

6.4 Limitations and outlook

While promising, many of the above-listed financing and insurance mechanisms are not yet widely used or evenly spread across European cities, with many considered novel and still in the piloting stage. Limitations and barriers to more systematic use persist, particularly for smaller urban municipalities with fewer resources. These include:

- Limited or insufficient knowledge, technical capacity and staffing in administrations in relation to management activities on the free financial market, or in engaging and establishing contractual relations with the private sectors. Where financial instruments are a new tool, applicants often need intensive financial and legal support (Wishlade and Michie, 2017).

- Limited attractiveness since engaging with many of these instruments is highly resource-intensive. Even with in-house experience and resourcing, it often requires a long-term perspective given the extended time periods between the initial explorations and eventual paybacks. This can also limit political attractiveness.

- Limited take up of certain financial instruments, which can be affected by the role of financial intermediaries for whom the bureaucracy and specific requirements associated with implementing publicly backed financial instruments can act as a disincentive to their involvement. Management fees and costs need to be sufficient to attract the calibre of fund managers required, or they need to consider that their involvement in implementing publicly-backed schemes provides market-building opportunities in the longer term.

- Limited access to certain funding because of national, regional or even local legal restrictions. This can be a major barrier. For example, in some countries, local authorities are legally constrained from taking on debt, which in turn limits their climate finance options. In these cases, they do not have the authority to access international climate funds directly but depend on the national level (CoR, 2017; Chu et al., 2019). For managing authorities in many EU countries, the regulatory framework (e.g. debt ceiling, tendering and use of investments), and the restrictions on management costs and fees, remain barriers to the use of certain financial instruments (Windisch, 2019; Wishlade and Michie, 2017).

- Cultural barriers to perceiving the private sector as a trustworthy and legitimate partner. Public entities and residents may be uncomfortable with private ownership of traditionally public-owned goods.

While the ever-expanding set of economic instruments and financial measures hold real potential, to date, only a relatively small number of local adaptation projects are being realised through their use. Overcoming the list of challenges and barriers highlighted in the above section will require concerted and coordinated efforts between national, regional and local public sectors and the diverse set of financial sector actors. In many cases, intermediary organisations may need to be engaged to act on behalf of individuals or clusters of municipalities to aid in the development and implementation of different financial instruments. This is particularly the case for Europe's smaller or less well-resourced urban municipalities. The clustering of smaller fundable municipal adaptation activities into larger portfolios may also increase their attractiveness for financial sector actors to invest.

Importantly, this will all need to be accompanied by a culture change effort. Historical tendencies of the public sector to mistrust the private sector will need to be overcome. Alongside that, to ensure ongoing strong fiduciary oversight of public sector operations, a concerted effort will be needed to develop robust and transparent mechanisms. They must adequately monitor and verify the delivery of the adaptation outcomes through use of these new financial streams.

Box 6.5

How do cities measure economic and finance actions?

- **Revision and adaptation of existing funding programs –** Munich, Germany (Subsidy programs for climate adaptation measures on private property)
- **Budget allocation used in grants and subsidies to facilitate fleet and modal split change –** Madrid, Spain (Supporting the mitigation/adaptation action on Low Emission Urban Management and Energy Efficiency)
- **Number of beneficiaries of economic incentives for efficient water management –** Murcia, Spain (Promote efficient water management and water quality in the domestic sphere)
- **Amount of subsidies dedicated to private sector –** Ajaccio, France (Raise awareness and support private companies to adapt to climate change)
- **Number of initiatives organised –** Bologna, Italy (Insurance involvement in risk management)
- **Number of multi-family residential buildings subjected to thermal modernization —** Rzeszów, Poland (Implementation of adaptation activities)
- **Investment costs in the warning system and rescue services –** Częstochowa, Poland

7 Physical and technological measures

Key messages

- Physical infrastructure has traditionally been used extensively for adaptation, especially measures such as dykes, levees and seawalls. The limitations of more traditional physical infrastructure include the lack of co-benefits and their limited flexibility to adjust to future needs.
- New or alternative construction materials, and innovative building or public space design, are increasingly implemented and further enabled by related regulations and taxonomies that accelerate their deployment. Physical and technological measures are increasingly used in water, energy and mobility systems to increase efficiency and reduce overall resource use.
- The most prominent shift in the nature of grey infrastructure is the accelerated integration of green elements with grey. Many of the measures are also accompanied by complementary actions that raise awareness or encourage behavioural change.
- Early warning systems (EWS) remain one of the most effective adaptation measures. Large investments in the development of climate adaptation-related technologies and the democratisation of their use further enhance local authority and public efforts to model, plan, detect and respond to climate hazards.

Given the enormity of the climate change adaptation challenges urban environments face, cities continue to look to physical (grey) adaptation measures and increasingly to technological options. However, a broad range of actions fit under these two sub-categories and are increasingly being deployed in complementary manners, suggesting that the separation of these categories is now somewhat artificial. Within this chapter, the physical measures section (7.1) focuses on the more traditional grey, engineered solutions. The technological solutions section (7.2) focuses on those measures relying on information and data systems, processes and applications, such as EWS, mapping services, artificial intelligence and smart systems.

7.1 Physical measures

Physical, or grey, infrastructure has traditionally been the term to describe the use of concrete and other long-lasting materials to form a barrier and protect the human, built up system from climate impacts (Depietri and McPhearson, 2017). More broadly, physical measures are engineering solutions that make use of non-natural materials to improve the adaptation of territory, infrastructures and people.

19% of all adaptation actions undertaken by cities reporting to the CDP are classified as grey (physical) measures (CDP, 2022). While physical infrastructure as an adaptation measure in urban settings takes many forms, it is most often used within the water, building and transport sectors. Table gives some examples for the urban context that are described in this chapter.

Table 7.1 Overview of physical measures in the urban context included in this chapter, following the KTM classification

Coastal protection: • beach nourishment; • hard structures including dykes, groynes, breakwaters and seawalls; • artificial or reinforced reefs; • combination hard structures with NBS.
Flood protection: • modern flood barriers (super-absorbent powder, large-scale inflatable tubes, self-raising barriers); • dams, diversion channels, pumping stations; • multi-purpose infrastructures such as parking lots with temporary water reservoirs; • amphibious or floating infrastructures.
Water scarcity: • water purification; • water re-use (for drinking water or other uses such as irrigation); • membrane or thermal desalination; • grey or nature-based water storage infrastructures; • managed aquifer recharge; • rainwater catchment systems/rooftop water harvesting.
Extreme heat: • passive cooling systems; • building and streetscape design/orientation/density; • cool pavements, permeable pavements, photocatalytic surfaces, white roofs; • cooling centres.
Infrastructure protection: • decentralised energy generation and transmissions systems; • decentralised water systems; • elevated roads, bridges; • use of heat-resistant asphalt for road construction, railway lines.

The form and function of physical infrastructure has changed over time. The most prominent recent shift and expected future direction is the accelerated integration of green infrastructure with physical or 'grey' infrastructure.

7.1.1 Water management infrastructure

An estimated 88% of local action plans include actions related to water management (Reckien et al., 2023). These relate mostly to infrastructure (e.g. enlargement or improvement of drainage systems), or conservation measures (e.g. greywater reuse, water restrictions and rationing), both mentioned in 70% and 48% of plans, respectively.

Although 75% of European coastal countries are planning responses to sea-level rise, they may not be sufficient and the variation in response levels may result in unequal impacts across Europe (McEvoy et al., 2021). In most European cities the 'protect'-oriented approaches (Cottar et al., 2021) often involve traditional grey infrastructures such as dykes and levees. In 2020, a large-scale investment to improve flood protection in the Odra and Vistula River basins in Poland — the Wrocław's flood protection system — was successfully completed. The project included new dykes, weirs and floodgates, reinforcing river embankments and constructing dams to manage the water flow through the canals.

Projects such as these now increasingly incorporate also more nature-based design elements in response to the limitations and costs of these structures and in recognition of their negative environmental impacts (e.g. on sediment cycles) (Ocean & Climate Platform, 2022). For example, the Flemish Government's Sigma plan for the Scheldt River now additionally includes plans to restore rare river habitats.

Urban local authorities are increasingly adopting also 'accommodate'-oriented measures (Cottar et al., 2021). This includes the construction of multi-purpose spaces designed to retain stormwater during large-scale but infrequent flooding events and that, when not needed, can serve other purposes and often include green elements. An example is Copenhagen's multi-purpose recreational infrastructure that forms part of its Cloudburst Management Plan. The city has plans to construct around 300 skateparks or playing fields, each designed to reduce flooding risks while improving urban liveability, social inclusion and biodiversity. In major rain events, these spaces become major flood water collection, retention and eventual discharge sites. Similarly, Rotterdam's Resilient BoTu2028 district-level plan foresees the development of water resilient infrastructure including water squares, rain gardens and water buffers double as social and climate infrastructure.

Designing infrastructure to be able to withstand flooding event impacts is another form of 'accommodation' measure. This includes elevating or flood-proofing houses and infrastructure to address smaller rates of sea-level rise (Glavovic et al., 2022), and the design and construction of amphibious or floating infrastructure. Floating buildings sit permanently in the water, while amphibious ones are situated above the water but are designed to float when water levels rise. Such infrastructure is now recognised by the IPCC and UN-Habitat as a transformative and sustainable adaptive urban habitat (Global Center on Adaptation, 2022). There is also a growing community looking at how to upscale their use, which includes the UN High Level Roundtable on Floating Cities, the Space@Sea initiative and the Global Centre on Adaptation Floating Development Community of Practice.

The city of Rotterdam, the Netherlands is a hotspot of innovation in this area. The city now hosts the world's largest floating office building, a floating farm and a floating pavillion used for meetings and events. Although examples also exist globally, the Netherlands is leading the way by including projects from individual homes to entire floating neighbourhoods such as IJburg's Waterbuurt and Schoonschip in Amsterdam. Further scaling will require more technical developments around physical structures and further development of regulations, policies and codes to support such developments. These efforts will benefit from referencing the Netherlands' already well-developed legal framework for building on water, which is already captured within the country's building codes.

Box 7.1

Looking beyond Europe: physical infrastructure for climate adaptation in Kuala Lumpur, Malaysia and Busan, South Korea

In Kuala Lumpur, Malaysia, the SMART Tunnel was built to alleviate flooding in the centre of the city. Currently the longest stormwater drainage tunnel in Southeast Asia, the system is designed to divert large volumes of water from flood-prone areas via a holding pond, a bypass tunnel and a reservoir to store the water. However, the real novelty is its multi-functionality. The tunnel also acts as a motorway to relieve traffic congestion at the main city centre gateway. Automated flood control gates are installed at the tunnel's entry and exit points, inhibiting drivers from entering when its stormwater functionality is needed.

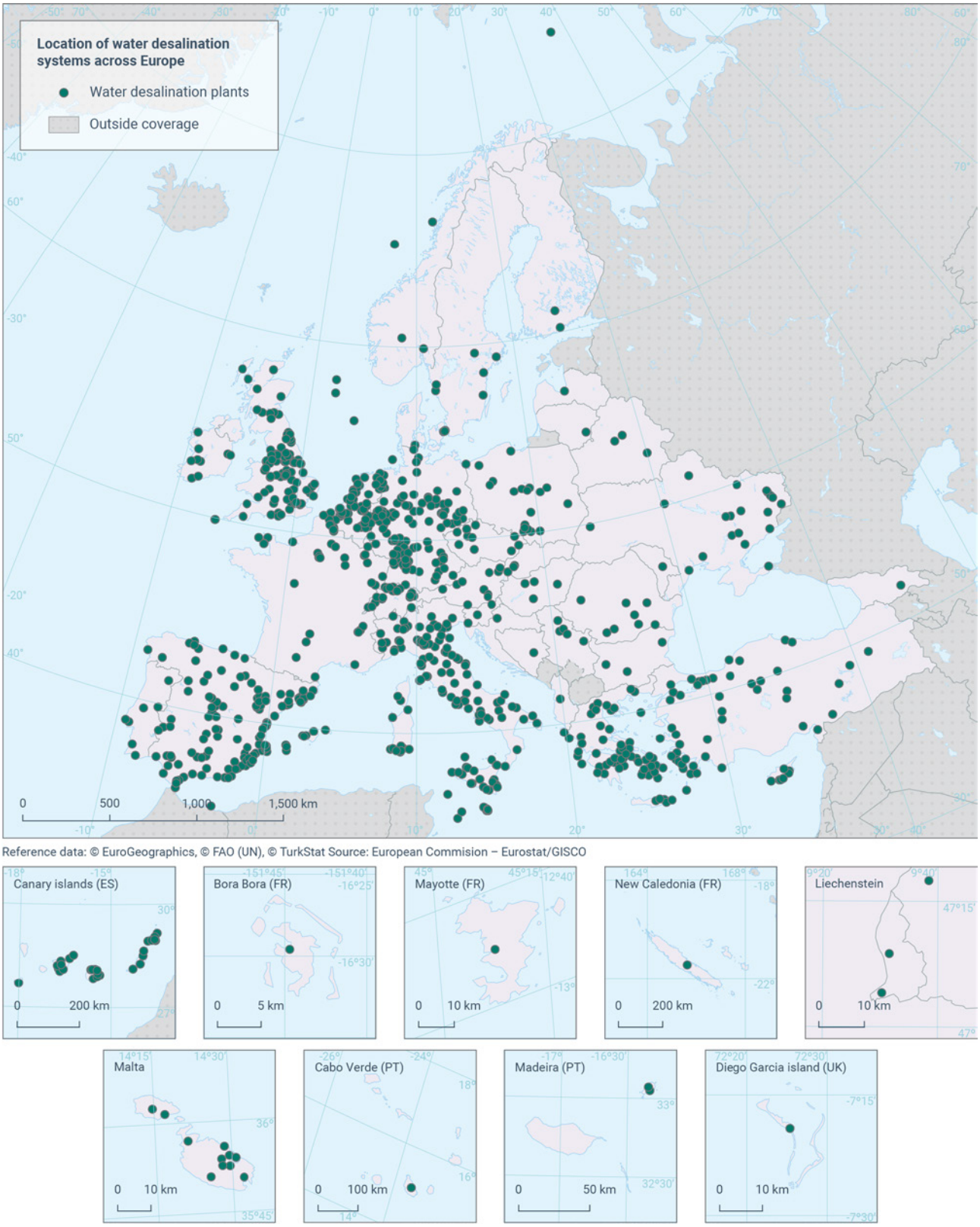
Off the shores of Busan, South Korea, OCEANIX Busan will involve the construction of three interconnected platforms, covering a total of 63ha. It will initially house around 12,000 people, with the potential to rise to 100,000.

Figure 7.1 **Aerial view of the planned OCEANIX Busan complex**

'Retreat' and 'avoid'-oriented approaches, which rely on zoning, land use planning and potential infrastructure and community relocation, are also increasingly considered at the local level.

Increasing drought and water shortages globally are driving huge growth in the global market for water recycling and reuse infrastructure. Water desalination systems, while expensive and highly energy-intensive, continue to be built across all EEA countries, with Spain dominating (Map 7.1). Decentralised, municipal desalination infrastructure accounts for a significant share of this global market, driven by the desire of local authorities to reduce dependency on increasingly unreliable water sources (Williams, 2022).

Map 7.1 Location of water desalination systems across Europe



Source: EMODnet, 2021.

The EU's 'climate neutral by 2050' targets require the adoption of circular approaches to managing water resources. This means that municipal and industrial water reuse is likely to play an increasingly important role in future water management. To date, most reuse has been in agricultural irrigation, but re-use in urban settings, particularly for industrial purposes, is now increasingly used in many countries. For example, in Antwerp, Belgium, the company TotalEnergies now uses recycled wastewater from Antwerp's 280,000 residents, saving up to 9 billion litres of drinking water per year (Bluefield Research, 2022).

Importantly, grey water reuse solutions have significant scaling potential. France currently only reuses 0.1% of treated wastewater and even countries with long-term traditions of water shortages, such as Italy and Spain, are still only reusing 10% and 15%, respectively (Basso, 2023). EU guidelines are given on the safe reuse of treated urban wastewater for agricultural irrigation, setting minimum water quality, risk management and monitoring requirements for water reuse.

Consumer acceptance of recycled water, a long-cited barrier to reuse, may now also be changing. A 2021 survey of 2,500 people in the Netherlands, Spain and the UK indicated that 75%, 73% and 67% of respondents supported, or strongly supported, the use of recycled water for drinking in their respective countries (Water Reuse Europe, 2021).

7.1.2 Building design and construction materials

Notable progress has been made in the development and deployment of new building materials and technologies, with innovations in the design of European buildings, homes and surrounding streetscapes. The aim is to make the built environment more climate-resilient.

The increase in the frequency and severity of heatwaves across Europe, combined with higher energy prices, have spurred the demand for more cost-effective and sustainable 'cooling' materials. Europeans spend 80-90% of their time indoors, which means that indoor thermal comfort, complemented by good indoor air quality, is increasingly important, particularly for more vulnerable population groups such as the elderly.

Examples of non-mechanical cooling approaches include installing white roofs, as in this example from Madrid, the application of white road paints, and the use of photo catalytic materials designed to reflect the sunlight away from buildings and homes (Khan et al., 2023). In addition to being relatively low-cost solutions for creating cooler ambient temperatures, they also support emission mitigation efforts by reducing the energy footprints of building infrastructure (EEA, 2022c).

Box 7.2

Rethymno, Greece: incorporating bioclimatic design in public spaces

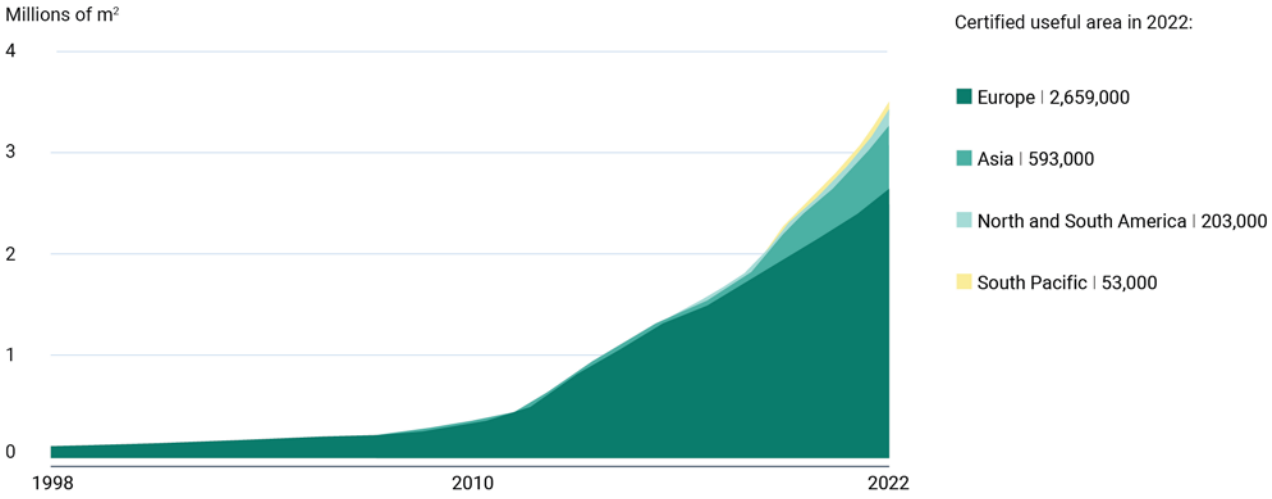
The coastal town of Rethymno, Greece, is in the process of upgrading its public spaces and streets using bioclimatic designs as a means of reducing ambient temperatures (Mirioke, 2023). Its first pilot, constructed in 2016, was a 25,000m² space that included Iroon Politechniou Square and incorporated the use of compressed soils, cool pavers and photo-catalytic road paint.

Weather station measurements taking readings throughout the entire renovation process indicated a reduction in the mean maximum air temperature of 1.69°C and a mean maximum surface temperature of 8.45°C. User thermal comfort was improved by about 46% and the energy needs of the surrounding buildings were also reduced (Tsitoura et al., 2016). The photo catalytic road surface reduced air pollution levels. With a maximum of a 30% cost premium for the project materials and installation, compared to traditional materials, the solution is considered cost effective given the multiple benefits it delivers. As a result, the municipality is implementing this solution in numerous other parts of town.

Figure 7.2 Iroon Politechniou Square, Rethymno, Greece

Innovations in building design further enhance the effectiveness of new building materials. High energy costs and ambitious emission mitigation targets are further catalysts to increasing interest in passive approaches for urban buildings and homes (Figure 7.3). Passive approaches focus on utilising the natural environment to provide heating, cooling, ventilation and lighting for buildings, rather than relying on mechanical systems. The energy savings can be significant given that heating and cooling in buildings and industry currently account for half of EU energy use (Pajek et al., 2022).

Figure 7.3 Passive house certifications worldwide



Source: International Passive House Association, 2023.

While most passive house buildings are currently found in Germany, Austria and Scandinavian countries, examples are emerging across Europe. In Zaragoza, Spain, for example, a social housing complex is testing a new bioclimatic design through understanding sun patterns (EEA, 2022c). During the winter, the capture of heat from the sun is maximised through south-facing facades with large, glazed areas. In the summer months, overhangs create shade, while west-facing facades include lattice works that provide additional sun protection. Appropriate tree selection ensures heavy shade canopies in the summer and sun infiltration in winter when leaves are shed. Street design also takes wind patterns into account.

The equity and justice dimensions of constructing or retrofitting buildings and homes to better withstand climate change hazards are important considerations. The EEA's 2022 briefing 'Cooling buildings sustainably' explores the key elements of sustainable cooling policies and their potential impacts on vulnerable groups by reducing health risks, inequalities and summer energy poverty (EEA, 2022c). Many of those same elements discussed are also relevant for heating buildings and homes in response to extreme cold.

A critical development over the past few years is the ability to enable policy for making building infrastructures more adaptable to climate change. The development of the EU taxonomy for sustainable economic activity is one such example. Under this taxonomy, an economic activity must deliver a substantial contribution to one of six sustainability areas, one of which is climate adaptation.

The European Commission guidance on adapting buildings to climate change is a particularly useful resource for municipalities, providing a synthesis of existing methods, specifications, best practices and guidance for the construction and renovation of buildings (EC, 2023b).

7.1.3 Adapted transport infrastructure

While Europe's transport sector currently sustains around EUR 800 million of climate-related damage each year, that figure is expected to skyrocket to over EUR 11.9 billion by the end of the century, with most of the costs resulting from heat waves (Forzieri et al., 2018).

A range of adaptation measures already exist; for example, using solid concrete slabs to hold train lines in place, or replacing current rail lines with more heat-resistant metals. However, the expensive nature of such solutions makes many of them somewhat cost-prohibitive, with rail operators in the UK, Spain and Switzerland opting instead for more low-cost solutions such as painting rail lines white. New options within this sector are continuously being investigated.

7.1.4 What are the potential limitations?

Physical infrastructure approaches vary widely in nature, scale and potential integration with non-physical measures. There are numerous, well-documented limitations to the use of more traditional physical infrastructures in addition to the very significant costs, including:

- High cost of implementation — larger-scale, higher-cost infrastructure may be cost-prohibitive to smaller, less wealthy urban municipalities. However, distributed and modular-type infrastructures, able to be implemented over longer timeframes as financing becomes available, may increase their accessibility to all.

- Potential contribution to maladaptation and/or working against climate mitigation goals (e.g. energy-intensive infrastructure such as pumped drainage or desalination plants) (Dawson, 2007).

- Limited ability to deliver co-benefits, i.e. they serve fewer objectives and provide less societal benefits than other measures (Browder et al., 2019).

- Lack of flexibility over time for adjustment and delivery for future climatic conditions. An example, '... seawalls effectively reduce impacts to people and assets in the short-term but can also result in lock-ins and increase exposure to climate risks in the long-term unless they are integrated into a long-term adaptive plan. The implementation of these maladaptive actions can result in infrastructure and institutions that are inflexible and/or expensive to change' (IPCC, 2022).

Developing new skillsets and ways of working across sectors and disciplines is an important but often overlooked challenge in shifting away from more traditional grey measures to ones that incorporate social and natural system elements. Newer forms of grey infrastructures such as green/grey hybrid infrastructures, new building materials or designs or approaches for treating or re-using water, are novel. Thus, this translates into real costs and opportunity costs related to experimentation, failure and delayed implementation of measures that have already been proven to protect people, assets and the environment.

7.2 Technological measures

16.5% of all actions undertaken by reporting cities to the CDP in 2022 were classified as technological measures (CDP, 2022). Technological measures include early warning systems (EWS), hazard and risk mapping, and digital tools and applications. Big data and the 'internet-of things' tools form part of these technological solutions and can provide information to decision-makers in real time to assist in making more effective decisions on resource needs and flows in cities. Table 7.2 provides examples of these measures.

Table 7.2 Overview of technological measures relevant to the urban context

Water scarcity: • demand control initiatives such as water efficient appliances, awareness and behavioural change initiatives; • sensors, the 'internet of things' tools, ICT for water pressure management and real-time leak detection.
Extreme temperatures and weather events: • smart heating and cooling systems; • early warning systems.

Climate change adaptation technologies have seen steady development globally, with an annual growth rate of 6.7% between 1995-2015. Coastal and river protection technologies have experienced the greatest growth at 17%, with water management and general infrastructure technologies both at 8%. However, this growth is still much less than for mitigation technology, whose share across all innovation types doubled over the same period. For the period 2010-2015, Germany, France and Sweden are listed in the top ten inventor countries globally (Dechezleprêtre et al., 2020). Limitations in knowledge transfer across countries, or between regions, mean that a lack of innovation in a particular location often translates to lower levels of technology access and use.

There is an increase in implementation of adaptation measures that integrate technological solutions with nature-based, physical and social measures. These approaches are recognised as providing multiple co-benefits to address complex socioecological issues in cities while increasing climate resilience. Freiburg, Germany is integrating techno-social and cultural solutions into its public transport systems (Lin et al., 2021). Tram corridors are built with grassed, pervious surfaces to support stormwater drainage. Public transport costs are subsidised to encourage their use over individual cars and reduce the overall travel cost burden for lower income households. In another example, the University of Calabria, Italy is using a sophisticated monitoring system that allows the institution to collect climatic, hydrological, hydraulic and thermo-physical data in real time on a series of NBS for integrated urban drainage (e.g. green roofs, permeable pavements and stormwater filters) (Pearlmutter et al., 2020).

7.2.1 Early warning systems (EWS)

EWS are highly effective and recognised as one of the most cost-efficient adaptation measures (Ijjasz et al., 2022). It is estimated that they provide a tenfold return on investment (ITU, 2023). While not all are yet in compliance, EU Member States were required to have a system in place to deploy a public warning via telephone networks in case of an ongoing crisis or upcoming disaster by June 2022.

Importantly, for EWS to be fully effective, their physical and technological deployment must be accompanied by active engagement with the people and communities at risk from hazards. Critically, forecasts and warnings need to be timely and targeted. This involvement can facilitate public education and raise risk awareness, assist with efficient and effective dissemination of messages and warnings, and ensure that there is a constant state of preparedness enabling early action. Part of the value of an effective EWS lies in the recognition of its benefits by local people. Box 7.3 provides a case study of what can happen when there is insufficient public engagement.

Box 7.3

Case study: performance of the flood warning system in Germany in July 2021

In July 2021, intense rainfall caused devastating floods in western and central Europe. Germany alone experienced 184 fatalities, raising questions about the effectiveness of the country's flood forecasting, warning and response system.

The first warnings of a major flood came four days before the rain, with alerts coming from scientists working on the European Flood Awareness System (EFAS). Severe weather warning messages were provided by Germany's Federal Office of Civil Protection and Disaster Assistance to the media, other intermediaries and through the NINA warning app, created to notify people of impending extreme weather. Nevertheless, post-event, these warnings were judged by many as being insufficient or ineffective, with most attention placed on:

- The limited reach of the NINA warning app. At the time of the event, the app had only a limited number of subscribers, numbering around 10 million people.
- Strict data privacy laws. This limited an authority's abilities to send mobile phone alerts directly to people that had not subscribed to any early warning service. Post-event, a debate has taken place on privacy versus protection of lives.
- The physical state of warning sirens. There was criticism that these had fallen into disuse.
- Behaviour-related deficiencies. In addition to the large number of residents who indicated that they had not received any warning, many of those who did receive them had not anticipated such severe flooding. Others reported that they had insufficient knowledge of the types of protective behaviours they should have deployed (Thieken et al., 2023).

Looking beyond flood-related warning systems, as extreme heat events become more common across Europe, heat warning apps are also becoming more widespread, providing information on heat related risks and the personal actions individuals can take to reduce them (Box 7.4).

Box 7.4

EXTREMA: emergency notification system for extreme temperatures

EXTREMA aims to improve city resilience to extreme temperature events. Real-time condition updates during heat events help prevent the consequences. A tool has been developed that can inform in real time which city areas would suffer the most during an ongoing event. The mobile app assesses the personalised health risk of the user in real-time and location, and provides instructions on how to get to a cooler place. EXTREMA uses real time satellite data, along with other models and city-specific data, to estimate the temperature, humidity and discomfort index for every km^2 in the city. In 2018, EXTREMA services were successfully implemented and launched in Athens, Rotterdam, Paris and the Island of Mallorca.

There is a significant opportunity to enhance the effectiveness of EWS by populating these systems with new sensor and local data sources (including crowd-sourced data) and complementing it with new technologies (e.g. machine learning and artificial intelligence) to enhance the value of both EWS and smart systems in urban settings.

7.2.2 Big data and smart systems

The OECD lists 'technologies' as one of the three 'enablers for action on climate resilience' (alongside 'data and information' and 'awareness and capacity') (OECD, 2021). Rapidly evolving technological areas are often those that form part of smart city strategies, including the use of big data, the 'internet-of-things' and smart sensors.

Some technologies are evolutions of existing approaches; for example, shifting from traditional air conditioning units that consume significant energy and contribute to emissions to systems-based cooling technologies that tap into cooling tower infrastructures.

Practical applications of smart systems to support climate change adaptation efforts include the management of water efficiency and/or flooding. This includes managing and mitigating floods through the use for real-time control of reservoirs, pumps, gates, sluices and other physical infrastructures. Smart systems can also increase the efficiency of distribution, considering both water and energy use. It can adapt operations to patterns of demand. Sensors and automated or unmanned systems (e.g. on-demand watering systems) are increasingly used to save, recycle and upcycle water before or during droughts and floods (Rathore et al., 2016).

Such systems can also enable early detection and the reduction of breakdowns and leaks. An estimated 23% of treated water is lost during distribution in the EU, and the revised European Drinking Water Directive specifically tackles leakages. This means there is increased attention on technologies that can support early leakage detection. Given the increasing water scarcity across Europe, investment in cheap sensor technologies that detect leakages in real time can be an extremely cost-effective solution.

Box 7.5

Using intelligent city approaches for climate adaptation

Santander, Spain implemented an intelligent city strategy in 2015. The city now has access to data collected by 20,000+ sensors already connected and installed throughout the city. From water fountains to parks and other public infrastructures, the real innovation is the creation of a 'system brain' that can anticipate events such as flooding in a particular location, allowing the city to activate timely contingency plans (Garteizaurrecoa, 2019).

Rotterdam, the Netherlands has likewise integrated ICT in its flood control systems in the form of integrated forecasting tools and sensors that are able to register real time conditions of dykes (García Fernández and Peek, 2020).

In Barcelona, Spain, urban flooding has been reduced through its installation of a network of stormwater tanks, monitored remotely via an ICT system. Results show operational savings of 30% and a reduction in the chance of urban flooding of up to 75% (García Fernández and Peek, 2020). This same city is also using ICT to manage its increasingly hot summers. The city developed a Cool Walks app to support people in selecting the shadiest walking routes to their destinations. The app draws on LIDAR: high resolution models of ground elevation that include trees and buildings. By choosing a starting point, destination and hour of the day, the app combines this modelled data with manually-collected data, resulting in it being able to model direct sunlight and shade. As a result, the app can provide users with a map for the shadiest route that also includes drinking fountains and shelter spots along the way.

7.2.3 Satellite technology and artificial intelligence (AI)

Advancements in the use of satellite technology and AI mean that cities are now able to access modelling systems that predict, with great accuracy, which neighbourhoods will be most affected by large flood, heat, drought or fire events. These technologies are proving critical for enhancing EWS (e.g. by forecasting), and for supporting the development of hazard and risk mapping in urban centres. Athens, for example, uses AI-powered drones to monitor forests and detect potential fires, allowing firefighters to respond more quickly and prevent fires from spreading.

Box 7.6

Advancements in flood forecasting

The use of satellite imagery and advanced terrain models has led to the possibility of providing increasingly accurate flood forecasting.

Under development since 2002, the European Flood Awareness System (EFAS) is a pioneering, operational, pan-European flood forecasting and monitoring system. Developed at the Joint Research Centre of the European Commission (EC-JRC), this initiative has been a close collaboration with national hydrological and meteorological services, the European Civil Protection Mechanism of the Emergency Response Coordination Centre (ERCC) and other research institutes. As of 2011, EFAS has been integrated into the Copernicus Emergency Management Service (CEMS) and transitioned to operational status in 2012. EFAS plays a crucial role in providing up-to-date early flood forecasting information, supporting the preparations of national and regional flood risk management authorities prior to potential flood events. Moreover, it offers a distinctive perspective encompassing Europe and neighbouring regions by presenting both forecasted and observed flood events as well as the potential socio-economic ramifications of those events.

Google's flood forecasting model, FloodHub, collects thousands of satellite images to build digital models of the terrain and simulate thousands of possible scenarios of how rivers could behave. Measurements sent by governments are then cross-referenced with these simulations and high-quality elevation maps. Google is credited for its advancements in AI-based flood forecasting models which allow the continued expansion of geographical coverage, with the majority of Europeans are able to find information for their locality (Matias, 2022).

The European Space Agency has two connected initiatives aimed at leveraging the use of space applications for earth-centred purposes. The Space for Smart and Green Cities Task Force aims to foster the development of sustainable solutions through the use of space applications. The Space for a Green Future Accelerator similarly aims to work with a wide range of government, private sector and civil society partners to develop practical, space-based solutions supporting carbon neutrality and the greening of society by 2050.

An increasing number of urban municipalities are also promoting the use of technologies that can be placed in the hands of the public. The dual purpose is to give them more control over things such as their own water consumption and to crowdsource data on local realities, be they weather-related or needs-related. For example, with 50% of Amsterdam households connected to water meters, household water use has dropped by 10-15% (Economist Intelligence Unit, 2009).

Climate services have a critical role to play, offering a dynamic bridge between climate data and informed decision-making. These services aim to deliver a diverse array of information, ranging from observations and satellite imagery to sophisticated climate models, in a user-friendly manner. The process involves active engagement between users and providers, ensuring that the information is not only scientifically credible but also aligns with the specific needs of the end-users.

7.2.4 What are the potential limitations?

Technological solutions will make a critical contribution to the resilience of European urban centres, but they do have limitations, which include:

- The cost of technologies and the implications of such costs on who can afford to access them. CoM signatories report high costs and immature technologies as substantial barriers to their use (Rivas et al., 2022).

- The ability of municipalities to address new governance-related requirements for the use of new technologies. Some technologies may require new laws, regulations and governance mechanisms to ensure their appropriate use. A particularly important element here is public privacy and protection (FRA, 2020).

An important role for European-level institutions may be in facilitating data creation and open data standards, where appropriate, in climate-critical industries. A practical way of approaching this is for regulators to support the development of standards and protocols for data sharing. The EU's INSPIRE Directive already provides a good example of leadership in this area, enabling the sharing of environmental spatial information among public sector organisations. It will be important to ensure access to AI and other technologies does not further exacerbate the digital divide.

7.3 Outlook

The demand from society for more sustainable solutions to enhance the well-being of citizens drives social willingness to accept new solutions, as long as the direct interests of people, businesses and nature are protected. The time to test, improve and demonstrate hybrid solutions has come so that the benefits of integrating green, grey and smart technologies can be evaluated, improved and demonstrated.

It is likely that as more traditional physical measures face increasing scrutiny, there will be an increasing push towards 'no-regret' NBS. Regardless, physical measures will continue to be part of adaptation action (Wright, 2021). The key is to continuously increase their integration with more holistic 'greened' efforts (Browder et al., 2019).

On the adaptation technology development and deployment side, an important determinant will continue to be the availability of climate technology funding, which is booming in Europe. In 2021, 13% of all European venture funding went to climate tech startups, an increase from the 5.9% reported in 2017 (King, 2022). However, it is important to note that adaptation-related initiatives only received 7% of this climate-related investment (Climate Policy Initiative, 2021). A lot will depend on whether the prediction that such adaptation-focused climate investments (e.g. venture funding) will be worth substantially more within the next five years holds true (Chidambaram and Khanna, 2022). This will represent a big shift from today, where most adaptation technology is financed by the public sector.

Regardless of the source of financing, resolving some of the ethical issues related to their use, particularly regarding the use of artificial intelligence and how privacy concerns are addressed, will strongly influence the future of these measures.

Box 7.7

How do cities measure physical and technological actions?

- **Building parts in new buildings and renovations optimised** – Munich, Germany (Optimisation of summer heat protection in building planning)
- **Number of shaded playgrounds in relation to total number of playgrounds in the city** – Radom, Poland (Mitigate health risks from heat waves and urban heat island)
- **Extension of systems to facilitate rain infiltration** – Bologna, Italy (Sustainable water management in new urbanisations)
- **Km of replaced sewerage network per year** – Zaragoza, Spain (Combating and adapting to climate change)
- **Number of people who have created a personal account to track their consumption** – Toulouse, France (Controlling water network losses through intelligent management: Water Smart System trial)
- **Number of residents using the Early Warning and Alert System as a proportion of total population** – Radom, Poland (Develop and implement a decision-making and emergency response system)
- **Number of stations monitoring air quality, water status and weather in the city** – Częstochowa, Poland
- **Number of rebuilt storm sewage systems in terms of using rainwater at the place of its formation or retention** –Zielona Góra, Poland (Increasing the city's resistance to extreme hydrological phenomena (precipitation, floods/flooding and drought) and anemometric phenomena (strong winds) and lightning discharges)
- **Number of environmental monitoring system devices in the city** – Gdańsk, Poland (Devices in catchments and reservoirs, and monitoring of groundwater and water supply networks)

8 Nature-based solutions (NBS) and ecosystem-based approaches

Key messages

- Key NBS for resilient European cities involve maintaining, restoring and creating new parks and urban forests, planting individual urban trees, improving urban water management and greening buildings (e.g. green roofs and facades). These measures help to combat UHI effect and regulate water in an urban environment.
- NBS are increasingly used across European cities, with 91% of local climate action plans including such measures. The multitude of co-benefits NBS can bring, such as biodiversity gains, recreation potential and mental well-being, mean that they are also increasingly recognised as 'no regret' measures.
- Financing, the technical capacity to implement, health concerns and competition for space are some of the main concerns related to the implementation of NBS. Importantly, equity concerns need to be addressed in the implementation of NBS. Priority should be put on areas most in need of additional green infrastructure while having mechanisms in place to limit green gentrification.
- A trend can be observed in shifting conversations from 'green versus grey' to 'green with grey', keeping in mind the limitations of green infrastructure (e.g. effectiveness for major flooding events).

8.1 What are nature-based solutions in an urban context?

The European Commission defines nature-based solutions (NBS) as 'solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions.' NBS is often used as an umbrella term for ecosystem-based approaches and green infrastructure and is defined as being the utilisation and support of natural systems, contrary to adaptation interventions based solely on civil engineering (Dorst et al., 2019).

Maintaining, restoring and creating new parks and urban forests, planting individual trees, greening buildings such as green roofs and facades, and improving urban water management through natural water retention measures are key urban NBS measures (EEA, 2021; van der Roest et al., 2023). Urban forests can be defined as networks or systems comprising of woodlands, groups of trees, and individual trees located in urban and peri-urban areas. Table 8.1 provides an overview of the different urban examples of NBS.

Table 8.1 Examples of NBS relevant to the urban context

Sub-KTM	Elements	Urban examples
Green options	Creation of new/ improvement of existing green infrastructures	• afforestation • revegetation • green roofs and facades • urban farming
	Natural and/or semi-natural land-use management (Brown Options)	• avoidance of soil sealing • soil remediation
Blue options	Creation of new/ improvement of existing blue infrastructure	• retention ponds • blue-green roofs • aquatic buffer strips • rainwater harvesting • sustainable urban drainage systems
	Natural and/or semi-natural water and marine area management	• wetland restoration • flood plain restoration

NBS in peri-urban and rural areas have an important function in the climate adaptation of urban areas as well. Cities and towns in coastal or delta areas might also develop more 'landscape scale' NBS closer to urban areas (e.g. beach nourishment and river estuary restoration). The added value of NBS surrounding cities is that they can enhance biodiversity, water quality and support urban water supplies. In addition, they can contribute to flood resilience by upstream greening and afforestation (Gunnell et al., 2019; De Boer et al., 2023; Markart et al., 2022).

In terms of climate adaptation, the most important functions of NBS measures are water management (e.g. reducing flood and drought risks by water retention and slowing run-off) and reducing heat island effects (e.g. with the cooling effect of shade by vegetation and the evaporation of water). NBS also have the potential to simultaneously provide additional environmental and societal benefits, which include increasing biodiversity, human health and well-being.

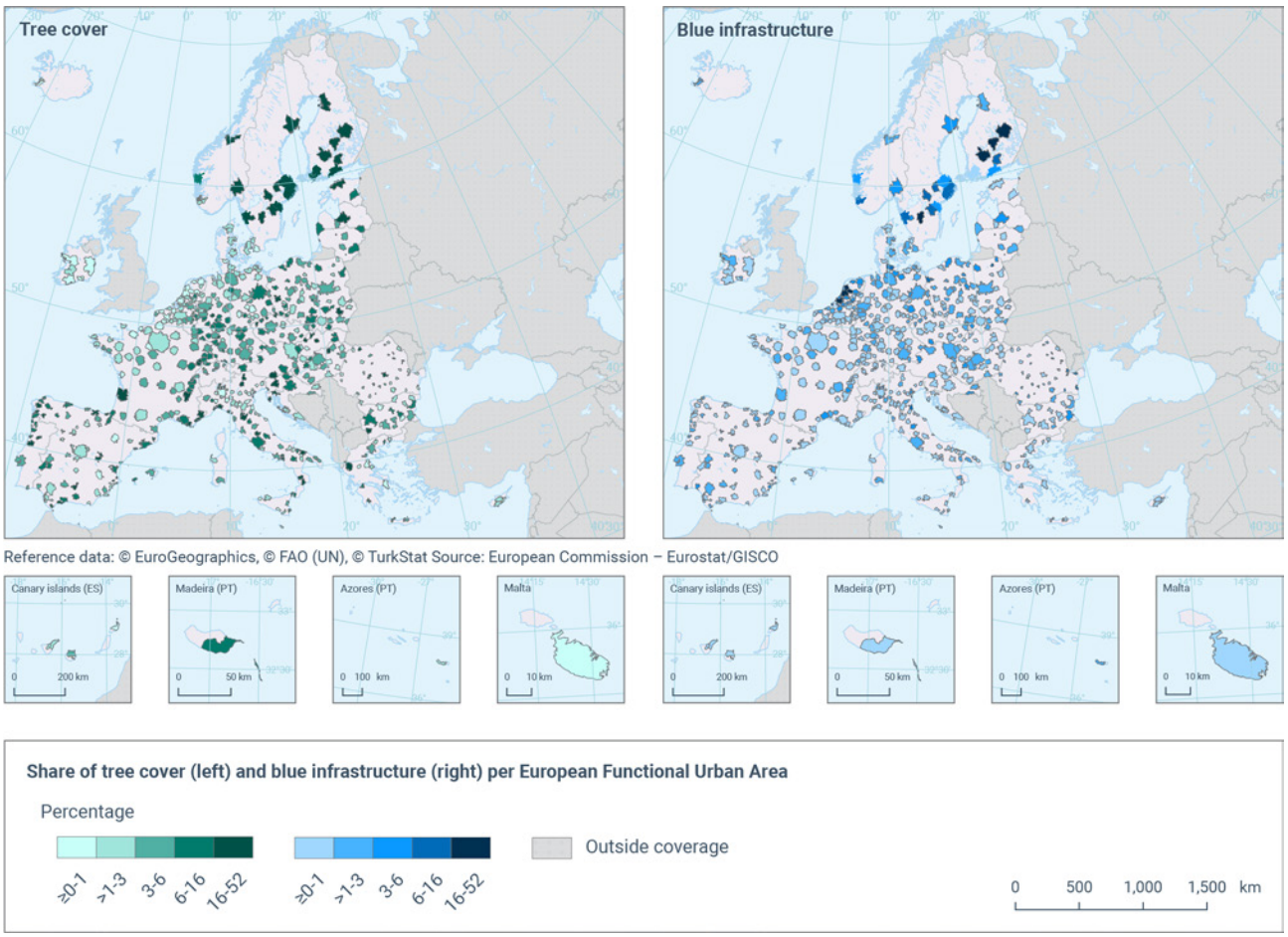
Further details and research into the effectiveness of specific measures can be found in the EEA's full report on NBS (EEA, 2021) and in the previous EEA Urban Adaptation report (EEA, 2020b), which includes results from the RESIN project.

8.2 Implementation of NBS in European cities

As of 2018, European cities were estimated to have 42% of their areas composed of green infrastructure (green and blue spaces) (EEA, 2022d). The amount of green infrastructure varies greatly from country to country though, with only 7% in Trnava, Slovakia and 96% in Caceres, Spain. Notably, publicly-accessible green areas account for only 3% of the total in city areas. This share also varies greatly, with Geneva (Switzerland), The Hague (the Netherlands) and Pamplona/Iruña (Spain) seeing accessible green space account for more than 15% of their city areas. 44% of Europe's urban population is estimated to live within 300m of a public park (EC-JRC, 2019).

Average urban tree cover across the EEA member and cooperating countries (EEA-39) in 2018 was 28.5% of the city core, and 34.7% of the larger functional urban areas (Map 8.1). The share of blue infrastructure (derived from Urban Atlas 2018), may contribute to cooling effect and be beneficial to overall well-being and have recreational potential if of high quality (see the EEA's state of bathing water).

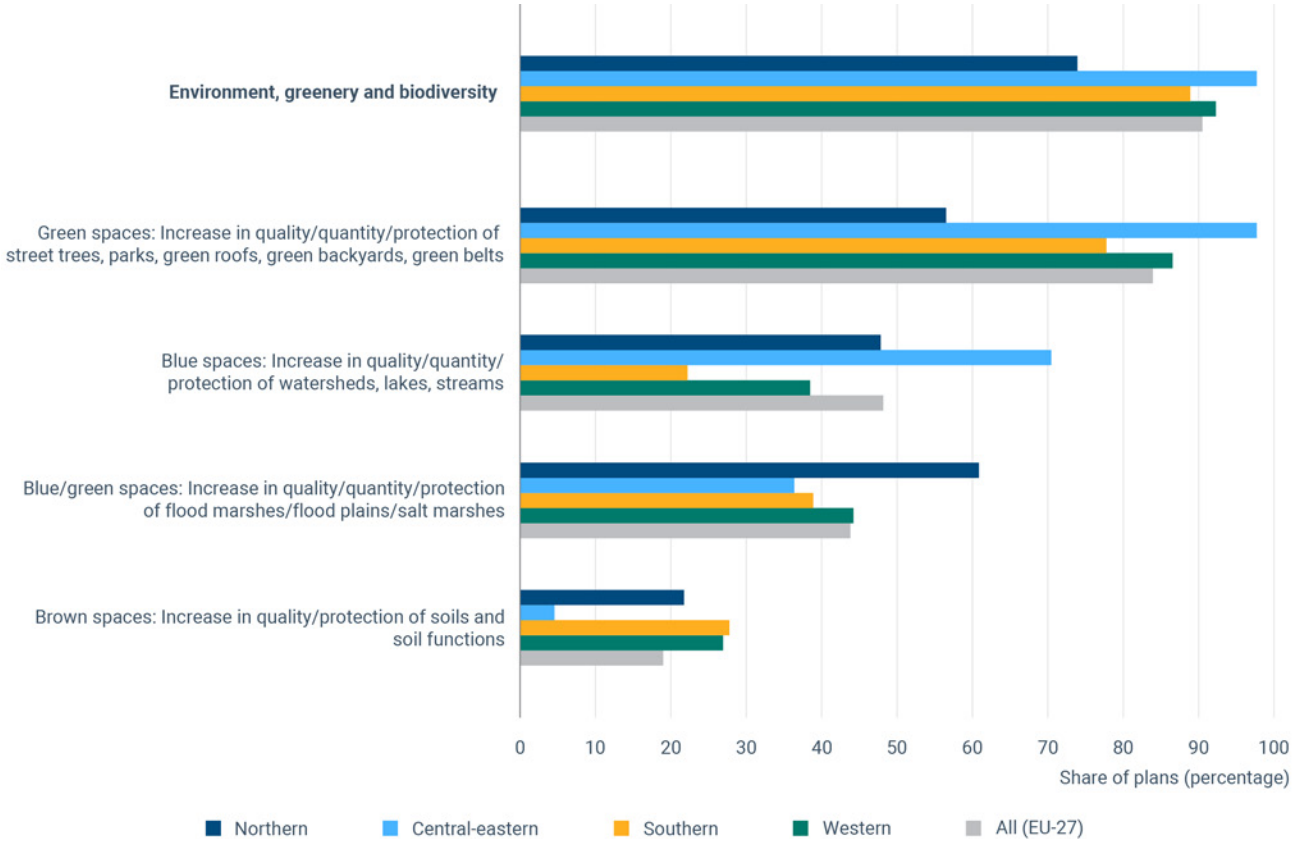
Map 8.1 **Share of tree cover and blue infrastructure within European functional urban areas (FUA) in 2018**



Source: EEA, derived from Urban Atlas, Copernicus, 2018.

The importance of NBS is increasingly recognised across Europe, and this is reflected by the uptake of NBS in local climate action plans. The analysis of 167 local climate action plans for European cities (Reckien et al., 2022) shows that, overall, 91% of plans include measures categorised as 'environment, greenery and biodiversity' (Figure 8.1). 84% of plans include specific measures on green spaces, 48% include measures relating to blue spaces and 44% mention measures integrating blue with green spaces. Notably, only 19% of plans include measures addressing brown spaces. This low number may be explained by the consideration that these measures are often implemented in combination with others (e.g. land preparation for the implementation of green spaces) and as such, might be difficult to identify and report as 'stand-alone' measures.

Figure 8.1 **Share of local climate adaptation plans that include actions categorised as 'environment, greenery and biodiversity', by European region**



Source: Reckien et al., 2022.

Over one quarter (26.6%) of actions reported to the CDP in 2022 by cities were related to NBS. Of these, the majority (84%) mentioned using 'green options', while only 15% focused on blue options (CDP, 2022).

While there is still no comprehensive uptake of NBS and ecosystem-based approaches (Zölch et al., 2018), many countries are undertaking quite extensive actions involving NBS. The Swedish National Board of Housing, Building and Planning has, in its guidebook on the integration of ecosystem services in planning, building and maintenance of the built environment, included information on nature's value for climate change adaptation. There are also specific guidelines for municipal green planning. The Swedish Environmental Protection Agency has also developed National Guidelines for NBS. Inspiration can be taken from a multitude of databases with actions and cases on adaptation actions using NBS in Europe and globally (Box 8.1).

Box 8.1

Overview of platforms and repositories on NBS in Europe

The Connecting Nature project aims to position Europe as a global leader in the innovation and implementation of NBS and presents several cases of urban applications.

INTERLACE HUB is a community for sharing knowledge, ideas and stories about restoring nature in cities. The hub is a collaboration between Europe and Latin America in using NBS to solve some of the challenges faced in cities.

GrowGreen aims to create climate and water-resilient, healthy and liveable cities by investing in NBS, and presents NBS demonstration projects of several cities across Europe.

Conexusnbs provide accessible knowledge on how to restore natural ecosystems, improve the quality of life in and around cities, and support collaboration between Latin America and Europe.

Oppla provides a knowledge marketplace where the latest thinking on natural capital, ecosystem services and NBS is brought together. It can be seen as the EU repository of NBS.

NetworkNature is a resource for the NBS community, creating opportunities for local, regional and international cooperation to maximise the impact and spread of NBS.

The European Natural Water Retention Measures platform promotes the use of green infrastructure in a range of policies, and gathers information at EU level.

SOLOCLIM is developed as a doctoral training programme that also enables young researchers to generate solutions for the climate adaptation of urban outdoor environments.

The CLEVER Cities project uses NBS to address urban challenges and promote social inclusion in cities across Europe, South America and China.

Climate-ADAPT features a wide range of NBS-focused cases studies.

8.3 Key examples of NBS

8.3.1 Green options

Many cities have strategies in place to improve and expand on green infrastructure networks in 'green belts' around their cities or 'green corridors' spanning from the city outskirts towards the centre. Stavanger city (Norway) is part of UnaLab and has implemented several NBS. Green belts throughout the city are important for recreational purposes, and for water and air management. Stavanger's vision for 2050 is to improve nature's integration into the city.

Cities such as Bratislava (Slovakia) and Budapest (Hungary) also have specific plans in place for greening their cities. The Green Urban Infrastructure of Vitoria (Spain) is an example of scaling up an urban adaptation measure that began with the creation of the city's green belt in 1993 and the city of Madrid is implementing an ambitious plan to establish a metropolitan forest (Box 8.2), with emphasis on establishing green areas in disadvantaged neighbourhoods.

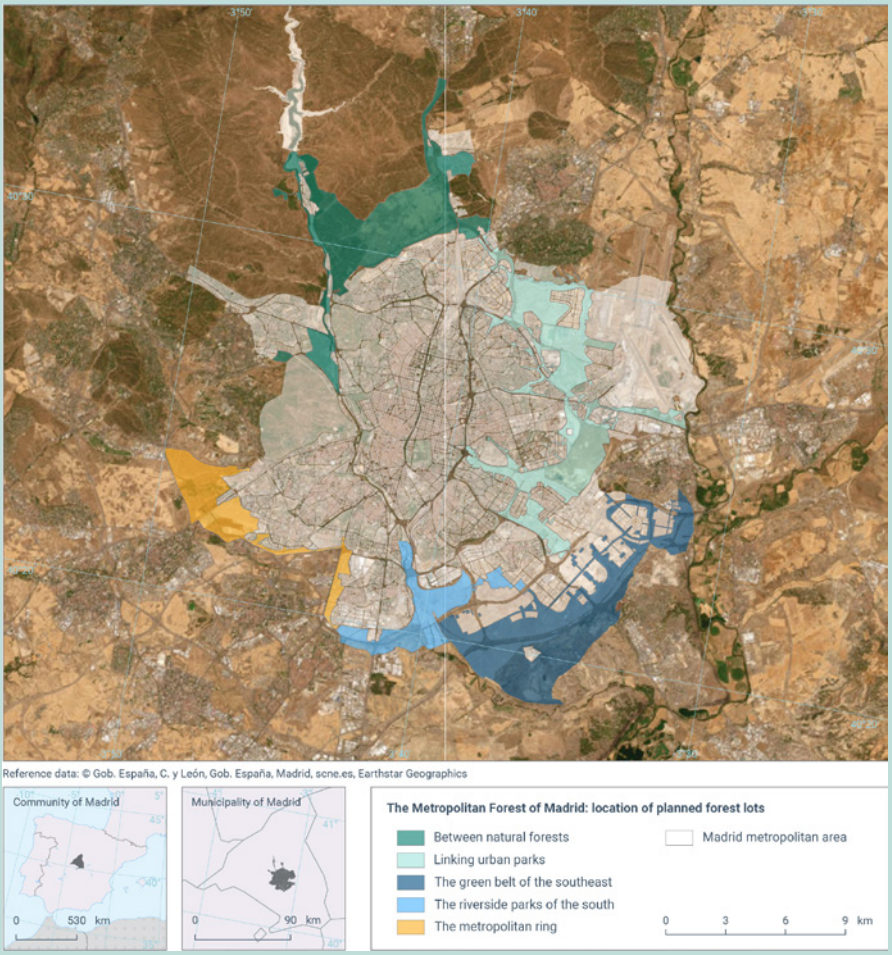
Box 8.2

Madrid Metropolitan Forest, Spain

The City of Madrid promoted the creation of a forested green ring around the dense urban centre known as the Metropolitan Forest of Madrid. It is part of the municipal plan Madrid 360 drafted to meet emission reduction targets agreed by the European Commission and the Climate-KIC Sustainable and Healthy Cities Demonstrator, and developed with the scope of becoming a climate-neutral city. The forest should bring multiple benefits such as climate change mitigation and adaptation, biodiversity support and social cohesion.

2 million trees will be planted in a 75km forest belt which has a total area of 32,035ha, 81% of which are existing natural environments (Map 8.2). The trees will be planted over the next 10 years in 2,300ha of residual peripheral land, 50% of which is privately-owned. Specific plans for the five parks have been developed through an international competition. The project has recently demonstrated some of the constraints faced by such extensive green infrastructure projects. These include the impact of extreme weather on the newly-planted trees (e.g. during periods of drought, storms or heavy snowfall) and also the struggles related to land ownership.

Map 8.2 **Planned areas for integration of green infrastructure in Madrid, Spain under the Metropolitan Forest project**



Source: Dirección de Planificación Estratégica, Ayuntamiento de Madrid.

Many cities are integrating more green areas directly into public spaces in denser urban areas in the form of pocket parks, green roofs and facades. Examples of initiatives aimed at adapting buildings using NBS include the Climate-resilient housing estates project in Bratislava, Slovakia and the MyBuildingIsGreen LIFE project, amongst many others (Box 8.3).

Box 8.3

Germany's green roof strategies

German cities are adopting NBS such as green roofs and facades to enhance rainwater absorption, cool buildings, improve air quality and promote public wellbeing. Germany has become a global leader in greening practices.

Municipalities have played a significant role in promoting the installation of green roofs and facades through their inclusion in local development plans. By 2019, approximately two-thirds of German cities had made it compulsory to incorporate green roofs into their local plans, a substantial increase from just one-third in 2010. In Munich, Stuttgart and Berlin, a mandatory green roof policy is applicable to all new buildings featuring flat roofs exceeding 100 m^2 and all new roofs with slopes below a 12˚ angle. These cities stand out with green roof areas exceeding 4 million m^2. Seven of every 10 cities with populations exceeding 50,000 have integrated roof greening into their development strategies. To incentivise green infrastructure, targeted funding programs have been initiated, often focusing on specific neighbourhoods or even entire cities. Roughly 25% of Germany's major cities subsidise green roofs. In addition, 25% of cities offer eco-points for green roofs as part of impact compensation, often promoting them alongside solar energy systems.

Hamburg implements a pioneering Green Roof Strategy, with subsidies covering up to 60% of installation costs. The city's goal is to maintain a compact urban structure while greening 70% of new buildings and suitable renovated roofs.

Figure 8.2 Visualisation of Hamburg's green roof strategy

The need for increased accessibility of green areas to the most vulnerable people (e.g. for cooling) is recognised in projects such as the natural playgrounds in Poznan, Poland (Box 8.4).

Box 8.4

Poznan natural playgrounds and city beaches, Poland

Poznan is introducing NBS in its urban spaces to improve living conditions and increase resilience to impacts from climate change, including 2 notable projects:

The schoolyard project (natural playgrounds) was initially implemented in a few schools, then scaled up to more than 20. These spaces, owned by public institutions, were opened to a wider group of users, thus contributing to the development of an interconnected green network of spaces across the city's more densely built neighbourhoods. The aim was to create multifunctional green spaces that prioritise children's development, health and skills. Among traditional playing facilities like swings and slides, the city introduced playing facilities made of living plants (e.g. willow tipis or mazes made of tall grass), of soil (e.g. hills and natural paths), or from natural materials (e.g. wood and stone) (Figure 8.3). Artificial impermeable safety surfaces in tarmac were replaced with natural, water-absorbing surfaces in sand or gravel. Vegetation was introduced to provide shade or natural isolation from traffic noise and pollution. There are also places designated for eco-education such as wild biodiversity zones, and meadows with houses for insects and flower beds. A handbook was also drafted with lessons and examples of how biogardens can be used to educate school children on biodiversity, climate change and nature.

The 'city beaches' project along the river Warta is an example of multifunctional development of areas at risk of flooding along the river Warta. They are recreational spaces created along the river on previous brownfield or neglected spaces. These spaces attract local residents and bring ecological benefits to the community and city.

Figure 8.3 **View of the green, modernised garden at kindergarten no. 7 (left) and a built hill with a slide in kindergarten No. 115 in Poznan (right)**

Notes: The garden (left) includes elements such as willow huts, sensory paths, and places to sit and play made of logs and stumps.

8.3.2 Blue options

Blue options refer to the maintenance of and/or establishment of new blue infrastructure in a city. The presence of water in a city can provide an additional cooling effect, and the proper management of blue infrastructure can significantly contribute to reducing the severity of both flooding and water scarcity.

In less dense urban areas, these options include wetland and floodplain restoration as well as larger retention ponds. An example of this is the Natural buffer against flooding in Vlijmen-Den Bosch, the Netherlands. The cooperation between three municipalities, Den Bosch, Heusden en Vlijmen, led to the connection of 750ha of agricultural, natural and recreational areas into a natural overflow and water retention area. The project combines protection against flooding with ecological and recreational targets, helping against drought and improving water quality. This is also an example of a regional approach to solving local flooding problems, with cooperation between several municipalities, water boards, regional authorities, nature conservation organisations and agricultural organisations.

Several cities are also re-opening covered canals, and making efforts to re-naturalise and reintegrate more natural water flows within urban areas. An example is Budapest's plan to bring the Danube River closer to its people in its Integrated Urban Development Strategy. The reopening of small urban streams is another increasingly common action, an example of which is the reopening of the Hovinbekken stream in Oslo, Norway (Dinić-Branković and Marković, 2021). Besides climate adaptation considerations, this also aimed at increasing recreational, aesthetic and biodiversity aspects of these areas.

In denser urban areas, where natural spaces become more limited, these measures may include physical infrastructure and take the form of sustainable urban drainage systems, rainwater harvesting and smaller natural water retention basins or overflow areas. In particular, the separation of sewage and rainwater collection systems, in combination with natural overflow areas, can significantly increase local water quality and reduce the amount of wastewater needing to be treated.

The increased integration of blue infrastructure into public spaces, and the management of rain and surface runoff, can be done in an engaging and even fun way. This can raise awareness while remaining functional, as in the example of Gothenburg (Box 8.5).

Box 8.5

Embracing the rain in Gothenburg, Sweden

It rains about 40% of the time in the Swedish city of Gothenburg. With a changing climate, its residents may expect even more rainy days in the future. But rather than seeing this as something negative, the city is implementing a creative project called 'Rain Gothenburg': it seeks to change attitudes towards the plentiful rainfall and encourage people to treat this water as a resource. This project was originally proposed by residents who saw the value in this water and wanted to use it to enhance the city.

The 'Regnlekplatsen' (rain playground) is part of the Rain Gothenburg project, with the idea of making Gothenburg 'the best city in the world when it's raining'. Local playgrounds are designed to be particularly fun in wet weather conditions. At a new school to be built in Torslanda (Torslandaskolan), the rainfall from roofs will be channelled down wide pipes on the side of the building into pools, then towards a river or canal that runs through the schoolyard where children can play with sluices and on stepping stones in a green area (Fig 8.4).

This approach to celebrating water is also being embraced in other European cities, with another example being the water squares 'waterpleinen' in Rotterdam, the Netherlands. In many cases, the landscape designs are not solely nature-based; rather, they use a hybrid green and grey solution where water is also stored underground.

Figure 8.4 **Torslandaskolan, Gothenburg, Sweden**

Many actions taken within cities combine both green and blue aspects; for example, by creating blue-green corridors in urban and peri-urban areas. In Belgrade, Serbia, the restoration of blue-green corridors in the experimental watersheds of several urban watersheds (Kaljavi, Jelezovac, Rakovicki, Pariguz and Precica streams) is estimated to decrease maximal river discharges by about 50%, reducing the risk of torrential floods and destructive erosion processes. Additional benefits include bringing people back into city spaces by creating areas for sports and recreation and conserving and protecting biodiversity.

Copenhagen's Cloudburst Management Plan, which is designed to protect the city against floodwaters, found the blue-green approach worked just as well as traditional solutions and at half of their cost. There were also the additional benefits of improved health and a more pleasant urban environment. At a smaller scale, in denser urban areas, initiatives include projects aimed at providing cool spaces to counter the heat island effect, such as the cool-INN project in Innsbruck, Austria.

8.3.3 Brown options: land management and restoration

The recovery and management of land can be done through the use of NBS. The resulting increase in water retention capacity, which is especially low in heavily-compacted soils, is important from a climate adaptation perspective. Land remediation measures focus on reducing to a minimum the presence of harmful substances in the soils on land that may previously have been used for industrial production (brownfields) or intense agriculture (Box 8.6). This ensures their readiness for alternative land uses such as the establishment of new parks, recreational areas and even new urban agriculture initiatives. The avoidance of soil sealing and the protection of soils against erosion are additional land management measures important to climate adaptation.

Box 8.6

Regenerating contaminated areas in Baia Mare, Romania

The Smart Post Industrial Regenerative Ecosystem Project (SPIRE) is aimed at the long-term environment, economic and social redevelopment of Baia Mare, Romania. Once the country's mining capital, the city has over 600ha of heavy metal-polluted land. To address this, SPIRE aims to make the case that the use of NBS that draw upon nature's inherent restorative capabilities is a cost-effective approach to remediating these contaminated sites.

Five pilot sites, covering 7ha, are being re-naturalised, with strong participation from local community members. The main techniques used are all forms of NBS phytoremediation, an approach that uses plants to remove heavy metals from the soils. The case shows that NBS can be used to help regenerate contaminated areas and those re-naturalised sites can, in turn, contribute to climate adaptation objectives. The project's interactive platform allows a broader range of stakeholders to track remediation progress and plant health in each of the sites. The project also offers a plant selection toolkit for all to use to ensure that appropriate plant species are selected based on the contamination characteristics of the soil.

8.3.4 Multi-functionality of NBS

There is increasing attention paid to the multiple co-benefits of NBS rather than implementing NBS with only a single purpose (e.g. reducing heat stress or floods). When NBS are combined, these benefits can strengthen each other. For example, water storage and greening measures which improve infiltration go well together since water is essential for the quality of the greenery; this leads to improved biodiversity, as well. In addition, blue-green roofs combined with solar panels have multiple benefits such as water retention and increased solar energy yields, resulting in a win-win situation. In particular, the involvement of different stakeholders offers many possibilities in creating these multifunctional purposes. An example from Amsterdam that both demonstrates both the synergies between mitigation and adaptation goals, and a way to deal with competition for space is described in Box 8.7.

Box 8.7

Synergies between mitigation and adaptation: project Urban PhotoSynthesis, Amsterdam, the Netherlands

Combining green roofs with solar panels is possible but has its limitations: green roofs need light and water to reach the substrate. A southward orientation of solar panels, combined with higher standoffs and larger gaps between solar panel rows, can provide green roofs with sufficient water and light to perform their climate adaptive and biodiversity functions and cool down the solar panels. This leads to increased efficiency on hot, sunny days. Available studies show the positive effects of green roofs on solar panels, with 4.4% more power output (van der Roest et al., 2023).

Project Urban PhotoSynthesis in Amsterdam combines stormwater collection, green roofs, circular water use and solar panels to cool the city, increase living comfort and energy yield, and reduce the burden on water resources. The project shows that green roofs and solar panels can indeed improve each other's productivity and efficiency. In addition, the building water management system supplies filtered and recycled shower water to the roof when there is a lack of rain.

Figure 8.5 **Urban Photosynthesis project, Amsterdam, the Netherlands**

The explicit multifunctionality is what makes NBS so attractive, leading to great opportunities to inspire and involve many other sectors. Evidence of this is NBS promotion within the 2021 Climate Adaptation Strategy, the European Green Deal, the Floods Directive, the Biodiversity Strategy, the Action Plan on the Sendai Framework for Disaster Risk Reduction 2015-2030 and the current proposal for a nature restoration law.

8.4 Limitations and outlook

There are several limitations to the implementation of NBS, in-line with those limiting the implementation of adaptation measures as a whole. Some limitations specific to NBS though include:

- Evidence of effectiveness: in general, evidence on the actual effectiveness, especially the upscaling potential of NBS, is still limited. Many projects are in their pilot phases and longer time periods are needed to allow proper monitoring and evaluation of these actions. Experience from EU-funded projects on how to evaluate the impact of NBS can be found in the Evaluating the impact of NBS handbook.

- Funding barriers: There are extensive studies and methodologies to assess the cost-benefit of implementing NBS (EC, 2021d; UNEP, 2023). The timeframes traditionally used to assess infrastructure returns on investments though do not always take into account the fact that NBS projects tend to have longer-term horizons, with benefits accruing at an increasing rate the longer the NBS infrastructure has been in place. In addition, NBS projects deliver co-benefits but the beneficiaries of those benefits may not always be able or willing to contribute to the costs of project implementation. Additionally, while capital funding might be available for project planning, design and implementation, there is not always sufficient recurrent funding to cover the often high ongoing maintenance costs.

- Technical capacity for implementation and maintenance: NBS are context-specific, needing very different approaches to traditional engineering and requiring different kinds of expertise (e.g. landscapers, ecologists, soil scientists, social scientists, architects and engineers). However, many senior project managers in organisations implementing these projects have had limited training in NBS design and implementation. Handbooks and specific guidance on green infrastructure implementation and renaturing can help build capacity. A recent example comes from the REGREEN project.

- Climate impacts on green infrastructure: The types of vegetation planted need to be carefully considered to ensure they are resilient to both the current local climate and the foreseen future climate. Indeed, the impacts of climate change on species are already being seen (Esperon-Rodríguez et al., 2022).

- Health concerns: potential unintended health outcomes may be increase in the risk of some infectious diseases eg. due to increased mosquito breeding sites (Rocklöv et al., 2023). A recent study in Brussels, Belgium, which analysed data from 5,940 trees across 18 urban green spaces, underscores the critical importance of carefully selecting tree species in urban green space planning. This consideration becomes especially significant as environmental changes may lead to longer pollen seasons, increased allergen potency and heightened sensitisation to specific species (Aerts et al., 2021).

- Competition for space: in an urban setting, NBS' multifunctionality becomes crucial, due to space claims and higher costs of urban NBS compared to NBS in natural or rural areas (Kabisch et al., 2022). Doubling green spaces as water retention areas or other multifunctional uses can help.

- Equity and justice: NBS implementation that does not embed equity and justice considerations into the design and implementation has the potential to reinforce existing injustices, or contribute to the development of new ones. The most common, unintended and negative consequences of NBS relate to gentrification and displacement.

Demand for NBS is rising strongly due to an increasingly enabling policy landscape. There is significant mainstreaming within international, national and local policies. For example, current European-level policy objectives include providing evidence for NBS; and advancing their development, uptake, upscaling and mainstreaming in international research and innovation.

There are indications that the use of NBS as opposed to, or at least in combination with, other adaptation options will be further promoted by increasingly strong regulations at national and European levels. NBS are seen as 'no regret' measures and their implementation is encouraged at most governance levels due to their clear co-benefits. Related to this is the increasing recognition of the contribution of NBS to Nature-Positive Economies and in achieving the transformative change needed to address interdependent climate and biodiversity challenges.

In Norway, central government planning guidelines for adaptation encourage municipalities to use NBS in their land-use and general planning processes. The municipalities are required first to consider conservation, restoration or establishment of NBS. If other measures are chosen, municipalities need to justify why NBS were not chosen.

The UK requires delivery of the 'biodiversity net gain' (BNG) while developing land. Developers in England are required to deliver 10% BNG when building new housing, industrial or commercial developments so that there are positive benefits for nature. In addition, BNG features need to remain in place for 30 years and monitored after implementation.

The proposed European Nature Restoration Law, if accepted, will provide a regulatory framework for the implementation and monitoring of NBS in European cities. It will require the maintenance of existing urban green infrastructure, and an increasing trend in urban green infrastructure and tree cover over time. A guiding framework will be developed to set the levels of urban green space and urban tree canopy cover in urban ecosystems.

There is now greater recognition, though, of the need to use grey or physical infrastructures with green, particularly in the face of extreme weather events that increasingly surpass green infrastructure's capacity to manage them. There is increasing consensus around the greater effectiveness of hybrid infrastructure approaches, particularly those that bring together infrastructural, nature-based and institutional solutions, in comparison to siloed approaches (UNEP, 2022). There is also an increasing economic case being made for integrating grey with green. Grey solutions usually entail high upfront capital investments and longer-term annual maintenance costs over the project's life compared to solutions with green components (Green-Gray Community of Practice, 2020). When the broad co-benefits from nature-based approaches are taken into account, nature-based infrastructure is, on average, estimated to be 42% cheaper and create 36% more value than infrastructure solutions that are fully grey (Bechauf et al., 2022).

Box 8.8

How do cities measure NBS and ecosystem based approaches?

- **New permeable surfaces** – Marseille, France (Develop and implement a metropolitan strategy to reduce soil sealing)
- **Renatured meter of the riverbank length** – Munich, Germany (Specific river renaturation)
- **Difference in the number of trees planted and felled within the administrative unit** – Prague, Czech Republic
- **Area of green roofs and green facades** – Brno, Czech Republic (Activities to reduce risks associated with heat waves and urban heat island)
- **Number of citizens benefiting from the Green Corridor** – Athens, Greece (Green Corridors — within the Municipality of Athens)
- **Number of urban revegetation projects** – Valencia, Spain (Include the climate change adaptation variable in urban planning design)
- **Number of shaded and 'green' public transport stops in the total number of public transport stops** – Radom, Poland (Mitigate health risks from heat waves and urban heat island)
- **Number of buildings with SuDS measures implemented** – Dublin, Ireland (Implement Sustainable urban Drainage Guidelines in Council buildings where feasible)
- **New fountains created/reopened** – Athens, Greece (Fountains)
- **Monitoring the number of leaks (% leaks)** – Saint-Étienne, France (Promote integrated water management and combat wastage of drinking water resources)
- **Volume of water used via the secondary raw water network** – Ajaccio, France (Develop non-potable secondary raw water networks to preserve water resources)
- **Urban and suburban Natura 2000 areas (units, m^2)** – Pécs Hungary (Preservation, possible increase and protection of the ecological and pictorial landscape potential of natural, close-to-nature and cultural landscape parts, as well as the landscape character)
- **Ongoing maintenance of fountains, water pergolas and street drinking water fountains** – Bydgoszcz Poland (Strategy to ensure the thermal comfort of residents)

9 Knowledge and behavioural change

Key messages

- Residents and private actors need to be aware of what they can do to increase their own resilience and contribute to overall societal resilience.
- Increased knowledge and capacity-building are essential to ensure that there are enabling environments for citizens, private actors, larger industries and major players in the private sector. This is to enable a shift to more sustainable practices and actions that contribute towards adaptation.
- Decision support tools, apps and climate adaptation portals are becoming increasingly available for cities to use. They can be effective in raising awareness about the local impacts of climate change, although they may still have limited effects on behaviour.
- Knowledge and behavioural tools must be differentiated according to the needs of different target groups. The most vulnerable groups may need direct hands-on training and workshops, while emerging interactive technologies may be effective in reaching younger people.
- Behavioural change often requires a multi-measure approach; for example, using information-based tools with economic instruments or even regulation.

9.1 What are the measures and how do they work?

Building resilient urban communities requires the active involvement of private actors, be it residents or businesses, in implementing precautionary measures against the impact of climate change. Adaptive behaviours include at-risk groups observing cooling practices during heat waves; residents and businesses conserving water during droughts and investing in water saving devices or rainwater harvesting, or residents and businesses signing up for early warning apps. In the medium-term, adaptive behaviour also involves building new houses or retrofitting existing ones so that they are less vulnerable to climate change. Research shows that precautionary behaviour against climate change increases when residents are aware of the risks from climate hazards and when they know which precautionary measures they can take (Papagiannaki et al., 2019; Bubeck et al., 2012; Grothmann and Reusswig, 2006; Schneider and Ingram, 1990).

Awareness about climate change is high in Europe. The 2023 Eurobarometer indicated that 77% of EU residents acknowledge that climate change is a very serious problem and agree that adapting to the adverse impacts of climate change can have positive outcomes for residents in the EU.

To increase knowledge and promote adaption behaviour among private actors, cities can implement two general types of measures: information and awareness-raising, and capacity building (empowerment). These measures can address local risks and

vulnerabilities resulting from climate change, and offer information about the actions residents or other societal actors can take to minimise their risk and increase their resilience. Information and awareness measures include a wide range of tools from information campaigns such as mass media, social media, information nudges or podcasts to more operational information designed to assist decision-making, including adaptation portals and early warning apps (Table 9.1). Capacity-building measures are typically hands-on, such as workshops or practice-sharing helping private actors turn knowledge into actual precautionary behaviours. Measures can aim broadly or they can target at-risk groups directly to promote empowerment.

Table 9.1 Overview of knowledge and behavioural measures relevant to the urban context

Sub-KTM	Elements	Urban examples
Information and awareness-raising	Research and innovation	
	Communication and dissemination	• information campaigns • podcasts • behavioural nudges
	Decision support tools and databases	• climate adaptation platforms/websites • early warning apps.
Capacity-building, empowering and lifestyle practices	Identification and sharing of good practices	• demonstration of practices
	Training and knowledge transfer	• workshops • community training

Among the total (711) actions reported in the CDP dataset, 14.3% (102) measures fall within the knowledge and behavioural change categories. Of these, 56% are information and awareness-raising actions, and 44% are actions related to capacity-building, empowering and lifestyle practices. Knowledge and behavioural change measures are relatively more widespread in western, eastern and central European countries (accounting for 18-20% of adaptation actions taken there) and less prominent in northern European countries (7% of actions) (CDP, 2022).

In addition to information and capacity-building measures, other policy tools serve to raise awareness and promote behavioural change, too. These tools include economic instruments, which incentivise and enable behavioural change (e.g. investments in water-saving equipment and direct regulations such as capping water use), or community-based initiatives. To maximise impact, it is recommended to combine several tools (Schneider and Ingram, 1990; Weaver, 2015; OECD, 2007).

9.2 How are these measures being implemented?

9.2.1 Information and awareness-raising

Information campaigns are a common policy tool used by public authorities to make residents and other societal actors pay attention to public policy problems and, in the best-case scenario, influence their behaviour (Box 9.1). Information campaigns may target residents broadly or target subgroups of residents, using mass media, social media, leaflets or even posters in public spaces. They draw on marketing techniques and are designed to gain and focus attention on a few key messages. Too much information in the public arena can increase competition between public information campaigns when it comes to gaining attention and creating awareness about climate adaptation among target audiences. Information campaigns thus need to differentiate and target their messages, formatting the delivery specifically to relevant audiences and using multiple platforms (Markowitz and Guckian, 2018). For lasting impact, campaigns also need to be repeated or reinforced through multiple channels or tools.

Box 9.1

Information campaign for saving water, Region of Gotland, Sweden

In 2016, the Swedish Region of Gotland initiated a 'Spara vatten' (save water) campaign, targeting both residents of the island and its many visitors (Figure 9.1). The campaign used multiple media outlets, among them posters in airports and ferry ports, social media, radio and a website with water saving tips. It also focused specifically on children, producing a film on water and handing out experimental boxes. The idea was that knowledge would spread from children to adults. The entire water saving campaign, including a restriction on watering, resulted in 20% water savings in the summer. It was estimated that the information campaigns alone resulted in water savings of 5-8%. Regional authorities concluded that it had made a difference to communicate clearly about the shortage in water resources.

Figure 9.1 Promotional material for the 'Save Water' campaign, Sweden

In the Upper Rhine plain, a number of cities have worked with the non-profit Communal Action Group to Control Mosquitoes (KABS) on information campaigns to involve citizens in controlling the spread of the virus-carrying Asian tiger mosquito. At the beginning of the tiger mosquito season, KABS staff hand out leaflets to residents to provide information about the tiger mosquito and preventive measures, urging residents to report sightings.

When the presence of tiger mosquitos is confirmed, municipalities send out press releases to inform the public about planned measures (e.g. biological control). They continue to inform the public through posters, local radio stations, information events and municipal events. The information campaign provides transparency and serves to engage residents, who play a significant role in controlling the mosquito both through reporting possible occurrences and by allowing authorities access to their properties. The effort is considered successful since the amount of mosquitoes each year is controlled to a tolerable level compared to areas without treatment.

Stand-alone, one-way information campaigns can increase awareness and knowledge, but they are not strong tools for affecting actual behavioural change (Snyder et al., 2004). Increasing a sense of urgency and prompting behavioural change may require more interactive communication approaches than simple one-way information campaigns (Lenzholzer et al., 2020). Newer campaign formats using visualisation techniques or interactive technologies may therefore prove more effective than traditional information campaigns, since they engage target groups directly and at a deeper level. The use of interactive technologies may also appeal to target groups who are hard to reach through traditional media, such as younger people (Saßmannshausen et al., 2021; Reaver, 2023)

Visualisations can be powerful tools for communicating vulnerabilities and threats, and demonstrating solutions. Simulations using augmented reality (AR) or virtual reality (VR) technologies offer more immersive experiences that may help audiences engage with the future marked by climate change and also with solutions.

The Local Climate Change Visioning project in British Columbia, Canada used digital and spatial graphic tools to localise and visualise the impact of climate change, as well as community responses. This resulted in an increased understanding of climate change impacts, knowledge about possible actions, a greater sense of urgency and an improved sense of coping ability (Sheppard et al., 2011). Thoma et al. (2023) found that VR tools are more effective in creating environmental awareness than traditional formats such as video or text with photos. They compared the impact on environmental awareness and nature-relatedness of different presentations on a melting glacier. The Dutch information campaign 'Het water komt' ('the water is coming') takes a different approach to bringing the message home. Combining a TV documentary series with an interactive Podwalk app, this campaign tells stories about towns that have been hit by flood disasters in the past, linking it to possible future conditions due to rising sea levels.

Podcasts increasingly present a venue for information about climate change and adaptation. The European Investment Bank's podcast 'Climate Solutions' contains an episode on how to tackle climate change impacts through urban planning. In Finland, a podcast series addresses eco-anxiety as a new mental health topic, which includes an episode on young people considering voluntary childlessness and another on music as therapy against eco-anxiety.

Further, art in public spaces broadens the palette for communication tools to raise awareness about climate change. Art projects such as Bosk in Leeuwarden in the Netherlands, which included a 'walking forest' mobile art installation that brought greenery to different parts of the town on different days, or the

2021 Vienna Biennale for Change both invite reflections on the relationships between nature and humans by inspiring awareness about human impacts on nature through art installations, talks, designs and architecture. In Kristianstad, Sweden, the art project 'Man and Biosphere – precarious situations' seeks to engage local actors in dialogues about the local impact of climate change, the links between local and global climate change and to inspire climate action. The idea was that artistic forms of expression allow different kinds of understanding and thinking about complex issues such as climate change. The project included participation from both artists and scientists in multiple formats such as art exhibitions, walks in flood-prone areas and a climate concert.

Information channels and their formats are key to the impact of information campaigns, but so is the actual message. A key consideration is whether to motivate through fear or hope. Behavioural research suggests that positive messages are more powerful than negative (Maskell, 2022). Appealing to fear may alert residents to paying attention, but such fear-based messaging should be coupled with concrete information about possible actions (Grothmann and Patt, 2005).

Behavioural nudges aim to alter people's behaviour 'in a predictable way without forbidding any options or significantly changing their economic incentives' (Thaler and Sunstein, 2008). Nudges are non-coercive and typically involve framing choices or presenting information in a way that counteracts known mental shortcuts such as short-term thinking, optimism, inertia, simplification and herding (Brandon, 2022). The City of Cape Town's response to a severe water crisis used an information campaign together with additional economic measures to drastically change behaviour around water consumption (Box 9.2).

Box 9.2

Beyond Europe: addressing a water crisis with information, Cape Town, South Africa

In 2018, Cape Town faced a severe water crisis due to a prolonged drought. The city's water supply system was under tremendous pressure, with water levels in dams dropping to record lows. The situation was so dire that 'Day Zero,' the day when the city would have to shut off the water supply to most of its residents, was looming. To address the water crisis, the city implemented a series of measures, including an extensive information campaign to educate residents about the severity of the water crisis and the need to conserve water. The campaign used a variety of communication channels to reach as many residents as possible. This included billboards, radio advertisements and social media platforms to inform residents about the water crisis and promote individual water conservation measures (Figure 9.2). Community meetings were held to answer questions about the water crisis. The city also actively engaged with local and international media to further raise awareness about the crisis and promote its water conservation efforts.

Cape Town also introduced subsidies for rainwater harvesting and water restrictions, limiting households to 50 litres per person per day (much less than the 2015 average of 240 litres). These measures helped the city avoid Day Zero and reduced its water consumption rate from 1.2 billion litres per day in 2015 to around 500 million litres per day in 2021. Many residents have installed water-saving devices and changed their behaviour to conserve water, leading to a new 'normal' of lower water consumption (Brühl and Visser, 2021).

Figure 9.2 **Promoted information on water saving, Cape Town, South Africa**

Information nudges do appear to work, but the behavioural effect is typically small (Nisa et al. 2019). For instance, a large-scale flood risk awareness campaign in Germany initially launched in 2013 and gradually expanded has not had a measureable impact on resident uptake of flood protection insurance, nor on their propensity to implement flood mitigation measures in their homes (Osberghaus and Hinrichs, 2021).

Decision support tools offer resources for private actors who are aware of climate change, possibly motivated to take action and therefore looking for information about the specific impacts of climate change, or how to reduce their vulnerability to it. Climate adaptation portals or platforms represent a venue for such information and may also include links to actual interactive decision-making tools. Decision support can also address more urgent information needs, such as early warning apps to alert actors to risk of floods, wildfires or extreme heat, and give advice on actions during emergency situations related to such incidents.

Climate adaptation portals are information-rich and often dynamic, addressing different types of climate impacts (water, biodiversity and diseases), impacts by sector and adaptation options. The municipality of Barcelona's website has climate information in Catalan, Spanish and English, covering climate change, climate change impacts, government responses and advice about possible resident actions to respond to climate change. One of these actions, headlined 'People First', advises residents to check up on vulnerable neighbours on hot days and links to a project on community support for elderly people. Another action headlined 'Starting at Home' advises on renovations and insulation and turning rooftops into green roofs, linking to information on available renovation grants and inspirational resources. In Amsterdam, a network of public, private and civil society organisations have created the Rainproof platform 'to make Amsterdam resistant to increasingly frequent downpours' and to improve the use of rainwater as a free resource.

In Switzerland, the portal meinklimaplan.ch/monplanclimat.ch offers canton-specific knowledge and advice about climate mitigation and climate adaptation measures, targeting businesses and residents across several western cantons. The portal uses different strategies to draw in users, including video stories in Freiburg from people involved in climate action and a quiz on preparedness for heat waves in Romandie. In Denmark, the national portal Klimatilpasning.dk offers comprehensive information on climate adaptation needs, policies and tools for decision-making, case studies and specific actions. While the portal is anchored in the Ministry of Environment, it has been developed jointly by various national agencies and associations, representing regional and municipal governments, respectively. The information on the website is therefore also applicable to specific geographical locations, municipalities, different business sectors and the public. It includes interactive planning tools, including Resilient House, which offers advice to residents on precautionary actions against different risks posed by heat, wind or downpours and for different parts of their dwellings. Likewise, an interactive BusinessWizard tool instructs businesses on how to protect their business infrastructure from the adverse impacts of extreme climate events.

9.2.2 Capacity-building, empowering and lifestyle practices

Awareness about climate change impacts is a crucial first step towards building resilient communities. But to translate awareness into adaptation actions, private actors must feel that they are capable of undertaking adaptation (Grothmann and Patt, 2005). For this, information campaigns may not be enough. Online decision tools and apps also serve to build capacity. But many residents may need very practical information and possibly even hands-on training to be able to implement knowledge about adaptation solutions. One form of capacity-building that cities can

undertake is facilitating the sharing of good practices among its inhabitants. Taking it a step further, local governments or organisations can organise workshops, seminars or education programs.

Practical examples may encourage residents to take action by making adaptation appear feasible. Cities can play an active role in identifying and sharing practical solutions to climate adaptation. In Deventer, the Netherlands, the municipality has appointed staff as enthusiastic ambassadors attempting to persuade residents to disconnect rainspouts and let them drain into their gardens to relieve the pressure on the sewage system during downpours. Switzerland's Solothurn Canton, under the headline 'Climate Stories', shares practical approaches to climate adaptation and mitigation behaviours from residents and professionals. In Dropie, Slovakia, Slovak and international partners, supported by EEA and Norway grants, are building a full demonstration centre to share adaptation practices with the general public. The Dropie Demonstration Centre will showcase green measures such as green roofs, green walls, rain gardens and water measures, including domestic wastewater treatment plants.

Cities may even serve as first implementers to test and demonstrate practices. The Swedish city of Malmö, for instance, has installed green roofs on many city buildings. While this offers immediate benefits to the publicly owned buildings, including cooling, reduction of stormwater runoff and biodiversity improvements, it also serves to demonstrate the green roof model to citizens and businesses.

Training programs depend on participants being willing and motivated to invest time and energy. They often target professionals, but they can also be employed with residents and non-professionals, in which case outreach may be easier and the impact greater if the training initiative targets neighbourhoods, community groups or other social contexts instead of individuals. The deeper the level of engagement, the greater the potential for lasting impact.

Visual tools can be used in workshops to help participants imagine a climate-impacted and climate-adapted local community. The Swedish Meteorological and Hydrological Institute (SMHI) has developed a 'future visioning tool' to be used as a decision support tool for municipalities, businesses or community organisations. The tool is applied in workshops, with different participants, to help them build adaptation strategies. Part of the workshop discussions is to identify and localise vulnerable groups or locations. Likewise, the Dutch knowledge portal includes a discussion map tool to serve as an aid to conducting dialogues among different stakeholders about the risks faced and possible measures. The tool invites the parties involved to look beyond the boundaries of their own interests and collectively explore solutions.

Box 9.3

Case study: the Mind of Eco-anxiety, Finland

The Mind of Eco-anxiety is a bottom-up initiative started by three Finnish NGOs working in the field of mental health. The primary objective of the project is to help build emotional resilience among those vulnerable to eco-anxiety, defined as anxiety related to the global ecological crisis. The most vulnerable are identified as people with a strong environmental identity or working within environmental sciences, young people and people otherwise burdened.

The project builds on three main activities:

1. Workshops and group support sessions for people affected by eco-anxiety. Support groups were typically run by social and mental health care workers. In 2021, about 360, mostly young people, participated in 30 workshops and support groups on how to deal with eco-anxiety.
2. Training professionals in social and health care and teachers to build capacity among those groups likely to encounter eco-anxiety among their clients or students. In 2021 1,160 professionals were trained.
3. Awareness raising-campaign 'Let's talk about eco-emotions' to promote discussions among the general public about eco-anxiety and the need for mental support, which reached 3.57 million viewers across different channels. The website with 35 information packages, podcast episodes and references to research now also has information specifically targeting parents.

In 2021, all mental health organisations in Finland declared an environmental emergency, pointing out that emotions related to climate change and other environmental crises represent a threat to mental health. The declaration was launched with the Finnish Shouting Man, a performance character who urges people to shout as a way to deal with emotions.

The numbers of participants in the project indicate that the project meets a need, and the project is being continued for 2023-2025 under the name 'The Environment and the Future in Mind'.

In Finland, a campaign to tackle the emerging mental health crisis related to climate change included support groups and workshops, sharing tools and skills to develop participant capacity to deal with environmental emotions or eco-anxiety (Box 9.3).

While economic and regulatory tools also serve to impact behaviour, so does infrastructure to the extent that it may enable or inhibit certain behavioural changes. While each of these topics are covered in other chapters, it is important to note that there is a certain amount of overlap between the different types of measures and that they are often used in combination with information-based tools to facilitate behavioural change.

9.3 Limitations and outlook

Both awareness raising and capacity building are useful and necessary tools, but they do have some limitations:

- Potentially limited impact of awareness-raising campaigns: It may not be possible to monitor who is exposed to the campaigns or how they respond to it. This also makes it difficult to do cost-benefit analyses and make the case for using these kinds of measures. Importantly, communication must be designed not only to raise awareness about risk but also provide information about coping measures (Haer et al., 2016). In addition, the impact of campaigns may be limited

if promoted only temporarily, they are not user-friendly or there is insufficient budget to maintain them.

- Limitations of training and capacity building: To be effective, training programs must be tailored to the needs of the specific participants. Here, cities can draw on intermediaries such as community organisations, housing associations or health care professionals to establish a connection between authorities and groups in need of training, especially with underprivileged groups. Online tools may facilitate participation for younger audiences or households with children who are more pressed for time. However, this may not work for groups who are less skilled in using digital tools or who need more hands-on instructions. Workshops and other physical training programmes, while usually reaching fewer people, have the potential for greater behavioural impact.

- Costs: These vary greatly, depending on the reach and the types of media used. Decision support tools, such as apps and information portals, and training and workshops may require more resources to develop and maintain, but can have significant impacts.

- Need for additional measures: Effectiveness of these measures may be enhanced and may even depend on the implementation of other types of tools. For instance, low-income households may be aware about the need for weather-proofing their homes but are unable to do so without economic support. At the same time, economic subsidies would be inefficient if distributed broadly, including to those who are already motivated and could afford to make the necessary investments on their own. Direct government mandates may, in some cases, be necessary complements to information. However, local governments vary with the types of behaviour-regulating tools they have at their disposal. In more centralised systems, local governments may have limited regulatory powers and their financial and administrative capacity may also vary.

Emerging technologies such as artificial intelligence (AI), augmented reality (AR) and virtual reality (VR) can offer many opportunities for inspiring behavioural change. Better visualisations can bring more immersive experiences that change behaviour in a positive way. However, it can involve risks with the easier spread of false information. When people are not well-informed due to incorrect information, it can create an aversion to science and negatively impact their behaviour on climate adaptation.

In general, an increasing number of people is becoming aware of accelerated climate change and the need for climate adaption and mitigation. For awareness to translate into behaviour, the public needs knowledge and tools that help them take precautionary actions against climate change impacts. Although climate extremes are increasing, early warning apps have contributed to increasing preparedness and are expected to become available for more people in the coming years (WMO, 2023).

Box 9.4

How do cities measure knowledge and behavioural change actions?

- **Number of professionals reached by an information campaign —** Clermont-Ferrand, France (Raising awareness among residents and communicating widely)
- **Number of awareness raising events organised per category of audience –** Ajaccio, France (Organising events targeting different audience on climate adaptation, hydrologic risk and risk mitigation)
- **Number of contents published on the resilience platform and other information access tools —** Barcelona, Spain (Systematising the use of climate information (2025))
- **Public perception —** Valencia, Spain (Including the climate change adaptation variable in urban planning design)
- **Volumes of drinking water saved by reducing consumption –** Marseille, France (Raising staff awareness about energy management and air quality)
- **Percentage of the economy devoted to repair, upcycling or value-added recycling, and product exchange —** Barcelona, Spain (Actions to reduce waste, encourage recycling and reduce packaging)
- **Catalogue of Good Practices in the field of blue and green infrastructure that can be implemented by housing cooperatives and individual property owners —** Zielona Góra, Poland (Increasing the level of residents' awareness of climate threats and adaptation to climate change)
- **Level of climate awareness of residents –** Częstochowa, Poland (Ensuring safety, spatial order, sustainable development, protection of biological and cultural diversity of the city of Czÿstochowa in conditions of climate change)
- **Number of people involved in neighborhood assistance in the event of extreme weather phenomena –** Lublin, Poland (Improving the quality of life and ensuring the safety of residents in the event of extreme phenomena related to climate change)

Spotlights

Areas of opportunity for adaptation action

The following three chapters (on urban agriculture, placemaking and cultural heritage) introduce areas of growing opportunity for the implementation of adaptation actions within urban areas, even if adaptation goals are not the primary driver for engaging in these types of activities. The fact that each topic is experiencing a growth in interest, research, funding and participation opens up real opportunities for increasingly embedding adaptation and resilience considerations where possible.

10 Urban agriculture

Key messages

- Interest in engaging in urban agricultural activities is growing across Europe. Urban agriculture can strengthen local food systems and build social cohesion and inclusion. In addition, they can locally help reduce flood risks and the impacts of high temperatures.
- An important component of urban agriculture is connecting people to nature and natural processes, as well as bringing individuals and communities together in shared endeavours.
- Limited coordination on urban agriculture and competition for space are two of the most important barriers to widespread implementation.
- More consistent support is needed for urban agriculture to become a viable climate adaptation option. The new European proposal for a legislative framework for sustainable food systems may be an opportunity to further support urban agriculture.

10.1 What is urban agriculture?

Urban agriculture is increasingly recognised as a dynamic concept with diverse forms across different geographies. In general, it can be defined as the production of food and other outputs and related processes, taking place on land and other spaces within cities and surrounding regions (FAO, 2022).

In Europe, the practice of urban agriculture encompasses and goes beyond this definition of food production. Across thousands of urban projects, urban agricultural activities contribute to food security, sovereignty, responsibility and bringing 'green' back into cities. It reconnects people to the source of food, expanding their knowledge and appreciation for nature's nourishing capabilities. Moreover, recognising the connection between ourselves, each other and nature is essential for supporting the transition to regenerative food systems (Conscious Food Systems Alliance, 2023). Urban agriculture brings individuals and communities together in creative and collective processes, with the objectives of inclusion, connection, reintegration and social cohesion often at the centre.

10.2 Why is urban agriculture important for urban adaptation?

Urban agriculture is undertaken across Europe in response to diverse sets of motives. The form it takes is strongly influenced by whichever of these motives is considered the most critical. This, in turn, impacts the degree to which urban agriculture can or does contribute to increasing resilience to climate change in our urban centres.

It is important to note upfront that resilience and adaptation objectives are seldom the primary drivers for urban agriculture initiatives, hence affecting the initiative's effectiveness when assessed against resilience goals. That said, urban agriculture initiatives have co-benefits that could be further enhanced and/or recognised if more explicitly identified as secondary objectives (Box 10.1). Urban agriculture's most direct contribution to adaptation is via the regulating ecosystem services it provides. As forms of green infrastructures, urban gardens and farms help manage climate-related hazards, including flooding and extreme heat.

Box 10.1

The Garden of Stene, Ostende, Belgium

The Garden of Stene covers 35ha of land on the edge of the highly urbanised city of Ostende, Belgium. Centred on agricultural production, the project was designed to meet a multitude of objectives, a key one being to address climate change-related risks. As a coastal city facing increased flooding from sea-level rise and more erratic rain events, the garden acts as a water buffer and storage opportunity. Guided by an eco-hydraulic study, the development of a network of water canals and gullies create and sustain smart water management.

This urban agricultural park is managed by Buitengoed vzw, a non-profit organisation managing the green areas for the city. Buitengoed produces a large variety of organic crops and fruits for members of the community, their farm shop, an elderly resident home and the city's central kitchen. In addition, two organic dairy farmers use the grazing fields in the park. Other project outcomes include the creation of public recreational green space, biodiversity protection, enhanced social and physical activities for all and the recreation of connections between people and where food comes from. There is also close collaboration with the neighbouring co-housing project and the school, which focuses on related educational activities.

Figure 10.1 The Garden of Stene, Ostende, Belgium

Another important aspect of urban agriculture for adaptation is its potential to build social cohesion and inclusion (Orsini et al., 2020), which can increase overall societal resilience and preparedness for climate change. Higher levels of community resilience have indeed been statistically associated with higher levels of social cohesion (Patel and Gleason, 2018; Townshend et al., 2015). The 'Edible City' solutions are an example of how urban agriculture contributes to social cohesion and resilience (Box 10.2). Edible city solutions also help support the local green economy and maintaining local material and energy cycles (Säumel et al., 2020).

Box 10.2

FUSILLI project, Rome, Italy

The city of Rome, Italy is one of 12 'Living Labs' that form part of the multi-country FUSILLI project. Its overall objective is the development of urban food plans to achieve integrated, safe and holistic transitions towards healthy, sustainable, secure, inclusive and cost-efficient food systems. One of the most effective activities, undertaken by the 250 members of the FUSILLI multi-stakeholder Living Lab, has been urban community gardens. This work has built on strong connections to other EU projects such as the EFUA H2020 project.

As a result of the project Rome now boasts more than 150 urban edible gardens, 20 of which are community gardens on public land in official agreement with the municipality. The current 3,200 community plots, in addition to food cultivation, have become gathering points for social engagement with vulnerable members of the community such as the elderly, people with disabilities and/or those facing social integration issues. This creates important opportunities for strengthening community cohesion and increasing resilience.

Importantly, since the first supporting EU project SidigMed began in 2014, all urban community garden experiences in the city have contributed to the process of creating the Agriculture and Food Strategic Plan of Rome. This plan is led by the city and was supported by the FUSILLI Living Lab until the summer of 2023, after which time the city's Food Council, an elective consultancy body that was approved by the City Assembly, was in a position to assume this responsibility.

Urban agriculture can also play a role in enhancing food system resilience in the face of climate change (EC, DG RTD, 2023). By promoting local food production within cities, urban agriculture can reduce dependence on distant agricultural regions, producing a mitigation co-benefit in the form of reduced carbon footprints associated with long-distance food transportation.

Producing food in an urban setting also offers the opportunity for diversified and decentralised food production, and reducing vulnerability to climate-related disruptions in rural areas. Urban agriculture could, in some situations, be as productive or more so than rural agriculture for a range of crops (Payen et al., 2022). Urban agriculture also presents an opportunity for experimentation around diversification of the way and the types of foods we may need to grow in the future, since traditional growing seasons and patterns are become increasingly affected by climate change.

Malmö, Sweden's Climate Garden is an excellent example of this (Dobak, 2018). This garden features a range of non-typical specimens including palms, bamboo and grasses that require warmer climates to survive in. The idea is to demonstrate what might, in the not-too-distant future, be feasible to grow in Sweden under climate

change. It also draws attention to the invaluable biodiversity equally likely to be lost when historical habitats for these species disappear. Urban gardens of this sort provide important educational opportunities for increasing awareness around the impacts of climate change.

Urban agriculture and the connection it enables between people and the natural world provides significant physical and mental health benefits. Studies have repeatedly shown the beneficial effects of being in nature, or even simply observing nature, on mood and mental health. Additionally, greater exposure to sunlight lowers blood pressure and increases vitamin D (Thompson, 2018). The physical benefits of incidental exercise while gardening are also not to be understated. Importantly, in relation to the topic being explored within this spotlight, enhanced physical and mental health are considered critical for building individual resilience (Nikologianni et al., 2022; Theodorou et al., 2021).

Box 10.3

Addressing urban heat through gardening in Prague, Czechia

To address the adverse impacts of urban heat island effects in the City of Prague, the city's Department of Nature Protection transformed 6ha of previously mono-cropped urban agricultural land into a multi-functional organic farm. Food production for local consumption is an important part of this initiative. Fruit from these trees can be picked and consumed. Crops including pumpkins, courgettes and beets are also grown by the contracted tenant farmer using organic methods, with produce supplied to local schools, retirement homes and orphanages.

Importantly, the physical, mental and social benefits offered by the farm have also been considered in its design. Rows of trees have been planted perpendicular to the road to provide a shaded promenade and recreational space for community members while also preventing the surface of the field from heating up, with the tree canopy reducing wind flow. A 2020 study aiming to better understand the motivations of Czech citizen engagement in community gardening, in both large and small cities, found the main motivation for participation was not the actual food production but the leisure time spent in social contact and relaxation (Dubová et al., 2020). In addition, the study noted a second common driver, which was the desire to pass on personal experiences and knowledge about nature to the next generation.

10.3 Trends

Over the past decade, increased attention has been placed on the role of urban agricultural systems in contributing to environmental health and human wellbeing. At the international level, the Glasgow Food and Climate Declaration brings together local and regional authorities from across the world to put food and farming at the heart of the global response to the climate emergency. Of the 110+ initial signatories, 37 European cities and two Turkish cities are represented. Other policy initiatives (Box 10.4), involving and being led by European cities, are set out below. There is a rapid growth in membership of urban food networks, such as the Milan Urban Food Policy Pact (Box 10.4).

Box 10.4

The Milan Urban Food Policy Pact

The Milan Urban Food Policy Pact (MUFPP) is a globally-focused, European-hosted initiative led by the City of Milan, committed to developing sustainable food systems that are inclusive, resilient, safe and diverse. It aims to provide healthy and affordable food to all people in a human rights-based framework, minimise waste and conserve biodiversity, all while adapting to and mitigating the impacts of climate change. MUFPP cities consider food an entry point to tackling some of the most urgent challenges: from climate change to social inclusion and from food waste reduction to biodiversity conservation. Currently, 100 European cities form part of the pact, having grown from 116 signatories in 2015 to more than 260 signatories in 2023.

Sitting under the MUFPP, the Barcelona Challenge for Good Food and Climate is an example of an international and multi-city policy effort that explicitly connects urban food systems to climate change adaptation. With 10 European city signatories, the initiative addresses mitigation and adaptation to the climate emergency. Its signatory cities make their commitments to transforming local agri-food systems to ensure access to sufficient, sustainable, healthy and nutritious diets for all, preventing food vulnerability and enhancing food justice.

There are also an increasing number of European urban agricultural initiatives, including:

- Edible Cities Network is a European and global city network focused on a wide range of sustainable urban food production, distribution and consumption activities. They all incorporate principles of ecological design combined with closed material and energy flows.
- European Forum on Urban Agriculture (EFUA) seeks to unlock urban agriculture potential through better networking, better knowledge, better deployment and better policies in the field.
- Food Trails aims to enable cities to reimagine, develop and implement sustainable, healthy and inclusive food policies.
- Food Shift 2030 empowers people to influence how food is produced, distributed, consumed and recycled.
- FoodE seeks to accelerate the growth of sustainable and resilient, resident-led urban food system initiatives across Europe.
- FUSILLI (Box 10.2) empowers its 12 Living Labs to integrate food in a city's transformation pathway geared towards a healthy, sustainable, secure and inclusive urban future.
- CityZen aims to promote urban farming as a successful driving force for economic and social transformation by introducing the concept to policy.
- URBACT offers support to 11 different networks on sustainable food and urban agriculture since 2013.

Many of these initiatives have specific climate and environmental objectives. Of 22 European urban food-system-transformation initiatives, 9 indicated an explicit climate focus (EC DG-RTD, 2023). Evidence suggests a positive trend in the uptake of urban agriculture, even if relatively small compared to total land area (Howard, 2014).

In Paris, for example, the 2016 creation of the initiative 'Parisculteurs' has led to the establishment of more than 50 new urban agricultural projects. Paris now has more than 30ha of agricultural land within its city limits, growing from 11ha in 2014. Over a similar time period, Brussels saw a 30% growth in the number of urban agricultural projects between 2013-2018, with the second phase of its Good Food Plan initiative further supporting the growth of commercial agroecological food production in periphery city neighbourhoods (Brussels Environment, 2019).

10.4 How to encourage broader implementation

In order to upscale urban agriculture actions even further across Europe, a range of technical, social and regulatory barriers needs to be addressed. This section captures some of the most commonly-cited barriers and provides examples of how urban centres are innovating to overcome them.

- Competition over space: Numerous cities are including urban agriculture within land allocation decision-making by transforming abandoned land or undeveloped areas into community gardens or other forms of urban agriculture. Rotterdam has established supportive policies and regulations that facilitated the conversion of underutilised spaces, such as rooftops and vacant lots, into productive urban agriculture sites (Si et al., 2016). The presence of clear guidelines and regulations provided a framework for residents and organisations to collaborate with greater confidence around urban agriculture initiatives.

- Health and safety risks: This particularly relates to soil quality and the costs associated with their remediation where urban farming is part of revitalisation projects on formerly industrial land (Righini et al., 2022). Established partnerships with university researchers may help to undertake soil assessments at lower than usual costs (Hardman et al., 2022).

- Cost barriers: Tax incentives for urban agriculture businesses and the provision of funding for urban agriculture initiatives can help reduce this barrier. The city of Brussels, Belgium provides financial support, along with technical and regulatory assistance, as part of its Good Food Strategy.

- Land use restrictions and/or undefined rights: Undertaking changes to zoning laws and the creation of regulatory frameworks that promote the leasing of public space for community gardens is a solution for providing more secure property rights-related assurances. Berlin has designated land specifically for community gardens and established policies that provide long-term security for community garden sites.

- Limited coordination across different policies at local, national and EU levels: De Schutter et al. (2020) make the point that 'Bottom-up alternative food system initiatives from community supported agriculture schemes to local sourcing for school canteens, are among the most promising steps towards healthy diets and sustainable food systems in Europe...'. EU policies are ill-equipped to support these initiatives. Legislation related to European competition policy, food safety and spatial planning are particular barriers. The city of Ghent, Belgium, has created an effective collaborative platform that aids in scaling urban agricultural initiatives (EPRS, 2017).

10.5 The future: food for thought

The supply chain-related disruptions to urban food systems experienced during the COVID pandemic led many to wonder what the potential of urban agriculture might be in terms of being a sustainable source of nutritious food for urban populations. However, is the pursuit of urban food production objectives likely to result in trade-offs with the other drivers for expanded urban agricultural production presented above in this spotlight? To increase food security, do we need to shift to different models of urban agricultural production that have less abilities to deliver important regulating and cultural ecosystem services? If so, what does that mean for urban resilience?

On a less philosophical level, an important 2023 development with the potential to further enable urban agricultural systems is a new European proposal for a legislative framework for sustainable food systems (FSFS), which is one of the flagship initiatives of the 2020 adopted EU Farm to Fork Strategy. Its goal is to accelerate and facilitate the transition towards more sustainable food systems. Currently, the Farm to Fork Strategy includes several elements that serve as enablers for urban food production, including promoting organic farming, encouraging local food systems and supporting alternative production models. The degree to which the 2023 legislative framework further strengthens the links between climate change adaptation and urban agricultural food systems will impact the speed and direction of the use of urban agriculture as a viable measure towards climate change adaptation.

11 Placemaking

Key messages

- Public access to attractive and liveable public spaces that are human-centric in design and use has emerged as an important issue for increasingly dense European cities. The practice of placemaking, in all its diverse forms, is gaining popularity in response and allowing people to collectively reimagine public spaces at the centre of their communities.
- Engaging in placemaking can strengthen individual and community resilience through its defining co-creation process that builds community cohesion and social capital. This plays an important role in society's ability to adapt to climate change events and other crises.
- Attractive public spaces can contribute further to climate resilience through the incorporation of green and blue infrastructure in their designs.

11.1 What do we mean by 'placemaking'?

Reclaiming urban spaces for people and communities emerged in the 1960s as a reaction to the proliferation of cars and shopping centres covering urban landscapes. Emerging from the United States, these bottom-up initiatives emphasised the social and cultural importance of active, lively, inviting neighbourhoods and public spaces for the well-being and creation of communities.

Placemaking subsequently captured the European imagination, leaning into its defining characteristics of 'inspire(ing) people to collectively reimagine and reinvent public spaces as the heart of every community.

At its most practical level, placemaking involves community members and other stakeholders working together to capture and then collectively implement their vision for what a community space should look and feel like. It goes beyond urban design and partly overlaps with creating visual local identities using iconic urban spaces and/or conserving urban cultural heritage. In fact, people and their participation, co-creation and ownership of design and space are central to placemaking. Placemaking connects to the concept of 'emotional spaces', i.e. the design concept placing people and their needs at the centre (Günther, C., 2021).

In a European setting, the concept of placemaking embraces a broad set of objectives, with sustainable, liveable and human-centric European urban environments at the centre and the co-creation of spaces that feature and celebrate innovation, cultural heritage, beauty, creativity and play.

11.2 Why is placemaking important for adaptation?

Placemaking presents residents with tangible opportunities to collectively reimagine urban landscapes as spaces that centre human needs. In practice, this often means reclaiming the abundance of car-centric urban spaces and transforming them back into much more people and community-centric environments.

Currently, public spaces make up about 2-15% of European public land, with their physical and social functions essential to urbanised and dense settings (EC-JRC, 2019). These public spaces are becoming increasingly green, with overall greenness of cities having increased by 38% over the past 25 years. This translates into 44% of Europe's urban population now living within 300m of a public park.

Placemaking activities can complement these positive trends by ensuring these existing public spaces, as well as potential newly-reclaimed spaces, serve multiple community needs. One of these is to contribute to enhancing individual and community resilience to the impacts of climate change. The collective process of reimaging spaces provides an opportunity for building community cohesion and social capital. Social networks can act as buffers against the negative impacts of climate disasters and help communities recover more quickly as a result (Feinberg et al., 2023; Petzold, 2017). The ability to bounce back and recover is the defining element of adaptive capacity.

Additionally, many projects revitalising or creating new public spaces heavily feature green and blue infrastructure in their designs. Of the many positive impacts of natural spaces, from an adaptation and resilience perspective, green and blue designs can perform ecosystem-regulating services. These include water capture and retention, which reduce flooding and regulate temperatures to provide cooler spaces for people to gather during periods of intense heat.

Box 11.1

Urban Gardens initiative, Belgrade, Serbia

The Urban Gardens initiative aims to motivate residents to take the lead in transforming neglected urban spaces, emphasising the value of green public spaces to enhance the quality of urban living, and to develop tools which can easily be transferred and adapted to other places in the area. Working with local NGOs Ekonaut and Komsije sa Dorcola, Placemaking Western Balkans has developed and implemented a prototype 'urban game' workshop approach to stimulate highly inclusive co-design processes with high participation from diverse public groups. Such broad representation and participation in placemaking activities is considered essential in the context of Balkan cities, which are combating uncontrolled urbanisation as well as an associated decline of urban ecology and quality of life.

One workshop in Belgrade's Mihizova Ulica neighbourhood engaged with children and young adults, resulting in the temporary transformation of a small public square into an urban garden. In two other cities, Pancevo and Novi Sad, similar placemaking workshops took place. In these instances, the workshops focused on raising awareness on how to co-create climate resilient and more attractive public spaces. It provided residents with the tools to help them negotiate the changes they wanted with the local municipalities. One example of a tool used was a set of visual representations of the positive transformation to more sustainable, attractive and accessible green spaces.

Figure 11.1 Workshop activities in Mihizova Ulica, Belgrade, Serbia

© Milena Ivkovic, Placemaking Western Balkans

The significant investment in initiatives such as the New European Bauhaus (NEB) also presents new opportunities to embed placemaking design and process features that contribute to climate change resilience. These initiatives are more focused on buildings and the infrastructure surrounding public spaces rather than the spaces themselves. However, they nevertheless aim to extend the goals of the European Green Deal to living spaces and the built environment. Sustainability, aesthetics and inclusiveness are the three central pillars of the NEB, each featuring strongly within placemaking initiatives. EUR 450 million has been earmarked for NEB efforts for the 2021-2027 period, recognising that the aesthetic qualities of living environments have an important role in well-being and how people identify with their environments.

The process of co-creation should be increasingly central to the design of liveable spaces, which is where placemaking approaches can be incorporated. The preservation of cultural heritage can be a 'primary attribute in creating coherent urban form and a key component in evoking place' (Newman, 2016).

Box 11.2

FREE RIGA, Riga, Latvia

Since the fall of the Soviet Union in 1990, Riga has lost nearly 30% of its population due to emigration and urban sprawl. In preparing for the celebrations around Riga being named the European Capital of Culture in 2014, local activists initiated a campaign to highlight the amount of under-used buildings throughout the city that had suffered from decades of neglect. They started to actively promote their creative reuse. Their initiative, which transformed into the association Free Riga, targeted the creation of spaces for cultural and social activities; it aimed to grow a sense of resident ownership and identification with places, elements known to be critical for creating resilient local communities. By 2020, Free Riga was managing temporary use social projects in four different locations of Riga, totalling 8,500m^2 across 23 buildings, as well as 2ha in outdoor space (Rubenis, 2021).

The association has further extended its activities beyond the typical temporary use period and towards community-oriented, co-creative and self-generative co-designed spaces, which address the negative effects of gentrification and abandonment of urban spaces in general. It now seeks to become a long-term partner in the ownership of vacant properties, or where appropriate, to acquire such buildings using ethical financing. The activities are supported by public policies aimed at supporting the use of vacant buildings through strong tax reductions for owners renting their vacant buildings to public benefit organisations (Vroblevskis, 2021).

Figure 11.2 Garden of D27, Riga, Latvia

11.3 Trends

Few international strategies link public space to climate adaptation efforts, and when they do, the link is usually with physical protections rather than social benefits derived from shared public spaces (Peinhardt, 2021). That said, an increasing number of cities are recognising the opportunity to use placemaking as a way to incorporate the re-design of public spaces into municipal climate adaptation strategies. This is driving urban municipal demand for placemaking tools, approaches and knowledge, with an increasing number of initiatives and projects are emerging to support the wider implementation of placemaking activities:

- Placemaking Europe develops and shares knowledge on this topic, designs and tests tools, creates networking and peer learning opportunities, and advocates for better public space policies. Its focus is on municipal officials, policy makers, researchers and community leaders. Its 2023 Cities in Placemaking programme works with municipal officials to devise placemaking strategies that address climate adaptation, intercultural integration, social inequality and more.

- Placemaking Western Balkans localises placemaking concepts within the rapidly urbanising and centrally-governed context of this region. It promotes a vision of green transformation of small-scaled public spaces across the region, encouraging conversations around the place-oriented, human-scaled innovation that is needed to address climate change, and support adaptation and resilience building.

- Placemaking in the Nordics is a co-creation project bringing together participants representing 18 municipalities, regions, property owners, construction companies and associations across the Nordics to explore challenges, success factors, ongoing placemaking projects and best practices.

In addition to witnessing an expanding number of placemaking initiatives, a noteworthy trend within placemaking practice is the incorporation of play and fun within initiatives and projects. While this is partly driven by the objective of engaging children in these efforts, it is also a response to the growing recognition of the role that games can play in fostering inclusion, health and sustainability in cities and concepts that feature strongly within placemaking efforts. An example of this is one of URBACT's transfer networks 'Playful Paradigm', which aimed to adapt and reuse the good practice of 'games for fostering inclusion, health and sustainability' in eight European cities.

Box 11.3

Green roof: school community space, Kranj, Slovenia

A green roof was created at Stane Zagar Primary School in response to an open call from the non-profit design studio Prostoroz, which supports school communities interested in creating a green roof as a multi-purpose space. Its design elements would incorporate NBS education, and play and community-building activities.

Teachers were involved in space design, thus ensuring academic and social requirements were incorporated. Students were also involved, leading planting and green space curation, with senior students caring for the plants until handover to the next class upon graduation. With the greening of one flat roof, the school gained 360 m^2 of additional usable space, including two outdoor classrooms. The roof is planted with various types of greenery including perennials, herbs, flowers and edible plants and fruits such as raspberries, blackberries, grapes and strawberries.

The green roof design allows the retention of up to 80% of rainfall, with this water reserved for the plants on the roof in the dry season. During the summer, the vegetation protects the building from the sun and lowers temperatures on the roof and inside the building. Just as important, however, are the benefits derived by the teachers and children. The roof has become a new common open space providing access to fresh air, contact with plants, and new learning and playing opportunities.

11.4 How to encourage broader implementation

There remain numerous barriers to the wider implementation of placemaking, not least creating greater awareness and understanding of what is meant by this concept and how it can contribute to climate resilience in European urban centres. The most common issues faced and some possible ways to overcome them are:

- Lack of technical capacities and know-how: placemaking requires a range of skills and expertise, including urban planning, community engagement, design and project management. Placemaking Western Balkans was created for the purpose of increasing the technical capacities of Western Balkan practitioners and communities around placemaking. It offers a range of programming to support the public sector and communities engaged in placemaking activities.

- Limited resources: In Senglea, Malta, a placemaking experiment, focused on the co-creation of NBS spaces by communities, researchers and local government, found that starting with smaller, tactical and/or semi-temporary features acted as a kind of proof of concept. This resulted in much larger financial investments from the national and regional government, the private sector and even individual residents. The key to attracting these larger funds was the placemaking project's ability to demonstrate the ownership of the community and their demand for such nature-inspired public spaces (Balzan et al., 2023).

- Lack of political will: the success of placemaking initiatives often depends on strong political leadership and support from local authorities. In Barcelona, Spain, the city's 'Superblocks' initiative, which involves transforming city blocks into car-free zones with new public spaces and green infrastructures, has gained widespread support from local residents and policymakers alike, in part due to the strong backing of the city's former mayor.

- Limited community engagement: Language barriers, lack of trust between citizens and government officials, and social inequality can all pose challenges to community engagement in placemaking initiatives. In Helsinki, Finland, the city used an online participatory platform called 'Helsinki Loves Developers' to engage the public and solicit their ideas for public space development. This platform helped increase public involvement in public space planning and fostered a sense of community ownership over the resulting projects.

- Regulatory and bureaucratic hurdles: Municipal officers recognise many of the hurdles that limit placemaking projects, including siloed government departments and budgets. More than 15 cities have begun engagement in Cities in Placemaking. This two-year peer learning partnership will include sharing examples of ways they have overcome regulatory and bureaucratic hurdles and administrative silos related to placemaking.

11.5 Outlook

While many placemaking initiatives are not directly centred around adaptation or climate resilience goals, their healthy proliferation presents opportunities for increasingly embedding adaptation enablers, or direct implementation solutions, into these initiatives. These can be in the form of green and blue infrastructure and actions for awareness raising, education and behaviour change campaigns. Otherwise, they can simply be places for communities to gather, connect, support and build the links critical for collectively responding to and rebounding from future climate shocks (Feinberg et al., 2023).

Expanding opportunities for placemaking relies on the ongoing existence and growth of public space. Growth in European urban populations and corresponding growth in land consumption is a potential threat to this. While there are many places where the World Health Organization recommendation of 9 m^2 of green open space per person is met or exceeded, access to public space is far from uniform across Europe. Most Mediterranean regions have lower levels of open green space per person.

That said, there is certainly the possibility that reimagined cities, centred around sustainability, liveability and communities, become less car-centric, freeing up new public spaces for communities to co-create, use and thrive in. But it is equally important to recognise that public access to public green spaces, let alone the possibilities for citizens themselves to co-create these spaces in response to community aspirations, remain somewhat contested notions, at least in practice.

12 Cultural heritage

Key messages

- Cultural heritage is particularly affected by the impacts of climate change. Adequate approaches to protect it need to be integrated into adaptation and risk management strategies.
- Focusing on cultural heritage can be a key opportunity for transformative climate policies since it can convey a sense of continuity, community and inclusiveness in the context of transformational policy changes.
- Cultural heritage can be an important asset for climate adaptation. It can embody historic knowledge and experiences of coping with extreme climatic conditions, from which much can be learned for adaptation.
- Revitalising and conserving historic buildings not only preserves cultural heritage is also a sustainable practice, meeting both mitigation and adaptation goals.

Cultural heritage is a representation of a community's history, traditions and identity, serving as a social, cultural and economic asset. In urban areas, tangible cultural heritage includes monuments, single buildings, artworks, historic urban landscapes, historic parks and gardens, and natural elements such as water courses and green areas. Intangible elements include craftsmanship, traditions, values linked to collective history, traditional knowledge, and practices and languages (ICOMOS, 2019).

European cities are rich in cultural heritage, which plays a crucial role in their social and economic development and therefore also the overall resilience of urban communities (UNESCO, 2011). Damage to cultural heritage not only threatens its intrinsic value but also impedes local economic and social development. The loss of cultural heritage has wider implications for the sustainable development of local communities. Moreover, urban cultural heritage faces growing challenges from urbanisation and economic activities like tourism.

Cultural heritage is particularly vulnerable to climate change-induced hazards and their impacts, including heat, drought, sea-level rise, coastal flooding, storm surges and wildfires. Such impacts pose threats to historic parks, gardens and urban built heritage. They affect their internal elements, artworks and structural integrity due to their age, fragility and locations, often sited in coastal and riverside locations.

Globally, approximately 21% of UNESCO cultural and mixed heritage sites are exposed to river floods, primarily in Europe, North America and Asia-Pacific (Arrighi, 2021). In the Mediterranean basin, 37 of 49 World Heritage sites in low-lying coastal areas are at risk from coastal flooding, with 42 facing coastal erosion (Reimann et al., 2018). In the Spanish regions of Castile and Leon, 25-30% of regionally-listed heritage sites are at high or extreme risk of river flooding (Garrote et al., 2020). In northern countries, there is an increased risk of building damage, including wood rot and heightened pest infestations, due to rising humidity and temperatures. Furthermore,

climate change threatens the integrity of materials like stone and metals, leading to chemical erosion and deterioration. Frequent freeze and thaw cycles can cause mechanical degradation, impacting structures, ruins and archaeological discoveries, as well as erosion and landslides, posing a substantial threat to archaeological cultural environments (Riksantikvaren, 2021).

Climate change can also affect intangible cultural heritage. Heat, for instance, can disrupt rituals and traditional festivals, while the loss of traditional materials used for buildings or costumes can have cultural implications. Climate change can disrupt the meaning and significance of traditional or sacred places, or alter the vocabulary used to describe climate or traditions and displace traditional stories from their original contexts. Furthermore, the migration to urban areas can result in the loss of knowledge and cultural practices tied to traditional communities (Markham, 2021).

Progress in risk assessment and management for cultural heritage is being made among EU Member States. The European Floods Directive mandates the inclusion of cultural heritage in flood hazard and risk plans, although not all EU Member States have fully implemented this (Figueiredo et al., 2020). For instance, Germany only includes some cultural heritage objects in their flood risk plans (Federal Institute for Research on Building, Urban Affairs and Spatial Development, 2023), while Italy assesses risks to heritage objects based on national listings.

While there are several initiatives assessing climate risk to tangible heritage (see Box 12.1), there is a significant gap in reliable data when it comes to intangible urban heritage. To address these challenges, the Urban Heritage Climate Observatory (UHCO) was launched as a new Group on Earth Observation (GEO). Pilot Initiative in 2021, led by the UNESCO World Heritage Centre and the Greek GEO Office. This initiative focuses on protecting, monitoring and managing urban heritage against climate change impacts using earth observations. UHCO adopts a bottom-up approach, serving as a platform to share good practices, needs and expertise aiming to inform global decisions and create a universal service to assist local practitioners in dealing with climate impacts on urban heritage.

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Box 12.1

Initiatives to advance risk mapping of cultural heritage in Europe

The Climate Vulnerability Index (CVI) offers a systematic tool to assess climate impacts on world heritage areas, considering both vulnerability and the associated community value. By involving stakeholders such as site managers, community representatives and local businesses, the CVI helps identify suitable adaptive measures for preserving natural, cultural and community assets. Notably, the Historic Environment Scotland (HES) is pioneering CVI workshops for all six properties in Scotland, including the Old and New Towns of Edinburgh, marking the first application of CVI to a major urban World Heritage property (Bruce, et al., 2023).

The Copernicus Climate Change Service (C3S) and the Union for the Mediterranean (UFM) partnered to create a user-friendly application that assesses risks on UNESCO World Heritage sites on the coast, exploring risks arising from coastal flooding. The tool uses a simple risk index to assess the potential impacts of coastal flooding on these significant sites. This application showcases the potential of climate data to assess the vulnerability of several world heritage sites in the Mediterranean.

Adapt Northern Heritage aims to address the impact of climate change on northern cultural heritage by engaging communities in informed conservation planning. The project will create an online tool for assessing risks and vulnerabilities of historic sites and guide strategic adaptation measures. This tool will be applied in nine case studies across countries, e.g. Iceland, Ireland, Norway, Russia, Sweden and Scotland, leading to the development of adaptation action plans. Particularly in remote northern regions, communities and authorities face challenges in managing cultural heritage in the context of climate change.

A series of regional and local mapping and vulnerability assessment initiatives have been implemented during the past years in Sweden, producing publicly-accessible maps and information on the vulnerability of single cultural heritage objects. Sweden has both a Conservation Plan and Management Plan for cultural heritage, both of which are regularly revised (Swedish Government 2023).

12.1 Why is cultural heritage important for adaptation?

Cities should not only focus on protecting cultural heritage from the impacts of climate change but should also recognise its potential as a powerful tool in climate action. The Spanish national plan dedicates particular attention to the potential of cultural heritage: 'Human societies, through trial and error, have built cultures that are adapted to the climates in which they have developed, shaping strategies and solutions in fields as relevant as agriculture, housing and urban planning. Knowledge of such solutions can inspire new practices, turning cultural heritage into a resource for adaptation' (Spanish Government/EIONET, 2023).

The European Commission underlines the importance of cultural heritage as a driver for increasing resilience and has incorporated it into its Disaster Risk Management Reporting Guidelines. They encourage EU Member States to report, map and inform on the potential impact of disaster risks on cultural heritage. Both the Paris Agreement and the Sendai Framework for Disaster Risk Reduction acknowledge the need for specific risk management for heritage assets, particularly in urban areas (ICOMOS, 2019). The Urban Agenda's working group on Culture and Cultural Heritage has proposed 11 recommended actions for urban policies, including: better regulation to foster activities based on sharing economy, reuse, innovative and collaborative

management; better funding for data collection, and improvement of knowledge by establishing an observatory on climate change and cultural heritage in urban settings, and developing educational programs addressing local cultural services and social inclusion.

12.1.1 Knowledge and tradition: learning from the past

Intangible heritage holds valuable traditional knowledge that can guide climate change adaptation in our built environment and way of life. This cultural heritage encompasses intangible values and traditional knowledge resources that extend beyond the heritage sector.

Cultural heritage can serves as a model for how societies have coped with climate challenges using limited resources, and local geographic and climatic features. Traditional building methods and the use of local materials offer insights for climate adaptation and mitigation strategies (Box 12.2). The recognition of places possessing heritage significance must be broadened to encompass values that promote climate action and resilience (ICOMOS, 2019).

Box 12.2

Traditional building methods for flood resilience, Bad Munstereifel, Germany

After the disastrous 2021 floods in western Germany, an ancient flood mitigation technique was rediscovered in Bad Munstereifel. Certain traditional half-timbered buildings had hidden open channels beneath their old cellar stone floors, designed to redirect floodwater directly back to the river. Originally used for productive purposes in the cellars, this technique facilitated the quick drying of walls without the need for pumps, thus aiding in the recovery of the buildings after the flood. Additionally, walls coated with traditional lime-based materials remained unaffected by mould and sustained less damage compared to those treated with modern cement-based plasters or synthetic paints (personal communication with Oliver Zahn, Stadt Bad Munstereifel).

12.1.2 Boosting societal resilience

Cultural heritage serves as a valuable source of inspiration and knowledge for building resilient communities, fostering a sense of identity and connection to a place (ICOMOS, 2019). Adapting tangible heritage to climate change presents an opportunity for cities to boost societal resilience, provided it is done inclusively and sustainably, and includes improving also the surrounding environment. By integrating cultural heritage into climate action strategies, cities can leverage its influence to strengthen climate resilience and sustainability. Achieving this requires comprehensive approaches that integrate conservation management and planning into local development processes and urban planning (Bonazza and Sardella, 2023).

Box 12.3

Traditional urban economies for resilience, Bamberg, Germany

The city of Bamberg, a UNESCO World Heritage site since 1993, is recognised for its cultural significance spanning over different parts of Germany, Hungary and eastern Europe. This includes the Market Gardeners' District, where commercial horticulture has thrived since the Middle Ages. In 2011, a joint venture of families and professional gardeners revived this tradition, marketing their produce locally. Additionally, liquorice cultivation, historically linked to the city, has been revitalised through a public-private partnership. Urban gardening receives support from local authorities and the World Heritage Office Bamberg, which includes awareness campaigns, tours, marketing efforts and sustainable land use practices. The city has also embraced water-based energy generation, installing a turbine for electricity production in the historic mill district, aligning with its decentralised renewable energy plan.

Figure 12.1 View of the Market Gardeners' District, Bamberg

Box 12.4

Roman Hadrian aqueduct: reactivating and reintegrating cultural heritage, Halandri, Greece

The Cultural H.ID.RA.N.T. project in Halandri aims to restore the town's ancient 24km Roman Hadrian aqueduct to its original function and integrate it into a broader strategy of revitalisation. This initiative views cultural heritage as a dynamic force that can evolve to incorporate new ideas and values, contributing to urban renewal, sustainable resource management and a sense of place. The reactivation of the Hadrian aqueduct as a functioning water source also provides an opportunity to create a 'water community' that promotes collective responsibility and wise resource management. Through urban design and engagement efforts, the aqueduct will be made accessible to the public, sparking discussions about memories, identities and intangible heritage. The project's success hinges on its multifaceted approach, encouraging collaboration among various stakeholders and addressing diverse objectives and interests. The aqueduct serves as a symbolic bridge that facilitates cooperation and dialogue among stakeholders to shape Halandri's future as a united and thriving community.

12.1.3 Circularity, renovation and revitalisation

Many cities have neglected, deteriorating areas, including old industrial sites, offering opportunities for urban revitalisation rather than expanding city boundaries. This is especially important in European cities with ageing populations and limited future population growth. Restoring existing historical buildings or infrastructure (e.g. the restoration of bridges in Norway) can reduce emissions related to building waste and the production of new materials for energy-efficient structures. Traditional building materials like adobe can match modern energy-efficient buildings when considering the entire building life cycle (ICOMOS, 2019) and increase resilience to flooding. Additional benefits include increased tourism attractiveness, the revival of historic and traditional knowledge, the potential of rebuilding connections between cities and water, and fostering social values and local identities crucial for social cohesion and resilience.

Retrofitting industrial areas, as planned for the Unesco Heritage site of Ivrea, showcases the potential for reusing old industrial buildings with both mitigation and adaptation benefits (EC, 2022). Ivrea's project in Italy, driven by inclusive planning, customises energy-saving techniques to highlight local historical remnants; it also aims to achieve a substantial 55% reduction in the building's energy consumption. In Ivrea, the revitalisation of historic buildings is leveraged to boost local tourism and stimulate the economy. Similarly, in Cordoba, Spain, the restoration of traditional structures is integrated into an innovative strategy that promotes equity and counteracts gentrification driven by tourism (Box 12.5).

Box 12.5

Revitalising the city: Patios de la Axerquía, Córdoba, Spain

Córdoba, a UNESCO World Heritage Site, has seen many residents leave its city centre in recent years in search of more comfortable housing options. To regenerate the historic centre, the Patios de la Axerquía association collaborates with resident groups organised as cooperatives to purchase, restore and repurpose vacant and abandoned buildings. This initiative not only aims to revitalise a vulnerable area but also to introduce green spaces into the city, countering the trend of tourism-driven gentrification. The traditional buildings, arranged around communal courtyards, are well-suited to the local arid and hot climate. Their restoration breathes new life into architectural styles and communal living practices integral to the city's historical and cultural heritage, fostering a space for a socially and solidarity-based economy.

12.2 How to encourage broader implementation

Despite increasing recognition of the need to protect cultural heritage and the opportunities it can bring, numerous barriers still hinder the upscaling of adaptation actions. One major barrier is the lack of awareness and understanding of the topic at various levels, from political to heritage stakeholders, or '… combination of the lack of awareness about the large diversity of cultural heritage and the lack of climate vulnerability and risk assessments' (Swedish Government, 2023).

- Political support: while cultural heritage currently has low priority in risk management planning, awareness about the intrinsic, social, environmental and economic value of cultural heritage is increasing in most European countries. There is the potential for well-documented and well described, listed objects and areas to be prioritized for interventions (Simpson, et al., 2022). Strategies for conservation therefore need strong stakeholder involvement to ensure the protection of all types of heritage (Heilen et al., 2018).

- Knowledge gaps: insufficient consistent methodologies are available to assess decay and loss of cultural heritage. The numbers of mapping exercises for cultural heritage are increasing, mostly stemming from research projects (e.g. the Proech2save and the STRENCH project). An increasing number of services are available, including the European Observatory for cultural heritage. The creation of a common European legal framework for undertaking multi-hazard assessments and management in facing climate change has been requested (EC, 2018).

- Conservation of cultural heritage: bears the risk of limiting benefits from protection to single buildings, or isolated ensembles disconnected from wider urban development (UNESCO, 2011). Heritage protection mainstreamed into local planning can be defined in a way which leaves more space for interpretation while extending heritage management over wider parts of the urban environment. In Lyon, where the city centre is protected by the UNESCO historic urban landscape programme, protection focuses on urban morphologies (e.g. limiting the height of buildings in public spaces and preserving green areas).

- Existing regulations on cultural heritage: The implementation of climate adaptation measures may be hampered by restrictions on renovation of cultural heritage objects (e.g. improving building insulation would change the characteristics of facades, which may be protected). In Estonia, a network of information centres for sustainable renovation organises training and consultations with technicians, architects and engineers for building owners and residents in historic buildings. It promotes the use of old buildings and provides knowledge on how to adapt historic buildings to modern requirements of energy efficiency with minimal intervention while maintaining a healthy indoor climate (EEA, 2022c).

12.3 Outlook

There is a growing emphasis on addressing climate change within international heritage organisations like ICOMOS and UNESCO, recognising the significance of cities as repositories of culture and traditional knowledge (Morel, et al., 2022). In recent years, there has been an increasing focus on assessing the risks that climate change poses to cultural heritage (Bonazza and Sardella, 2023). UNESCO has released multiple policy documents and reports, highlighting the need for comprehensive strategies to address climate impacts on World Heritage Sites and harnessing heritage knowledge for inclusive climate action (Quesada-Ganuza et al., 2021).

Engaging with all levels of cultural heritage, including the World Heritage Convention, is crucial. Heritage-related institutions advocate integrating cultural heritage into climate planning, emphasising its role in shaping the acceptability of policy changes and fostering resilient outcomes rooted in cultural values and identities (Potts, 2021). Whilst cultural heritage was initially missing from the EU Green Deal, an Open Method of Coordination was recently established to enhance cultural heritage resilience. Among the 28 EU Member States participating, 12 acknowledged cultural heritage in their climate change policies, while only seven integrated climate change in their cultural heritage policies (EC, 2022). Notable examples include Ireland and Sweden, both of which have developed dedicated climate action plans for cultural heritage. Ireland's sectoral climate change adaptation plan for built and archaeological heritage, published in 2019, is designed to establish a baseline for monitoring future climate-related changes.

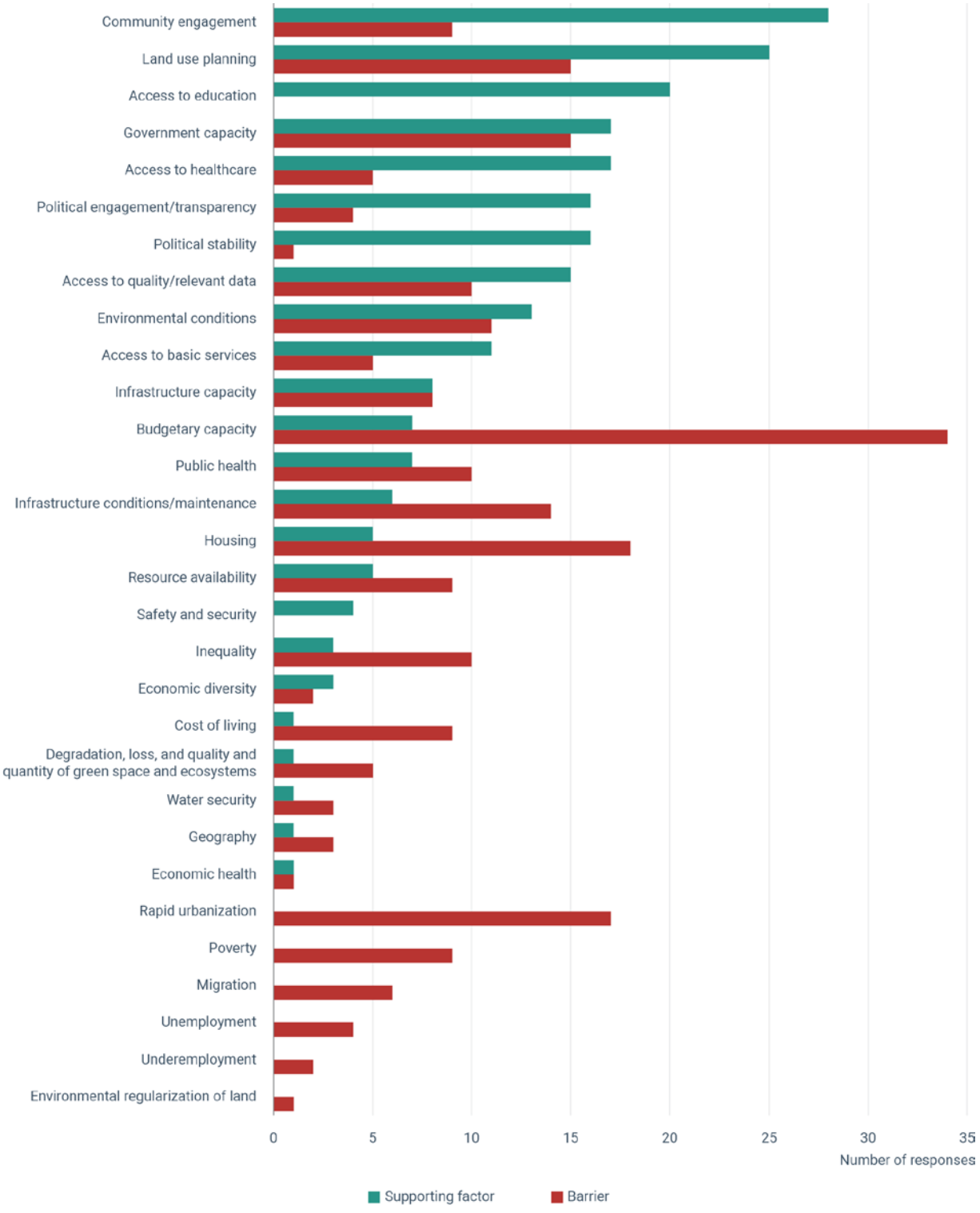
While progress is being made, the long-term impacts of climate change on both tangible and intangible cultural heritage are not yet fully understood. There need to be continuing efforts in utilising the best available data and science to implement effective adaptation strategies, addressing both slow, cumulative damage from climate variations combined with air pollution and the sudden impact of extreme weather events (Bonazza and Sardella, 2023).

SECTION III

Enablers of urban adaptation

This section dives deeper into the potential 'enabling factors' of adaptation. These are factors that can directly support the implementation of adaptation actions at the local level. Inversely, if they are not well-developed, they can act as potential barriers to the implementation of adaptation actions.

Figure S3.1 **Factors supporting and challenging the implementation of adaptation actions, as reported by European cities to the CDP**



Source: Full Cities Database (CDP, 2023). Responses to the questions: 'Identify and describe the most significant factors impacting on your jurisdiction's ability to adapt to climate change and indicate how those factors either support or challenge this ability'.

The enabling factors described in this section are based on the outcomes of a survey asking EEA member state representatives in the field of adaptation to identify challenges faced in implementing adaptation and what issues they would like to see addressed in this report. The specific challenges experienced in the implementation of adaptation actions were reported to be:

- ensuring political support;
- ensuring adaptation is addressed across all sectors;
- how to scale up;
- cooperation between sectors, e.g. public and private;
- public participation i.e. getting public support;
- how to secure funding and finance;
- how to adapt in dense urban areas;
- the importance of smaller towns and peri-urban areas.

Although not exhaustive, these enablers describe areas in which there is greater potential to invest time and resources to be able to upscale and accelerate the implementation of adaptation action as required by the European Climate Adaptation Strategy.

This report identifies six enablers as being the critical building blocks for successful adaptation planning and action:

1. Sustained political support. How can cities lay the ground for effective adaptation action and ensure they have much-needed support from governance bodies?
2. Good governance. How can the implementation of actions be streamlined across all relevant sectors and administrative levels?
3. Learning from each other. How can cities ensure all relevant stakeholders are involved, including the research and private sectors? What is the added value of city networks and peer-to-peer learning?
4. Placing citizens at the centre. Why should citizens be involved? How engaged are they and how can they enable the upscaling of adaptation actions?
5. Putting data to work. Why is the use of the right information important? How can data help in ensuring effective adaptation action?
6. Funding the change. What are the main funding sources available to cities to implement adaptation actions? What are the emerging options that may help in funding the much-needed change?

While the elements themselves are not new, having been identified in previous EEA Adaptation Reports, this report re-emphasises the critical role each plays for successful adaptation. It focuses on the progress made in strengthening each element, unpacking why progress may not be as substantial as needed and asking what it will take to move each element in the direction needed to really scale up effective adaptation action. Importantly, while we have divided these enablers into separate chapters, there is actually great overlap and synergy between the issues addressed. They very much need to be seen as factors that are supporting each other. All are essential.

13 Sustained political support

Key messages

- Sustained political support is crucial for successfully implementing climate adaptation measures. It enables large-scale and long-term adaptation planning, as well as cross-sectoral coordination and resource allocation.
- Maintaining consistent political support over multiple administrative cycles is vital due to the long timescales of adaptation initiatives.
- International and European initiatives provide financial and legislative backing that can serve as catalysts for local political commitment to climate adaptation.
- Increasing public and administrative awareness, creating binding climate action plans and emphasising co-benefits such as public health improvements are ways to overcome challenges related to sustained political support for adaptation actions.

13.1 Why do we need to ensure long-term political support?

Lack of political support is a key barrier to successful adaptation measures (Colloff et al., 2017). Urban climate adaptation demands more than isolated projects: it necessitates comprehensive, large-scale planning action and policy changes that address the interconnected challenges of a changing climate. Effective governing makes it easier to coordinate adaptation measures and ensure a cross-sectoral involvement of stakeholders, including community engagement (EEA, 2020b). However, the successful development and implementation of these strategies and measures requires the allocation of adequate human resources with sufficient capacities. It hinges on the approval of decision-makers and the allocation of funding (Adriázola et al., 2018).

Political leadership is essential for making climate adaptation a priority in the organisational agenda. Political endorsement of adaptation initiatives also signals to different urban sectors, including the private sector and urban community groups, that climate resilience is a collective imperative (Major and Juhola, 2021). This is crucial for overcoming bureaucratic obstacles and funding challenges. It also ensures the necessary collaboration and cooperation for aligning policies, regulations and investments under a unified vision led by political leaders.

In urban contexts, where administrative cycles may be relatively short, maintaining political support over successive terms becomes essential. Adaptation initiatives often take years to materialise, requiring sustained investment and resources and often have long timelines. The planning and implementation of these initiatives can take several years due to changing cost estimates and project complexity. For

example, the Cloudburst Management Plan in Copenhagen, the objective of which is to reduce the impacts of flooding due to heavy rain, foresees around 15 projects per year to be carried out over the next 20-30 years.

Consistency in policy and funding is vital to ensure that projects initiated under one administration are not abandoned or neglected by the next administration (C40, 2023b). The longevity of these efforts depends on political leaders recognising the transgenerational significance of climate adaptation and institutionalising it within urban governance structures.

One way of ensuring longevity is to create binding commitments, with strategies such as enshrining climate adaptation in local policy frameworks or creating independent bodies responsible for monitoring and implementing adaptation plans that can be adopted. Progress and review reports can be made public to ensure transparency and accountability. By making climate resilience a core value of urban development, regardless of changing political dynamics, cities can ensure that the momentum gained under one administration is not lost with the arrival of another.

13.2 The role of international and European initiatives

There is strong support for adaptation at the EU level, with top-down recommendations and requirements driving action across different governance levels. International frameworks can lead to the development of national adaptation plans, which, in turn, can provide financial and legislative support for local-level initiatives. Countries with well-established national plans tend to have a higher proportion of local adaptation efforts (EEA, 2020b). However, the lack of political will at the national level may also hinder efforts at the local level, sometimes due to legislative restrictions (CoR, 2020).

In the EU, sectoral climate policies allocate funding for local urban adaptation measures. This financial backing, coupled with top-down mandates, can incentivise decision-makers to allocate resources and prioritise the implementation of adaptation measures in urban contexts. In addition, requirements for horizontal and vertical coordination can be a condition for receiving funding, incentivising further collaboration (Chu et al., 2019). The availability of consistent national and subnational data, as well as monitoring and reporting tools can support local adaptation efforts, which might be hampered by the lack of local data (Adriázola et al., 2018). A political commitment to climate change adaptation agreed by the local council and signed by the mayor, such as joining the Covenant of Mayors (CoM), can be an important step towards gaining political support.

Box 13.1

Nicosia, Cyprus: support from civil society and the European Commission

Nicosia is taking steps towards climate resilience through initiatives that are supported by the European Commission and a strong civil society sector. The Cyprus Energy Agency (CEA), which is the local representative of the CoM, has supported the development of numerous local sustainable energy and climate adaptation plans (SECAPs) and other initiatives in collaboration with several stakeholders and local authorities. Under the guidance of the CEA, the bottom-up motivation of civil society members and the top-down direction setting from the European Commission combined have enabled:

- the establishment of a fund for rural communities (a systemic project to implement adaptation actions);
- the drafting of a Technical guide on NBS focusing on what can be implemented to empower individuals, communities and local authorities to mitigate the impacts of climate change through actionable measures;
- NBS projects in rivers, which were developed and implemented in collaboration with the Water Development Department, the Town Planning Department, the Ministry of Interior and the Department of the Environment.

13.3 Making the case for local adaptation action

This section outlines some of the steps that can be taken to make the case for adaptation and ensure political support at the local level, derived from the Urban Adaptation Support Tool, and Major and Juhola (2021). Many of these steps align with the recognised factors enabling the implementation of climate change adaptation actions, discussed extensively in subsequent chapters of this report.

13.3.1 Collecting evidence and knowledge

Research to support decision-making is crucial in making an informed case for adaptation. It is essential to consider reporting instruments in order to track progress on adaptation commitments and monitoring instruments for documenting the results of climate action (Adriázola et al., 2018). An understanding of challenges and incentives lays the case for evidence-based policy decisions. For example, making the evidence-based case for economic and other values created by NBS can support their mainstreaming (Biasin et al., 2023). Evidence of the full range of climate change impacts as well as the co-benefits of adaptation actions is essential to also be well communicated. Especially climate-related impacts on human health need to be better understood and highlighted to policymakers and the general public, as this may help to drive support for adaptation (see the Climate and Health Observatory).

13.3.2 Gathering funding information for support

Efforts to align adaptation planning with existing funding mechanisms are crucial not only for mainstreaming adaptation but also to ensure the effective and efficient utilisation of funds. Conducting a comprehensive cost-benefit analysis can demonstrate the value and potential impact of adaptation measures to stakeholders and decision-makers, considering both short-term investment and long-term benefits such as economic growth, improved public health and reduced environmental impact.

For example, Copenhagen's Cloudburst Management Plan found that alternative stormwater adaptation approaches could yield greater net benefits compared to traditional sewer solutions when considering socio-economic impacts.

Challenges in assessing the economics of adaptation measures include inherent uncertainties and difficulties in quantifying both costs and benefits (Biasin et al., 2023), such as estimating sea wall costs versus benefits related to damage prevention, which are reliant on various factors like future storm severity and sea-level rise. Despite these challenges, economists have developed methods to evaluate adaptation measures, often considering long time-horizons, uncertainties and potential technological advancements.

13.3.3 Engaging stakeholders and raising awareness

Prioritising climate change adaptation across scales and sectors requires the provision of mandates and enabling of wider coordination, collaboration and learning. The complexity of multi-level governance acts both as a challenge and strength (Nevens et al., 2013). The cross-sectoral nature of adaptation planning creates opportunities to explore new and even surprising assemblages of cooperation between actors (Piattoni, 2009).

13.3.5 Exploring synergies with other policies

Mainstreaming efforts can be supported through sustained and effective public communication (World Bank Group, 2011). Political support can enable climate adaptation mainstreaming into e.g. spatial planning, building and infrastructure design, and economic development plans, increasing just resilience (Chu et al., 2019). With conflicts between policies being a major barrier for implementing adaptation actions, finding synergies is a crucial step for successfully moving forward (CoR, 2020). Linking adaptation plans with established processes and policies can also help secure funding for adaptation measures. The evidence base for ongoing processes is more established, which then provides certainty for decision-making. Larger municipalities are more likely to have resources for administrative reorganisation with the goal of including climate adaptation throughout the organisational structure. For example, Rotterdam's 'floating city' vision included a technological experiment (a floating pavilion). The experiment ended up influencing Rotterdam's spatial planning policies related to waterfront construction and created a new taxing scheme (Nevens et al., 2013).

Box 13.2

Making the case for adaptation through co-benefits, Cascais, Portugal

Rather than framing initiatives solely in terms of climate adaptation, Cascais, a municipality in Portugal, strategically highlighted their additional benefits. For instance, in the restoration of the riverbed project, the emphasis was not just on climate adaptation but also on biodiversity enhancement and recreational opportunities. By showcasing these co-benefits, Cascais successfully garnered political backing and specific funding, illustrating the usefulness of a multi-dimensional approach to adaptation.

The Cascais Action Plan for Climate Change Adaptation is a comprehensive strategy consisting of 13 measures, 82 actions and an investment of EUR 11.5 million. Notably, the plan places a strong emphasis on non-structural or green solutions, which align with Cascais' commitment to NBS and sustainability. The plan also incorporates grey solutions for water supply infrastructure. This balanced approach not only enhances resilience but also contributes to Cascais' broader environmental and societal goals, showcasing the integration of adaptation into a holistic, co-benefits-driven strategy. Cascais also actively seeks to share its expertise. The municipality is an active member of the 'National Network of Cities for Climate Change Adaptation', aiming to promote adaptation knowledge sharing with the Portuguese-speaking community and stakeholders.

Figure 13.1 Riverbed restoration project, Cascais

13.3.4 Developing practical adaptation ideas

Transnational municipal networks have shaped local government policy processes and promoted adaptation actions (Bellinson, 2018). In order to develop practical adaptation ideas, it might help to draw examples from peer cities, as well as existing projects and networks. Examples include:

- ClimateADAPT – Case study and adaptation options catalogues;
- EU Mission on Adaptation to Climate Change;
- ICLEI – Local Governments for Sustainability;
- Covenant of Mayors (CoM);
- EU Urban Agenda Partnerships;
- Eurocities;
- Smart Mature Resilience.

13.4 What are the challenges to overcome?

To minimise tensions and conflict that are likely to arise and secure sustained commitment, broad political support for advancing urban adaptation is crucial (Leonardsson et al., 2021). The EU's new strategy for climate change adaptation emphasises the importance of a fair and just transition, recognising that the impacts of climate change affect various socio-economic groups differently (EC, 2021a). Therefore, adaptation measures should address these disparities and provide adequate support to all groups. In some countries, a lack of trust in local institutions hampers the organisation of adaptation measures at the local level.

The lack of sufficient and skilled human resources can hinder the implementation of adaptation measures, which require steering and monitoring as well as horizontal and vertical coordination (Adriázola et al., 2018). Smaller municipalities, in particular with limited resources, might find themselves constrained by a lack of resources for successful implementation. In such cases, regional and national political support is necessary to provide funding to improve adaptation capacities.

Ambitious adaptation measures come with their own set of challenges, including varying effectiveness and cost-efficiency depending on location and scale (Chu et al., 2019). Factors such as the monetisation of benefits require transparent calculations, methods and assumptions to gain public acceptability and support. Standardised methodologies for evaluating benefits and trade-offs, especially for NBS, are currently lacking (Biasin et al., 2023). Additionally, the cross-sectoral nature of adaptation actions and unclear responsibilities among stakeholders make inclusion in decision-making processes difficult (CoR, 2020).

To overcome these challenges and align with short-term economic and political priorities, emphasising the co-benefits of climate initiatives, such as improvements in public health, the urban environment and economic growth, could assist. However, to ensure genuine commitment and progress, climate action plans (CAPs) should be integrated into policy frameworks that establish clear accountability mechanisms, holding governments and institutions responsible for meeting climate goals. Finally, maintaining political pressure from grassroots movements and community groups is essential in keeping climate action on the political agenda.

13.5 Trends and outlook

In the context of advancing the political agenda for urban adaptation in Europe, several key trends have emerged. European-level initiatives and legislation are gaining strength. There has been an increase in the participation of local authorities across Europe in various international and European initiatives in recent years (EEA, 2020b). For example, close to 123 million people in Europe lived in local authorities committed to adaptation under the Covenant of Mayors in 2020. According to the 2022 dataset, this number has already increased to 202.5 million. These initiatives provide support to local decision-makers and help sustain political support for adaptation measures. Additionally, as the impacts of climate change become more evident, there is growing urgency for adaptation, driven by citizens, businesses, organisations and decision-makers witnessing the effects of extreme events.

As awareness of climate change impacts expands, advocacy efforts gain traction, fostering increased political support for adaptation measures. As these measures are put into practice, they produce tangible outcomes that further emphasise the benefits of adaptation. This self-perpetuating loop not only fortifies the argument for climate adaptation but also speeds up its execution.

We might expect to see more organised methods for establishing advocacy networks (Barnes et al., 2018). Such networks could, in turn, generate momentum and gain traction in local governance. Advocacy networks create sustained narratives and build coalitions. When they become influential, they can contribute to a shift away from traditional, entrenched modes of governance, opening up opportunities for the creation of novel collaborative governance platforms and arenas. These platforms, in turn, can ensure continued pressure on decision-makers.

The long time-frames of many adaptation plans mean that people have time to observe the changes taking place over successive election cycles and thus, the support for adaptation stays high. The increasing focus on ensuring effective horizontal and vertical governance supports this development (Piattoni, 2009). The creation of more formal platforms for local politicians to come together and advocate with one voice is likely to happen. The involvement of cities and local governments in global, national and regional city networks is growing.

Participation in knowledge co-production processes can lead to decisionmakers and stakeholders feeling deeply engaged and empowered (Leonardsson et al., 2021). The collaborative nature of these processes plays a pivotal role in mitigating conflicts and fostering the creation of multi-scale partnerships. It also allows for a better inclusion of issues related to environmental justice, just transition and the concerns of vulnerable groups of people (Chu et al., 2019; Major and Juhola, 2021). Transformative governance, which is inclusive and includes interactive knowledge co-production, increases the acceptability of governance measures (Leonardsson et al., 2021). In broad issues such as climate change adaptation, figurative bridge-building between actors holding different, or sometimes even conflicting views, enables broader support for adaptation measures across the board.

14 Good governance

Key messages

- Adapting to the wide range of impacts of climate change requires action across many different thematic areas and coordination at local, regional, national, European and even global levels.
- Vertical coordination and cooperation with regional authorities is particularly important to small municipalities, which may need additional support to secure funding and set adaptation goals.
- Climate change adaptation is being increasingly mainstreamed in many of the sectors most directly affected by climate change impacts.
- There is progress in the creation of coordination mechanisms to facilitate adaptation action in EEA member states. An increasing number of countries and regions are also now setting requirements for local adaptation planning.

14.1 Why do we need good governance in adaptation?

Climate change affects a wide range of economic sectors and has severe impacts on human health and the wellbeing of our natural environment. Adapting to these impacts will require action across many different thematic areas and coordination at local, regional, national, European and even global levels. Good adaptation governance essentially means good coordination horizontally (across different sectors and departments) and vertically (across all administrative levels). It relates to the ways that actors at various government levels and from various sectors interact, communicate, cooperate and coordinate their plans, decisions and actions.

The existence of multi-level governance frameworks in which information and resources are shared across scales is crucial to identifying risks and adaptation priorities at an appropriate spatial scale. Both vertical and horizontal coordination mechanisms are essential for the development and implementation of climate change adaptation strategies and plans (EEA, 2022a). Successful governance may also improve the perceived legitimacy of decision-making through increased participation and representation, but new types of governing configurations can raise questions about the legitimacy of the arrangement (Piattoni, 2009). Indeed, an important part of good governance is ensuring the active involvement of all stakeholders from planning through to implementation and maintenance of adaptation actions. Chapter 16 specifically highlights the importance of citizen engagement.

14.1.1 Horizontal Coordination

Horizontal coordination mechanisms refer to the institutions and processes that support the integration of adaptation into sectoral policies. It requires those responsible for different policy areas within an administrative level (e.g. national)

to exchange information and adjust their activities to ensure that adaptation efforts result in coherent action. To make cities more resilient to climate change, mainstreaming adaptation will continue to be necessary into all policy areas (EEA, 2020b). Mechanisms that enable horizontal coordination include city leadership that ensures streamlining and recognition of adaptation across relevant departments, policies, or strategies outlining cross-silo actions and the establishment of cross departmental organisational units.

Box 14.1

The rise of the Chief Resilience Officer (CRO)

The 100 Resilient Cities programme, initiated by the Rockefeller Foundation in 2013, aimed to support cities in developing resilience strategies. One of the most valued outcomes of the programme is the establishment of a global network of Chief Resilience Officers (CROs). These are city officials appointed with the specific intent to lead and facilitate the planning and implementation of resilience strategies. CROs were put in place to coordinate across city departments and engage a wide array of stakeholders such as government officials, private sectors, non-profits and civil society, to build support for individual and community initiatives. They also serve as the main contact point on resilience, keeping an overview of the challenges faced by the city and ensuring that actions aim to achieve multiple resilience or department goals.

The position was funded in approximately 100 local administrations globally, with the additional objective to learn from each other and share knowledge. In the United States, following on from the city example, some states have also created CRO positions. Many of these were created immediately following the occurrence of large-scale disasters, for example, Hurricane Florence in North Carolina in 2018.

A more recent important position, inspired by the CRO, is the Chief Heat Officer (CHO). This role is similar to that of a CRO, but focused on developing plans and coordinated actions to anticipate, prepare for and respond to heatwaves. The first European CHO was appointed in 2021 in Athens. The original intention was to have one per continent, but there are already more, with CHOs appointed in Byblos (Lebanon), Christchurch (New Zealand), Los Angeles, Miami-Dade County, Phoenix, San Francisco (US), Medellin (Colombia), Melbourne (Australia) and most recently, Freetown (Sierra Leone). In June 2022, the position of Global Chief Heat Officer was created in collaboration with UN Habitat.

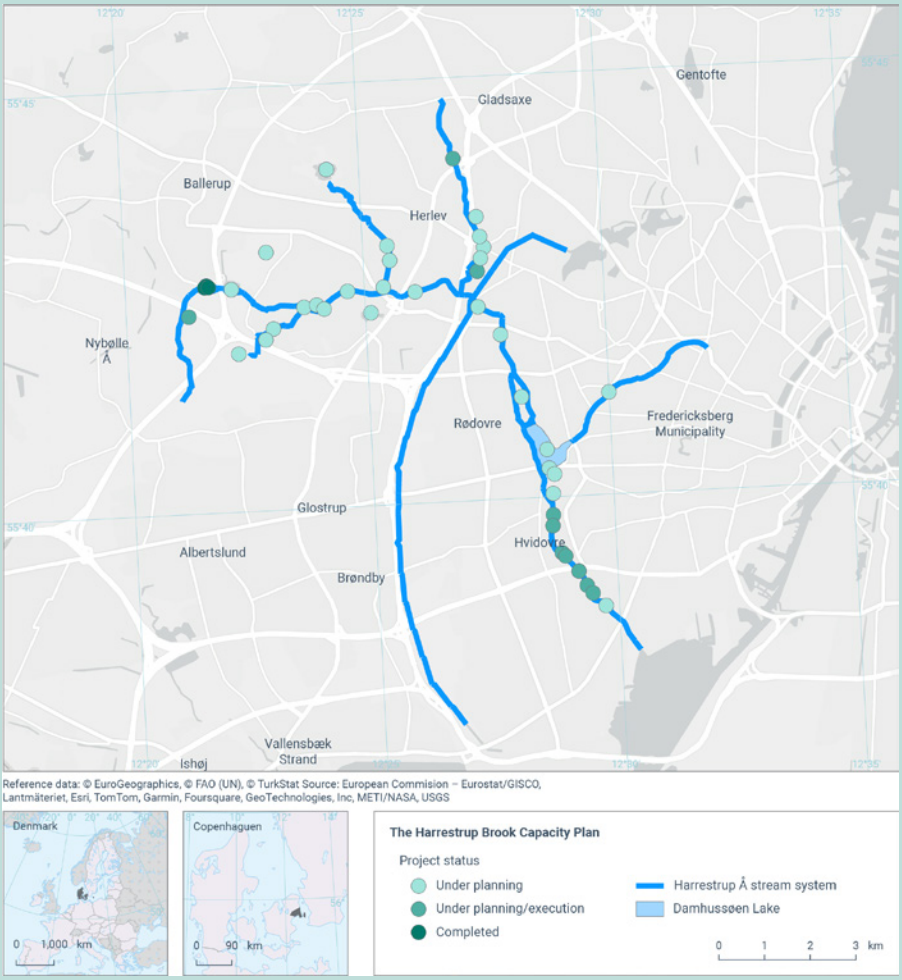
An important part of horizontal coordination is the close work between municipalities, ensuring that adaptation actions are implemented correctly across neighbouring areas. This can also help to reduce costs and resources needed in implementing specific actions. Climate impacts are not defined by artificial administrative boundaries and actions to reduce their impacts will have to be streamlined, which counts as much for local collaborations as for larger-scale transnational collaboration. Box 14.2 gives a specific example of such coordination where close collaboration was needed between neighbouring municipalities and also with utility companies.

Box 14.2

A collaborative effort to protect residents from 100-year flooding in Greater Copenhagen

Through an ambitious collaboration effort, ten municipalities and their utility companies in the Greater Copenhagen area have joined forces to develop a capacity plan for the Harrestrup brook system. The objective of the collaboration is to protect residents in the catchment area from damage caused by 100-year flooding events. The brook flows through 10 municipalities and to secure all residents along the brook and the catchment area, the upstream municipalities should be able to flood-proof and divert rainwater to the stream through stormwater routes and nearby areas, while the Harrestrup Brook system itself should also be protected against damaging flooding. The protection of the Harrestrup Brook system is carried out though a common capacity project, through which the municipalities are working together to find a common solution that can ensure sufficient capacity in the brook system. The local flood protection projects are carried out individually by the municipalities. The reasoning behind the collaboration across municipalities and utilities is based on the expectation that by collaborating on the joint use of the Harrestrup Brook, the parties will achieve a better and cheaper solution than if they were to solve the challenges alone. Implementation of the plan began in 2021 and is due to end in 2038.

Map 14.1 Harrestrup Brook capacity plan



Source: Lotte Kau Andersen.

14.1.2 Vertical coordination

Vertical coordination mechanisms refer to the institutions and processes that support the integration of adaptation through multiple administrative levels within a country (e.g. national, provincial, regional and local/city levels). This requires that information and approaches to adaptation are transferred and exchanged effectively within each policy area, from national to subnational levels and vice versa (EEA, 2020b). Mechanisms that enable vertical coordination are national task forces, national/EU level strategies, regional adaptation strategies and plans and specific funding instruments.

Climate laws play an increasing role in institutionalising national adaptation policies and embedding national adaptation strategies (NASs) and national adaptation plans (NAPs) in binding regulatory frameworks. Most NASs and NAPs recognise the role of local authorities in successful adaptation actions, listing cities or municipalities alongside other key sectors for adaptation. Cities and local administrators have been recognised as key actors in climate adaptation following the changing approach introduced by the Paris Agreement.

Regional level governance of adaptation plays an important role in coordinating and supporting local actions, especially for small municipalities with limited capacity. Small municipalities may need additional support to secure funding and set adaptation goals. In Austria, based on an international literature review and empirical case studies, the research project GOAL (governance of local adaptation) identified barriers and success factors and developed recommendations for agenda setting and long-term institutionalisation of climate adaptation in small municipalities. The Regional Government of Valencia and Valencia City Council are signatories to both the EU Missions on Adaptation to Climate Change and Climate-Neutral and Smart Cities. The Valencian Collaboration Space is a multi-level governance framework set up to foster collaboration among these regional and local authorities with a focus on achieving the objectives of the Missions.

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Box 14.3

Governing the landscape and watershed recovery programme, Košice, Slovakia

Košice region is implementing an ambitious restoration programme for 2020-2030 to address the region's landscape degradation and water management issues. Adopted in 2021, it builds on the previous programme (2010-2012) that successfully implemented water retention measures and green infrastructure across 488 towns and villages within the region. However, the programme was ended prematurely due to a change in government. The new programme proposes implementing NBS on a larger scale to restore the landscape and watersheds of the whole region, installing water retention measures and groundwater recharge projects across 6,754km^2 of land.

In urban areas, measures include rewetting land, urban bioretention projects, permeable pavements, green walls and green roofs. The estimated cost is around EUR 400 million, but it is expected to create 3,200 new green jobs. Six Water and Land Restoration Advisory Boards were established to coordinate the implementation of water retention projects in each district, one of which is the City of Košice. The six boards together form an Umbrella Regional Water Board. The board members are representatives of municipal and regional governments, state administration bodies, research institutes, activists, volunteers and the public. Members of the boards created plans for integrated water protection in their territory, which became part of the development strategy of the region. Municipalities and city governments support the programme and appoint their 'water ambassador' to coordinate the projects at the municipal level. Municipal plans will be subject to the Umbrella Regional Water Board's coordination. Municipalities are encouraged to prioritise the restoration of public spaces and flood plains and seek funding and approval from property owners and managers. The further support from the national government is essential to ensure proper funds and long-term continuity in the proposed approach.

Figure 14.1 Rainwater retention in Košice region: Košice Water Protocol pilot project

Note: A 3-hectare green infrastructure project was implemented to prevent flooding and repair degraded erosion gullies, creating suitable moisture conditions for optimal new vegetation growth.

14.2 What are the challenges to overcome?

Adaptation strategies are mostly implemented at the local level, with planning regulations typically set at regional or national level. This can be limiting to the implementation of adaptation actions at the local level.

Recognising the growing importance of supporting small municipalities and rural communities, addressing their challenges in funding and resources is crucial. In addition, they often have to deal with additional challenges such as ongoing demographic and economic structural changes (e.g. an aging population and loss of

jobs) and limited access to mobility, health or supply services, which are affected by the changing climate. Regional level coordination can facilitate knowledge sharing and resource pooling for local communities, as was done in the Evolving Regions project (Box 14.4).

Box 14.4

Empowering rural small municipalities through multilevel governance for adaptation in North Rhine-Westphalia, Germany

The goal of the Evolving Regions project (2019-2023) was to enable stakeholders in seven rural districts in the German Federal state of North Rhine-Westphalia (NRW) to actively address the impacts of the changing climate. For this purpose, cross-thematic dialogue processes, designed for the collaboration of a wide range of actors from administration, policy, science, business and society, were carried out. These were supplemented by detailed district-wide climate impact analyses and the development of easily applicable monitoring schemes. The Interactive Climate Atlas North-Rhine Westphalia gives an overview of current and future potential impacts of climate change in the state.

A special focus was put on the particular challenges and requirements of small municipalities in rural regions that often lack adequate staffing or financial capacities. The Evolving Regions project is an important component of the climate adaptation goals and activities of NRW, which was the first federal state in Germany to enact its own climate adaptation law. However, to date, only 22% of municipalities and 45% of districts have developed climate adaptation concepts.

Knowledge about the implementation of climate adaptation processes, according to the project method and the findings from the processes, were passed on to other regions in NRW, in Germany and across Europe and to actors via different formats and products.

Methods to support cities may be different depending on country size. For instance, Germany utilises regional conferences to disseminate knowledge at regional and local levels, while Denmark contacts municipalities directly. To address large-scale risks, especially transboundary climate risks, there needs to be a shift in responsibility from local to national level and beyond. This can be informed by the findings of initiatives like the Nordic Adaptation Conference (NOCCA), which offers valuable insights into effective strategies for managing these risks.

14.3 Trends and outlook

Adaptation governance is a shared responsibility across all levels, with central governments primarily responsible for policymaking (EEA, 2022a). In particular, subnational governments have made significant progress in recent years, benefiting from voluntary and bottom-up initiatives. They often have dedicated coordination bodies for regional policymaking, driving legislative processes. To ensure successful adaptation, an integrated approach is crucial, particularly at regional and local levels. This approach seeks to prevent maladaptation, encourage synergies and capitalise on complementarities among different adaptation efforts. Corfee-Morlot et al. (2011) suggest that more integrated and inclusive governance is, in part, a response to the increasingly complex and nuanced urban adaptation issues.

There is an increasing trend towards the multi-level mainstreaming of climate change adaptation into a broad range of sectors most directly affected by climate change impacts. Policy instruments for sectoral integration of adaptation mostly exist in sectoral policy fields with EU mainstreaming requirements (e.g. EU directives transposed into Member State legislation) and especially in the water sector (EEA, 2022a). For instance, in Jena, Germany, a concept for adapting the city to climate change impacts was developed between 2009 and 2012 under the frame of 'JenKAS — Jena Climate Adaptation Strategy', as part of a project funded by the Federal Ministry of Transport, Building and Urban Development and the Federal Institute for Research on Building, Urban Affairs and Spatial Development. The overall goal of the project was to lay the ground for mainstreaming climate change adaptation into urban planning.

Box 14.5

Efforts towards advancing horizontal and vertical coordination in EEA member states

EEA member and cooperating countries are making progress in the horizontal and vertical coordination of climate adaptation actions. Some examples emerged from the 2022 survey, with responses from national focal points on adaptation:

- **Belgium:** the Belgian working group on climate change adaptation and the Flemish Task Force on climate change adaptation facilitate structural consultation between regional governments, the provinces and local governments, on climate change adaptation.
- **Germany**: the Centre for Climate Adaptation (ZKA, Zentrum Klimaanpassung) was established in 2021 by the Federal Ministry for the Environment and it is the first nationwide advisory and information centre for climate adaptation, which specifically addresses municipalities and social institutions throughout Germany. The centre provides support in the planning and implementation of adaptation measures, in the selection of appropriate funding, offers training and organises networking events.
- **Spain**: the Working Group on Impacts and Adaptation (GTIA), an interadministrative, technical forum was created by the Spanish Climate Change Office to improve information, collaboration and aligned actions on adaptation between the national and regional administrations.
- **Sweden:** the Swedish Network on Climate Adaptation facilitates cooperation and many county administrative boards offer networks for their municipalities to exchange experience and good examples in relation to climate adaptation measures and projects.
- **Switzerland**: in the Swiss administration, a climate-related committee across governmental departments has been implemented to facilitate coordination across the different disciplines.

An increasing number of cities and municipalities are developing their local adaptation strategies and plans as signatories of the CoM initiative (e.g. Czechia, Italy, Latvia, Romania, Slovakia, Slovenia and Spain) (EEA, 2022a).

Implementation of adaptation actions vary in the way they are carried out across Europe. This depends on the administrative system in place and the traditions of each country. In some EU Member States (Denmark, Ireland and Sweden), and the UK, adaptation planning at the local level is mandatory , while in other countries local adaptation planning is enforced through urban planning legislation (Slovakia), or may be an obligation imposed by the region. Municipalities in the Valencia region will need to have a SECAP by 2024. In Poland, cities with more than 100,000 inhabitants (44 in total) were supported in developing climate action plans through a project implemented by the Polish Ministry of Environment has been concluded. These adaptation plans will be adopted and are formally binding for the cities.

Supported by national level strategies and plans, the enabling EU policy environment, new initiatives and new tools all play a role in fostering increased adaptation planning and implementation at the subnational level. The EU Climate Law establishes requirements for adaptation at European and national levels. All EEA member states have national adaptation policies in place. However, the legal requirements for subnational adaptation and mechanisms to interact with regional and local level governments are diverse.

The ways in which adaptation is carried out at subnational level is determined by the countries themselves. In some countries, top-down regulatory approaches determine how subnational governments must develop and implement adaptation plans and actions. This can be through a climate law with adaptation provisions, as in Croatia, Ireland and Portugal, or other national legislation, such as those in France and Sweden. In most cases though, voluntary and bottom-up initiatives are responsible for driving subnational adaptation (e.g. Denmark and Italy). In other cases, regional authorities are taking an important role in advancing adaptation, as in Greece and Sweden, both of which have Regional Adaptation Plans. Independent of the mode, subnational adaptation policymaking is progressing in all EEA member states.

Table 14.1 Examples of subnational adaptation progress in different national adaptation policy contexts

Country	Adaptation policy framework	Legally binding adaptation obligation	How it works at the subnational level
Croatia	CL, NAS	Climate Change and Ozone Layer Protection Act	Local and regional authorities have an obligation to include adaptation measures in their strategic documents and to periodically report on their implementation.
Denmark	NAS, NAP	-	Local level initiatives, such as the DK2020-network, drive adaptation. Of the 98 municipalities, 96 are part of the DK2020-network where municipalities take inspiration from C40 initiatives and develop climate action plans compatible with the Paris agreement.
France	NAS, NAP	Law on the New Territorial Organisation of the Republic	The regional plan for development, sustainable development and territorial equality is required to include a section on adaptation to climate change. Territorial climate-air-energy plans, mandatory for all inter-municipal bodies with more than 20,000 inhabitants, must include a vulnerability assessment, a strategy, quantified objectives, programme of actions and a monitoring and evaluation system.
Greece	CL, NAS, RAP	National Climate Law 4936/2022	Regional authorities are responsible for the development and implementation of regional adaptation action plans, which often include actions to support the development of local plans though the CoM or other initiatives.
Ireland	CL, NAS, SAP, RAP	Climate Action and Low Carbon Development (Amendment) Act 2021	Local authorities have a legal requirement to prepare local authority climate action plans every 5 years in line with national guidelines.
Italy	NAS, SAP	-	Regions and municipalities approve their own adaptation strategies and plans and implement the related measures. Seven of the 21 regions/autonomous provinces have adopted a strategy or plan. Three regions have approved regional laws on climate issues, including adaptation. Several regions address adaptation in their regional sustainable development strategies. Many municipalities have adopted local adaptation plans and/or sustainable energy and climate action plans.
Portugal	CL, NAS, NAP, SAP, RAP	Portuguese Climate Law	Development of climate action plans (both mitigation and adaptation) is mandatory for all municipalities, intermunicipal communities and regional development and coordination commissions.
Sweden	NAS, SAP, RAP	Adaptation Ordinance	County administrative boards coordinate regional adaptation and ensure that the national targets are achieved. They are also required to develop municipal action plans and to monitor adaptation.

Notes: All information included in the table comes from the 2023 reporting under Art. 19(1) of Regulation (EU) 2018/1999).
CL, climate law (including adaptation).
NAS, national adaptation strategy.
NAP, national adaptation plan.
RAP, regional adaptation plan.
SAP, sectoral adaptation plan (not necessarily urban).

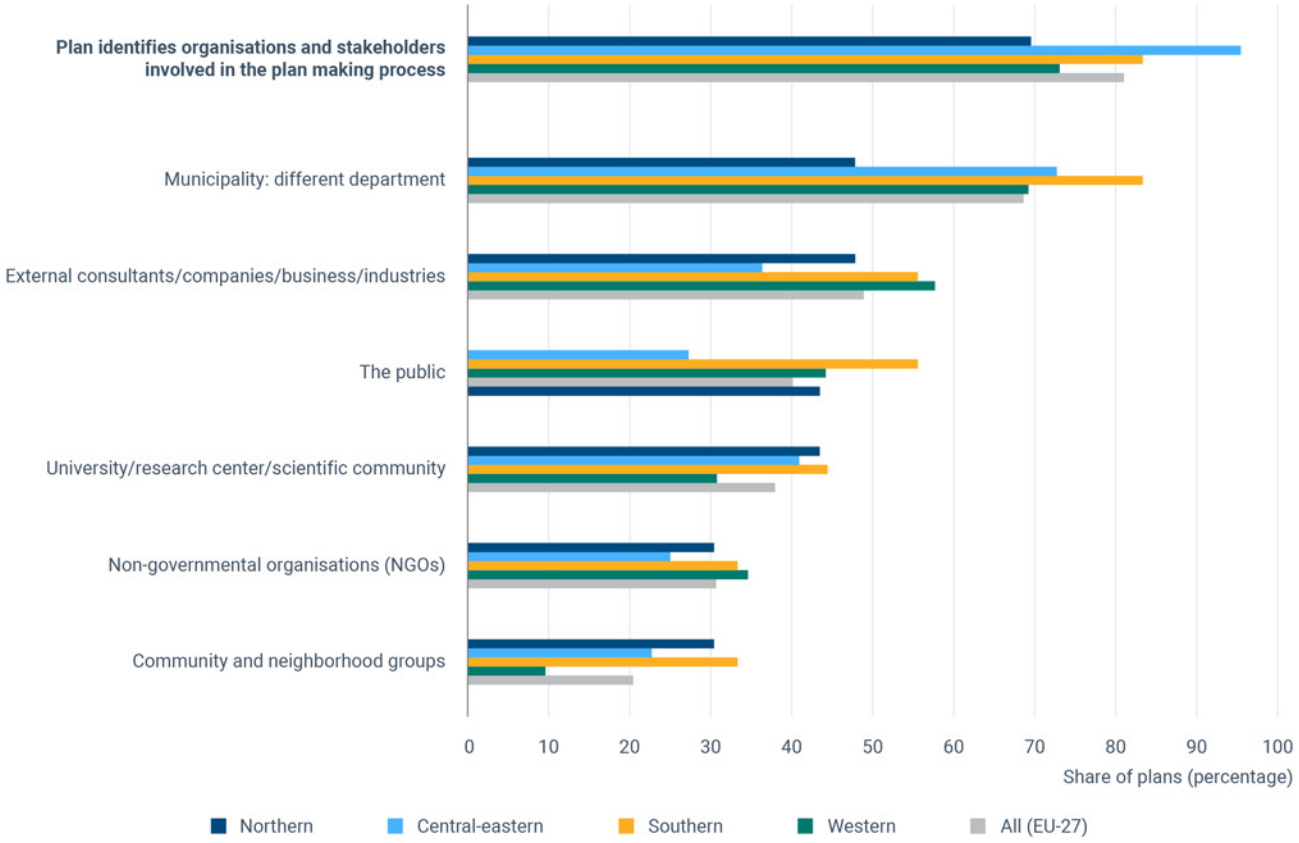
15 Learning from each other

Key messages

- The urban dimension has gained significant visibility in the broader European conversation around adaptation to climate change. Tailored support, technical guidance and innovative tools for urban adaptation planning are increasingly needed.
- The number of urban initiatives and programmes dedicated to knowledge sharing, capacity building and exchange of best practices has increased. These include networking, engagement in research projects and cooperation with the private sector.
- Networking initiatives play an important role in strengthening the adaptive capacity of cities. They promote peer-to-peer exchange, provide technical assistance and facilitate access to data and tools.
- Access to scientific knowledge and high-quality information remains a key challenge for local authorities. Strengthening partnerships and cooperation, with research institutions in particular, can help to overcome this.

Building resilience to climate change requires cross-cutting actions that transcend traditional sectors, administrative levels and disciplines (Braunschweiger, 2022). There is growing recognition that the implementation of successful adaptation actions requires purposeful and ongoing collaboration, bringing together a diversity of stakeholders and perspectives. This is essential to avoid maladaptation, to recognise trade-offs or limitations and promote synergies between different urban development efforts. 81% of local climate action plans across Europe identify stakeholders (Figure 15.1). While different municipal departments are most frequently mentioned (in 69% of plans), the private sector (49%), the general public (40%), research institutes (38%) and NGOs (31%) are also increasingly recognized and engaged in local climate action planning and implementation.

Figure 15.1 Stakeholders mentioned in local climate action plans by European region



Source Reckien et al., 2022.

This chapter explores the benefits that come from learning from each other, focusing on the benefits of networks at all levels and engagement with the private, and research and innovation sectors. It also addresses some of the barriers to successful collaboration.

15.1 Benefits of networking and collaboration

Climate networks foster learning across different contexts and disciplines and serve as repositories of expertise and procedural guidance for local authorities (Rashidi and Patt, 2018). Participation in urban adaptation initiatives can support the development of explicitly urban approaches to climate change, provide cities with easy access to best practices and help them develop local capacity (Heidrich et al., 2016). Such networks are drivers of urban innovation that promote horizontal dissemination of knowledge and information, while potentially influencing a vertical governance framework.

15.1.1 Support at all governance levels

Cities can use networks strategically at all governance levels to influence national or international climate policies and build local cooperation. The benefits of networks have been reported at all levels (Heikkinen, 2022). At global and European levels, cooperation with similar cities can help to create meaningful change and engage

local politicians through branding and a sense of competition. Engaging in European projects can also help to influence national legislation from the top down.

National networks can help to spread information from global networks and allow cooperation in a similar national context. Within a municipality itself, local networks and collaboration can help by reducing single-sector thinking and pooling resources, both financially and technically, to overcome limitations. The European Covenant of Mayors was seen as the most prominent initiative in terms of usefulness to local authorities in a recent study (CoR, 2023).

Box 15.1

Examples of city networks relevant to climate change adaptation

Global networks

C40 unites nearly 100 mayors globally in action to confront the climate crisis. It provides adaptation master classes with workshops, training, tools and good practice repositories. Adaptation-related subnetworks include the Connecting Delta Cities Network, the Cool Cities Network and the Urban Flooding Network.

The Making Cities Resilient 2030 initiative was launched in 2020 by the UNDRR, following on the Making Cities Resilient Campaign (2010-2020). It aims to increase the overall resilience of cities to disasters by implementing risk reduction strategies. The participating local governments were expected to be proactive in both their jurisdiction and knowledge sharing with others. As of June 2023, more than 1,500 cities have joined the network.

The Resilient Cities Network continues on the work of the 100 Resilient Cities (Rockefeller Foundation), established in 2013. In partnership with its global community of cities and chief resilience officers, the network builds partnerships to design, invest and scale urban resilience solutions worldwide. Eighteen European cities participate in the initiative.

European networks

The European Covenant of Mayors for Climate and Energy (CoM) was launched in 2008. In 2014, Mayors Adapt (the CoM's initiative on climate change adaptation), was created by the European Commission as one of the actions of the EU adaptation strategy to engage cities in taking action to adapt to climate change. In 2015, the two initiatives merged in an effort to promote an integrated approach to climate and energy action. Signatory authorities must commit to submitting a Sustainable Energy and Climate Action Plan (SECAP) within 2 years of joining the CoM. In return, signatories benefit from technical guidance, feedback on the SECAP and access to knowledge resources and events. Importantly, they are part of a well-respected platform that raises the collective voices of local authorities up to regional, national and European levels. As of 2023, there were over 11,000 signatories across the EU-27 countries. Nearly 8,000 have submitted SECAPs.

Climate Alliance has nearly 2,000 members comprised of cities, towns, districts and provinces across 26 European countries. In addition to committing to climate justice via a partnership with indigenous peoples, each town, city and district joining Climate Alliance must pass a municipal resolution committing itself to continually cut greenhouse gas emissions, aiming for a 95% reduction by 2050. Climate Alliance combines expertise in mitigation, adaptation, resilience and energy poverty, and develops tools to support comprehensive municipal climate action planning and monitoring, climate and energy reporting and climate impact assessment.

The Council of European Municipalities and Regions (CEMR) brings together 60 associations of local and regional energy authorities across 41 European countries. They aim to influence European policy and legislation in all areas having an impact on municipalities and regions and provide a forum for debate between local and regional governments via their national representative associations.

Box 15.1

Examples of city networks relevant to climate change adaptation (cont.)

Eurocities brings together local governments of over 200 cities in 39 countries. Through a wide range of forums, working groups, projects and events, it provides a platform for promoting the urban agenda in European policymaking and for sharing knowledge and exchanging innovative solutions among its member cities.

European Federation of Agencies and Regions for Energy and the Environment (FEDARENE) is the collective voice on the energy transition for regions and local/regional energy agencies, counting over 80 members in 24 EU countries. FEDARENE promotes the initiatives taken by its members at European level and brings local and regional dimensions into European debates. It organises and coordinates, on a regular basis, working groups where participants exchange ideas, experiences and best practices.

ICLEI-Europe is the European secretariat of the global ICLEI local Governments for Sustainability, a network of more than 2,500 cities, towns and regions across 125 countries. ICLEI Europe supports more than 160 subnational and local governments across Europe, connecting with peers and tools to drive positive environmental, economic and social change. It places significant attention on climate adaptation and urban resilience and organises the annual European Urban Resilience Forum alongside the EEA.

Energy Cities supports over 100 local authorities across Europe in their energy transitions. They represent member interests by contributing to discussions around the policies and offers made by the EU institutions in the fields of energy, environmental protection and urban policy. They also develop and promote local initiatives through the exchange of experience, expertise and the implementation of joint projects.

15.1.2 Peer learning and capacity building

Peer-to-peer exchanges are particularly useful for local communities and small municipalities, which are often left out of wider debates on how to deal with the difficulties of implementing adaptation strategies. They are an opportunity for municipalities to share best practice and lessons learned and a valuable resource in assessing what could be effective in each city. Actions that have been tried and tested in one setting may be seen as novel and innovative, but just as effective in another. The International Urban Cooperation (IUC) programme supports pairings between European cities and global counterparts. For example, the Portuguese city of Vila Nova de Famalicão is working with the US city of Fort Collins on sustainable urban mobility, climate resilience and increasing citizen engagement. The European Covenant of Mayors also facilitates an extensive twinning programme and gives technical support (Box 15.2).

Box 15.2

Covenant of Mayors policy support facility: twinning opportunities and technical support

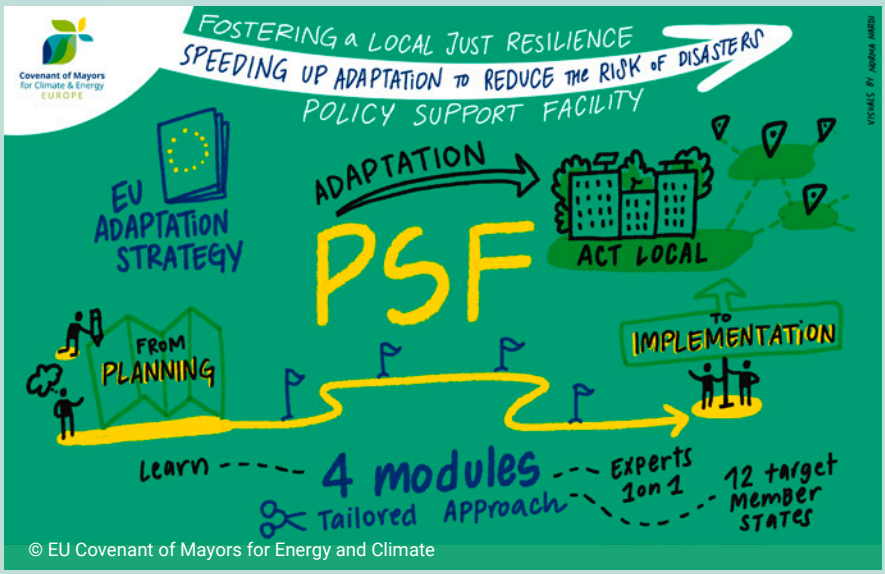
Twinning opportunities: in 2022-2023 the CoM policy support facility (PSF) supported four exchanges dedicated to adaptation in Greece, Italy, the Netherlands, and Spain. Municipalities were matched with peers with similar interests or challenges and had the opportunity to learn from each other, particularly during site visits, taking turns in the roles of mentors and mentees.

Penne (Italy) and Tavernes de la Valldigna (Spain) focused their twinning opportunity on fire management and hydrogeological instability. Tavernes de la Valldigna, a coastal community bordered by the Iberian and Betic mountains and the Mediterranean Sea, showcased policies they put in place to reduce wildfires and preserve tourism in their forests. Penne, a town on the Adriatic side of the Abruzzo region in central-southern Italy, characterised by hot summers and mild winters, focused their visit on urban regeneration and ecosystem preservation. For the Tavernes representatives, Penne's key strengths were the services provided to the public through cooperatives and how local participation engages with global imperatives on subjects such as immigration and the environment.

Technical assistance programme: 36 signatory cities were selected to each identify an adaptation pilot action, to be developed and implemented with the support of two external technical experts over a year-long period.

One community that benefited from this initiative is Cox, in southern Spain. The municipality suffers from summer droughts and occasional flooding during periods of heavy rainfall and is prioritising NBS to improve its local water management system. As part of the technical assistance programme, two experts guided the municipality in the development of an extensive tree planting exercise in an abandoned quarry to increase the area's capacity to retain and capture water. An unintended positive outcome was the high level of involvement of local high school students in the design workshops and tree planting. The activities have not only increased community involvement in adaptation practices but have also raised environmental awareness among local youths.

Figure 15.2 Policy Support Facility illustration



Networks can also promote capacity building at the local level by providing access to funding, technical support or experts, which may be limited in some municipalities. Some, such as the Covenant of Mayors - Europe, also provide guidance on how to access EU funding sources and how to bring local and regional authorities together to develop joint applications. The Spanish Climate Change Office and the Spanish Network of Cities for Climate, for example, organised a course for local technicians to facilitate the integration of climate change into municipal planning, including a set of practical resources for the development of local adaptation strategies. It also served to spread among local authorities the commitment to take action to adapt to climate change.

Box 15.3

Climate change adaptation network in Guadeloupe

The Guadeloupe Climate Change Adaptation Network promotes adaptation to climate change by sharing experiences. It is led by ADEME Guadeloupe (Agence de la transition écologique), in partnership with the Guadeloupe Region, the Agence Française de Développement and the Banque des Territoires. Calls for projects have been made since 2014 to help institutions carry out vulnerability assessments and develop adaptation action plans. Eleven municipalities and a public institution in Guadeloupe are now involved in this process.

To further share and develop this approach, ADEME Guadeloupe recently submitted the CLARAC project (Caribbean Local Authorities Resilience and Adaptation to Climate Change) to the Interreg Caraibe programme. With partners from Guadeloupe, Dominica and Martinique, CLARAC aims to boost the implementation of restoration and conservation actions for strategic ecosystems. It hopes to do so by developing the capacity of local communities to act through networking actions, creating an exchange platform; mobilisation of financial resources serving the objectives of the communities; training technicians and elected officials, and an economic reward system for territories that preserve their environmental heritage.

Every 2 years, the Regional Observatory for Energy and Climate (OREC) publishes a profile of Guadeloupe's vulnerability to climate change and the main climate indicators. Guadeloupe is one of the six demonstrators under the Horizon 2020 TransformAr project.

15.1.3 Fostering research and innovation

Large research projects can bring cities and researchers together and support knowledge development that cities could not always afford on their own, especially smaller municipalities that often do not benefit from high visibility. The availability and sharing of good knowledge and information is a key prerequisite for successful planning, ensuring the right evidence is available for policymaking. Collaboration and partnerships with researchers and stakeholders and peer-exchange activities can improve city access to up-to-date information and data (Giordano et al., 2019). A wide range of EU-funded projects is now promoting collaborative knowledge production in the context of climate change adaptation to support local authorities in developing tailor-made options for urban planning (EEA, 2020b).

The EU Mission on Adaptation aims to support EU regions, cities and local authorities in their efforts to build resilience to the impacts of climate change. A survey of signatories of the EU Mission on Adaptation indicates that knowledge sharing and the development of new skills and capabilities are two critical factors for a successful adaptation process (EC-DG CLIMA, 2023a). In particular, scientific

data and risk assessments are challenges identified among 51% of signatories and knowledge is identified as a specific need by 72% of signatories. The Mission provided EUR 370 million of funding between 2021-23 for adaptation projects to test and scale up adaptation solutions across Europe via the Horizon Europe funding mechanism (Box 15.4).

Box 15.4

Research projects under the EU Mission on Adaptation

REGILIENCE: fosters the adoption of regional climate resilience development pathways. It develops, compiles, shares and promotes tools and scientific knowledge to support European regions in identifying and addressing their climate-related risks.

ARSINOE: aims to create climate-resilient regions through systemic solutions and innovations. It builds an ecosystem for climate change adaptation solutions through a platform co-created and co-designed by stakeholders.

IMPETUS: uses an adaptation framework based on multi-sectorial, multi-scale and multi-impact solutions, and aims to align various governance levels and adaptation policies.

TransformAr: aims to accelerate and upscale adaptation in Europe by developing and demonstrating solutions and pathways to achieve rapid and far-reaching transformational adaptation. The project combines cross-sectoral and multi-scale innovation packages, looking for example at water resilience in 6 demonstrator cities and regions.

CLIMAAX: aims to accelerate the design and implementation of risk management plans for climate adaptation and emergency response across Europe. It will provide substantial financial, analytical and practical support to regions and communities to develop and improve their climate risk assessments.

Regions4Climate: aims to collaboratively develop and demonstrate a socially-just transition to climate resilience. The project will create and implement innovations combining sociocultural, technological, digital, business, governance and environmental solutions to reduce the vulnerability of European regions to the impacts of climate change.

Pathways2Resilience (P2R)**:** takes an innovative, systemic approach to regional climate resilience. It will empower at least 100 regions and communities to co-design visions of a climate resilient future and transformative, locally led pathways and innovation agendas to ensure long-term impact through political commitment.

RESIST: tests adaptation solutions to five key climate challenges: floods, droughts, heatwaves, wildfires and soil erosion, in four demonstrator regions and eight twinning regions across Europe.

In the Netherlands the unique partnership between the Municipality of Amsterdam and the Amsterdam Metropolitan Institute (AMS) is addressing urban challenges through collaboration, funding, networks, and citizen engagement. The AMS Institute was founded in 2014 by three universities: Delft University of Technology (TU Delft), Wageningen University and Research (WUR) and Massachusetts Institute of Technology (MIT). The AMS Institute is a networking organisation that works with

a broad coalition of stakeholders, including academic researchers, industry, civil society, policy makers and all organisations that are part of the urban innovation community. Another example is the Horizon 2020 REST-COAST project, where the City of Venice is bringing together public administrations, research centres and universities (e.g. Ca' Foscari University, the CMCC Foundation, the University of Padova and CORILA) and other relevant stakeholders, to plan a restoration strategy for the entire lagoon.

Increasingly European funding programmes are prioritising dissemination of the knowledge and tools developed through projects, for broader use and benefits (EEA, 2020b). This is often achieved through online platforms such as Climate-ADAPT. Most EEA member states have created online climate adaptation platforms to coordinate information and knowledge sharing among municipalities. One such example is Belgium's policy wide Flemish web portal on climate change adaptation. Thanks to the Horizon 2020 Highlander project, Italian municipalities now have access to a tool that allows them to explore local annual or seasonal anomalies of daily maximum, minimum and mean temperatures, from the last 40 years.

15.1.4 Engaging with the private sector

Engaging and networking with the private sector can help urban local authorities gain critical support and even financing for pursuing climate goals. These collaborations can also create new business opportunities from climate actions (Heikkinen, 2022). A primary motivation for local authority involvement of private sector partners in the adaptation process is that they can implement adaptation measures (EEA 2022). In many cases, they are already working on adaptation efforts and can be a source of finance for adaptation, which is one of the most critical aspects in the implementation phase of adaptation measures. Some cities have developed city-to-business networks (CBN), such as Climate Partners in Helsinki, where businesses are cooperating with one another and the city. Other strategies include voluntary investments, the creation of guidelines for green space development and incentives for upgrading existing structures. For instance, this is what the city of Madrid planned under the project Madrid + Nature, which aims to increase its adaptive capacity.

City-business collaboration can also boost the development of green jobs and skills and accelerate the transition to a low-carbon economy while generating municipal revenue. Recognising the need to work together to tackle climate change, cities are moving beyond mere stakeholder consultation, instead prioritising real collaboration between communities and businesses to co-create projects that empower residents and lead to greater support for city climate actions (C40, 2023a).

Box 15.5

C40 network initiatives to promote cooperation between cities and businesses

City-Business Climate Alliance (CBCA), in collaboration with the CDP and the World Business Council for Sustainable Development (WBCSD), provides cities and business leaders with a platform to convene, set joint commitments, co-create and implement projects that help cities deliver on their climate action plans.

City Solutions Platform (CSP) is an innovative co-creation methodology developed in partnership with CLEAN, a world-leading clean tech cluster. It facilitates pre-procurement engagement with global and local climate solution providers, including large corporates and consultancies, SMEs, academia and NGOs, to co-create innovative, scalable and tangible solutions.

New Economies and Innovation Forum (NEIF) creates a space for experimentation where C40 member cities explore how to better empower community and business networks.

Reinventing Cities is a global competition for innovative ideas to transform underutilised sites into beacons of sustainability and resiliency that act as a showcase for future zero-carbon urban developments.

15.2 What are the challenges to overcome?

The need to continue to improve access to knowledge is commonly cited by European municipalities. Lack of knowledge can sit at different levels. In some cases it may be a lack of knowledge about climate change and its impacts, but in other cases the relevant people in the local community may not be aware of the existence of information, or may not be able to obtain it from national or regional authorities (EEA, 2020b).

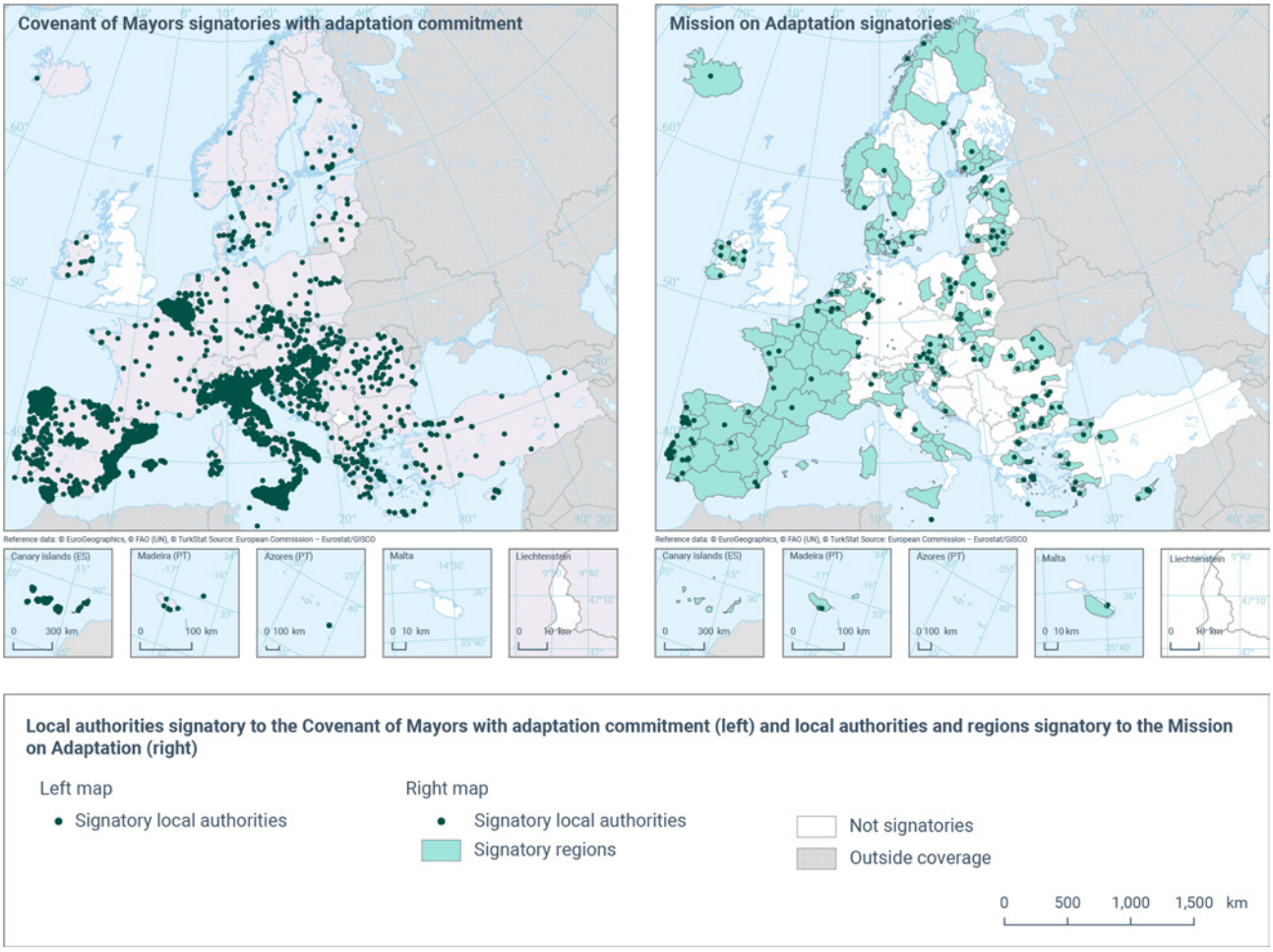
Platforms, tools and methodologies need to be flexible, effective and adaptable. They should be user-friendly and provide clear messages and guidance to ensure inclusive participation. They should respond to the specific urban challenges and needs of cities. Sometimes the proposed methodologies are the same for all regional and local authorities in Europe and thus may be useful for some but not for others. While there are many benefits to the growth of city networks and initiatives aimed at local authorities, their proliferation can also lead to overlaps between the issues addressed and an excessive draw on the time of network members. It is critical that existing initiatives are accounted for in the design phase of new efforts, with a view to synergy and coordination. The lower the number of similar initiatives, the higher the added value.

Linked to the above, the strategic use of networks at different levels of governance is not always possible for all cities, because it requires human, time and financial resources and it is often easier for a city that already has some reputation as a climate leader than for a relatively unknown city (Heikkinen, 2022). Participation in networking is only considered meaningful if it can be active, which means that the availability of human resources is a limiting factor. This closely relates to funding limitations. The lack of direct funding to network members under some of the initiatives is reported by many cities as a missed opportunity (CoR, 2020).

15.3 Trends and Outlook

At the European level, there has been an increase in cooperation between cities and different actors, sectors and disciplines. Over the years, an increasing number of networks and initiatives have emerged to support cities in their adaptation efforts, varying in scale, scope, target audience and the services offered. The Covenant of Mayors, with an increasing number of signatories with adaptation commitment, and the Mission on Adaptation, with currently 308 signatory regions and local authorities, are two notable examples (Map 15.1).

Map 15.1 City engagement in European initiatives on adaptation to climate change



Source: EU Covenant of Mayors for Energy and Climate, Mission on Adaptation Secretariat.

An increasing number of urban initiatives and research projects are also creating space for learning and exchange, to allow the sharing of diverse experiences and forms of knowledge. Cities are formalising cooperation across borders at an unprecedented rate, i.e. 'city networks' now form a vast ecosystem of global partnerships between local authorities (Acuto and Leffel, 2021).

Local administrations and policy makers now have access to numerous tools, datasets, knowledge and professional support to define best practices for their specific urban context. Upgrading existing platforms and materials and the

introduction of new portals and innovative approaches help to facilitate climate change adaptation planning in terms of increasing the engagement of local stakeholders, greater sharing of skills and experience, wider access to scientific knowledge and increased funding opportunities. A variety of actors, both national and international, can contribute to the process of developing the capacity needed to enable successful urban adaptation planning through appropriate knowledge, skills, expertise and financial resources. Action is needed to collect, store, share and link information at the local level and provide more sophisticated urban measurements (Wachsmuth et al., 2016).

The importance of a broad system of cities working together on climate adaptation has emerged from wider global conversation on building climate resilience. The process of creating innovative tools and platforms that span a global network of engaged cities, provinces and municipalities of different sizes, characteristics, risk profiles and locations that can help and learn from each other, must continue. This momentum will also facilitate dialogue on urban adaptation at the international level, with the ultimate goal of bridging governance scales to elevate urban and local authority voices into the global arena.

16 Placing citizens at the centre

Key messages

- It is critical to involve citizens in planning and implementation because they can provide important information about the local impacts of climate change and the appropriateness of specific adaptation measures.
- Public resources and the motivation to participate in climate adaptation planning vary significantly. It is essential to offer different venues and forms of engagement.
- Cities should base their public engagement strategies on knowledge about the needs and wishes of different stakeholder groups. It is particularly important to engage vulnerable groups to ensure equitable outcomes of climate adaptation planning.

16.1 Why do we need to place citizens at the centre?

Placing citizens at the centre of the process of transformation of cities towards societal resilience is fundamental to its success. The public must play a role at all stages of planning and implementing urban climate adaptation responses. The chances of successful implementation increase when adaptation measures build on knowledge about the context in which they will be implemented, including the needs and capacities of those who will be affected by, or who must contribute to, adaptation (Schneider and Ingram, 1990; Hill and Hupe, 2014; CDP Worldwide, 2022). When citizens are engaged in adaptation planning, adopted plans and measures benefit from the contextual knowledge they bring to the table, which generally enhances the likelihood that the plan will be implemented as intended (Khatibi et al., 2021).

Citizens may actually push climate adaptation onto the local policy agenda, asking policy makers to implement climate adaptation measures, often following extreme climate-related events (Birkland and Schwaeble, 2019). Their involvement may contribute to more effective, efficient and potentially equitable climate adaptation responses (Uittenbroek et al., 2019; Mees et al., 2012). Public involvement in local adaptation planning through participatory, co-creation processes potentially sparks innovation and more informed actions, which increases the fit of adaptation plans and community resilience.

Innovation occurs when participatory processes bring together actors with different interests, experiences and knowledge (Bauer and Steurer, 2014). Engaging vulnerable groups in particular may help cities address social inequity and increase social resilience as well (CDP Worldwide, 2022). It may also prevent maladaptation, i.e. the planning and implementation of measures that create new problems or shift problems to other areas (Schipper, 2020). Involving citizens in adaptation planning, when done right, also generally increases the perception of public decision processes as legitimate, leading to greater acceptance of the measures adopted among

affected groups (Cattino and Reckien, 2021; Uittenbroek et al., 2019). In contrast, the lack of public acceptance of a project can stall or prevent its implementation. Citizen engagement in adaptation planning may therefore speed up implementation.

At the individual/household level, citizens can take action to protect their personal health or property against flooding, drought, heat, wildfires, or similar extreme events related to climate change, or at least take out insurance policies against some of these hazards (EEA, 2020b; Osberghaus and Hinrichs, 2021). Yet, citizens are not necessarily aware of their vulnerability or personal responsibility with regard to climate change. Moreover, some citizens do not have the resources, be they knowledge or financial, to undertake necessary actions. Thus, to ensure effective and equitable responses at the citizen level, municipalities need to engage with them, prompting and enabling them to undertake climate adaptation responses. Public engagement is important for the upscaling of adaptation solutions because engagement processes promote awareness about the need to adapt, which is necessary for households to implement their own adaptation actions. Moreover, adaptation measures that evolve through citizen input are more likely to spread and be implemented effectively (Uittenbroek et al., 2019). Engaging the public in climate adaptation can also leverage private funding of local climate adaptation efforts, for instance through crowdfunding.

16.2 Citizen awareness and grassroots initiatives

Public engagement requires awareness about climate change. People who have knowledge about climate change and adaptation are more likely to participate in adaptive activities (Khatibi et al., 2021). Awareness of climate change has risen over the last decade and is currently generally high among the Europeans. In the 2019 and 2021 Eurobarometers, 8 out of 10 Europeans scored climate change as 'a very serious problem', while 15% considered it 'a fairly serious problem'. People from Mediterranean countries, including Cyprus, France, Greece, Italy, Malta and Portugal, gave the highest average scores to the seriousness of climate change, while countries in the Baltic and central European areas gave the lowest scores. However, when asked to point to the most serious problem facing the world right now, people who live in the northern or western parts of Europe are more likely to point to climate change than those living in the eastern and south-eastern countries.

Climate change also spurs concern. According to the 2021-22 EIB climate survey (EIB, 2022b), nearly half of young Europeans (48% in the 15-29 age group) believe they will certainly or probably have to move to a different region or country in the future due to climate change, while 29% (across all groups) think they may have to move. This belief is strongest in France and Latvia (37%) and Spain (35%). The 2023 Eurobarometer survey on climate change showed that 37% of Europeans feel personally exposed to environmental and climate-related risks, varying from as much as 64% in Portugal to 9% in Finland. At the same time, nearly two-thirds (63%) of Europeans tend to, or totally agree that adapting to climate change can have positive outcomes for citizens, although this is down from 70% in 2019 (EC, 2023c).

The confidence that climate adaptation carries benefits for people differs slightly across socio-demographic groups. Importantly, people who have difficulties paying their bills 'most of the time' are less likely to agree that climate adaptation can have positive outcomes (57%), than people who do not struggle to pay their bills (63%). People in the middle age category (25 to 54 years old) are more positive about the outcomes of climate adaptation (65-67%) than younger or older residents (58-60% are positive about climate adaptation).

People across Europe are organising grassroots initiatives to mobilise climate action. Many of these initiatives revolve around educational activities, but also the implementation of practical measures targeting both climate mitigation and climate adaptation.

- Barcelona En Comú: A citizen-led political party in Barcelona, Spain that has implemented a number of initiatives to promote climate adaptation. The party has prioritised urban green infrastructure and has worked to improve access to public transportation and reduce car use. It also supports citizen-led initiatives that promote sustainability and climate adaptation, such as community gardens and bicycle-sharing programmes.

- Transition towns: a network of grassroots initiatives in the UK that aim to build community resilience to climate change by promoting sustainable practices and reducing reliance on fossil fuels. Transition towns organise community events, create educational resources and support citizen-led projects that promote sustainability and climate adaptation.

16.3 Citizen engagement in adaptation

Citizen engagement in climate adaptation may be bottom-up, where citizens (individually or collectively) take adaptation initiatives or ask local decision-makers to do so. However, the engagement of private actors may also require a deliberate push from local authorities.

16.3.1 Engaging citizens in planning

Successful planning and implementation of climate adaptation strategies cannot rely on citizen initiatives alone. It also requires city efforts to actively engage citizens in city policymaking processes. While 81% of local action plans in selected European cities identify the stakeholders, only 40% indicate the public as a stakeholder and only 20% indicate community and neighbourhood groups as stakeholders (Reckien et al., 2022). Similarly, only 20% of actions reported by the Covenant of Mayors signatories in 2022 mentioned citizens as stakeholders (CoM, 2022 Dataset). Recognition of the public as stakeholders varies greatly across Europe, with 56% of local plans in southern countries mentioning the public as stakeholders, western countries at 44%, northern countries at 43% and central and eastern countries at only 27% (Reckien et al., 2022).

Comparing the quality of adaptation plans over time, Reckien et al. (2023) note that public participation has currently improved from their participation levels for plans adopted between 2015 and 2018, but they conclude that participation scores remain 'at a very low level'. The City of Galway in Ireland, received the highest score of all plans for participation because it involved a wide range of stakeholders in its planning process.

Despite the slow movement towards participatory adaptation planning, European cities offer many examples of citizen engagement initiatives. These range from surveys on citizen views (Box 16.1) or involving citizens in data collection in citizen science projects to more elaborate forms of participatory or collaborative planning.

Citizen science projects engage citizens in climate adaptation planning as providers of data. An additional benefit is awareness raising. In Germany, citizens are actively involved in tracking the spread of potentially disease-spreading mosquitoes, through the 'Mosquito Atlas', which can supplement traditional monitoring methods to function as an EWS for planners and researchers.

Box 16.1

Citizen survey as an input to a climate adaptation plan, Kispest district, Hungary

In 2015, when the Kispest district in Hungary set out to make a Sustainable Energy and Climate Adaptation Plan (SECAP), it conducted an online citizen survey to engage citizens in climate adaptation planning and to get district-level data on the experiences of climate-related hazards. Respondents were asked to identify what areas of the city most urgently needed action and what climate adaptation actions they would prefer to see implemented. This information was integrated into the SECAP, including green spaces, which was one of the citizens' preferred actions. Other actions that were developed in response to the citizen survey were thermal insulation of buildings to protect citizens against extreme heat and revitalisation of local gardening initiatives to secure local food supplies.

Surveys represent a relatively low-intensity approach to citizen involvement and have the potential to reach many citizens broadly. However, response rates in public surveys are often relatively low. In Kispest, only 202 responses were received, yet were considered representative of the district's population.

Many cities also experiment with more elaborate forms of engagement of community stakeholders through participatory planning approaches. An early example of this in area regeneration is what came to be known as the Eco-city Augustenborg in Malmö, Sweden. Initiated in the late 1990s the aim of the project was to turn this previously deprived area into a sustainable neighbourhood and because the area suffered from flooding, a specific objective was to create a sustainable urban drainage system. The city involved residents of the area extensively, including at regular public meetings, community workshops and even gatherings at sports or cultural events. Nearly 20% of the tenants in the area participated in dialogue meetings and school students were involved in developing a rainwater pond that doubles as an ice rink. This community involvement, which was both wide, deep and ongoing, resulted in broad local support for the redevelopment activities. Among these activities was the disconnection of rainwater from the conventional sewerage system and channelling of the rainwater through ditches, wetlands and ponds. In addition, a total of 11,000m^2 of green roofs were installed in the area. The area no longer experiences flooding and the participatory approach continues with residents being involved in further green activities such as urban farming.

In Sevilla, the revitalisation of a public space took place in the Cartuja Technological Park to ensure its liveability, especially during increasingly hot summers. This required cooperation between public and private partners, including the City of Sevilla, the University of Sevilla, as well as businesses in the technological park, civil society organisations and other potential users of the public space, all of which have different needs and stakes in the park. Through an extensive consultation process lasting more than 2 years, stakeholders came up with a new governance model for the public space, a 'flexible agreement' for its co-management, which can also be implemented in other areas of the city. Key lessons from this project are to involve stakeholders, especially internal stakeholders, early in the process and that the process requires flexibility from its partners and a predetermined evaluation period.

One approach to engagement is participatory budgeting, where community members are actively involved in decisions on how public funds are spent. Typically, a state or local government sets aside a portion of the public budget and invites community members to make proposals and then decides which ones to fund. The method was developed to improve the democratic functioning of governments and does

not necessarily target climate or climate adaptation. However, some Europeans cities, including Lisbon and more recently Vienna (OECD, 2022), have implemented participatory budgeting specifically focused on climate and the environment. A study of 15 cities around the world, including four European municipalities, found that the share of projects targeting climate varied from 2% to 100%. Among the four European cities included in the study, Bordeaux, France, had the highest share of climate-related projects (66% of 41 projects), while Molina de Segura, Murcia, Spain, had the lowest share (only 2% of 188 projects) (Cabannes, 2021).

Box 16.2

Green participatory budgeting, Lisbon, Portugal

The Portuguese capital, which in 2008 was the first capital to introduce participatory budgeting at municipal scale, recently chose to focus its participatory budget 'exclusively on proposals that contribute to a more sustainable, resilient and environmentally friendly city' (referred to as green participatory budgeting). Citizens are engaged in two ways:

1. they can submit proposals, and discuss and vote for them on an online platform;
2. they can participate in person through citizen assemblies, workshops and polling stations.

There has been a move to diversify participatory avenues to ensure broader representation and to encourage participation from youths, seniors and immigrants. The winning projects are included in the City Council's Plan of Activities and Budget.

In 2021, EUR 2.5 million was made available for participatory budgeting, to be distributed within themes related to climate, climate adaptation and the environment, including sports, in order to contribute to the implementation of the European Ecological Pact, Climate Action Pact and the European Capital of Sports. Among 251 proposals, 42 related specifically to climate adaptation and climate mitigation.

Participatory processes may benefit from using decision tools, including visualisation tools, to facilitate the dialogue between different stakeholders. The Climate Resilient City Tool developed by Deltares is an interactive online tool that can be used to explore and compare different adaptation measures. In workshops with multiple stakeholders, for instance, it can facilitate dialogue about the pros and cons of different measures.

Augmented Reality (AR) and Virtual Reality (VR) tools are also increasingly proposed to aid stakeholder involvement and decision processes. Some suggest they may be particularly useful for the engagement of younger people in participatory processes (Saßmannshausen et al., 2021; Reaver, 2023). The positive experiences with the use of visual tools suggest that experimenting with different formats in participatory planning may appeal to a broader range of people than traditional verbal dialogue meetings. Art, humour and even play may attract more people. Initiatives such as the New European Bauhaus point to the transformative power of art and other creative forms of expression in developing sustainable urban areas.

Box 16.3

Tejiendo La Calle: knitting the street, Extremadura region, Spain

Among the many local projects highlighted under the New European Bauhaus initiative is 'Tejiendo La Calle' by Marina Fernández with the weavers of Valverde de la Vera in Spain's Extremadura region. This initiative involves citizens in knitting structures, made primarily from repurposed plastic bags, that are mounted over streets to provide colourful shade from the heat while also offering spatial, social and cultural community.

Figure 16.1 'Knitting the street' interventions

16.3.2 Engaging citizens in implementation

Public strategies count on households and businesses taking precautionary measures to protect themselves and their living spaces, but municipalities may have to create awareness and knowledge about what measures to take. Cities can implement information campaigns using mass media and social media, but they can also offer education programmes and workshops to share knowledge about concrete measures and good practice.

Citizens should also be engaged in the implementation of collective or communal measures, where possible. The coastal town of Juelsminde, Denmark, faces tidal flooding due to rising sea levels. Each property owner is responsible for protecting their property against coastal flooding and erosion. Assisted by the municipality of Hedensted, in which Juelsminde is located, residents have established a dyke association, which will be responsible for implementing measures to protect the coast against tidal flooding. The association has 1,400 members, including the

municipality. To ensure that the measures also align with the more general interests of residents, such as continued access to water both visually and physically, a second initiative called 'Property Owners Decide' has been set up to help develop specific ideas on how to implement coastal protection.

In Athens, Greece, in an effort to engage citizens in the maintenance of new green infrastructure, they have been invited to adopt and water some of the 600 new trees planted every year. Citizens can sign up through an app or a platform, which offer specific advice on how to care for the tree and a reminder of when the tree needs to be watered. This project started as a pilot in 2019 and has continued since. The city won a golden award for this climate change action in the Best City Awards in 2021.

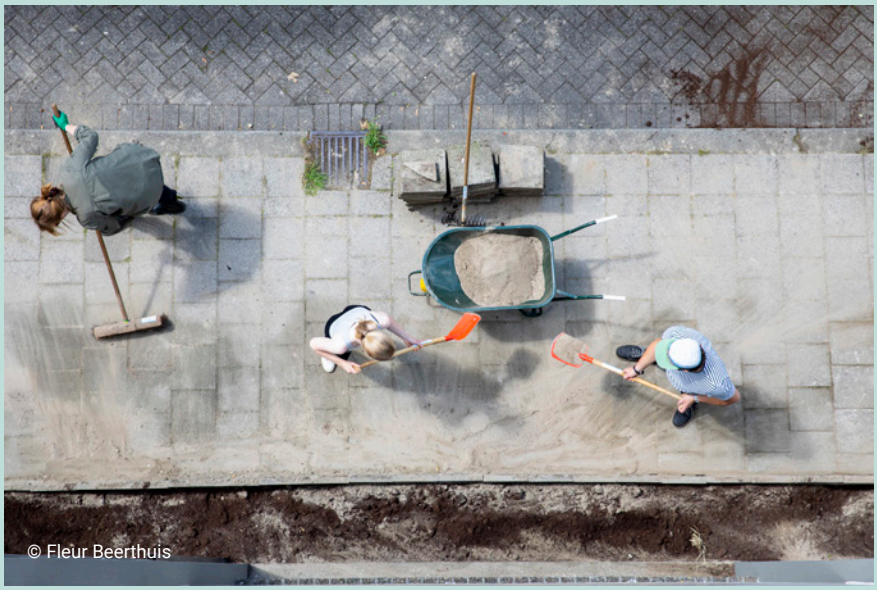
Box 16.4

Playing with competition: replacing paving tiles with greenery in Dutch cities

In the Netherlands, cities challenged citizens to remove their front yard tiles and replace them with greenery. The campaign was supported by the Dutch infrastructure Ministry and the city councils of Amsterdam and Rotterdam. The campaign played on rivalry between cities. Replacing paving tiles with greenery contributes to carbon reduction, flood risk and heat stress reduction and increased biodiversity. The campaign increased the amount of green space by 140,000m^2.

More than 80 local authorities participated in the campaign, often actively urging their residents to remove the tiles. The cities of Amsterdam and Rotterdam invoked the well-known rivalry between the two cities to provoke their citizens to participate. Councillors of the two cities followed the progress and used social media to encourage their citizens. In the end, Rotterdam inched out Amsterdam by pulling up 47,942 tiles versus 46,484 tiles. However, both cities were beaten by The Hague, with the small city of Rugphen taking the prize of removing most tiles per capita.

Figure 16.2 Repaving activities in the Netherlands



16.3.3 Engaging who: how to ensure involvement of the most vulnerable

Resilience at the local level requires equitable protection of citizens, and if vulnerable groups are not involved in adaptation planning, adopted measures may be ineffective or socially unacceptable (Cattino and Reckien, 2021). While cities do, to some extent, analyse the impact of climate change on vulnerable groups and plan adaptive measures directed at specific groups, who may be vulnerable, their plans only rarely mention the involvement of such groups in the production of local adaptation plans (Reckien et al., 2023). On average across European local adaptation plans, 'vulnerable persons' are mentioned as participants in just 2% of these plans, although cities in southern Europe are more likely to mention the involvement of vulnerable persons in planning. None focus specifically on people who are vulnerable due to poverty and only 4% of plans mention the participation of particular population groups.

In one example of involving potentially vulnerable people in adaptation planning, the Slovakian cities of Košice and Trnava conducted surveys among their residents for input to a plan addressing vulnerability to heat related climate hazards. The survey covered public awareness about heat waves, observations on the need for local heat adaptation planning and their preferred adaptation measures. Public input, along with objective social vulnerability indicators, informed the local strategy.

16.4 What are the challenges to overcome?

Placing citizens at the centre of local climate adaptation requires commitment on the part of policymakers. It also requires municipal staff who are skilled in participatory planning processes. All of this requires capacity building at the local level.

For innovative solutions to materialise, participants must be given leeway and influence, which sometimes conflicts with the steering ethos of public agencies that are ultimately accountable to politically elected decision-makers (Agger and Sørensen, 2018). Thus, it is important that local policymakers, politicians and administrators, define what space they will allow for participatory governance processes, when to include non-governmental actors and how these processes relate to the local representative democratic decision-making system.

Administrators need to know that they have the backing of politicians to engage the public in impactful collaborative processes. Transparent principles about when and how to participate and with what objectives, will help prevent disappointment among citizens and promote both participation and its potential benefits (Fung, 2015). Generally, studies of citizen engagement show that participatory processes should target decisions where citizens have a non-trivial stake, be designed in a manner that seems meaningful to citizens and should have some impact on final decisions. This suggests that involvement should be timely and take place throughout all phases of the policy-making cycle (Fung, 2015; Jäntti and Kurkela, 2021). If citizens perceive public participation as perfunctory, this may reduce trust in the local government, compromise the legitimacy of decisions and discourage participation (Font et al., 2018; Arnstein, 1969).

Local administrations must develop new skills in collaborative planning. Case studies among European cities indicate that cities, even in countries such as the Netherlands and Sweden with strong participatory traditions, still have a long way to go in developing systematic and deliberate participation approaches (Uittenbroek et al., 2019; Glaas et al., 2022). Traditional planners can receive training in new methods and mindsets but departments responsible for climate adaptation can also hire administrators with different professional backgrounds, such as anthropologists or sociologists, who are trained in interactive approaches. For instance, the Danish

municipality of Hedensted was heavily involved in facilitating citizen involvement in coastal climate adaptation. To build the necessary capacity, the municipality participated in workshops and study trips on co-design and citizen involvement organised under the EU-Life project, Coast-to-coast climate challenge.

Ensuring that all affected groups are involved in climate adaptation planning is another challenge. The capacities, interests and incentives of different groups all influence climate action plan delivery as do social, political and cultural norms and values. Stakeholders who see themselves as disadvantaged by a climate action, or who do not have the capacity to implement it, may affect or even block implementation (Wamsler, 2016). Moreover, engaging socio-economically vulnerable groups is crucial to ensure equitable outcomes of urban climate adaptation. Engaging broad groups of stakeholders and particularly hard-to-engage groups such as youths or the disadvantaged citizens, may require new forms of involvement, tailored to their needs (Nyseth et al., 2019).

Cities can experiment with different arenas for engagement, for instance moving interactions from municipal offices into the streets, schools or other gathering places of affected communities. Generally, participation formats should be easy to access and use (Jäntti and Kurkela, 2021), including online interactions, which may appeal to younger audiences and families with small children. In disadvantaged neighbourhoods, participation can be fostered through the activities of community activists, government frontline workers who know the communities, or other intermediaries (De Graaf et al., 2015).

16.5 Trends and outlook

Awareness of the impacts of climate change is generally high among Europeans, but awareness about specific impacts at the local level and knowledge about climate adaptation measures is low. As extreme climate events increase in frequency, awareness about the need for sustainable climate adaptation planning is expected to increase. The summer of 2023 has demonstrated what the future holds with widespread droughts, flooding, extreme heat and wildfires (World Meteorological Association (WMO), 2023) calling for large-scale emergency measures but also highlighting the need for long-term precautionary measures. This makes the need for municipalities to involve citizens in climate adaptation planning even more urgent, to ensure coordinated and efficient action across private and public actors, leading to more resilient communities.

Climate adaptation planning at the local level is also expected to increase its focus on equitable outcomes, targeting those groups most vulnerable to climate change. These include the elderly or people with health problems, who tend to suffer most in extreme heat or who are less mobile during extreme weather events, and the socio-economically disadvantaged whose health risks are higher due to poor living conditions and whose financial means to protect themselves and recover from extreme events are limited (EEA, 2022e).

Younger people and children may be particularly vulnerable to mental health problems stemming from direct and indirect experiences of extreme weather events and from concerns about the future of the planet. Involving the youth in adaptation planning could also help build their sense of self-efficacy and coping capacity, which may reduce the mental stress from feeling disempowered (European Climate and Health Observatory, 2022). Youth-led initiatives have focused primarily on climate mitigation, but younger people are now also organising around climate adaptation (Box 16.5).

Box 16.5

Youth and climate change

Young people are concerned about climate change. Since 2018, with Fridays for Future as the most visible youth-led initiative, students have organised repeated school strikes around the world, using this platform to call on policymakers to take climate change seriously and implement significant policy measures to combat climate change. This has contributed to invigorating climate activism and, in some cases, propelled it to the top of electoral agendas. Youth involvement in climate adaptation planning is less visible, but there are significant examples:

- **Global Youth Climate Network/Generation Climate Europe** and the **Climate Reality Project** are working to provide education and training programmes for youth on climate adaptation. These programmes teach young people about the impacts of climate change and how to take action in their communities to build resilience to climate change.
- **The Youth Arctic Coalition** is conducting research on climate impacts in the Arctic region and advocating for policies that promote climate adaptation in this vulnerable area.

The international organisation, the Global Center on Adaptation (GCA) has organised a series of regional 'Youth adaptation forums', gathering youth organisations, student organisations, international organisations, the private sector and UN agencies, to increase the influence of young people on climate adaptation actions and develop solutions with their input. More than 1,600 people from 145 countries have participated. These regional fora were followed up with a Youth Adaptation Forum in Bonn, Germany in 2023, where participants developed a number of proposals on how to further include and engage the youth in climate adaptation efforts.

17 Putting data to work

Key messages

- The use of high-quality, consistent and reproducible data is essential throughout the planning, implementation and monitoring stages of adaptation plans. Knowledge on specific conditions for adaptation actions is key to avoiding maladaptation.
- More and more local data are becoming available (e.g. from smart sensors and citizen science campaigns) and while the use thereof may be in its initial stages in many cities, much can be learned and reproduced from example projects. Local initiatives to create indicators may also be reproducible at the European scale.
- It is important to set up a monitoring and evaluation framework at city level. Quantitative assessments of the implementation and effectiveness of measures (including cost-benefit analyses) help to adjust approaches where needed and to make the case for upscaling successful local initiatives.

17.1 Why are data so critical?

The increasing recognition of the need to integrate adaptation in society's response to climate change has led to an understanding of the need for making targeted, justified, effective and cost-efficient policy decisions on adaptation (Mäkinen et al., 2018). This chapter explores the role that the ever-increasing amount of available quantitative and qualitative data plays, or should play, in building urban resilience across Europe.

Targeted data are needed in every step of the adaptation policy cycle, as represented in the Urban Adaptation Support Tool. When preparing the way for adaptation, an important first step is to identify and collect existing data on current and future climate-related impacts and risks. In the second step, climate change risks and vulnerabilities need to be assessed, ideally based on spatially detailed local data sources and taking into account knowledge gaps and uncertainties. Existing data sources can be used to identify suitable adaptation options. These options need to be assessed regarding their effectiveness, costs and benefits in order to select the most suitable ones for the local situation. This requires detailed local data analysis, the results of which will vary significantly across Europe due to local geographic, climatic, economic or social factors.

17.2 Monitoring and evaluation of adaptation actions

When implementing an adaptation plan, data are needed to define the timeline for implementation, the estimation of resources and the design, monitoring and evaluation framework. A monitoring, reporting and evaluation (MRE) system needs to be put in place to define whether objectives are being achieved or not, if measures

implemented remain effective and if this is being done in a cost-effective and equitable way. Effective MRE systems can help identify when and where further efforts are needed, including the identification of priorities related to those needs and point to knowledge gaps, triggering further risk and adaptation assessments. The implementation of actions may then need to be adjusted accordingly.

The provision of a common pan-European framework would help set up and improve adaptation monitoring programmes. The use of Key Type of Measures (KTMs) to report on actions and measures for adaptation is encouraged to systematise and track adaptation (Leitner et al., 2021). Eight EU Member States (Austria, Czechia, Denmark, Estonia, Germany, Hungary, Portugal and Slovakia) already did so and reported a total of 228 KTMs in 2021. Although reporting KTMs is a first step in a common methodology, this does not provide insight into the progress in implementing these measures.

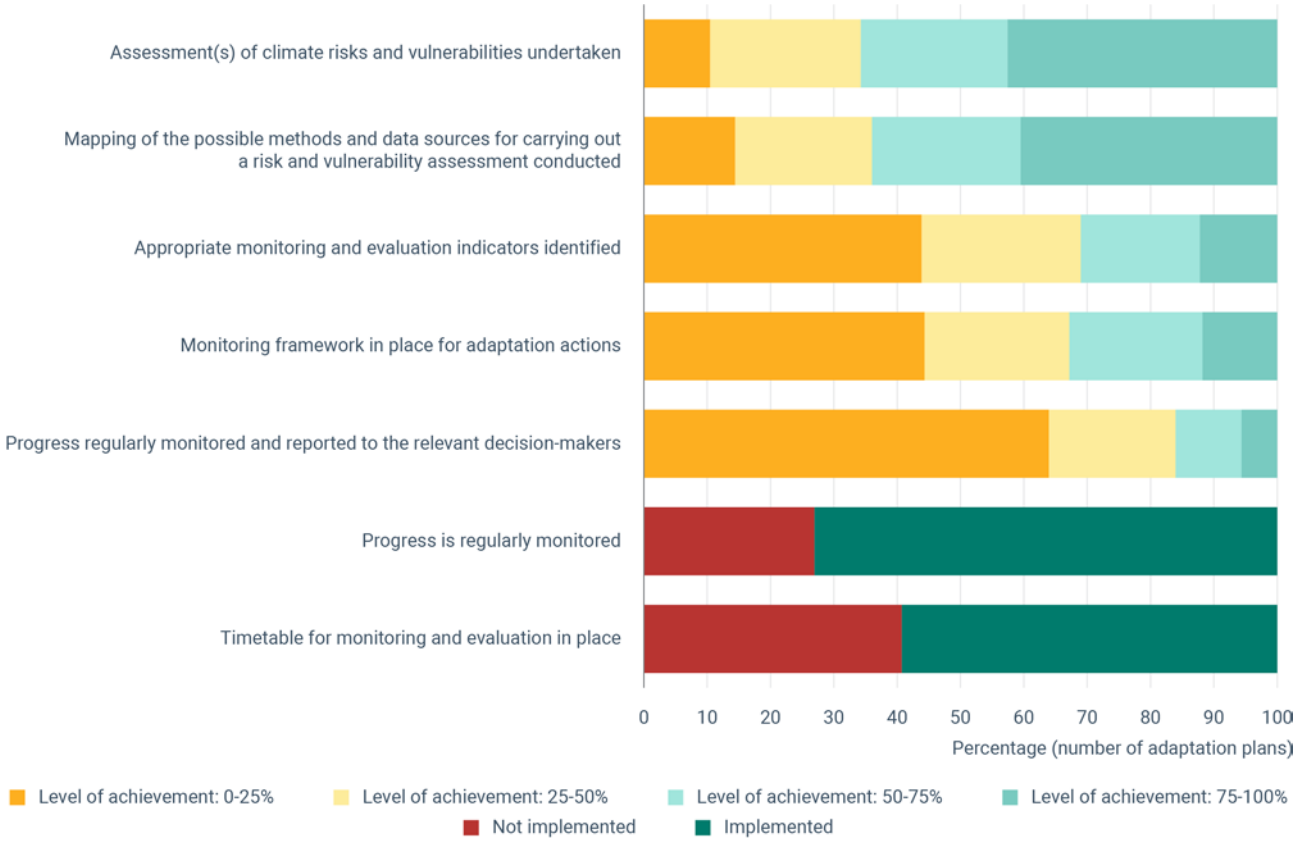
Overall, only 44% of climate action plans identify a responsible party for the implementation of adaptation plans - most likely the same as the one that wrote the plan, although possibly a different department in the municipality (Reckien et al., 2023). 15% of these plans indicate the involvement of external consultants, although notably not in any of the plans coming from northern or central/eastern European cities. Good coordination among the stakeholders involved is essential in ensuring the right feedback is given and the implementation process is adjusted according to the continuous evaluation planned in the monitoring and evaluation strategy.

Cities and regions are developing their own adaptation monitoring and evaluation indicators and tools. This has the advantage that they can choose indicators that help guide them and are contextually appropriate. But it makes aggregation or comparison across cities and also across different kinds of measures very difficult. Only an estimated 55% of European local climate action plans analysed defined metrics which could be used to measure progress. Of the indicators included in these plans, 72% related only to the output of the actual action taken rather than the targets set or outcomes expected. In fact, only 2% of indicators were linked to a specific target (Ramboll, 2024).

There are initiatives to help cities set up effective MRE systems, for example from ADEME in France, or from European research projects. A good example of a climate adaptation plan with a clear set of monitoring indicators is made by the City of Barcelona, Spain. For five identified priority areas, 18 lines of actions are defined with a number of short-term, medium-term and long-term actions and a set of monitoring indicators. The City of Antwerp, in Belgium has also made a detailed climate adaptation plan, with a large set of adaptation actions. For each action, an overview table is filled in, detailing responsibilities, goals, success factors, motivation, methodologies, targets, implementation period, estimated results, estimated financing needs, etc. This approach makes it very easy to regularly evaluate progress and adjust efforts if needed.

Figure 17.1 shows the share of local climate action plans from 167 European cities (out of 327 reviewed), which self-reported on their MRE system (Reckien et al., 2022). The majority of cities with a climate adaptation plan do include an MRE system, but only a minority have clear indicators and objectives defined.

Figure 17.1. Status of monitoring and evaluation of adaptation actions in European cities, based on three datasets



Notes: The figure combines data from the Covenant of Mayors (local authorities reporting on level of achievement in adaptation steps relevant to MRE (0-100% completion). For comparison, also reporting cities responses to whether progress is regularly monitored (CDP, 2022) and whether a timetable for MRE is in place in the local climate action plan (Reckien et al., 2022) were added (in both cases either implemented or not)

Sources: EC-JRC, 2022, CDP, 2022 and Reckien et al., 2022.

17.3 Making the most of available local data

In past years, cities have increasingly invested in data analysis when designing and implementing climate adaptation plans. An evolving data application area that can be used in the context of city climate adaptation plans is the use of big data, the 'internet-of-things' and smart sensors in the framework of a smart city strategy. A smart city is defined as a municipality that uses information and communication technologies (ICT) to support the management of city assets and services. Smart cities rely on an 'Internet of Things', which is a network of sensors, automated or unmanned systems, devices, appliances, processors that can communicate autonomously (receiving and sending data) and collect real-time data from sensors and other installed devices in different areas of the city. The insights gained from those data are then used to manage assets efficiently, share information with the public and improve both the quality of government services and citizen welfare. However, the term 'smart city' remains unclear in its specifics and therefore, open to many interpretations (Cavada et al., 2014). In addition, the normalisation of the collection and aggregation of big data by governments raises issues of privacy and autonomy (Finch and Tene, 2016).

An interesting application of cheap, smart sensors is in the context of citizen science campaigns. Help from citizens is extremely valuable to gather 'big data' on the spatial distribution of environmental variables. Citizen science projects do not just target the collection of hard datasets to advance science, they also have a softer side, since they can raise awareness by providing information to the general public. An example is the 'Curieuzeneuzen Flanders' project, in which 20,000 citizens measured the air quality near their own house (Box 17.1). Input from citizens can also be used to check or refine climate vulnerability maps, as was done in a study on the mental mapping of heat stress in two Czech cities (Lehnert et al., 2021). The results showed that the mental hotspots did not always overlap with the heat stress indicator maps, triggering additional local measurement campaigns. Cities can also use smart sensors to give citizens access to real time data to encourage behavioural change. For example, apps that show people their water consumption in comparison with that of their neighbours are a way of encouraging reduction in water use.

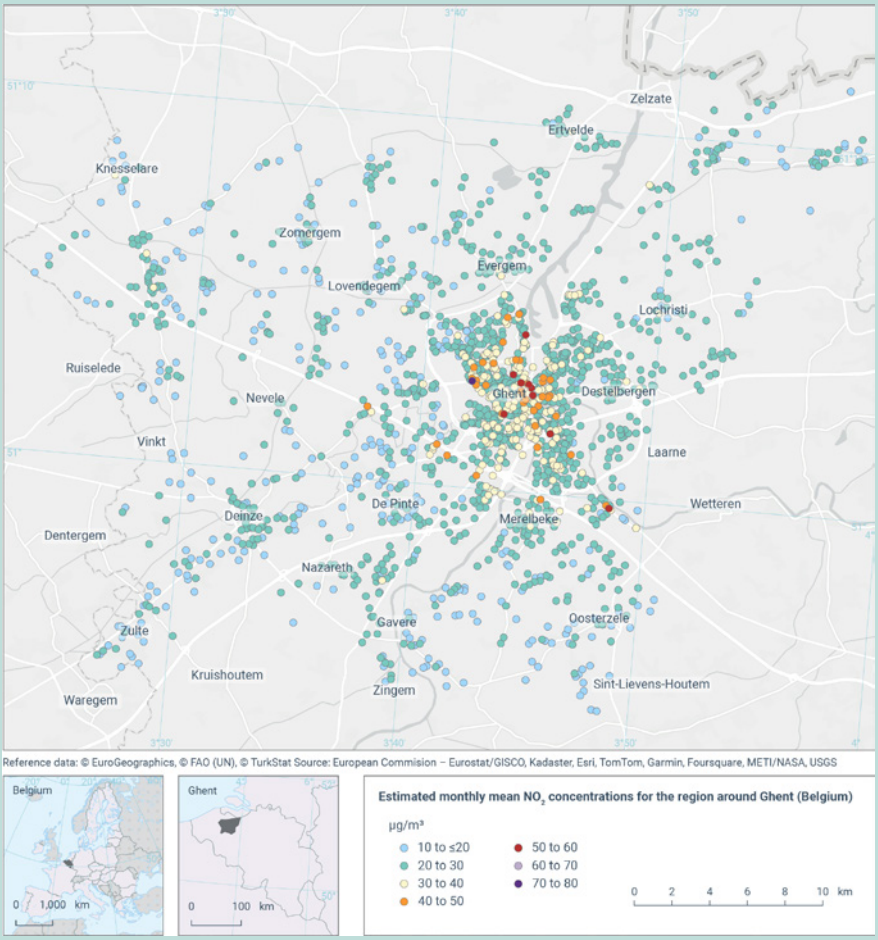
Box 17.1

The potential of public science: CurieuzeNeuzen Vlaanderen

CurieuzeNeuzen Vlaanderen was a citizen science project in which 20,000 citizens measured the air quality near their own houses. The aim was to acquire a detailed map of air quality across Flanders, Belgium. It was the largest citizen science project on air quality at the time. CurieuzeNeuzen Vlaanderen also aimed to increase public awareness of the importance of air quality for a healthy environment and wanted to stress the need and importance of performing reliable air quality measurements.

Air quality can vary significantly over short distances, especially due to the street canyon effect where pollutants accumulate to higher concentrations in narrow, poorly ventilated streets with intense traffic density. Because air quality is so spatially variable, a large number of measurement locations are required to properly assess the predictive capacity of the air quality model and help from residents is extremely valuable to be able to do this. Participants installed a simple, standardised measurement device on a street-facing window of their house, apartment or building. Two diffusion tubes determined the mean concentration of nitrogen dioxide (NO_2), an important indicator for traffic pollution, in the ambient air over a month (May 2018). The data collected were quality controlled and calibrated with NO_2 measurements at reference monitoring stations operated by the Flemish Environment Agency (VMM). The large dataset collected by CurieuzeNeuzen Vlaanderen was used to test the ATMOSYS model (developed by VITO for VMM) that is currently used to assess air quality in Flanders. By improving the predictive capabilities of this model, a better estimation of the population exposure to NO_2 and its effects on public health was achieved, providing better information and recommendations to policy makers.

Map 17.1 **Estimated monthly mean NO_2 concentrations for the region around Gent, Belgium**



Source: Antwerp University.

City level data can be quite detailed and can assist in the upscaling and production of consistent indicators used to measure aspects of adaptation across Europe. An example of such an initiative is detailed in Box 17.2.

Box 17.2

Making the most of city level tree inventories: the Urban Biodiversity Index

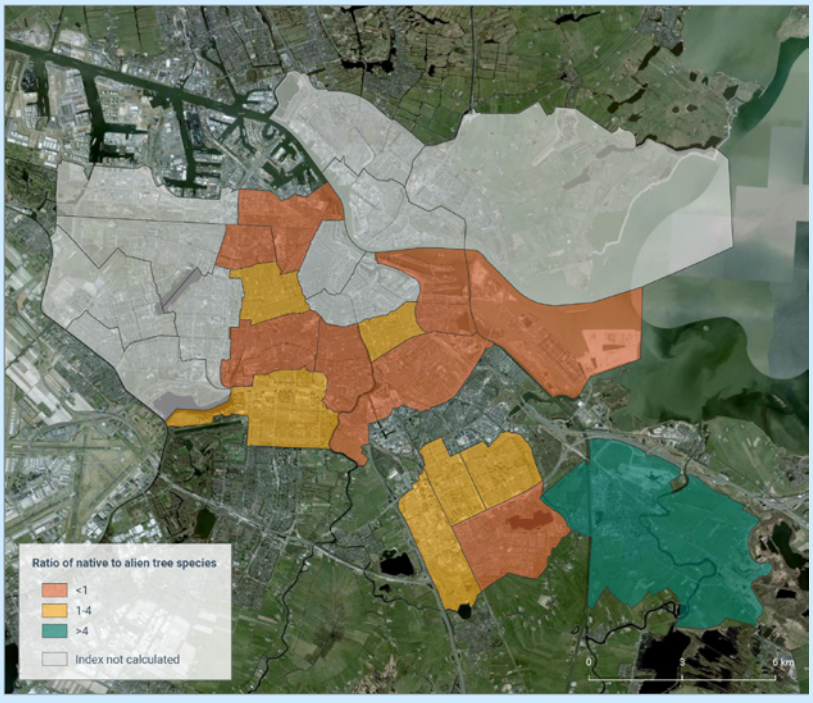
Cities often collect very detailed information, which may serve different purposes than climate adaptation, but can also be used to better inform and monitor climate adaptation strategies. One example is the establishment of city level tree inventories, which usually include a geospatial database with the year of planting and species name and type. These inventories can be relevant to monitoring climate adaptation, not only in tracking how many trees there are, along with their planting needs, but also the quality of greenery in terms of urban biodiversity and related services, as well as their overall resilience to climate change.

The National Observatory of Athens (APCG), in collaboration with DG RTD and the EEA, developed an 'Urban Biodiversity Index' (UBI), which makes use of such tree inventories to assess the ratios of native, alien, invasive and toxic trees in a city. It consists of three computationally independent, yet conceptually complementary, indices:

1. UBI_1 = native trees/alien trees: measures the status of native biodiversity of the city, framing the policy initiatives that must be adopted accordingly;
2. UBI_2 = invasive trees/alien trees: forms an alert index for the city, taking into account the well-recognised threat of invasive species;
3. UBI_3 = toxic trees/alien trees: constitutes an environmental health index.

The indices were calculated for the city of Amsterdam (Map 17.2 shows UBI_1). They showed that there is significant variation across the city in the presence of native species. The city of Barcelona also has a detailed tree inventory, which allowed the calculation of the UBI and currently further investigation is being done into the potential for upscaling this indicator for use in all European cities.

Map 17.2 **Ratio of native to alien species, part of the Urban Biodiversity Index, calculated for Amsterdam, the Netherlands**



Reference data: © Esri, Maxar, Earthstar Geographics, and the GIS User Community

Source: National Observatory of Athens.

In recent years, more and more relevant observational, satellite and modelled data with an increasing temporal and spatial resolution are becoming publicly available, which can feed into the assessment of local climate risks and vulnerabilities. Good examples of the use of local data for such assessments and the presentation thereof are the Climate ranking of Norwegian municipalities and a study on local climate threats to municipalities in Slovakia.

The Copernicus services catalogue also contains a long list of relevant data for climate risk assessments. More and more open access data has become available from European, nationally or regionally funded research projects through user-friendly data portals. Examples are the Flanders Open Data Catalogue and the resources provided by the Network of European Regions Using Space Technologies (NEREUS). The Green Information Transition Factory, a pilot project of the European Space Agency in Austria, maps the presence of green roofs, among many other indicators relevant to climate adaptation.

17.4 What are the challenges to overcome?

The drawback of this abundance of data sources is that it requires continuous efforts to keep up to date and a certain skill set and capacity to be able to find, select and analyse the most relevant data sources in the context of a given city's adaptation project. Smaller municipalities do not always have the in-house capacity to use these types of data sources and lack the financial means to outsource this work.

This comes with a considerable risk since sufficient data and modelling are needed at the planning stages of climate adaptation actions, in order to not take ineffective or counterproductive measures. An example of such a less desired side-effect is roadside urban trees sometimes leading to increased pollutant concentrations in some cases, rather than improving the air quality (Vos et al., 2013). This can be explained by the fact that trees and other types of vegetation reduce the ventilation that is responsible for diluting traffic emitted pollutants.

Data must be accessible and freely available. An example of an initiative working towards this is the European Space Agency's Space for Smart and Green Cities Taskforce. Open data can more easily allow spin-off companies to develop new services and thus, apply data in novel ways.

In the case of designing effective monitoring and evaluation plans for adaptation actions, there is little consistency in indicator choice and often, only a limited number of indicators are used by cities, meaning that comparability between cities and between actions within a city is difficult.

17.5 Trends and outlook

Due to the increasing amount of available data, there is a need for streamlining and higher technical expertise to be able to make sense of it all at city level. This is an area where upcoming Artificial Intelligence (AI) technologies can be of added value, for example in building early warning systems (EWS) (Maher et al., 2022). AI for use in climate adaptation is in its infancy, with many efforts using advanced data analytics (van den Bergh, 2022). To leverage the true potential of AI for climate adaptation responsibly, such as the use of synthetic data and predictive modelling, critical barriers must be addressed collectively. Currently, the widespread use of AI in climate adaptation is hindered by barriers in data compatibility, access to existing and new AI and machine learning models, access to computational resources to run

these complex models, technical expertise to derive actionable insights and domain and management expertise to make adequate policy decisions.

At the same time, cities need more disaggregated and detailed local data, which allows for more targeted analysis and interventions. An example is the heat stress mapping tool of the city of Utrecht (Netherlands), which gives a spatially detailed overview of the local heat stress situation. Based on high resolution input data, tools can be developed that estimate the impact of potential adaptation measures, ideally in an integrated way, tackling several climate risks at once. An example of this is the Flemish Climate Adaptation Project Tool, which allows local authorities to assess the climate resilience of projects in an interactive way, both for a single plot and for an entire district. The tool combines land use and climate modelling maps to calculate an impact score (0-10) for potential adaptation measures on pluvial flooding, drought and heat stress indicators. A cost-benefit analysis is also implemented in the tool, which is another important aspect for cities, used to design climate adaptation actions. First efforts on this topic are being made (e.g. the Dutch climate damage estimator), but more effort is still required to get useful data at the local level in most countries. In this type of integrative approach, it is important to include socio-economic and demographic data along with other data such as temperatures, flood zones etc., to help cities prioritise actions that seek greater equity.

There is a move towards involving the public in reviewing evaluations and also in being part of monitoring efforts. For example, Barcelona's Climate action plan commits to publishing monitoring results every 2 years, complemented by evaluation meetings with the public to ensure their participation in the monitoring and evaluation of all collaborative citizen projects.

A new concept that is attracting a lot of attention in the context of smart cities, data streams and AI is the so-called 'digital twin cities'. Digital twins are often proposed in the form of interactive platforms to capture and display real-time 3D and 4D spatial data in order to model urban environments and the data feeds within them. While the development of digital twins in European cities is still in its early stages, the application of digital twin technology is poised to play a pivotal role in future urban planning, construction and operations (Caon, 2022). In the context of climate change and adaptation, the European Commission is investing heavily in Destination Earth (DestinE). DestinE will use unprecedented observation and simulation capabilities, powered by Europe's high-performance computing and AI capacity. Thanks to this, we will be better prepared to respond to major natural disasters, adapt to climate change and predict socioeconomic impacts. The initiative is a key component of the European strategy for data, consolidating access to valuable sources of data across Europe.

18 Funding the change

Key messages

- Financing is an important enabling factor for the implementation of adaptation measures in local and regional authorities.
- The EU offers numerous funding programmes to finance climate change adaptation actions, but mobilising these funds can be a challenge, particularly for smaller urban municipalities. Local authorities therefore also rely on national, regional and local funding sources.
- Increasingly, technical assistance and other forms of complementary support are being offered by providers of financing. This is in recognition that not only access to funding, but also the technical capacity to implement the actions financed, remains a challenge for cities.
- The multi-sectoral and cross-cutting nature of adaptation measures presents funding coordination challenges since most budgets are still established at the individual departmental or sectoral level. Mainstreaming adaptation across city budgets can help address this.

18.1 Why is funding so crucial for implementation?

Building the resilience of Europe's urban spaces becomes more urgent by the day. From a purely monetary perspective, delays in achieving this will result in more expensive recovery efforts to respond to disasters, compared to more cost-effective preparedness activities (Arnold, 2021). Sufficient, recurring and ongoing financing to fund the ever-growing number of investments required to ensure Europe's resilience to climate impacts is a critical enabling factor for cities (Kates et al., 2012). Funding is critical at all phases of the cycle of developing, implementing and monitoring adaptation activities, but is especially make-or-break in the implementation phase. In a 2023 survey among the signatories to the EU Mission on Adaptation, nearly all respondent signatories (93%) cited insufficient financial resources as being among the greatest challenges they face (EC-DG CLIMA, 2023a).

European urban municipalities today are funded predominantly through a combination of intergovernmental fiscal grants from EU, national and regional level governments. This is done through locally-imposed taxes, user fees and charges for services provided, and from investments and sales of assets or services (Geißler et al., 2019). It is clear that these traditional funding sources alone are, and will increasingly be, insufficient for financing the efforts required to make European cities resilient. The gap between the financing available today and what is needed is growing.

Municipalities account for over 45% of government investment. Since the majority of European urban centres were designed for the conditions, challenges and needs of the past, they now require significant re-investment, re-design and retrofitting to become climate resilient for the future. The reality is that the costs associated

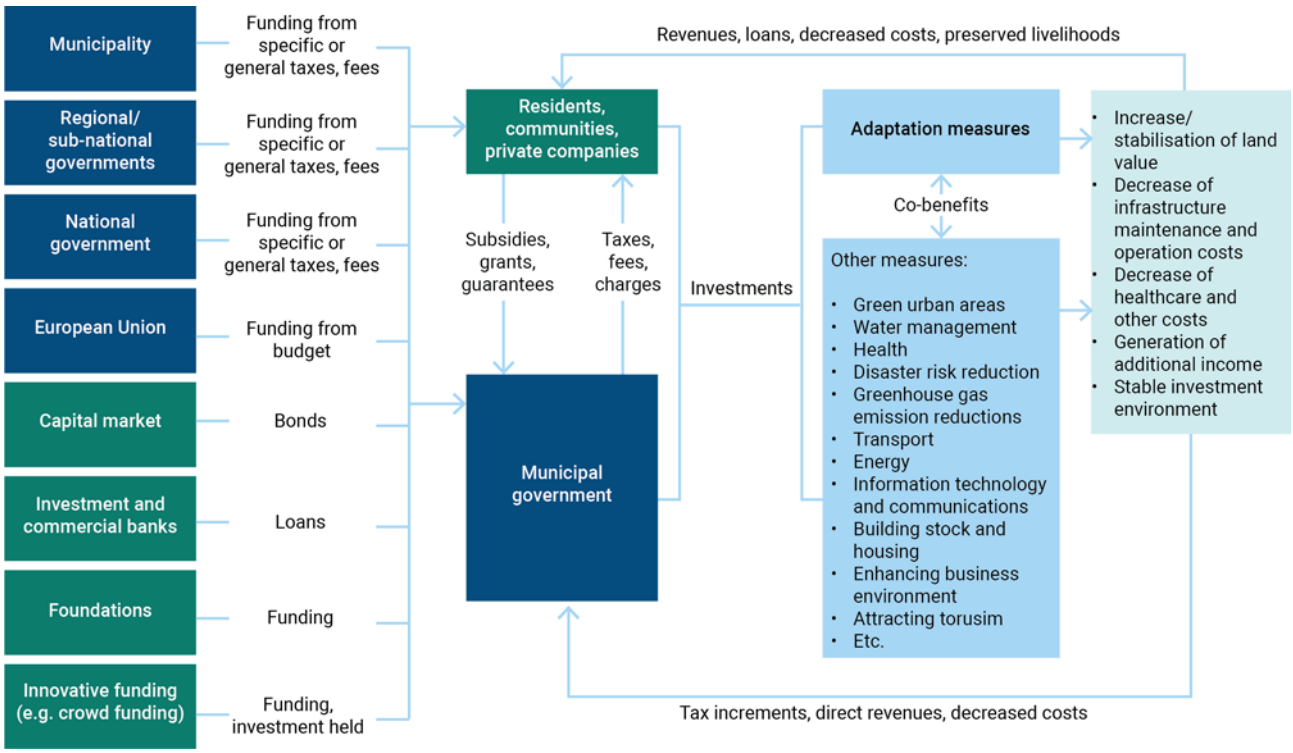
with implementation of such critical investments well exceed the budget sources currently at the disposal of local authorities. Local authorities are all too aware of this implementation funding gap. In a survey of 685 European municipalities in 2020 adaptation-related investments are considered to be slightly or substantially lacking by over 70% of respondents (EIB, 2021).

Importantly, the lack of financial resources available to implement adaptation is not the only hindering factor during this phase. Many urban municipalities also lack the organisational, financial and human resource capacities to spend the money effectively (CoR, 2022a). For example, in the first 2023 Mission on Adaptation survey, 69% of signatories indicated that they also required financial technical support (EC-DG CLIMA, 2023a).

18.2 Trends in funding at all levels

The 2015 Paris Agreement states that addressing climate change will require 'making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development'. However, a strategy that aligns global financial flows with these goals is yet to materialise, leaving Europe's urban municipalities to rely on more ad hoc funding and financing options. Urban authorities are funding the implementation of their adaptation measures in numerous ways, most often relying on a combination of local, regional, national and EU funding. The private sector and a newer set of innovative financing schemes are also playing an increasing role. Figure 18.1 depicts this relatively complex funding and financing ecosystem.

Figure 18.1 Opportunities for financing climate change adaptation in municipalities and the interplay between the various stakeholders involved



Source: EEA, 2017.

18.2.1 EU level funding

The EU committed to spending at least 20% of its 2014-2020 budget on climate action, a target that was met by 2021, although spending may not always have been completely relevant to climate action (CoR, 2022b). The EU budget target for climate action spending for the 2021-2027 period was increased to a target of 30%, or EUR 578 billion, more than double that of the 2014-2020 period (EC, 2023c). The breakdown, by budget source, is shown below, noting that it covers both mitigation and adaptation related activities (Figure 18.2).

Figure 18.2 EU budget for climate action spending 2021-2027

Source: EC, 2023c.

The most important European-level sources of funding for urban adaptation measures, according to the EU's long-term budget, the Multiannual Financial Framework 2021-2027 (EC, 2021e), are:

- The LIFE Programme, which provides funding for projects that support environmental and climate action, including those focused on climate change adaptation in cities.

- Interreg, which is one of the key instruments of the EU supporting cooperation across borders through project funding. Interreg NEXT supports economic and social development of the border areas. Both fund joint actions, including environment protection, public health services, safety and security measures, connectivity, support to SMEs and entrepreneurship. URBACT as part of Interreg supports cities to develop integrated practices.

- Horizon Europe is the EU's research and innovation funding programme, which provides support for research and development projects related to climate change adaptation in cities.

- The New European Bauhaus (NEB) connects the European Green Deal to living spaces and experiences.

- The European Urban Initiative (EUI) supports urban areas of all sizes with innovative actions, capacity and knowledge building, policy development and communication on sustainable urban development.

Additional sources of funding that could be used for adaptation include:

- The Recovery and Resilience Facility (RRF): This is a temporary instrument under which EU governments have submitted national recovery and resilience plans, outlining the reforms and investments they will implement by the end of 2026, with clear milestones and targets. It supports the way out of the COVID-19 crisis and aims at making Europe more resilient and better prepared for the challenges and opportunities of the green and digital transitions. All submitted EU Member State national plans were required to allocate at least 37% of their budget to green measures and 20% to digital measures.

- European Agricultural Fund for Rural Development (EAFRD): This fund supports rural development projects, including those focused on climate change adaptation in rural areas surrounding cities.

- European Investment Bank (EIB): The EIB provides loans and financing for projects that support climate change adaptation and mitigation, including those in cities.

Success in navigating this relatively complex EU level funding scene is not uniform across Europe's urban municipalities. Table 18.1 shows the results of the 2023 survey of the signatories to the Mission on Adaptation regarding knowledge and use of different sources of adaptation financing. While many of the abovementioned EU funding sources are being accessed, more than half of the Mission on Adaptation signatories indicate they have never used many of them. (EC-DG CLIMA, 2023a).

Table 18.1 **Sources of adaptation financing that Mission on Adaptation signatories have been using or intend to use**

Sources of adaptation funding	I have used	I intend to use	I know	I do not know
Cohesion policy funds (ERDF, Interreg)	48	26	14	11
LIFE Programme	31	31	24	14
European Rural Development funds	22	21	30	28
Horizon Europe	25	44	20	11
Other EU funds	27	26	18	29
European Investment Bank financing	9	12	32	47
Private/commercial banking financing	8	10	31	50
National funds	62	19	11	8
Regional funds	52	17	12	19
Own local funds	56	14	10	20
Other	7	12	12	69

Source: EC-DG CLIMA, 2023a.

Box 18.1

Financing resilience in Athens, Greece

The Municipality of Athens is taking proactive measures to enhance the city's resilience to climate change. In order to finance these efforts, Athens received support from the Natural Capital Financing Facility (NCFF) (now replaced by InvestEU) to implement four green infrastructure projects as part of its Athens 2030 Resilience Strategy approved by the City Council in 2017. It was the first city to benefit from this financial instrument. The NCFF provided a loan of EUR 5 million for four projects, mainly implementing blue and green infrastructure and redesigning public spaces around the areas of Lycabettus and Strefi Hills, the Academy of Plato, and the Lambrini Square. The rest of the funding for the projects comes from national funds and other international funding sources.

Additionally, the Municipality of Athens developed the 'Adopt your City' platform enabling partnerships between the Municipality of Athens and private initiatives to develop and implement change adaptation actions and projects. The 'Adopt Your City' programme is exclusively financed through donations from private entities, associations and foundations, with over 100 entities having participated in the programme by 2023. Interested individuals use the platform to submit their requests and contributions, with follow up by the Athens Partnership. Some examples of projects funded are the creation of 'pocket parks' and the regeneration of existing parks and squares. As of 2023, 12 pocket parks have been established through this programme.

18.2.2 National level funding

National level funding continues to be an important source of funding for urban adaptation actions. More than 62% of Mission on Adaptation signatories have accessed national funds to progress with their adaptation plans, with an additional 20% indicating their intention to do so in the near future. In some cases, in response to this demand, EU Member States have begun developing specific funding programmes to support urban municipalities in accelerating their adaptation efforts (see Box 18.2).

Box 18.2

Examples of specific funding programmes at national level to support urban municipalities implementing adaptation actions

Austria: The KLAR! pilot programme supports regions that are making targeted and structured efforts to implement adaptation measures that will enhance resilience to future climatic changes. Funded by the Austrian Climate and Energy Fund, it supports these efforts through a two-stage programme. The KLAR! regions receive technical and content-related support from the KLAR! service platform and can participate in KLAR! events up to three times a year as additional capacity building and networking opportunities. According to programme reports, as of April 2021, 74 regions have received funding to develop a local adaptation strategy, to raise awareness for climate change adaptation and to implement adaptation measures in their regions.

Sweden: The Civil Contingencies Agency is tasked by the Government to administer state funds for preventive measures to reduce the risk of natural hazards, although not explicitly nor exclusively targeted at climate adaptation measures. Municipalities can apply for dedicated funds, which have been increased significantly over the last few years in the state budget. This budgetary allocation is to be used mainly by national and regional authorities to prevent and reduce vulnerability to climate change, including knowledge, information, cooperation and guidance.

An interesting hybrid approach to that of national and EU level funding is the EEA and Norway grant programmes. EEA grants are a pooled funding mechanism, with Norway (95.8%), Iceland (3%) and Liechtenstein (1.2%) providing over EUR 1.5 billion over the 2014-2021 period. The Norway grants are solely funded by Norway to the amount of EUR 1.3 billion for the same time period. The aim of the grant programmes is twofold, to reduce social and economic disparities in Europe and to strengthen the bilateral relations between the three donor countries and the 15 European countries that receive the funding.

While pursuing a broader agenda of topics than climate change adaptation, numerous European urban municipalities undertaking adaptation efforts have benefited from this programme. For example, The EEA and Norway Grants programmes, in combination, provide around EUR 20 million to support numerous projects as part of a Slovakian climate change mitigation and adaptation programme. The first area of key work is focused on supporting local urban authorities to develop their mitigation and adaptation plans. Awareness raising, particularly within school systems, is a second key area of focus. Restoration of degraded ecosystems work is also being undertaken and the Slovak national government is contributing around 15% of the overall programme budget.

18.2.3 Regional and local level funding

Access to regional budget resources is becoming an increasingly important source of adaptation financing. 69% of Mission on Adaptation signatories stated that they had accessed or planned to access funds from a regional budget that could be used for climate adaptation measures. However, 34% indicated that such a regional budget does not exist, or if it does, they are unaware of it (Table 18.1). This highlights both the need for the provision of funding at this level and/or the need to raise awareness around the existence of such funding sources.

Regional financing is complemented by other support provided by regional authorities to their local authorities. This includes technical assistance, coordination activities, broader capacity building and a platform from which to channel messages up to national governments. In some instances, this support includes dedicated funding grants for the development of the SECAPs required under the Covenant of Mayors initiative. Box 18.3 provides some examples from Italy and Spain.

Box 18.3

Regional level support for municipal climate adaptation planning

Emilia Romagna, Italy: With a dedicated fund of EUR 1.2 million between 2019 and 2020, over 30 municipalities were eligible for grants between EUR 2,000 and 20,000 (based on inhabitants) for the development of their Sustainable Energy and Climate Action Plans (SECAPs) (Regione Emilia-Romagna, 2019). Additionally, 19 groups of municipalities developing joint SECAPs were eligible for grants of between EUR 16,000 and 60,000. Additionally, the region provides a range of technical support including the curation of the Climate Regional Observatory, whereby CoM-Europe signatories can access climate-related data and information down to the municipal level, which is useful for the development and monitoring of their SECAP risk and vulnerability assessments. The regions of Sicily and Apulia set aside similar dedicated funds to support the development of SECAPs, as well as awareness raising and capacity building activities.

Region of Galicia, Spain: A technical office has been established to support municipalities in the development and implementation of their SECAPs. Services include administrative support, guidance and technical assistance in addition to a 2023-2024 funding allocation of up to EUR 20,000 per municipality, or up to EUR 50,000 for joint municipal efforts around SECAP development. The region additionally facilitates networking among stakeholders, ensures the promotion of their activities and helps municipalities identify other sources of technical support and funding. The province of Barcelona also offers technical and financial support for the development of SECAPs.

At the local level, governments generate significant revenues from a range of sources, the most common ones being locally imposed taxes, especially property and business taxes, through user fees and charges for services provided and from investment and sales of assets or services (Geißler et al., 2019).

The financial autonomy of Europe's municipalities varies significantly though. This is relevant because a greater level of financial autonomy translates into a greater ability for a municipality to raise local revenues and allocate them towards local priorities. Local authorities in Nordic countries tend to have high levels of financial autonomy. Swedish local governments derive up to 68% of local government revenues from local revenue sources. This percentage decreases in other examples, namely France (50%), Italy (36%), Germany (23%), Poland (20%) and Hungary (13.5%). Local financial autonomy is often inversely correlated with local government access to state allocations, with Poland and Hungary accessing over 50% of local budgets from national sources (CoR, 2022a).

30% of regional and local authorities report using only their own (jurisdictional) resources to implement adaptation actions, with 70% reporting they use a combination of resources that could include local, regional, national, EU and private financing (CDP, 2022). 70% of municipalities signatory to the Mission on Adaptation fund or intend to fund adaptation actions using local sources (EC-DG CLIMA, 2023a).

Regardless of the original source of financing, many municipalities across Europe are distributing the responsibility for resilience building across sectors through the practice of mainstreaming adaptation into other municipal policies and actions. One way of effectively doing this is through incorporating climate resilience and adaptation into city budgets (Gorelick, et al., 2022).

18.3 Potential for mainstreaming funding from the private sector

18.3.1 Public-private partnerships

Public-private partnerships (PPP) are defined as all types of cooperation between the private and public sectors, aimed at public welfare or as partnership cooperation developing public services and meeting public expectations. The main objective of PPP projects is the optimum performance of a public service (Kościelniak and Górka, 2016).

Some European municipalities are recognising the importance of engaging with the private sector to finance and share risks related to the implementation of adaptation projects. An example of how this recognition is translating into new forms of partnerships is Bilbao, Spain. The city used an innovative PPP approach to regenerate an abandoned industrial area by developing a new flood-proof residential quarter. This involved a complex governance arrangement and the coordination of all the actors involved, including the Regional Basque Government, Bilbao City Council, the Port Authority of Bilbao and a number of private entities. Particular attention was given to the citizens and their involvement in the design phase. The citizens did not pay for any costs of the project and some of the existing owners and tenants received support to improve accessibility and energy saving. A series of claims from citizens have been taken into consideration (for example, the maintenance of a former historical industrial building that will be converted into a cultural centre). Another example comes from Greater Manchester (Box 18.4).

Understanding exactly how to engage, communicate and establish financial and legal arrangements acceptable to all parties, is still a challenge for many urban authorities. Projects such as the 2020-2024 Life funded project CityAdap3 seeks to build municipal capacities to undertake successful PPPs. This project aims to create public-private mechanisms to finance urban adaptation measures through the participation of local industries and companies from four municipalities in Italy and Spain. Ultimately, the project aims to test collaboration models that could be transferred and replicated across Europe.

Box 18.4

Tailored co-investment approaches built on multiple benefits of NBS boosts green infrastructure in Greater Manchester, UK

In light of its vision to become greener, fairer and more prosperous, Greater Manchester is aiming for a substantial uplift in urban green infrastructure by 2038. However, the scale of the challenge means it will be difficult to address through public financing alone. Through the UIA-project IGNITION, Greater Manchester developed and tested innovative public and private investor financing and delivery mechanisms for large scale NBS.

A first financing model was developed on the assumption that the water charges saved through decoupling areas from the sewerage and stormwater network and, instead, managing stormwater through sustainable drainage systems (SuDS), could deliver adequate financial returns. It was tested in practice at Moorland School prior to the project and while the scheme worked there, mainstreaming and upscaling this approach proved difficult. Although the discounted water charges meant it was able to deliver a return on the SuDS investment, the risk levels around securing this for the estimated 10-20-year payback period have been a major blocking factor for investors. The benefits were not easily understandable to investors and they were not necessarily taking advantage of the whole range of co-benefits such investments in NBS provided. Many additional actors benefited from the investments but were not paying for them.

To overcome these challenges, specific sites were identified and selected, which were affected by climate change and where co-benefits could be maximised. The full range of potential beneficiaries were then mapped and assessed to determine to which extent they could contribute to a co-investment in NBS, whether via monetary contributions or other means to develop co-investment and co-implementation approaches instead. Different localised co-investment pilots have been developed. Some involve blended funding such as those for the delivery of SuDS at a neighbourhood scale. Others, instead, focus on enabling strong citizen engagement, for example through citizen involvement in designing their own ecostreets in unused or degraded alleyways, backyards and other small spaces, with the support of technical assistance and seed money.

The project has created a large database of evidence of such benefits that is publicly accessible. This sharing of tangible experience was required to finally convince potential investors. This has been provided by building the Living Lab at the University of Salford, combining different NBS and delivering live data about their effectiveness. The expanding number of pilot and further spin-off sites have added to this growing tangible experience and created momentum for further boosting green infrastructure in the city region.

Figure 18.3 **An example of green infrastructures financed through the IGNITION project in Greater Manchester**

18.3.2 Philanthropic funding

Philanthropic funding can take many forms, but fundamentally it describes any act of charitable giving that improves the well-being of others. Key actors in this space include foundations, charitable Limited Liability Companies (LLCs) and individual donors. Importantly, while financial contributions from philanthropy are critical in and of themselves, philanthropy is recognised as a stimulant for innovation and critical for seeding and testing new ideas, which can eventually be scaled using more risk averse funding sources such as public.

While in 2020, global philanthropic contributions to all sectors were estimated at over EUR 660 billion, in Europe, only around 2% of that went towards efforts to prevent adverse climate change. While philanthropic funding for climate mitigation is increasing, with a rise of 25% between 2020 and 2021, a growth three times faster than overall philanthropic sector donations, there is significant scope for the growth of partnerships between philanthropy and Europe's municipalities on climate adaptation (Roeyer et al., 2021). Box 18.5 provides an example of what one such partnership between a foundation, a research organisation and a group of small municipalities in northern Italy looks like.

Box 18.5

Philanthropic support for climate adaptation action in smaller municipalities in Italy

Starting in 2021, Fondazione Compagnia di San Paolo provided funding for a collaborative project with Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC) to support climate adaptation projects by small municipalities (under 20,000 inhabitants) in the regions of Piedmont, Valle d'Aosta and Liguria, Italy. The Call for Change awarded grants to 12 applicant municipalities, focused on developing and then implementing a particular adaptation action in each of their communities. Up to EUR 20,000 was awarded to each municipality in a first phase, to support the development of a data driven plan and design for their action with local stakeholder engagement. Under the second phase, each municipality received a grant of up to EUR 150,000, covering a maximum of 60% of the anticipated project costs, to move forward on project implementation. Importantly, the project also recognised the importance of building the capacity of participating municipalities in building local resilience. Networking among grant recipients was also an important aspect of the project, with peer exchange and sharing of good practice considered important for longer term collaborations.

18.3.3 Crowdfunding

Crowdfunding as a term was first used in 2006. While it is still a relatively new financing instrument, it is beginning to be used to scale up finance for climate adaptation (IISD, 2023). Crowdfunding involves the collection of money from a large number of people via online platforms, with form and level of sophistication varying widely. A general distinction should be made between donation-based and investment-based crowdfunding though. The latter can further be divided into lending and equity crowdfunding. Lending crowdfunding refers to the practice of lending relatively small amounts of money from a crowd instead of a bank. In equity crowdfunding, individual investors purchase equity in a company or a product. In both cases, banks are absent and do not serve as mediators. By contrast, donation-based crowdfunding includes concepts that involve non-monetary or symbolic rewards and those where no reward at all is provided (Sedlitzky and Franz, 2019).

One example is the Ghent crowdfunding platform, which is open to citizens to come up with their own ideas for projects for the city and to get them privately funded. The initiatives put forward need to be for the greater societal good, be sustainable, innovative and promote social cohesion. They should also address a specific challenge the city faces, for example climate change.

18.4 What are the challenges to overcome?

While urban municipalities work tirelessly to access funding and financing to move from planning into implementation, numerous obstacles remain. Interestingly, the nature of many of these obstacles corresponds with the enabling topics tackled within this section of the report.

- **COVID-19 budget impact**: the heavy impacts of COVID-19 on municipal capital budgets have stressed the already tight budgets (World Bank, 2021). Now, with the additional demand to adapt to climate change, financing adaptation in cities is becoming an even greater challenge.

- **Lack of awareness**: many people, including policymakers and investors, continue to underappreciate the urgency and importance of adapting to climate change, resulting in insufficient budget allocations for adaptation projects. Gaining political support continues to be critical in constantly raising awareness among politicians, officials, the private sector and citizens .

- **Complex funding ecosystem and mechanisms**: many urban officials continue to be unaware of all the available funding opportunities and, even when aware, there are significant capacity barriers to overcome to access and use them (EEA, 2017). In particular, there is often limited funding available for small-scale or community-led projects.

- **Political barriers:** climate change adaptation can require significant changes to existing policies and regulations, which can be politically difficult to implement. This can limit the availability of funding for adaptation measures.

- **Lack of coordination:** adaptation efforts often require collaboration across multiple sectors and stakeholders, which can be challenging to coordinate (CoR, 2020). This can make it difficult to secure funding for adaptation projects, particularly when there is a lack of consensus among stakeholders about the best approach to take. Extended stakeholder consultation and the establishment of a horizontal adaptation unit in the administration can help here. Mainstreaming adaptation into city budgets is also proving effective.

- **Limited skilled human resources**: urban municipalities may have sufficient funds, but not the capacity to spend them well. A related limitation is staffing capacity to identify funding sources, or having the capacity to develop often hugely time-consuming proposals. This is particularly the case in Europe's smaller urban municipalities, where municipal size correlates directly to their ability to mobilise sufficient finances to deliver on all of their responsibilities (CoR, 2022b).

- **High costs, long timeframes**: transformative adaptation may receive less social or political support because it requires high financial investment and it takes a long time for the benefits to become apparent (Fedele et al., 2019; Kates et al., 2012). The fact that the benefits of avoiding impacts are only felt far into the future, outside of the current political cycle, is also problematic. Decisionmakers often need to seek economic justifications for certain investments and financiers may require this kind of cost-benefit analysis. However, it is difficult to collect

and measure this information due to a lack of data on 'successful' adaptation actions, the lack of robust metrics to quantify adaptation losses and benefits and uncertainties about the capacity and resources needed to adequately monitor complex, multi-sectoral adaptation actions (Chu et al., 2019)

18.5 Trends and outlook

While EU programmes such as Interreg, Life, Horizon 2030 and the European Urban Initiative will continue to be important sources of adaptation funding for Europe's urban municipalities, national, regional and local sources of funding will be most critical in shifting from the implementation of stand-alone pilots or projects, towards more programmatic and transformative approaches to implementing climate adaptation measures.

The scale of funding required will mean that municipalities will also increasingly need to harness private sector financing sources. An example of one EU level effort to leverage private financing is the European Commission and EIB joint financing initiative under the investment plan for Europe, namely the European Fund for Strategic Investments. Over the period 2015-2020, the fund mobilised over EUR 500 billion in new public and private investments to boost economic growth and job creation in the EU. Its successor programme, InvestEU (2021-2027) is expected to be equally successful, with a goal of triggering more than EUR 372 billion in private investments for high priority EU policy areas, including climate change adaptation. Building local authority capacity to understand and access these kinds of financing opportunities will be very important and will require constructive collaboration with national and regional governments.

Equally, exploiting the potential of other innovative and alternate financing sources and building local capacities to take the lead on this, will also be important. A more systematic tracking of the financial flows towards urban climate change adaptation efforts would help to identify any remaining funding gaps and devise new approaches for overcoming them.

Finally, an increased effort will be required to overcome ongoing structural barriers to fully harnessing cross-departmental efforts and budgets for adaptation measure implementation. Increasingly taking more 'whole-of-government' approaches to making cities sustainable and liveable will ensure that investments across all sectors, including water, transportation, infrastructure, health and natural resource management, are fully leveraged to support urban resilience efforts.

SECTION IV

The way forward

19 Conclusions and outlook

19.1 A landscape of increased ambition

As Europe's cities feel the impacts of climate change more regularly and more severely, the case for investing in societal resilience has never been clearer. All levels of governance have increased awareness of the climate change related challenges faced by urban centres. Indeed, the significant climate threat is resulting in elevated climate-related ambitions, which are increasingly (and arguably) not quick enough in transforming into significant adaptation actions on the ground.

European institutions have stepped up their ambitions on adaptation over the last decade, playing their role through the creation of enabling policies to accelerate local level action. The EU Adaptation Strategy introduced in 2021, prepares the ground for making Europe the first climate neutral continent, with the European Climate Law writing the climate neutrality target for 2050 into a binding legal obligation. These policy and legal directives are supported with increased sources of funding to co-finance the adaptation actions needed. Implementation mechanisms such as the 2023 Mission on Adaptation and other complementary initiatives have been established to support the scaling of actions.

EU level action is further reinforced by action in EU Member States, be it national, regional or local governance levels. This includes increased coordination in many EU Member States within those levels and understanding that each has a critical role to play. Additionally, in many cases, local authorities are increasingly being given seats at decision-making tables to inform their regional, national and European governments of what their citizens need to be resilient.

The public sits at the centre of these adaptation efforts. Cities are made up of people, for people and by people and with this recognition of the centrality of people, the Green Deal commitment to leave nobody behind becomes increasingly tangible within an urban context. An expanding understanding by many people of what 'just resilience' actually means and equally importantly, how this can manifest in the design, implementation and monitoring of adaptation measures is quite evident.

19.2 Implementing local adaptation action

Cities across EEA member states have highly diverse contexts, capacities and experiences and are at very different stages of adaptation readiness, but all are taking some form of action. This report provides examples of what cities in Europe's northern, eastern, southern and western regions are doing. Good practices are being tested and shared, even if the scaling up and out of such practices is not always keeping pace with the speed of climate change.

While many cities are indeed pushing ahead with the implementation of their adaptation strategies, it is still difficult to assess what is really working. This report gives an overview of the different types of adaptation actions that are being implemented by cities and, as far as possible, highlights cases where actions are proving to be effective. Where there is limited quantitative proof of effectiveness,

emphasis has been put on examples that have co-benefits (e.g. lead to greater health and wellbeing, biodiversity gains, pollution reduction or other key environmental and social goals), or where it is assumed that no harm is done in furthering objectives other than adaptation.

A decision to use the Key Type Measure classification for this report changes the focus of responses from hazard-specific approaches, to one which emphasises the importance of selecting adaptation actions that build overall resilience. This ideally can result in a society that can withstand the impacts of multi-hazard events and other potential economic or political shocks. The KTM classification can also be used to facilitate the reporting and monitoring of progress on adaptation actions. The main categories of adaptation actions addressed in this report, following this classification are:

- **Governance and institutional measures**: a comprehensive local climate action strategy and plan is essential to the implementation of adaptation measures. At the local level, adaptation goals can be achieved through urban planning mechanisms influencing urban form and infrastructure. Governance measures can also be used to restrict urban expansion (at least in high-risk areas), and maintain and create new space for green infrastructure. The update of specific building codes and design regulations can also promote circularity in material use and efficiency in energy and water use.

- **Economic instruments and finance**: subsidies and economic incentives can help to encourage the uptake of adaptation options, including, for example, the creation of green roofs or energy efficiency renovations. Affordable insurance measures are also essential to help reduce the impact of climate-related economic losses.

- **Physical and technological measures**: physical infrastructure continues to be a necessary adaptation option, although it is increasingly combined with NBS in its implementation. Water recycling and building design are physical measures with multiple co-benefits. Technological options are a growing area, where there is much potential for additional measures in the future. For now, comprehensive risk assessments and efficient early-warning systems are the most important.

- **NBS and ecosystem based approaches**: maintenance and re-integration of nature into our urban areas is essential. NBS provide a multitude of co-benefits and space should be prioritised for green (vegetation) and blue (water) elements in dense urban areas. Due to the magnitude of current and expected future climate impacts, we recognise here that it may still be necessary to combine NBS with physical infrastructure to ensure they can meet urban adaptation needs.

- **Knowledge and behavioural change**: information campaigns and awareness raising can lead to higher individual resilience and impact a wider range of stakeholders. Importantly, training and capacity building are also key measures here. These measures ensure that there is an ability to take effective action and not only create an awareness of what should be addressed and how.

The interconnectedness between different adaptation measures is especially important and most of these measures cannot be implemented in a vacuum if effective outcomes are sought. This is not only because limited financial resources must address as many challenges as possible, but also because in any one activity there are social, natural, technological and financial dimensions that interact.

To avoid maladaptation, a systemic approach is imperative, where the right combinations of adaptation actions are implemented and complementary goals are reinforced. Adaptation actions are necessary across all sectors and at all governance levels.

19.3 Enabling conditions for climate action

There are a range of identified enabling conditions. These are areas in which improvements can be made to streamline and upscale the implementation of adaptation actions. Although the enabling factors covered in this report are not exhaustive, they include:

- **Sustained political commitment:** societal resilience must be recognised and supported by the governance structures in place and with long-term vision and goals in place too.
- **Good governance:** streamlined communication and organisation of actions must be ensured across all governance levels and relevant sectors and stakeholders.
- **Sharing of good practice and peer-learning:** what is already proven to be effective needs to be shared to allow faster implementation and upscaling of actions.
- **Citizen engagement** – Citizens sit at the centre of these adaptation efforts. Cities are made up of people, for people and by people and their involvement is key to both the implementation and maintenance of adaptation actions.
- **Effective use of knowledge and data:** this is essential to ensure that adaptation actions are implemented in the right way, in the right place and with the desired effect.
- **Sustained funding:** ensuring sufficient financial resources are available in the longer term is essential. So is the technical capacity to be able to access them and use the resources effectively.

19.3 Towards urban societal resilience: what else is missing?

Throughout this report, we emphasise examples of good practices and signs of progress. These are found across the board in the types of actions taken and in the many enabling conditions that cities are actively working on. However, we still miss the tools to be able to say whether real progress is being made or not and if the wide range of individual actions being taken by cities are really making an impact at the continental scale. Progress is being made, but it is clearly not yet enough. But how do you measure 'enough' and how much do we really need to be doing so it is not just 'enough', but instead ensuring a secure future for the next generations?

What do sustainable and resilient cities look like? To open up thinking about how the future could unfold, the EEA and the Eionet developed 4 'imaginaries' of what a sustainable Europe could look like in 2050 that capture some of today's most prominent discourses on sustainability (EEA, 2022g). When used to explore sustainable futures for Europe's built environment in 2050, several common trends emerged across most imaginaries which are also relevant to urban adaptation and overall societal resilience within dense urban areas. Almost all of these trends coincide with what we describe in this report as enabling factors, or responses, for climate resilience. They include:

- **Repurposing and renovation of the existing building stock** rather than demolition and new construction, with a focus on material reuse and recycling, and a shift towards modular construction and the use of bio-based materials.

- **Increasing the amount of integrated natural elements** to enhance biodiversity, deliver ecosystem-services, mitigate and adapt to climate change. For example, by creating more extensive blue and green infrastructure.

- **Reducing energy demand and increasing the share of renewable energy production**. This could be done through both technological advancements, improving the efficiency of energy production and storage, and through behavioural change.

- **Increasing demographic diversity and integration as an important social goal to pursue through changes to the built environment**. The creation of mixed-used buildings and shared common areas and spaces was seen as key to creating demographically integrated communities by encouraging intergenerational and intercultural exchanges.

- **Focusing on accessibility and reducing mobility and transportation needs through design.** Mixed land use and multipurpose public spaces were viewed as central to the goal of reducing individual transportation needs (and associated emissions and energy costs) and increasing safety within public areas for pedestrians and cyclists.

- **Increased digitalisation** and the use of big-data and various technologies to improve the performance of services and reduce resource consumption.

- **Increasing community engagement** in the co-design of public spaces and participation in decision-making.

Similarly, although in a more ad-hoc manner, we asked experts in the field of resilience to consider what a truly resilient urban future might actually look like (Box 19.1).

Box 19.1

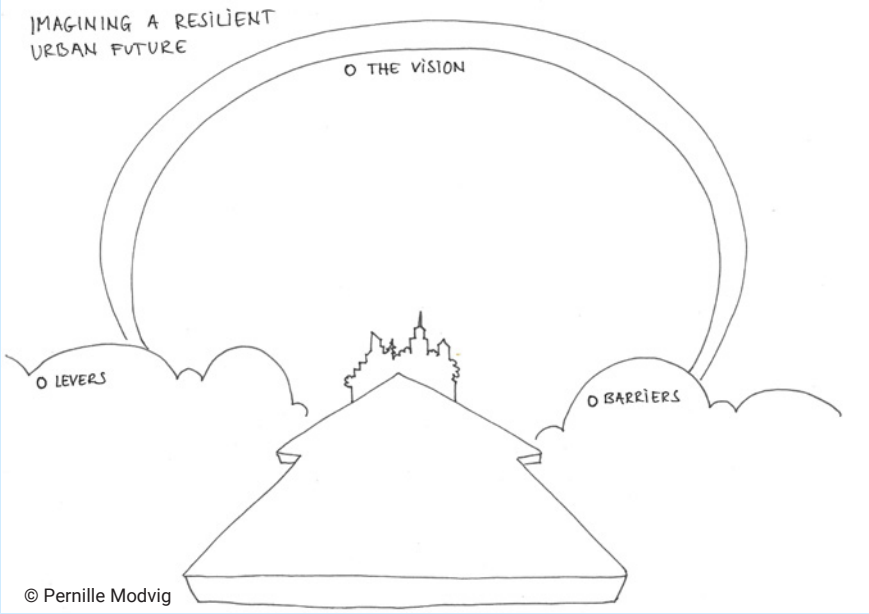
Imagining a resilient urban future: what does it look like?

What does 'success' actually mean in terms of societal resilience in an urban context? Can we agree on where we are headed? What does our resilient urban future look like and can it help us to set more specific targets to work towards? These were the questions posed to participants of the European Urban Resilience Forum 2023 in a dedicated session. Participants (mainly city representatives and researchers) were asked to envision a resilient future for their cities and reflect on what the main levers and hurdles were in the pathway towards that future.

The eight groups generally agreed that the vision would be a city that prioritised the wellbeing of the community, ensuring basic needs, while nurturing a sense of belonging, trust, equity, inclusiveness and hope. The integration of nature was also seen as essential, with increased efforts to make space for nature and ensure its resilience to a changing climate. One group imagined the resilient future modelled after a garden, with key principles being care, aesthetics, experimentation, food provision, identity, sharing, connection and managing uncertainty.

Potential barriers mentioned were resources, political short-term vision, the current national security-first world and the power of the fossil fuel industry. On the other hand, levers or factors potentially speeding up the transition mentioned were knowledge and technology, increased visibility for adapting to climate-related disasters and youth engagement.

Figure 19.1 **'Imagining a resilient urban future', template used to facilitate discussion around what success could look like in terms of ensuring overall societal resilience in cities.**



Building a truly resilient urban future will require us to establish agreed targets on urban adaptation. A much more tangible target around adaptation in Europe has to be established as a means of pulling everyone in the same direction and signalling if the continent is on or off track. This is similar to the important guiding role the EU's climate neutrality targets play. A first step in that direction is establishing a common vision for a resilient urban future.

Abbreviations

AI	Artificial Intelligence
AMS	Amsterdam Metropolitan Institute
AR	augmented reality
BAF	Biotope Area Factor
BNG	biodiversity net gain
C40	Cities Climate Leadership Group
C3S	Copernicus Climate Change Service
CBCA	City-Business Climate Alliance
CBN	city-to-business networks
CDP	Carbon Disclosure Project
CEMR	Council of European Municipalities and Regions
CEMS	Copernicus Emergency Management Service
CF	Cohesion Fund
CHO	Chief Heat Officer
Climate-ADAPT	European Climate Change Adaptation Platform
CMCC	Euro-Mediterranean Centre on Climate Change
CoM	Covenant of Mayors
CoR	European Committee of the Regions
CVI	Climate Vulnerability Index
CRO	Chief Resilience Officer
CSP	City Solutions Platform
TU Delft	Delft University of Technology
DestinE	Destination Earth
DG	Directorate General
DG CLIMA	Directorate-General for Climate Action
DG-RTD	Directorate-General for Research and Innovation
DRR	Disaster risk reduction
DT	Digital twin
EAFRD	European Agricultural Fund for Rural Development
EC	European Commission
ECDE	European Climate Data Explorer

ECMWF	European Centre for Medium-Range Weather Forecasts
EEA	European Environment Agency
EFAS	European Flood Awareness System
EFFIS	European Forest Fire Information System
EFUA	European Forum on Urban Agriculture
EGCA	European Green Capital Award
EGLA	European Green Leaf Award
EIB	European Investment Bank
EP	European Parliament
EPA	Environmental Protection Agency
EPRS	European Parliamentary Research Service
ERDF	European Regional Development Fund
ERCC	Emergency Response Coordination Centre
ESF+	European Social Fund Plus
ETC/CCA	European Topic Centre on Climate Change Impacts, Vulnerability and Adaptation
EU	European Union
EUCRA	European Climate Risk Assessment
Eurostat	Statistical Office of the European Union
EUSF	European Union Solidarity Fund
EU-27	27 EU Member States
EWS	Early warning systems
FAO	Food and Agriculture Organization
FD	Floods Directive
FEDARENE	European Federation of Agencies and Regions for Energy and the Environment
FRA	European Union Agency for Fundamental Rights
FRMP	flood risk management plan
FUA	Functional Urban Area
GCA	Global Center for Adaptation
GEO	Group on Earth Observation
GHG	Greenhouse gas
GRCN	Global Resilient Cities Network
GTIA	Working Group on Impacts and Adaptation
H2020	Horizon 2020 framework programme
ha	hectares
HHAP	Heat health action plan

HES	Historic Environment Scotland
ICLEI	Local Governments for Sustainability
ICOMOS	International Council on Monuments and Sites
ICT	Information and communication technology
IISD	Institute for Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
IT	Information technology
IUC	International Urban Cooperation
JRC	Joint Research Centre
JTF	Just Transition Fund
KTM	Key Type of Measures
MFF	Multiannual financial framework
MRE	Monitoring, Reporting and Evaluation
Mt CO_2e	Million tonnes of CO_2 equivalent
MIT	Massachusetts Institute of Technology
MUFPP	Milan Urban Food Policy Pact
NAP	National adaptation plan
NAS	National adaptation strategy
NBS	Nature-based solutions
NCFF	Natural Capital Finance Facility
NEB	New European Bauhaus
NEREUS	Network of European Regions Using Space Technologies
NEIF	New Economies and Innovation Forum
NGO	Non-governmental organisation
NO_2	nitrogen dioxide
NOCCA	Nordic Adaptation Conference
NUTS	Nomenclature des unités territoriales statistiques
OECD	Organisation for Economic Co-operation and Development
PPP	Public-private partnerships
PSF	CoM policy support facility
RRF	Recovery and Resilience Facility
SDG	Sustainable Development Goal
SECAP	Sustainable energy and climate action plan
SIB	Social impact bond
SME	Small and medium-sized enterprise

SRC	Stormwater Retention Credit
SUDS	Sustainable urban drainage system
SURGe	Sustainable Urban Resilience for the Next Generation Initiative
SYKE	Finnish Environment Institute
UBI	Urban Biodiversity Index
UFM	Union for the Mediterranean
UHCO	Urban Heritage Climate Observatory
UHI	Urban heat island
UIA	Urban Innovative Actions
UN	United Nations
UNDRR	United Nations Office for Disaster Risk Reduction
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
UNSCR	United Nations Security Council resolution
VR	virtual reality
VITO	Flemish Institute for Technological Research
VMM	Flemish Environment Agency
WBCSD	World Business Council for Sustainable Development
WEI+	Water Exploitation Index+
WENR	Wageningen Environmental Research
WFD	Water Framework Directive
WHO	World Health Organization
WUR	Wageningen University and Research

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Annex 1 Overview of key type measures (KTM)

A: Governance and institutional

- **A1: Policy instruments**
    - **Creation/revision of policies** (e.g. laws, decrees, directives, strategies, plans)
    - **Creation/revision of (implementing) regulations** (e.g. rules, arrangements, official instructions)
- **A2: Management and planning**
    - **Mainstreaming adaptation into other sectors** (e.g. institutional/organisational/ administrative changes made in public or private programs, plans and management processes)
    - **Creation/revision of technical rules, codes and standards** (e.g. technical rules for construction, specific building codes, national or subnational standards)
- **A3: Coordination, cooperation and networks**
    - **Creation/revision of ministerial coordination formats** (e.g. formal or informal, high-level, technical cooperation forums)
    - **Creation/revision of stakeholder networks** (e.g. formal or informal, societal-focused forums)

B: Economic and finance

- **B1: Financing and incentive instruments**
    - **Creation/revision of incentive mechanisms** (e.g. tax exemptions, tax credits, tax regimes, subsidies, tariffs, transfer payments)
    - **Creation/revision of funding schemes** (e.g. sectoral, crisis preparedness)
- **B2: Insurance and risk sharing instruments**
    - **Creation/revision of insurance schemes and products** (e.g. preparedness, response, disaster relief, recovery)
    - **Creation/revision of contingency funds for emergencies** (e.g. preparedness, response, disaster relief, recovery)

C: Physical and technological approaches

- **C1: Grey options**
    - New physical infrastructure(s)
    - Rehabilitation, upgrade and/or replacement of physical infrastructure(s)

- **C2: Technological options**
    - **Early warning systems (EWS)** (e.g. temperature, wind, water, solid-mass related hazards)
    - **Hazard/risk mapping** (e.g. climate-related hazards such as floods, hail, torrents, drought, water scarcity)
    - **Service/process applications** (e.g. water metering, efficient irrigation, home automation, smart solutions)

D: Nature based solutions (NBS) and ecosystem based approaches

- **D1: Green options**
    - **Creation of new/improvement of exiting green infrastructures** (e.g. afforestation, revegetation, riparian woodland, protection of forests in mountainous areas, increased landscape cover, creation of landscape elements and hedges, urban green roofs, urban farming, wildlife overpasses, beach nourishment)
    - **Natural and/or semi-natural land-use management** (e.g. forest management, avoidance of soil sealing, fire hazard management, multifunctional farming, agroforestry, integrated pest management)
- **D2: Blue options**
        - **Creation of new/improvement of existing blue infrastructures** (e.g. retention ponds, flood breaking hedgerows, water in urban areas, aquatic buffer strips, shelter belts, flood storage areas, reservoirs, fish ladders, urban rainwater harvesting, sustainable urban drainage systems)
        - **Natural and/or semi-natural water and marine areas management** (e.g. wetland restoration, flood plain restoration, marine protected areas)

E: Knowledge and behavioural change

- **E1: Information and awareness raising**
    - **Research and innovation** (e.g. programmes, projects, actions)
    - **Communication and dissemination** (e.g. website, brochures, flyers, information brokerage, media outlets)
    - **Decision support tools and databases** (e.g. portals, platforms, call centres, services, online interactive tools)
- **E2: Capacity building, empowering and lifestyle practices**
    - **Identification and sharing of good practices** (e.g. guidance materials, observatories)
    - **Training and knowledge transfer** (e.g. workshops, seminars, schools, participatory schemes)
    - **Reporting on lifestyle practices and behaviour**s (e.g. use of climate-resilient crops, changes in livestock practices, individual preparedness, mobility, dietary changes)

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