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Urban adaptation to climate change in Europe 2016

Transforming cities in a changing climate

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Abbreviations

ADEME	French Environment and Energy Agency
BASE	Bottom-up Climate Adaptation Strategies towards a Sustainable Europe
BlueAp	Bologna Local Urban Environment Adaptation Plan for a Resilient City
CCA	Climate Change Impacts, Vulnerability and Adaptation
COP21	Conference of the Parties 21 (of the United Nations Convention for Climate Change)
EEA	European Environment Agency
ELTIS	European Local Transport Information Service
ETC	European Topic Centre
FPC	Portuguese Carbon Fund
GHG	greenhouse gas
ICLEI	Local Governments for Sustainability
ICT	information and communication technology
MRE	monitoring, reporting and evaluation
NGO	non-governmental organisation
PACT	Performance Acceleration through Capacity-building Tool
PCET	territorial climate-energy plan
PPP	public–private partnership
RAMSES	Reconciling Adaptation, Mitigation and Sustainable Development for Cities
SYKE	Finnish Environment Institute
UAST	Urban Adaptation Support Tool
UKCIP	United Kingdom Climate Impacts Programme
ULS	Urban Land and Soil Systems
UNISDR	United Nations Office for Disaster Risk Reduction

Executive summary

Chapter 1 This report

This report is addressed to the many different stakeholders concerned with urban adaptation.

It gives an overview of action that can be taken to adapt cities in Europe and the progress made over the last couple of years, and it puts this in relation to the future challenges that the impacts of climate change pose: Is what cities are already doing leading to attractive and climate-resilient cities? If not yet, what needs to change? The report provides food for thought about reviewing and adjusting urban adaptation to climate change. It thereby supplements many other tools, reports and initiatives on urban adaptation in Europe.

The report targets local, regional, national and European governments and organisations as well as experts and researchers concerned with urban adaptation. Beyond that, it includes perspectives and ideas that may interest communities, individual citizens or businesses too.

Chapter 2 Climate and urban Europe — changes ahead

Cities matter to people living within and beyond their borders. Urban adaptation is one key element that can prepare cities and Europe for the future climate.

Cities matter for Europe. They are centres of innovation and growth, and the engines of European economic development. They provide fundamental services for their inhabitants and people living beyond them, such as living spaces, work places and education. At the same time, they depend on services provided by other cities and rural areas, such as the production of food and other goods, flood retention or provision of drinking water. The impacts of climate change challenge these services. The EU has an Adaptation Strategy, which resulted in the Covenant of Mayors for Climate and Energy ([1]), an adaptation initiative. The Paris climate conference (COP21) also defined an action plan in December 2015. These and the new UN Sustainable Development Goals highlight the need for cities to take action. Well-adapted and climate-resilient cities therefore matter for a climate-resilient Europe.

Climate change is a systemic challenge. It interacts strongly with socio-economic factors and their regional and global trends.

Climate change is a systemic challenge that does not happen in isolation but interacts with socio-economic factors. Regional and global trends in these factors add an extra dynamic. They include geopolitics and conflicts; economic growth or decline; demographic change such as increase or decrease in populations, ageing, social segregation and migration; further urbanisation and urban sprawl; technological developments; a move to low-carbon energy systems; and many others. These can change the vulnerabilities of cities, for example by simply having a greater number of elderly people, who are generally more vulnerable to extreme events, or by placing people and assets in potentially risk-prone areas. On the positive side, some trends, such as better education or more trust in society, can offer the potential to increase the capacity to adapt. Climate change itself can trigger direct and indirect impacts that go beyond the sector or area originally affected. Interruptions in the supply chain and their impacts on production, jobs and income in other regions are one example of such knock-on effects. Adaptation solutions that focus on dealing with the direct impacts of climate change might therefore not be enough by themselves in the face of the much broader direct and indirect impacts of climate change.

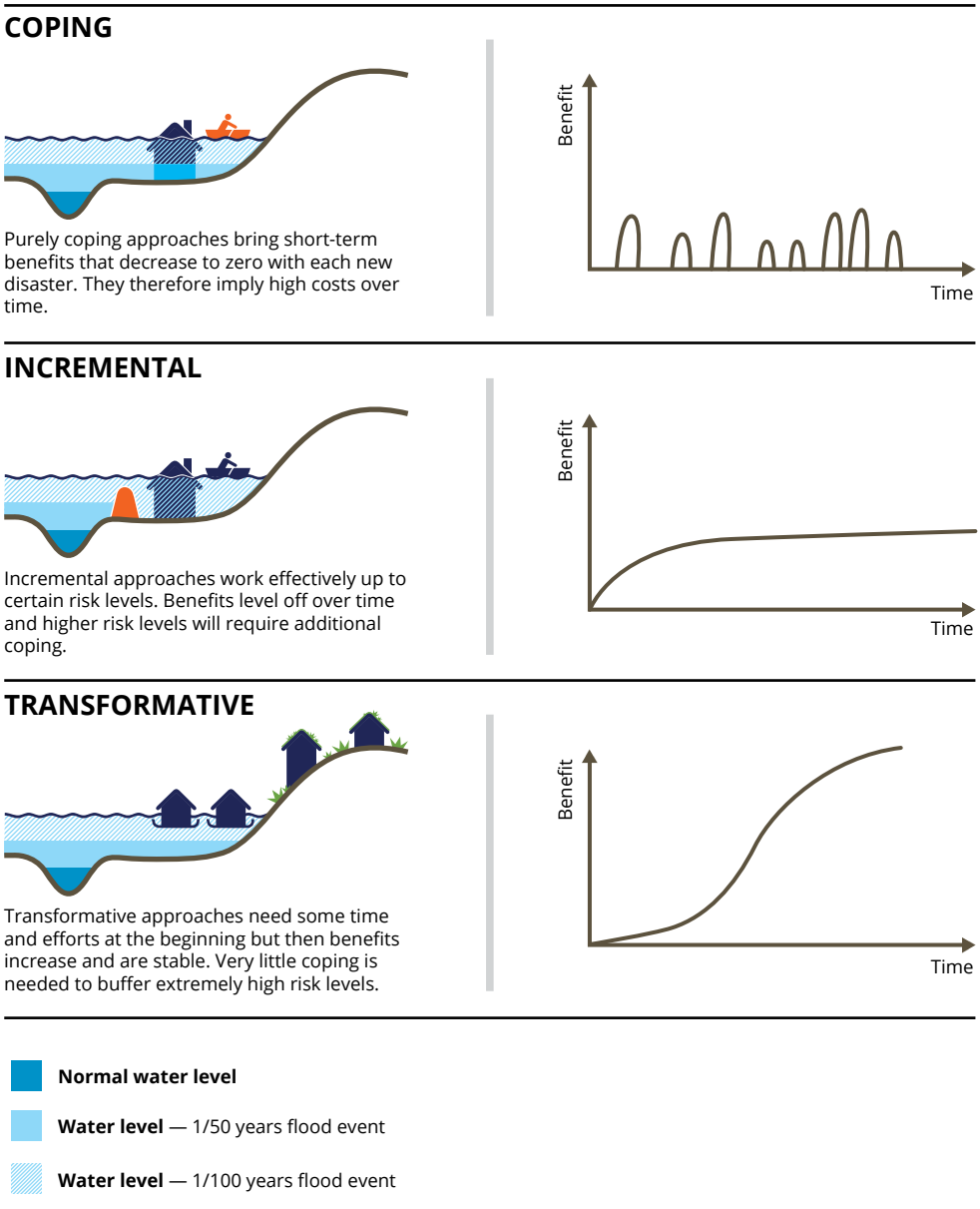
([1]) http://mayors-adapt.eu.

Chapter 3 The road to adapt and transform cities into attractive, climate-resilient and sustainable places

Coping with extreme events and incrementally improving existing adaptation measures can offer effective short- and medium-term solutions.

Coping and incremental adaptation are two approaches to dealing with climate change impacts. Coping mostly means responding to the damage arising from a disaster and recovery afterwards. Incremental adaptation builds on existing adaptation measures and known solutions by improving these, bit by bit, and increasing their capacity to avoid any damage under future levels of risk. Both approaches aim to maintain or regain the city's current level of service. Both are also based on proven knowledge gained over decades, for example in disaster risk management. Incremental adaptation often focuses on individual measures as appropriate and as opportunities appear. Measures

Figure ES.1 Examples of different adaptation approaches and complementary benefits at different water levels due to flooding



Source: EEA.

are relatively quick to put in place. They can often deal sufficiently and very effectively with many short- and medium-term challenges.

Certain long-term effects of climate change, however, may be more than these approaches can cope with. Then, the measures can no longer protect against much larger impacts. For example, the city of Vác in Hungary successfully protected itself against flooding of the Danube with sandbags in 2002 and 2013, and has established a plan for using mobile dams. However, the second of those floods was higher than the first, and the question is whether or not the planned level of protection will be sufficient in the long term too (Box 3.4).

Combining these solutions with transformative adaptation offers long-term solutions that address the systemic character of climate change and enable cities to embrace change.

Transformative adaptation, in our understanding (Table 3.1), follows a broader and systemic approach. It addresses the root causes. Vulnerability to climate change is often a result of human actions, such as settling in risk-prone areas, inadequate building design or other behaviours that aggravate the impact of climate change. In the example of Vác, providing more retention areas upstream to give room to the river may be part of a solution. This would, however, require a large-scale approach by cooperating with other cities, regions or even countries (Box 3.4).

The design of the city, its buildings and its infrastructures are supposed to last for decades or even centuries. Transformative adaptation can avoid letting these elements lock the city in to ways of functioning that will not work adequately in future climatic conditions and are hard to change. The transformative approach takes a systemic perspective. It seeks to integrate adaptation with other aspects of urban development and turns the challenge into an opportunity, capitalising on many additional, non-climatic benefits. It departs from the state of the art of current city functioning and organises it differently, with the opportunity to function better and improve quality of life. For example, the amphibious houses in Maasbommel in the Netherlands are an attempt to live with different water levels instead of keeping the water out (see Box 5.26). Hamburg's green roof programme supports building owners to establish green roofs (Box 5.28). This measure will retain excess water and delay its entry into the sewerage system when rainfall is heavy. Extending the existing sewerage system as much as needed would cost a lot. It would still be uncertain how the system would work under long-term climate change and would also lock the city in to this way of dealing with excess water. The combination with green infrastructure solutions costs much less, is more flexible and is a low-regret measure: one with low costs and large benefits.

Chapter 4 Urban adaptation action to date

Urban adaptation combines action from different stakeholders and comes in different forms: planning, implementing and supporting.

Planning and implementing urban adaptation takes place primarily at the local or regional level and often across different sectors. Addressing climate impacts at the appropriate scale, for example in water management and safeguarding of external public services, calls for collaboration at the regional scale. For instance, Dresden in Germany needs to cooperate with its surrounding region and regions further up the River Elbe in the Czech Republic (Box 5.23) to deal with river flooding. Cities can often address other impacts such as urban heat islands or stormwater at local level.

Regional, national and EU governments and organisations provide the political, legislative and financial framework in which local and regional implementers can act. They need to develop systems that support cities and reduce obstacles to action. Finally, knowledge providers such as researchers and experts, but also individual citizens and communities, help to close knowledge gaps. For urban adaptation to be successful, multiple stakeholders need to interact and collaborate coherently across different sectors and levels of government.

In practice, urban adaptation has taken off.

While climate change adaptation is still a novel item on the agendas of cities, many cities in Europe are already working to mitigate the effects of climate change, decrease energy use and reduce greenhouse gas emissions; more than 6 700 have committed to mitigation efforts as part of the Covenant of Mayors for Climate and Energy initiative ([2]). Concerning adaptation, hundreds of cities have started to assess their vulnerability to climate change over

([2]) http://www.covenantofmayors.eu/index_en.html.

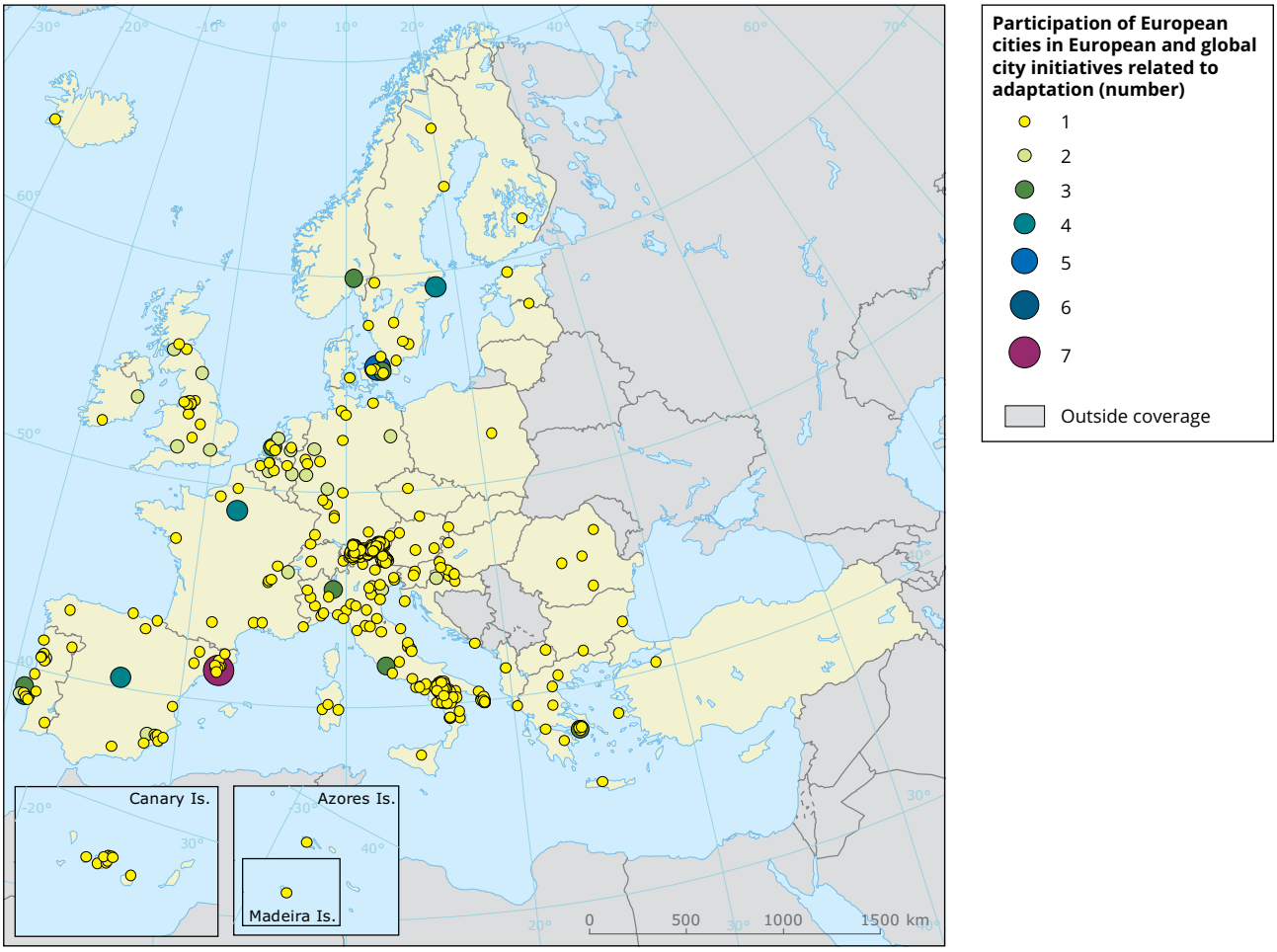
the last couple of years and have developed plans and strategies (Map ES.1). The very first ones, such as Copenhagen, Rotterdam, Barcelona or Helsinki, started putting measures into practice and exploring monitoring schemes. Apart from specific adaptation measures, many cities have implemented measures that can support adaptation too, but are not labelled as such. These include reducing the risk of disasters, managing water and creating green urban space. Whether or not these in fact contribute to adaptation depends on their specific design — will it work not just in the current climate and according to past risk levels but also under future impacts of climate change.

Governments and organisations at EU level and, to varying degrees, at national and regional levels have further developed the political, legislative and technical framework for cities to implement adaptation measures — among them the EU Adaptation Strategy and the Covenant of Mayors for Climate and Energy initiative. Several countries have included urban adaptation in their national adaptation strategies or have made it a standard part of other subject-specific strategies or plans (Table 5.2).

The challenge is to find ways to close the gap between the few frontrunner cities and the many cities that have just — or not yet — begun.

Despite the encouraging progress of some hundred frontrunner cities, many more cities in Europe are not yet planning for climate change adaptation. Those that are planning often experience difficulties turning

Map ES.1 **Participation of 650 European cities in European and global city initiatives related to adaptation, December 2015**



Note: Initiatives included Covenant of Mayors for Climate and Energy, Compact of Mayors, C40 with adaptation action, Making Cities Resilient (UNISDR), European Green Capital Award, European Green Leaf Award, Metropolis no regret charter and Rockefeller 100 resilient cities.

Source: http://climate-adapt.eea.europa.eu/tools/urban-adaptation.

strategies and plans into practice. In stakeholder events, such as the Open European Day Resilient Cities ([3]), Mayors Adapt events and stakeholder meetings of EU projects such as RAMSES (Reconciling Adaptation, Mitigation and Sustainable Development for Cities) ([4]) or RESIN (Climate Resilient Cities and Infrastructure) ([5]), city authorities name barriers including a lack of awareness among politicians and decision-makers, and their own lack of knowledge and ability to find, access and utilise finance. Institutions at EU, national and regional levels can help enable these many cities to follow the frontrunners and close the gap; so can other stakeholders, such as researchers, city networks or organisations that cross the boundary between research and politics.

Chapter 5 Spotlight on selected areas of action

Getting it 'right' in certain areas is the key to effectively mastering the different steps of planning and implementing urban adaptation.

Supportive and well-tailored governance that covers horizontal and vertical engagement and broad stakeholder participation is a basic condition for all steps of the adaptation planning, implementation and monitoring process as is awareness and tailored knowledge creation.

Awareness raising is important to ensure support from decision- and policymakers, such as sufficient financial resources or a supportive legal framework. Together with knowledge creation, it supports all other capacity-building activities, as well as planning, implementing and monitoring adaptation.

If cities make a persuasive economic case for adaptation, it will help create better knowledge and thus raise awareness and finally support decision-making on what adaptation measures to plan and implement.

Monitoring, reporting and evaluation create knowledge about the effectiveness of the measures implemented as well as of the adaptation process. They thus allow cities to adjust the performance of the systems and the single steps of planning and implementing adaptation.

If they are all developed and streamlined, these key areas can support cities in implementing their chosen combinations of coping, incremental and transformative adaptation approaches.

Action already under way might not yet be able to address systemic and long-term climate challenges.

Cities that have started adapting may do so systematically, spontaneously or both. Overall, it seems that most cities prioritise low-cost and soft measures, such as emergency plans, institutional procedures and behavioural advice. For example, London is installing white panels on top of its public transport buses to reflect the rays of the summer sun and keep the vehicles cooler. The city of Kassel has set up a 'heatwave telephone' for volunteers to call elderly people to tell them about health risks during a heatwave and possible ways to avoid the dangers. Another category is low-regret measures that also offer non-climatic benefits, such as boosting urban green space including parks, trees in streets, green walls or roofs. Well-known technical solutions, such as raising the height of dykes, are also common, as they are often relatively easy to plan and build if financial resources are available.

All these measures are certainly useful in reducing the risks, but often not as much as is necessary in the long-term future. In the extreme, they might even lead to locking-in to unsustainable pathways and greater vulnerabilities, for example when people settle in flood-prone areas currently protected by dyke systems. If this conventional approach reaches its limits, one of the most extreme and very expensive measures is to tackle the problem at the root and relocate houses. This has happened in Odense in Denmark and Röderau in Germany, for example, and is starting in Eferding in Austria (Box 5.29).

The framework and supporting actions provided by regional, national and European institutions vary from country to country. It seems that they seldom directly hinder municipalities from applying more advanced adaptation approaches, but neither do they actively support it. Gaps in awareness, knowledge, political support, sectoral procedures and legislation still pose many barriers to municipalities that want to apply a broadly systemic approach and use unconventional measures to solve problems. For example, in order to build the floating houses in Maasbommel, legal barriers to obtaining permission had to be overcome because no building regulation considered such buildings (Box 5.26). In Denmark, the original legislation did not

([3]) http://resilient-cities.iclei.org/bonn2014/open-european-day.
([4]) http://www.ramses-cities.eu.
([5]) http://www.resin-cities.eu/home.

allow companies to use water fees for climate change adaptation including green infrastructure. It became possible after the national government amended the legislation (Box 5.4).

It can be done!

A vast range of transformative adaptation options, in particular, are available to reduce the future long-term risk substantially. To realise the potential of transformative adaptation in combination with coping and incremental adaptation, however, we need to change mindsets by acting on the root cause of vulnerabilities: the way we organise our living, working and service provision in cities. This can imply higher transaction costs at the beginning, to overcome prevailing mindsets, inappropriate institutional structures and governance approaches. In the example of Maasbommel, mentioned above, another main difficulty was that potential house owners were hesitant to build in areas that they considered dangerous. This explains the slow uptake of the scheme although building land in areas not at risk of flooding becomes increasingly scarce (Box 5.26). However, once established, such solutions can have relatively low costs and provide flexible and long-term solutions. They may also require action at different levels and in areas not directly affected such as education or economic activities.

If regional, national and European institutions and research provide the right policy framework, they can help change mindsets by providing knowledge about, and incentives for, climate-resilient lifestyles, passing legislation that is supportive, and enabling transdisciplinary approaches, for example including social innovation and business behaviour.

A systemic approach to adaptation can boost innovation and quality of life, attracting people and businesses, and improve economic performance.

Transformative adaptation is systemic. It aims to change urban design and structures, the organisation of living, working, moving and other services. It delivers multipurpose solutions and is an integral part of city development and regeneration. This offers an opportunity to transform cities for the better, promote innovation and boost quality of life, making cities more attractive and vital. A few cities, such as Copenhagen and Rotterdam, are already actively pursuing such comprehensive and highly visionary strategies, making innovative solutions an asset for their quality of life and economies. Innovative adaptation solutions become a business opportunity (Boxes 5.33 and 5.22). A systemic approach changes adaptation from a need to an opportunity to embrace change.

While we are just beginning to explore the potential of transformative adaptation, we can learn from the first encouraging examples.

Cities, with very few exceptions, have not yet implemented comprehensive adaptation approaches that combine coping, incremental and transformative action and that use the vast potential of transformative adaptation. Nevertheless, cities such as Bologna in Italy, the municipalities of the Emscher valley in Germany, Bilbao in Spain, Eferdingen in Austria and several others, also described in this report, have taken transformative steps. These actions include ensuring a climate-resilient design when regenerating urban areas, building in safe places, using green infrastructure to cool urban areas and houses and to retain rainwater, and establishing transition management. Urban adaptation is a learning process. Exchanging knowledge and experience is key for climate-resilient and attractive cities and for Europe as a whole — for both beginner and frontrunner cities and for all other stakeholders.

Chapter 6 Conclusions

Tackling urban adaptation and transformation in Europe requires complementary action from stakeholders at different levels.

Cities need to connect global long-term change with action here and now. They need to invest in a better urban future to capitalise on the opportunities that, in particular, transformative adaptation action with its novel solutions can offer. In reshaping and transforming urban environments, they need to expand planning horizons in space and time, and collaborate across sectors and governmental levels, and with business, communities and citizens. As cities start to enter the implementation phase, building a sound economic case early in the process enables decision-makers to choose measures wisely and keep the costs reasonable.

Transforming cities enables Europe to become a more attractive and climate-resilient place. Regional, national and international bodies can provide and legal and institutional frameworks that enable the transformation of cities and. They can also facilitate

better city networking across Europe and harvest and transfer urban adaptation knowledge, thus enabling cities to learn from each other and follow the example of frontrunners.

Knowledge on urban adaptation is still relatively weak and fragmented but is growing rapidly. Researchers and knowledge providers can fill gaps, but only the effective co-creation of knowledge with practitioners, the communities affected and businesses ensures that the knowledge will be relevant and applicable. To create the knowledge base for transformative adaptation, research must pursue much more systemic approaches and integrate the socio-economic and demographic dimensions of urban development.

1 This report

1.1 Do you recognise this situation?

A city administrator's perspective

There are many challenges to cope with in your municipality right now. The financial crisis has reduced the municipal budget and unemployment is high. You need to create jobs, but investors are hard to find. Also, the municipality is ageing and an ever smaller proportion of the population is of working age. You have to take care of multiple vulnerable groups such as elderly people or migrants.

Climate change appears increasingly in discussions. Some cities have had serious problems with heatwaves, flooding or droughts in the recent past. You have not yet experienced any serious impacts, so it seems to be a future challenge that might affect your municipality, but the effects are uncertain. Therefore, you will deal with it when there is more certainty and urgency. For now, other problems are more important to solve.

However, climate change is already a reality. Even though we do not know all of the possible impacts yet, climate change impacts will most probably challenge the quality of life in your city and its economic basis in some way. Already, serious floods are happening more frequently. They have disrupted services and caused large amounts of damage to people and businesses. In 2003 and 2010, heatwaves led to several tens of thousands premature deaths in several parts of Europe.

Uncertainty does not mean you have to wait before acting. By addressing climate change in a proactive and flexible way, you can take many unique opportunities to create even more attractive cities. Climate change challenges are intertwined with economic, social and environmental challenges. You can see that as a risk but also as an advantage. If you integrate climate change adaptation into current decision-making and planning of urban renewal and growth, action will be more affordable. It can help you, at the same time, to make your city not only more resilient but also more attractive for business and citizens.

➔ **Find inspiration in this report for proactive local adaptation action to tackle the risks and seize opportunities.**

Whether you want to start the process or are already on your way, learn more about the complex challenges and opportunities ahead and find inspiration on how to deal with them. Learn about other cities' experience and about supporting frameworks from national governments, the European Union and international organisations. Get ideas about better designs for selected key areas while adapting. Find links to practical guidance, tools and information sources.

A national, European and international stakeholder's perspective

Climate change is already a reality and will most probably challenge the quality of life and economy in many cities and towns. Policy at the local level is not your responsibility. However, the sum of local action determines the situation in your country and throughout Europe. With the *Europe 2020* strategy, the EU and its Member States want to become smarter, greener and more inclusive. A low-carbon and resilient Europe needs low-carbon cities resilient to climate change. The *EU Adaptation Strategy*, the action plan defined during the Paris climate conference (COP21) in December 2015, the new UN Sustainable Development Goals and many national strategies highlight the importance of climate-resilient cities and towns, but how can you get the necessary action from local authorities? How can you address proactively the impacts of climate change on cities?

➔ **Find inspiration in this report about how European, national and international institutions can provide a supporting framework for effective local adaptation.**

Learn about cities' needs to develop and implement adaptation that meets not only short-term but also long-term challenges. Get an overview of current adaptation action at local, national and European levels and how the levels and different policy areas interact. What are the obstacles to better adaptation and what options support it?

A researcher's perspective

You recognise that climate change is already a reality and will most probably challenge the quality of life and economy in many cities and towns. You also see that addressing climate change in a proactive way offers many opportunities to create even more attractive cities, and you want to support this.

You have already contributed to various projects on urban adaptation. The reports provide a rich source of knowledge. However, you feel that cities in general and other stakeholders that could implement the findings do not really make use of the results. What might be the reason? Are you researching the right things? Are you sharing the knowledge appropriately?

➔ **Find inspiration in this report to deliver valuable knowledge to make cities more climate-resilient and attractive.**

Learn more about the needs of cities, both large and small, and of national and European stakeholders working on urban adaptation: the knowledge they need, how to present it and make it accessible, and the barriers that stop them taking up the knowledge.

... and many other stakeholders' perspectives

Extreme climate events have increased in recent years. This indicates to you that climate change is already a reality and will most probably challenge your quality of life or the economic reality of your city. As a representative of the business sector, a member of a non-governmental organisation (NGO), a student or an interested citizen, you want to inform yourself about how climate challenges to cities will affect you. Whether you are considering urban adaptation from a local, regional, national or European perspective, and whether you want to know about certain areas and aspects only or urban adaptation in all its complexity, this report will inspire you and give you hints about where to look further, even if it is not specifically aimed at you.

1.2 How to read this report?

This is one piece in the urban adaptation landscape. It supplements and builds on the many other tools, reports and initiatives shown in Figure 1.1 and others you can find in Climate-ADAPT ([6]). It provides an overview on action to adapt cities and progress since 2012. Is what cities are already doing leading to attractive and climate-resilient cities? If not yet, what needs to change? The report should thus broaden your perspective and provide food for thought about reviewing and adjusting urban adaptation to climate change.

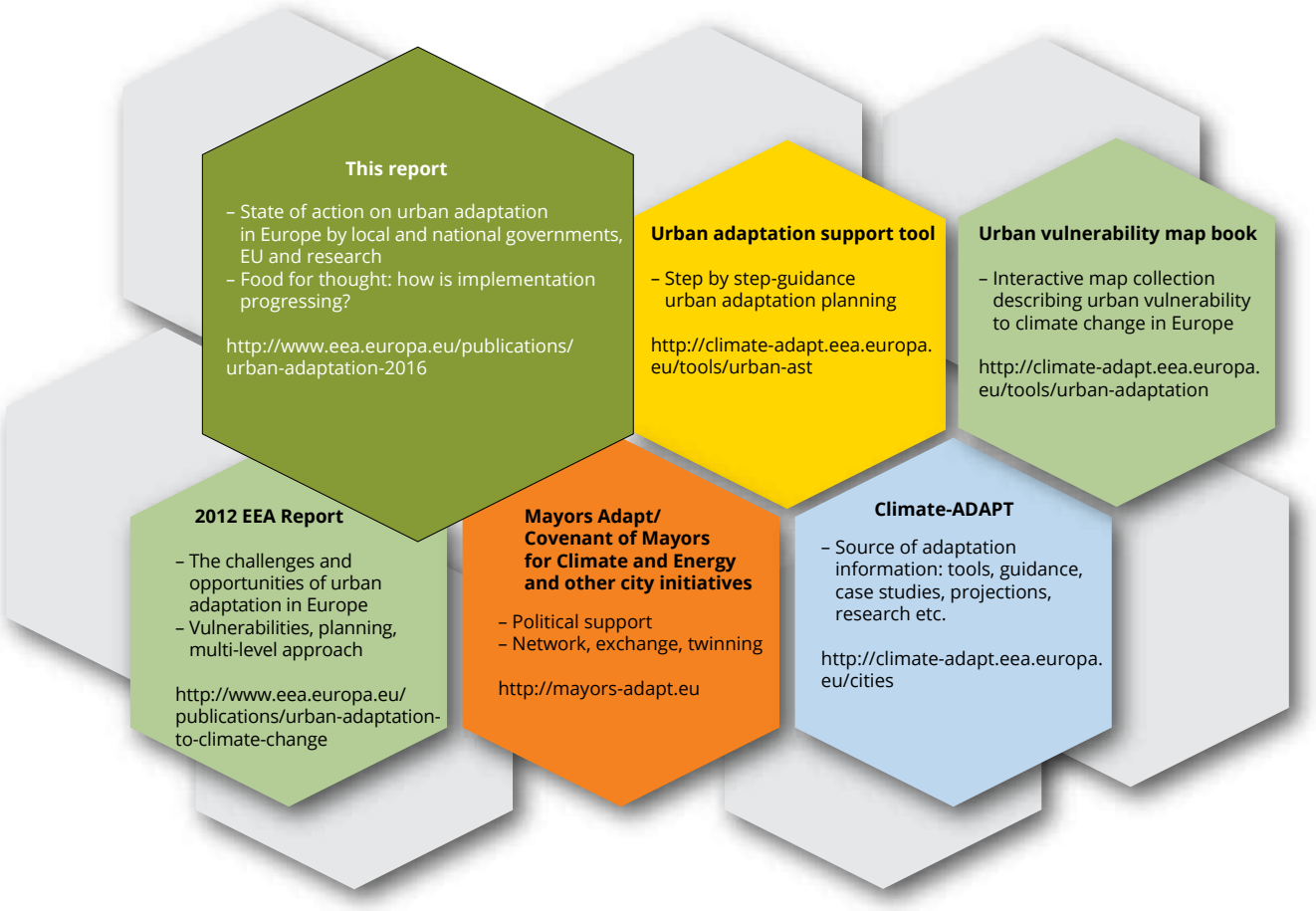
This report is therefore not a guidance tool. You can use the Urban Adaptation Support Tool for that. Neither does it repeat the vulnerability assessment from the 2012 EEA report.

In the following chapters, this report:

- briefly outlines the climate changes and interrelated socio-economic challenges that cities face or will face and the possible consequences (Chapter 2);
- describes how to meet these challenges with a systematic approach that can transform cities into attractive, climate-resilient and sustainable places (Chapter 3);
- describes what local, regional, national and EU stakeholders are doing to adapt cities (Chapter 4);
- looks in more depth at selected key areas of action and reflects on how local, regional, national and EU stakeholders are already doing what the systemic challenges of climate change require (Chapter 5);
- draws conclusions and provides an outlook (Chapter 6).

([6]) http://climate-adapt.eea.europa.eu.

Figure 1.1 This report in relation to other tools and initiatives on urban adaptation in Europe



Note: This is not exhaustive, but lists a selection of tools and initiatives that are particularly relevant. You can find these and many more tools and information at Climate-ADAPT (http://climate-adapt.eea.europa.eu/cities).

Source: EEA.

2 Climate and urban Europe — changes ahead

Key messages

- Cities are centres of innovation and growth and the engines of European economic development. They provide essential services for their inhabitants and people living beyond. A climate-resilient Europe needs well-adapted and climate-resilient cities.
- Climate change is not isolated; it is strongly intertwined with socio-economic factors that make it a systemic challenge. Regional and global megatrends change these factors further, and cities need to consider them together with climate change.
- Climate change is already happening. Cities suffer direct impacts such as flood damage or premature death from heat. The indirect cascading effects can stretch much further and affect other sectors, cities and regions, for example when they hit logistics centres.

2.1 Climate change is a systemic challenge for cities

European cities are centres of innovation and growth and the engines of European economic development. They are responsible for an ever bigger share of Europe's economic output. They are projected to grow from housing nearly 73 % of the population now to more than 80 % by 2050 (EEA, 2015d).

The *Cities of Tomorrow* report sees that, at the same time, cities face complex environmental, social and economic challenges (EC, 2011). National governments increasingly delegate responsibilities to them, which they must meet with often limited resources. Current trends in Europe suggest that socio-economic disparities between different parts of Europe will continue. Major urban centres (metropolitan areas) are connected to urban networks with many small and medium-sized cities, but at the same time they face different conditions for tackling the challenges and have different resources. We expect climate change to increase the frequency and intensity of heatwaves, floods and droughts, which will exacerbate other challenges (Section 2.2). Many cities in Europe are already working on mitigation, that is decreasing energy use and greenhouse gas emissions, but adapting to these climate risks is a novel challenge for most cities (Chapter 4).

Climate change is a systemic challenge for cities; it does not happen in isolation but is intertwined with other environmental and socio-economic factors. Socio-economic structures are among the root causes of climate change and its impacts; they also make us vulnerable to them. For example, lifestyle, consumption and production affect the amount of greenhouse gas emissions and hence the mitigation challenge. On the adaptation side, trends such as ageing or the spread of cities into low-lying, risk-prone areas increase sensitivity to climate, and the economy influences the opportunities to respond. Conversely, climate change will have profound impacts on a wide range of city functions, infrastructure and services (Revi et al., 2014). These impacts can trigger knock-on effects. For example, extreme events can break energy or water supply links, and so affect production, which effects other producers and wealth generation. If large ports on deltas flood, such as Rotterdam, Piraeus or Thessaloniki, this might have impacts on the national economy and areas beyond the country. Box 2.1 takes the example of Dortmund, which hosts a major European logistics centre for furniture, and describes another potential knock-on effect.

Box 2.1 Possible knock-on effects of climate change impacts: an example from Dortmund, Germany

Photo: © Mbdortmund

Population 571 143
Biogeographical region: North-western Europe

The Ruhr metropolis is an urban region in Germany. Dortmund, like most cities of the Ruhr metropolis, is vulnerable to climate change. Storms, heavy rainfall, flooding and increasingly intense heat waves are having a severe impact. They harm the population living in urban areas as well as the flora, fauna and critical infrastructure. To compound the problems, the legacies of coal mining and heavy industry have resulted in substantial subsidence. More than 100 pumping stations are constantly in use to pump the groundwater collected in mining subsidence areas to a higher level and prevent widespread flooding.

Economic and social changes have caused these multiple challenges and cascading impacts. Adapting to climate change requires integrated solutions coupled with low-emission development strategies. Severe storms, road flooding and blocked railway lines can severely affect business supply chains, with knock-on effects on the European economy. Dortmund is a hub for logistics, including for many multinational companies such as Thyssenkrupp and IKEA, and for the information and communication technology (ICT) sector. The city has an adaptation strategy, and has already undertaken a number of projects (e.g. Lake Phoenix and the Phoenix-West technology park in Dortmund-Hörde). The state of North Rhine-Westphalia has a climate protection act. However, many levels of governance — EU, national and city — need to work together with both public and private actors to ensure greater resilience to the cascading impacts of climate change.

Sources: Mabey et al., 2014; direct communication from Rosalind Cook, E3G, March 2016.

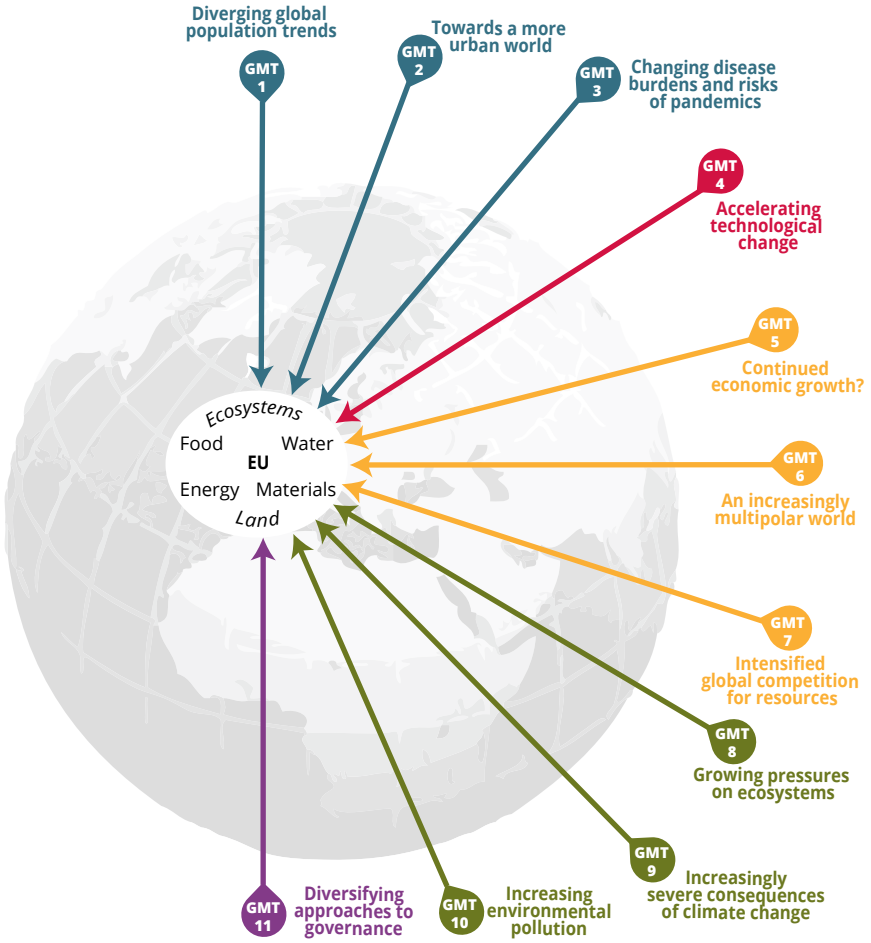
The climate is changing, but so are socio-economic structures. Regional and global trends include changes in the following (EEA, 2015e; EC, 2011; Coutard et al., 2014):

- geopolitics and conflict;
- economic growth or decline;
- unemployment;
- increasing social segregation and exclusion;
- demographic change such as growth or decline, ageing and migration;
- urbanisation and urban sprawl;
- increasing or decreasing dependency on external resources such as energy, food and water;
- technological innovation;
- solid waste, air and water pollution, declining biodiversity and other environmental pressures on urban ecosystems.

Figure 2.1 summarises global megatrends that the SOER 2015 report describes in depth (EEA, 2015e).

Climate change is linked with socio-economic structures and regional and global trends, so we need to treat them all together, in a systemic approach. This requires us to predict socio-economic change at the same time as climate change. We also need to explore other approaches to analysis, for example from social science or arts. Hence, we must consider adaptation and mitigation options not only together but also from this even broader perspective. Options can vary from more specific measures, targeting sources of greenhouse gas emissions and vulnerability hotspots, to more general measures, addressing the underlying and intertwined socio-economic and institutional drivers. They can be oriented to a single sector or integrate more than one. For example, urban design and citizens' behavioural patterns relate to multiple sectors.

Figure 2.1 Global megatrends



Note: GMT, global megatrend.

Source: EEA, 2015e.

2.2 Climate change is happening and affects cities in multiple ways

Exposure to weather and climate is already important. Climate change may make any potential exposure and subsequent impacts more or less damaging. The EEA reports *Climate change, impacts and vulnerability in Europe 2012* and 'Climate change, impacts and vulnerability in Europe 2016' (forthcoming) and the IPCC's Fifth Assessment Report (EEA, 2012a; EEA, 2016d; Kovats et al., 2014) describe the current situation and provide projections for Europe. Figure 2.2 summarises them. The impacts of climate change will affect cities and towns just like the rest of Europe. Because of the concentration of people and economic assets, cities are particularly at risk.

Urban areas generally have the same exposure to climate as their surrounding region, but the urban setting — its form and socio-economic activity — can alter the microclimate of the city. Built-up areas in cities create unique microclimates because they have artificial surfaces instead of natural vegetation. This affects air temperature, wind direction and precipitation patterns, among others. Climate change already affects all of these components to varying degree. Heat, flooding, water scarcity and droughts are the main climate threats relevant specifically to cities. Others can also be important for some cities, such as forest fires, damage from high wind speeds during intense storms, spread of pests and infectious diseases. They can have additional impacts on human health, well-being and economies.

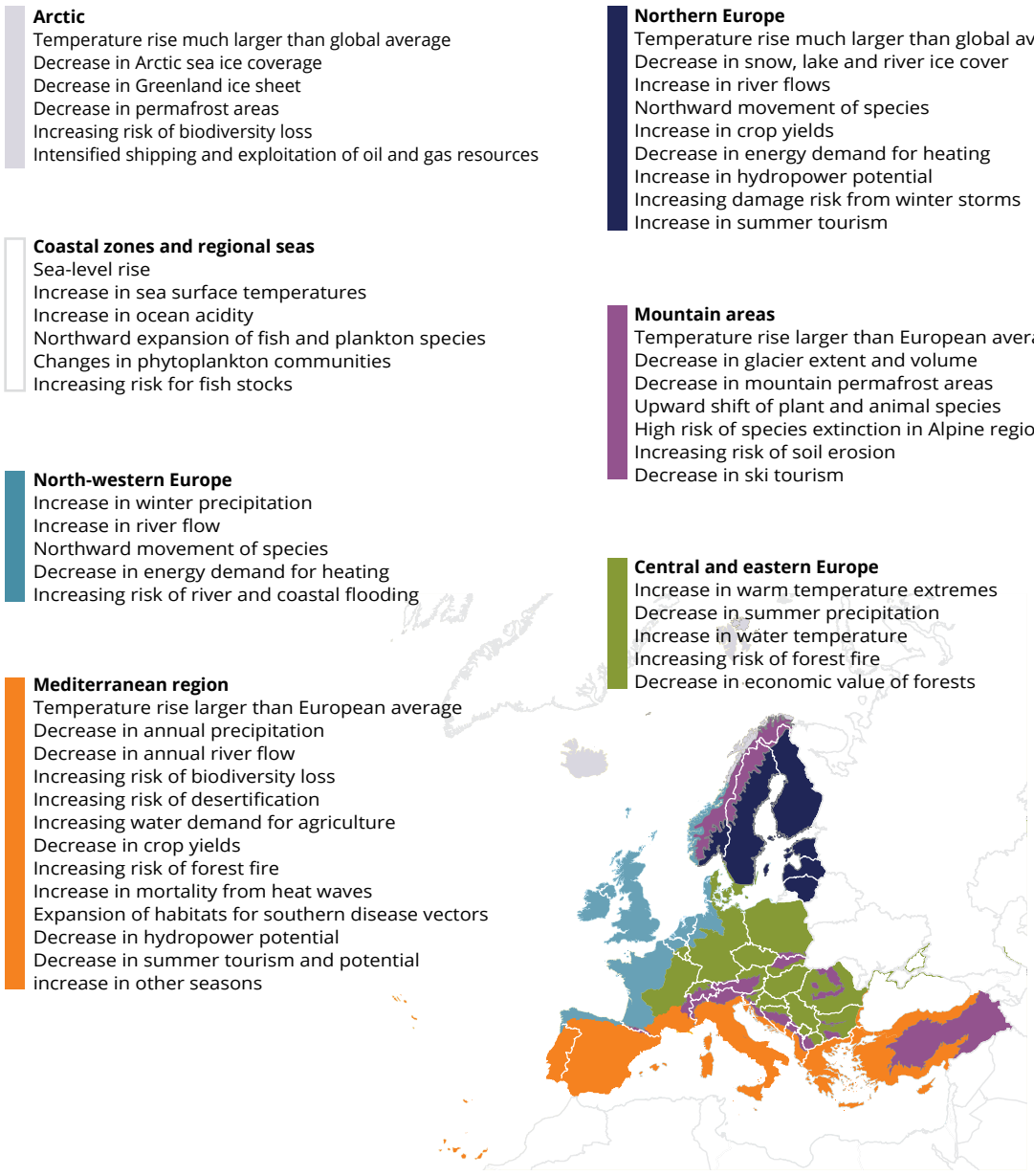
You can study these climate impacts and vulnerabilities in the EEA report *Urban adaptation to climate change in Europe* (EEA, 2012b). New information has become available since that publication. It confirms the risks the report describes and is in the interactive online map book *Urban vulnerability to climate change*. Since 2012,

we have become even more aware of the importance of extreme events such as heavy rainfall and heatwaves, and how vulnerable cities are to disturbances of vital supplies of water, food and electricity, which impacts outside the city's boundaries can affect. Box 2.2 gives the example of increased frequency of high waters in Venice. We need more detailed forecasts of socio-economic scenarios that would affect greenhouse gas emissions as well as vulnerabilities and the capacity to act in the future.

Climate change has direct impacts on cities, such as health problems due to heat, or flooding damage to buildings and infrastructure. Many knock-on impacts affect other areas, sectors and people inside and outside the city. As already mentioned in Section 2.1 and in the example of Dortmund in Box 2.1, the knock-on effects can be far away, in other cities and regions.

Heavy rainfall can cause floods on coasts, beside rivers and from urban drainage. Floods and landslides can destroy homes, business sites and infrastructure as well as indirectly contribute to loss of jobs and other sources of income. They can cut off people and businesses from vital services such as energy, transport and clean water. Heatwaves can compromise public health directly as well

Figure 2.2 Key observed and projected climate change and impacts for the main regions in Europe



Source: EEA, 2015e.

as by increasing the burden of air pollution. They reduce the ability to work and result in lower productivity. This reduces or delays the delivery of products and services to clients in the city and elsewhere. They can reduce the use of public spaces and thus constrain social life. Higher temperatures increase the spread of certain infectious diseases into new regions. High temperatures can also put infrastructure at risk. Deformed roads and railways can hamper the movement of goods and commuters. Power plants may not get sufficient cooling water so they fail to deliver energy, and energy suppliers need to use expensive alternative sources. If the production of food, goods and services outside a city drops, it may constrain services in the city. Cities that are short of water have to compete for it with other sectors such as agriculture and tourism. It costs the city or individuals more to get enough water, which challenges social equity. These direct and indirect impacts challenge the economy and quality of life in cities and in Europe as a whole. Table 2.1 summarises them.

The average climate and extremes are both changing. These changes may cost a lot for many and varied urban activities. There are two kinds of consequences: market impacts directly affect the economy (e.g. losing assets because of flooding) and non-market impacts affect humans and the environment in a broad way (e.g. health, biodiversity). The impacts can also be direct (e.g. earning less or more from tourisms) or indirect (e.g. earning less or more from people whose livelihoods depend on tourism).

> *If we would not adapt to the effects of heat waves, our city would face a higher death rate for vulnerable citizens like elderly or sick people. Because of the higher temperatures during the night more citizens will face sleep deprivation and this will affect the work productivity.*
>
> Geertje Wijten, City of Amsterdam

Knowledge of actual effects of recent disastrous events has improved in recent years, but it is hard to estimate the costs of climate change impacts, as we lack necessary data, which also need to include socio-economic trends. There are also methodological problems. Data might exist about insurable economic losses and damages following extreme events (e.g. in Dresden, Genoa and Malmö, Box 2.3, or Copenhagen, Box 5.33), but not about non-economic losses. These range from health effects of climate change to lost culture and damaged ecosystems.

Box 2.2 Venice in Italy faces more frequent high-water incidents affecting a long-admired feature of the gondola

Photo: © Margaretha Breil

Population: 264 534
Biogeographic region: Mediterranean

The Guardian reported in October 2014:

'The increased frequency of high water incidents is clear: according to figures on the Venice city council's website, there have been 125 'acque alte' this year, seven of them reaching more than 110 cm above normal sea level. Somewhat unusually, they continued throughout the summer months.

'In 1983 there were 35, with only one reaching over 110 cm. In 1993 there were 44. Last year there were 156.'

The *risso*, a long-admired ornamental feature of gondolas, is also under threat from these rising waters, the article continues. Gondoliers increasingly have to remove the iron ornament from the stern to get their boats under bridges during high waters.

Source: Davies, 2014.

Table 2.1 How climate impacts affect urban living, working and moving

	LIVING	WORKING	MOVING
HEAT	Decreased comfort Health risks Increased energy use for cooling, decreased for heating	Reduced labour productivity Increased energy use for cooling, decreased for heating	Discomfort on public transport Rail buckling Increased energy use for cooling, decreased for heating
FLOODS	Nuisance/health risks Damage to houses Power and water failures	Reduced accessibility Economic asset damage Power and water failures	Blocked roads and rail
WATER SCARCITY	Discomfort Health and safety risks	Reduced productivity Power and water failures	Shipping constraints
WILD FIRES	Health and safety risks Damage to houses	Damage to economic assets	Transport route blockage
STORMS	Nuisance/health risks Damage to houses Power and water failures	Economic asset damage Reduced accessibility Power and water failures	Blocked roads and rail

Note: The examples are not exhaustive and they may not be relevant for all cities.

Box 2.3 Examples of economic impacts of catastrophic events

Population: 5 530 754 (Dresden)
596 958 (Genoa)
302 835 (Malmö)
Biogeographic region:
Central and eastern Europe/
Mediterranean

The 2002 flooding in Dresden (Germany) caused about EUR 80 million worth of damage to community services alone. The damage to flood protection infrastructure cost an estimated EUR 300 million. Damage to agriculture and forestry is estimated at about EUR 45.6 million. Flooded public and private buildings suffered several more millions of euros' damage.

The 2014 flash flood in Genoa (Italy) caused damage to buildings and their contents of approximately EUR 100 million, according to estimates by the CIMA Foundation, and exposed 12 710 residents to risk.

In August 2014, a cloudburst in Malmö (Sweden) caused damage in excess of SEK 250 million (EUR 26 million) in immediate insurance claims and over SEK 100 million (EUR 10 million) in clean-up costs for the city. In insurance claims alone, that single flood accounted for approximately one third of the annual costs from flooding in the city. We still do not know the total costs. One year after the event, insurers had yet to process hundreds of claims.

Photo: © Landeshauptstadt Dresden, Umweltamt

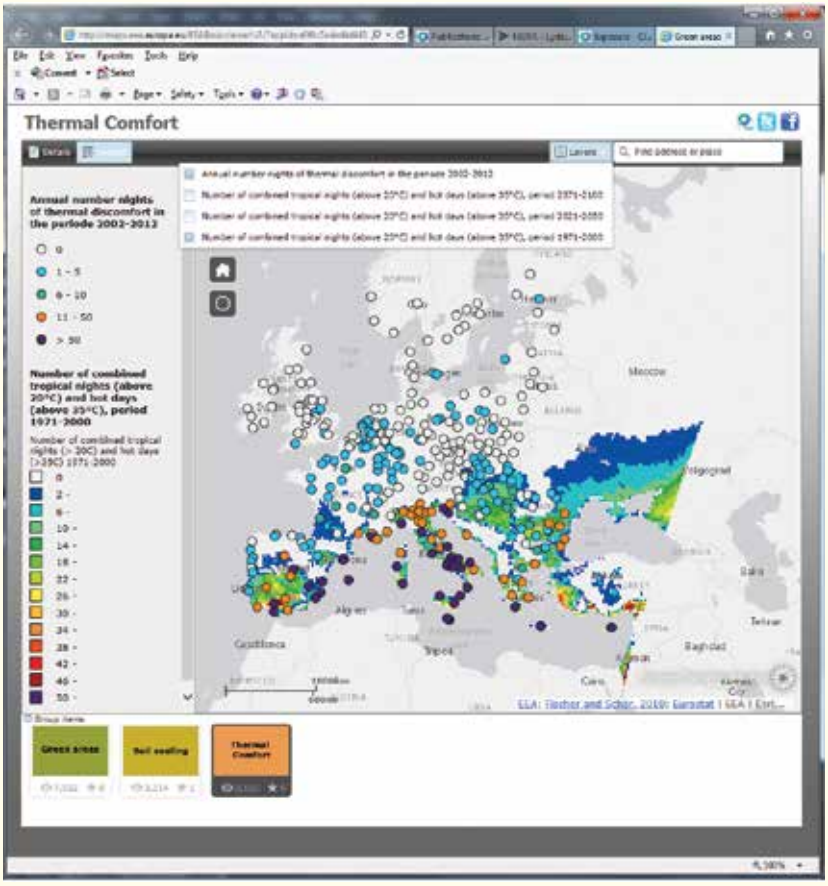
Sources: http://statistik-dresden.de/archives/7823; http://statistik-dresden.de/archives/7794; Forcade, 2016; Mottaghi, 2015; http://www.sydsvenskan.se/malmo/ett-ar-efter-oversvamningarna-i-malmo.

Further resources

- ➔ *Urban adaptation to climate change in Europe* (EEA, 2012b): http://www.eea.europa.eu/publications/urban-adaptation-to-climate-change/
- ➔ Interactive map book *Urban vulnerability to climate change*: http://climate-adapt.eea.europa.eu/tools/urban-adaptation/
- ➔ *Climate change, impacts and vulnerability in Europe* (EEA, 2012a, 2016) (update available in autumn 2016): http://www.eea.europa.eu/publications/climate-impacts-and-vulnerability-2012
- ➔ *Climate Change 2014: Impacts, Adaptation and Vulnerability. Part B: Regional Aspects* (IPCC, 2014a): https://ipcc.ch/report/ar5/wg2

Map book *Urban vulnerability*

The map below is an example from the book. Thermal comfort in cities is one indicator related to heat waves. You can explore this and many other interactive maps. The map book provides a scheme to help you interpret such separate data in the broader context of vulnerability.



Source: EEA, map book Urban vulnerability to climate change: http://climate-adapt.eea.europa.eu/tools/urban-adaptation.

3 The road to adapt and transform cities into attractive, climate-resilient and sustainable places

Key messages

- Adaptation can follow different approaches: coping with the consequences of disasters and change; incrementally improving existing conventional measures such as increasing dykes or sewage capacity; and/or transforming the way to address climate impacts by finding different solutions.
- All three approaches have their justifications. Which combination of coping, incremental and transformative measures a city prefers to choose depends on the specific circumstances.
- Transformative adaptation is broader and systemic. It addresses the root causes of vulnerability to climate change. Humans often cause vulnerability by settling in risk-prone areas, designing buildings inadequately or behaving in ways that aggravate climate change impacts. This perspective thus takes an integrative and long-term view, aiming to avoid locking cities in to unsustainable development pathways.
- Such a broad systemic approach can turn adaptation from a pure need into an opportunity to transform cities into attractive, climate-resilient and sustainable places.

Strong mitigation efforts are needed to keep climate change impacts down to a level that still allows the major services we get from nature and society to function reasonably well. However, even if global greenhouse gas emissions were to stop today, climate change would continue for many decades as a result of past emissions and the inertia of the climate system. Therefore, we need to adapt to the unavoidable impacts of climate change. Addressing climate change requires mitigation and adaptation in a complementary approach.

While acknowledging the need to integrate mitigation and adaptation, this chapter focuses mainly on adaptation. Section 3.1 describes and analyses three different approaches to adaptation: coping, incremental and transformational. Coping and incremental adaptation are generally well developed already. Section 3.2 concentrates on transformational adaptation and what it adds to the other two approaches. Describing it also helps us reflect on how current action already meets the needs of a systemic approach, which we do in Chapter 5.

3.1 Different approaches to adaptation

Based on their circumstances, starting points and key actors, city administrations currently follow different approaches to climate adaptation. We can distinguish them mainly by their degree of foresight, proactiveness and integration. Adaptation planners and/or the responsible decision-making bodies can opt to cope with the immediate impacts of extreme events once they appear or when stresses become obvious: the *coping approach*. They can build on existing adaptation measures and knowledge gained, for example in disaster risk management, by incrementally improving them and increasing their efficiency: *incremental adaptation*. Both are already in use and can include the optimisation of existing measures. Alternatively, adaptation managers can opt to fundamentally change the way they approach the challenges, by establishing new and innovative solutions that aim to develop opportunities to transform the city to be resilient and sustainable: *transformational adaptation*. Box 3.1 and Table 3.1 describe the differences between these approaches, for better understanding. In practice, however, they overlap. Combined solutions exist as well.

Box 3.1 Definitions of 'transformational' and 'incremental adaptation' used in this report

- **Transformational** adaptation measures are ways of using behaviour and technology to change the biophysical, social or economic components of a system fundamentally but not necessarily irreversibly. It includes planned and responsive measures using a different approach from the standard method; they include innovation or shifting certain activities to new locations. Transformational adaptation looks forward to the long term and takes a systemic approach to planning and implementation. It can result from single initiatives or a series of rapid incremental changes in a particular direction. Transformational adaptation may be positive, in terms of gains, or negative, in terms of losses or reaching the limits of adaptation.

- **Incremental** adaptation is less radical. It is the extension of actions that are normally taken to reduce losses or enhance benefits from climate variability and extreme events. These can include increasing existing flood defences; modifying extreme weather warning systems; augmenting water supply by increasing the size or number of reservoirs or decreasing demand; and ecosystem and forest management measures. Incremental adaptation measures are what people have already tried and are familiar with in a region or system — doing more of the same to deal with current climate variability and extremes.

Sources: EEA, 2013, and adapted from Lonsdale et al., 2015.

Table 3.1 Characteristics of different adaptation approaches as used in this report

	Coping	Incremental adaptation	Transformational adaptation
Aim	Restore current way/ quality of life after disaster (disaster risk management) Reduce negative impact of disaster	Includes aims of 'coping'. In addition: • protect current way/quality of life under changed external conditions; • prevent negative impact of disaster	Includes aims of 'coping' and 'incremental'. In addition: improve/change way/quality of life under changed external conditions
Management	Reactive management of change, focusing on current conditions	Reactive management of change, focusing on current conditions Management of change is focused on finding ways to keep the present system in operation	Foreseen, planned management of change Management of change includes questioning the effectiveness of existing systems and processes
Time horizon	Cope with current disaster Consider current risk levels	Forward-looking, short to medium time horizon; focus on current conditions and short-term change; future uncertainty is not acknowledged May be sufficient for low levels of change (e.g. 1.5–2 °C)	Forward-looking long-term vision; focus on future and long-term change; uncertainty in the future is acknowledged and built into decision-making Preparedness for higher levels of change (e.g. 4–6 °C)
Planning	Disaster driven/coping with consequences Mainly intermittent Emergency budget finance Action-focused stakeholder involvement mostly of professionals Prevailing instrument: disaster risk plan	Opportunity- and needs-based implementation Sustained over urban management cycles Regular but limited budget allocation Project-focused involvement of stakeholders immediately addressed by measure Prevailing instruments: zoning plan, building code	Programme-based implementation Strategically planned according to the systemic, long-term perspective Sustained over long-term urban development programme and management Funding development and sustained financing streams linked to long-term planning policies Broad and integrating involvement of stakeholders in planning Prevailing instrument: sustainable urban development programme

Table 3.1 Characteristics of different adaptation approaches as used in this report (cont.)

	Coping	Incremental adaptation	Transformational adaptation
Scale/ integration	Sectoral and local orientation with little connection to larger area (watershed, region, country) High risk of maladaptation	Smaller, discrete, within-system changes, mainly sectoral and local orientation with modest connection to larger area (watershed, region, country) Using some opportunities for joint benefits Medium risk of maladaptation	System-wide or multisystem perspective Integrating climate mitigation and adaptation Integrated across environmental and socio-economic sectors (climate change adaptation is a natural part of urban sustainable development) and different levels of governance Explicitly taking into account external services and possibilities to induce changes elsewhere that have a beneficial effect on the city Low risk of maladaptation
Dealing with lock-ins and uncertainty	Possible lock-ins into unsustainable pathways under future conditions Ignore uncertainty	Possible lock-ins into unsustainable pathways related to long-term changes Partly deal with uncertainty	Avoid lock-ins into unsustainable pathways Stay flexible, deal with uncertainty
Dealing with change	Change seen as a risk Applies known and trusted technologies and approaches; lessons learned from past experience	Change seen as a risk Applies known trusted technologies and methods and increases their efficiency	Change seen as an opportunity Fundamental structural changes/going beyond efficiency gains Niche development Explores alternative, innovative solutions (solve problems differently) in replacing or complementing traditional solutions

Source: EEA, based on Lonsdale et al., 2015.

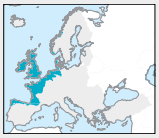
The three approaches have advantages and disadvantages (Table 3.2). Adaptation managers need to deliberate on these carefully in relation to their specific case to find the optimal approach.

Coping can be passive, simply reactive and hesitant. It runs high risks in terms of human and economic losses and requires rebuilding after each disaster. The coping approach to disaster risk management prepares actively for a possible disaster, typically considers current risks and learns from experience of past events. It focuses on responding to individual disasters and consequences of extreme weather events rather than addressing complex issues and interdependencies of climate change. These solutions are well proven but might be limited, even controversial. Proper adaptation needs to consider the expected magnitude of future changes and extreme events.

It may be reasonable to decide on a coping approach if a vulnerability assessment finds that, overall, the city is not prone to risk or vulnerable to consequences of climate change in the future. Adaptation planning could include it once cities agree what level of risk is acceptable after implementing a certain adaptation measure. Thus, it would deal with the remaining risks of very extreme events that incremental or transformational adaptation did not avoid. However, a city might apply only a coping approach because climate change had a low political priority or for other reasons. If it had not thoroughly assessed its vulnerability, it might underestimate the danger of serious risks and damages. Consequently, the decision-makers could be responsible for serious risks (and damages) to their citizens and economic assets in their territory (Box 3.2).

Incremental adaptation builds on vulnerability assessment and adaptation plans, but follows an approach based on opportunity. Such measures build on proven knowledge. Implementation often focuses on individual measures as appropriate and as opportunities appear. Incremental adaptation is often sufficient and very effective to deal with many short- and medium-term challenges. It is relatively quick to set up but it might not be adequate for certain long-term impacts of climate

Box 3.2 Coping: citizens hold local authorities accountable after storm Xynthia



Biogeographical region: North-western Europe

Climate change tests governance and management, demanding strong political leadership and commitment. In times of uncertainty, such as during storm Xynthia, good public management ensures that public and governmental institutions fulfil their obligations to promote citizens' well-being and to sustainably manage the resources available.

Xynthia arrived in the early morning of 28 February 2010. It brought wind, water, destruction and death. The cyclone hit the French Atlantic coast, central France, Portugal, Galicia and the Basque country in Spain, and parts of Germany. It left a trail of devastation that led the French government to declare a national disaster in the affected area.

Xynthia took 65 lives in France, almost 1 million households were disconnected from the electricity network and the agricultural areas flooded by sea water will be unable to grow crops for many years to come. The overall damage was calculated at more than EUR 3 billion. Weather forecasters predicted Xynthia, but within just six hours it had unleashed untold power. The tragedy was worse because people did not believe it would hit their homes, because they underestimated the flooding and because local authorities had given planning permission for houses in areas vulnerable to flooding. The planning approval was especially due to delays in approving the PPR-L (Plan de Prévention des Risques Littoraux).

Photo: © Julien Prineau

Sources: ICLEI, 2011b; Chadenas et al., 2014.

change. Then the measures can no longer protect against certain more severe weather events.

Transformational adaptation is a rather recent concept that still has only a vague definition ([7]). The IPCC's fifth assessment report (2014b) sees transformational adaptation as inducing fundamental change by scaling up adaptation. Transformation, in its view, means addressing underlying failures of development, including the increase in greenhouse gas emissions, by linking adaptation, mitigation and sustainable development. To this end, transformational adaptation arguably aims to turn a risk into an opportunity, thus creating joint benefits. It seeks to integrate adaptation with other aspects of urban development to avoid lock-ins. An example of a lock-in is constructing buildings and infrastructures in risk-prone areas, intending them to last for decades, but not designing them to cope with the effects of climate change. Kates et al. (2012), argue that transformational adaptation is much larger in scale or more intensive, is truly new to a particular region or resource system, and transforms places and shifts locations. All the definitions that Lonsdale et al. (2015) analyse include scale, dimension and potential for fundamental change.

Given the advantages and disadvantages (see Table 3.2), which combination of approaches would adaptation managers choose for certain challenges? We expect climate change challenges to be tremendous and heavily intertwined with socio-economic developments. They will reach far into the future and partially they are highly uncertain. There is also a risk that optimising existing solutions and reinforcing them without reflection might lead us into unsustainable pathways.

Assuming that severe climate-driven events will become more extreme and frequent, at least in the long run, in many cities in Europe coping and incrementally improving adaptation may not be enough

([7]) Lonsdale, Pringle and Turner (2015) have analysed the use of terms such as 'transformative' (Park et al., 2012), 'transformational' (Kates et al., 2012), 'transformative agency' (Westley et al., 2013) and 'transition' (Tompkins et al., 2010). They argue that these terms suggest a more fundamental change within and across systems, emphasising that current adaptation is not enough and seeking to move away from a perception that 'incremental is enough'. The IPCC has also taken up the term in its recent report on *Managing the risks of extreme events and disasters to advance climate change adaptation* (2012) and in its *Fifth assessment report* (IPCC, 2014b).

Table 3.2 Advantages and disadvantages of the coping, incremental and transformational approaches following the description in Table 3.1

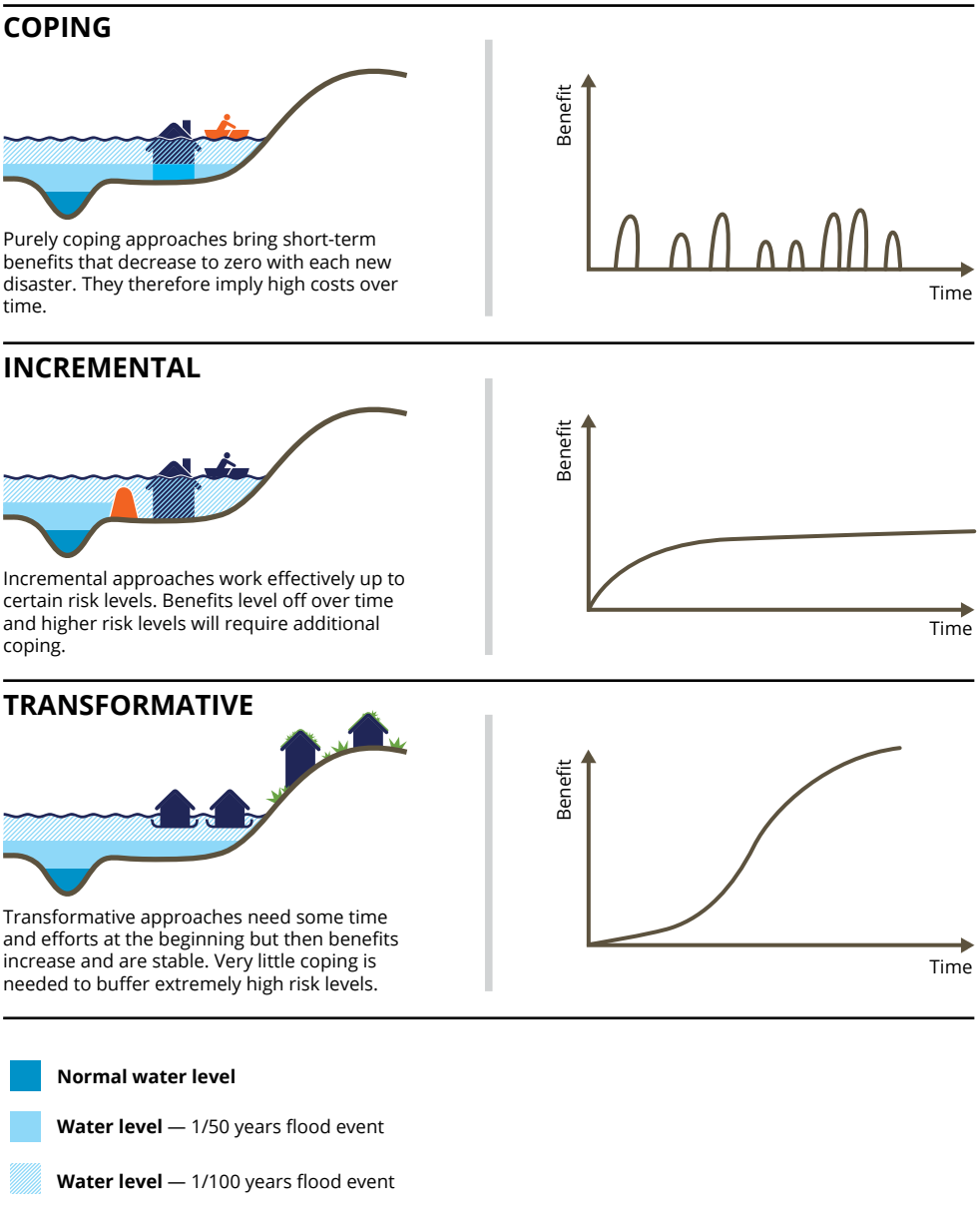
	Coping	Incremental adaptation	Transformational adaptation
Known/unknown grounds	**+** Applies known technologies and methods Low development costs	**+** Applies known technologies and methods Low development costs	**–** Explores new technologies and ways to solve adaptation challenges that can bear some uncertainty and risks regarding functionality or side-effects. Reduces risks, however, by applying a large-scale, systemic approach to planning and implementation, and applying innovative, tested solutions Eventually higher development and learning costs
Sufficient/insufficient	**–** Based on current risk assessment and experiences In most cases, insufficient to cope with future change Risk of recurring disasters	**+/–** Based on concurrent risk assessment and experiences Efficiency gains might not be sufficient to cope with future change	**+** Builds in redundancies to deal with uncertainties Sufficient to meet long-term future challenges
Flexible/inflexible	**–** Moderate flexibility Risk of lock-ins to unsustainable pathways	**+/–** Low to medium flexibility Risk of lock-ins to unsustainable pathways	**+** High flexibility Minimises the risk of lock-ins to unsustainable pathways
Effectiveness and efficiency	**+** Potentially highly effective for cities where assessment identified low vulnerability, or to cover remaining, 'acceptable' risks after adaptation Fast and relatively easy to implement, if resources are available	**+** Potentially effective for purpose Opportunity-based implementation Relatively easy to plan and implement, as involves only a few stakeholders; budget needs to be available	**–** Potentially highly effective thanks to joint benefits Plan-based implementation Great initial efforts needed from stakeholder involvement Relatively high planning and development costs
Risk of losses	**–** High risk of human and economic losses	**+/–** Medium risk of human and economic losses (i.e. as long as solution works and remains appropriate)	**+** Low risk of human and economic losses
Costs	**–** High replacement costs	**–** Lock-in means medium to high installation and maintenance costs as well as replacement costs (e.g. of infrastructure) if the solution is no longer sufficient	**+** Medium to high installation costs but low maintenance costs, as the solution is part of the design of (urban) sustainable development

Sources: EEA, building on Lonsdale et al., 2015, and Capela Lourenço et al., 2014.

by themselves. Instead, a transformational approach might be appropriate to address the severe challenges from a changing climate — at least as long as is needed to achieve a certain level of resilience. Of the three principal approaches, transformational adaptation often requires the most time, capacities and resources in the establishment phase, with no guarantee that it could completely remove the risks associated with extreme weather events. It also requires conscious transition management. Therefore, in the short term, coping and incremental adaptation are likely to prevail, as socio-economic and political conditions in most cities might not allow large-scale transformation.

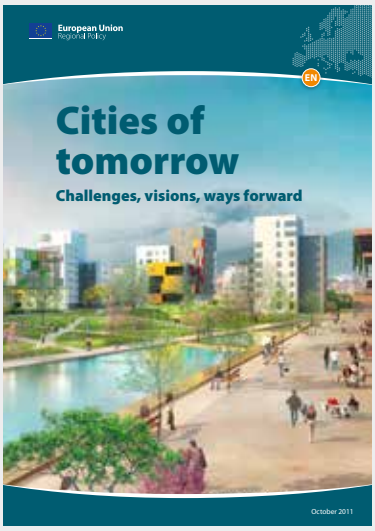
Initially, cities may opt to use 'low-regret' and other 'soft' measures at low cost, such as emergency planning and awareness-raising campaigns. These may address some immediate vulnerabilities very effectively but will not necessarily increase the city's safety in the long run. It will be a good idea to prepare the ground and gradually increase transformational adaptation. This will give more opportunities for urban development. Figure 3.1 depicts the differences in resilience and benefits between the approaches and how they can complement each other. See Box 5.33 for how Copenhagen applies all three approaches in a complementary way.

Figure 3.1 **Examples of different adaptation approaches and complementary benefits at different water levels due to flooding**



Box 3.3 The vision: living in attractive, climate-resilient and sustainable cities of tomorrow — turning challenges into opportunities

Cities of tomorrow will provide a high quality of life and welfare, will be places of advanced social progress, platforms for democracy, cultural dialogue and diversity, and be green places where environmental regeneration takes place. These were the conclusions of the Cities of tomorrow process that the European Commission initiated (EC, 2011). How can cities turn these challenges into opportunities and embrace the vision of making cities an even better place?



Source: EC.

What could living, working and moving in a changing climate look like?

➔ **With incremental adaptation**

There is no such thing as business as usual. Remembering the changes in our cities and urban lifestyles over recent decades, it is not hard to imagine that in a few decades from now our cities will be very different from today even without a changing climate. Addressing increasing temperatures incrementally could lead Europe to follow practice elsewhere in the world by using more air conditioning in homes, office buildings and transport. Not only would it increase indoor comfort and protect the health of the elderly and sick during hot summer days, a booming air conditioning business might also boost economic growth. Obviously, it would also increase energy consumption and possibly greenhouse gas (GHG) emissions. There may be less need to cool cities with large new green public spaces, as compact cities develop and land prices in city centres are high. Citizens can take responsibility themselves and green their own neighbourhoods, both in private gardens and in public spaces, as far as city rules and regulations allow. Incremental solutions can reduce exposure to floods by not storing valuable objects in basements or lower levels of houses in flood-prone areas. Local governments can raise awareness using relatively cheap campaigns, inform vulnerable populations about the risks and what they can do about them, and develop and maintain emergency plans.

Extreme weather-related events often expose businesses' climate vulnerabilities. Small actions can make a big difference in reducing vulnerability, often at a low cost. For example, when you have to repair or replace drainpipes or sewers anyway, you can replace them with slightly bigger ones. Air conditioning can provide relief for workers, and city health care services can draw up health care plans that also address the health of the working population. The authorities can plan emergency power generation and water prioritisation in case supplies fail. In this way, a city can follow a business-as-usual type of path, which can be a low-risk choice, especially in the short term.

City managers are usually well aware of the weak points in transport systems inside and to their cities. In an incremental approach, to move people and freight, they can upgrade key routes into the city, taking away vulnerable spots such as low-lying tunnels and ensuring that multiple routes to get into or out of the city are always open and people can reach health-related structures (hospitals, emergency centres) under all conditions. Large cities may plan for temporary or portable emergency roads and bridges. The ongoing peri-urbanisation trend will lead to more movement between the city periphery and centre, and between cities. This will require regular expansion and upgrading of transport networks and services. Incremental actions may be able to accommodate this trend but not indefinitely.

Incremental adjustments can definitely enhance the resilience of our cities in the short term, but it is doubtful if they are sufficient in the long term. This path alone may not be adequate to ensure the continuity of urban life as we know it.

➔ **Combined with transformational adaptation**

Longer-term urban planning can include green public infrastructure that is both larger and more accessible. A fabric of connected public green spaces and bodies of water can improve social cohesion and living conditions for all, avoiding socio-ecological inequities. New city designs can also consider other cooling options, such as creating wind corridors along the dominant wind direction. In the transformed climate-resilient city of tomorrow, people live in houses that are secure and pleasant to live in, even when outdoor temperatures are high, rivers flood and other extreme events take place. Cities and neighbourhoods share knowledge about risks and opportunities, helping prepare for natural hazards. Green roofs and walls make dwellings cool and attractive. ICT-enabled social networks minimise social exclusion and ensure special attention to sick and elderly people in case of heat stress and other exceptional situations. The transformed European city of tomorrow finds novel ways to add green space while limiting urban sprawl, by making compact neighbourhoods denser. Smart spatial and infrastructure designs minimise the urban heat island effect, air pollution and flooding of streets and houses.

Box 3.3 The vision: living in attractive, climate-resilient and sustainable cities of tomorrow — turning challenges into opportunities (cont.)

In the transformed climate-resilient city of tomorrow, people work flexibly in different places and at different times. ICT innovations make work increasingly easy and effective. Building designs make people, equipment and data more secure, and services more reliable. They can withstand the impacts of extreme weather events without damage or loss of function. Workplaces use cool building and city designs to control their temperatures, rather than increase energy demands from artificial cooling. Companies have analysed the vulnerability of their supply chains and have reduced it by making their supply chains flexible and diverse. Cities and their hinterland together address the vulnerability of services such as water, energy and communication. They safeguard essential services by ensuring that, if one source fails, at least one other source remains functioning. They have a system of coordinated small-scale, distributed, mainly renewable energy sources. Smart digital systems manage all services, matching supply and demand in an optimised way, increasing efficiency and reliability even in extreme weather.

Photo: EC © SLA

There is no need for citizens to travel long distances to spend leisure time in a welcoming outdoor environment, as green public spaces are close to everyone. Flexible working hours and work places considerably decrease the need for mobility. Reliance on private cars is largely obsolete because urban systems are compact and public transport is rapid, affordable and safe. Real-time monitoring of transport flows gives transport systems greater capacity and decreases recovery time in case of extreme events. Decreased reliance on cars has also enabled the use of permeable or semi-permeable surfaces in parking spaces, increasing infiltration and reducing the amount of stormwater run-off. Port authorities, airport managers and railway operators have acknowledged the increasing risks posed by climate change in time and taken steps to minimise transport failures. Demand for transport has decreased because of decentralisation and zoning, which have brought working places and tertiary structures closer to residential areas.

Transformational adaptation enables cities to find more sustainable solutions to long-term change. They can realise many joint benefits and thus turn challenges into opportunities for attractive, climate-resilient and sustainable cities.

Sources: EEA; EC, 2011.

Béné et al. (2012) put coping, adaptive (i.e. incremental) and transformational in context as three approaches that tend to lead to a system in balance. In their view, the more the urban system needs to adapt, the more intense the change is. It ranges from stability to flexibility. As resilience gradually increases (transformational responses, incremental adjustments and persistence), the city can scale its activities back to a coping approach. Thus, in most cities an adaptation strategy will use all three complementary approaches according to the specific framework conditions, its means of acting and options; it will thereby minimise the shortcomings of just one approach.

Box 3.3 illustrates opportunities to use incremental and coping approaches by themselves or in combination with transformational measures in key areas of urban development: leisure, work and mobility. It also shows possible consequences.

3.2 Transformational adaptation: a systemic approach turning challenges into opportunities

The approaches of coping and incremental adaptation are generally well developed already. Therefore, this section concentrates on the transformational adaptation approach only and on the qualities it adds to the other two approaches.

As Section 2.1 suggests, adaptation measures have to account for other pressures and challenges on cities coming from international megatrends, policies

at national, regional and urban levels, and other developments. There are many links between climate change and other trends challenging Europe's cities. Climate change is a systemic challenge that needs systemic and integrated solutions. Considering urban development as a logical, integrating framework for responding to climate change will allow cities to establish multiple links between climate and non-climate policies. Thus, they can use available capacities and financial means most efficiently and effectively, reduce costs and, at the same time, realise additional benefits and opportunities for attractive, climate-resilient and sustainable cities (Box 3.3). Hence, the systemic approach of transformational adaptation includes the following key characteristics:

- cooperation, involvement and appropriate governance;
- a long-term perspective that deals with uncertainty and avoids lock-ins;
- integrating mitigation and adaptation;
- using integration broadly to create resilient and highly liveable cities;
- measures that induce profound structural changes.

Cooperation, involvement and appropriate governance

Section 2.1 introduced the systemic challenge of climate change. It requires a systemic response that would consider adaptation not in isolation but with all these interlinkages, aiming to integrate the different policy areas and sectors affected. Such a systemic approach should help avoid possible conflicts and trade-offs arising from using separate solutions in different areas.

Appropriate governance is the key to exploiting its potential. Creating synergies effectively and avoiding trade-offs depends very much on the degree of collaboration between individuals and organisations and, at city level, between different municipal departments. Small and medium-sized cities often claim to have few resources to build up effective governance structures, but they have the advantage that the lines of communication are short and straight and often the same staff or department is responsible for more than just one policy area. This suggests a great potential for integration, which they may exploit already.

Cooperation across different governmental levels is also decisive (EEA, 2012b). Cities are strongly connected to their hinterland and within a region, and they depend on national governments and the EU to set the administrative and legal framework in which municipalities operate.

If a wide range of stakeholders participate, including business, communities and citizens, the city can benefit from social innovation. People relate to urban spaces and re-create them. Their innovative ideas and changing social relationships can play a positive role in urban adaptation (see more in Section 5.1).

A long-term perspective that deals with uncertainty and avoids lock-ins

Cities are built to last for centuries. In Europe, most cities have origins in the Middle Ages. The resulting physical structures often limit the options for adapting to current needs and future changes, particularly if they are to maintain valuable heritage at the same time. Some of the current adaptation needs stem from unsuitable and inflexible infrastructures that are almost impossible to change. Examples include Venice and other cities built in low-lying areas, such as the Netherlands, that need to cope with rising sea levels and storm surges.

Long-term adaptation planning considers a period of at least 50–100 years. This is a difficult task for adaptation managers and decision-makers, who are used to deciding and acting with much shorter periods in mind (see for example Box 3.4). Cities need to be aware that their choice of adaptation measures can restrict them to a pathway that is effective in the short term but can be expensive in the long term. Further risk reduction requires continuous technical maintenance and incrementally increasing safety levels; the costs increase until eventually they become disproportionate. They are locked in to a situation that is difficult to change afterwards. Buildings and infrastructure, once built in a risk-prone area, are often hard to relocate or change when incremental adaptation measures such as dykes can no longer protect them effectively in the long term.

The place, level and nature of future climate change impacts are uncertain. So are socioeconomic trends. Therefore, it is difficult to plan adaptation, especially for the long term. In dealing with uncertainties, cities can follow a three-step approach: identify and characterise the source of uncertainty; weigh, appraise and prioritise uncertainties; and select and apply methods to deal with them. The most appropriate adaptation policies focus on enhancing the city's ability to deal with possible future changes, including unexpected ones, by building adaptive capacity and resilience, favouring robust measures and maintaining flexibility so it can use a wide range of alternative measures (Capela Lourenço et al., 2014).

Box 3.4 The need for a regional and long-term perspective: the example of Vác, Hungary

Population: 33 475
Biogeographic region: Central and eastern Europe

Photo: © City of Vác

The city of Vác, just outside Budapest, faces severe flooding almost every four years. The flooding is not only a result of increasingly severe impacts of climate change; cities upstream from Vác, including in Slovakia, Austria and Germany, have built flood defences that in turn aggravate flooding in Vác. Coordination across national borders on flood management is challenging for local decision-makers because they often focus on emergency response.

Vác has put together a plan to build a mobile dam to protect the city and the project is going ahead with funding from the Hungarian government. However, the dam is only 1 m higher than the 'last worst' flood. Already, city officials have had to adapt their flood scenarios from 700 cm to 900 cm when a flood turned out to be even more severe than the previous one. Vác's 2002 flood reached 730 cm, requiring 80 000 sandbags to protect the city. In 2013, the level rose to 804 cm, requiring 400 000 sandbags.

This example shows that we need a long-term perspective using future climate projections instead of relying on past experience. This will prevent subsequent events from causing damage over and over again, entailing costs that we could otherwise have avoided. Moreover, a European and regional perspective is also imperative, as adaptation measures in one place can have substantial impacts on others.

Sources: Mabey et al., 2014; direct communication from Rosalind Cook, E3G, February 2016.

Hence, transformational adaptation invests not in unsustainable pathways that result in lock-ins, but in long-term, systemic solutions and flexible adaptation options that can be modified if climate change effects become more drastic and if technological, socio-economic and political conditions change. It will, for example, work towards 'living with water' rather than 'fighting the water'. For instance, it will restore floodplains to their natural state and provide space for water instead of building ever more or higher dykes; it will build floating structures that automatically adapt to different water levels; or it will raise buildings above the ground. A big challenge is that most of our cities are already built; this approach applies more easily to new developments and might be more difficult to apply to existing structures.

Developing transformational adaptation measures takes a long-term perspective to planning. It does not just wait for an opportunity to make structural changes, for example replacing buildings if flooding destroys them or taking a different approach to governance only when political or legislative changes require it. It will also try to generate such opportunities proactively by planning and conscious implementation, considering maintenance and replacement cycles, decision-making and investment processes, financing needs and funding opportunities, and the needs of stakeholders and citizens to get involved.

Integrating mitigation and adaptation

So far, cities have mostly dealt with mitigation and adaptation as two separate strategies. Only in the past five years or so has climate adaptation appeared to be of concern for delivering municipal services. However, mitigation and adaptation are not alternatives, but complementary. Mabey et al. (2014) propose a related three-tier 'ABC' risk management framework for EU cities to 'aim to stay below 2°C, build and budget for 3 to 4°C; and contingency planning for 5 to 7°C'. This would integrate both mitigation and adaptation in one challenge to deal with a changing climate.

Still, city governments often assess climate risks and develop adaptation strategies separately from their mitigation efforts. There are good reasons to consider mitigation and adaptation in combination. These include efficiency gains, improving the use of locally

available resources and creating new opportunities and solutions by aligning procedures and policy and investment cycles. A renewable energy strategy, for instance, will need to consider the potential impacts of a changing climate on the energy sources, and the adaptation strategy would include safeguarding the continuous provision of energy. Low-carbon urban development programmes would aim to make cities compact and strengthen regional markets to reduce GHG emissions from transport. The same measures would well suit efforts to mitigate the disruption of services and supply chains to citizens due to events resulting from climate change.

Some of the possible synergies, trade-offs and complementarities are as follows:

- ***Synergies***

  Synergistic options are significant for particular important niches, such as green infrastructure and urban and building design. Some adaptation measures in themselves have synergies with mitigation.

  Examples include measures relating to passive or active cooling of the indoor climate, such as building insulation, white roofs, green roofs, sunscreens or storing heat and cold to prevent buildings from overheating and also save energy for cooling. Tree canopies cool the city and remove atmospheric pollutants. Reducing transport or shifting to cycling and walking mitigates GHG emissions as well as anthropogenic heat in the city (see Box 4.3).

- ***Trade-offs***

  Adaptation options, particularly those of conventional 'grey' (technological) infrastructure, may make greater demands on energy and material resources. Thus they require a smart design to minimise trade-offs in terms of GHG emissions and, hence, to limit the mitigation challenge.

  Mitigation measures such as insulation programmes may well lead to overheating in buildings/apartments when solar radiation enters the building through windows and is trapped. Insulation should therefore be combined with adaptation measures to prevent overheating, such as shading and ventilation.

  A dense and compact city offers more potential for energy and transport efficiency, but it can reduce green space and ventilation that could help to adapt.

- ***Complementarity***

  Mitigation and adaptation options both use such core instruments as urban planning, urban design and building design. These tools offer a good opportunity not only to create synergies and avoid trade-offs but also to develop complementary adaptation and mitigation measures. For example, an integrated urban development plan could aim for a compact city and a low-carbon and adaptive urban design.

  Coupling climate mitigation and adaptation strategies can also raise awareness among the community and economic actors. If these are aware of the local risks, they may be more motivated not only to increase their resilience but also to consider their energy use.

Using a broadly integrated approach to create resilient and attractive cities

Many adaptation measures so far have been part of other urban policies such as urban water management, greening and biodiversity programmes, disaster risk management or health care. However, adaptation is about to become an integral part of urban planning at both city and district levels. Responding effectively to climate change — including mitigation and adaptation — ensures a good quality of life for citizens (i.e. keeping them healthy and safe) through effective and efficient municipal services and urban systems. To fulfil their tasks and accomplish the desired objectives, municipal services and urban systems need to take account of the effects of a changing climate (adaptation) and of how they contribute to climate change (mitigation). The same holds true for urban resilience (i.e. the ability of cities to withstand crisis) and urban sustainability (i.e. urban development that respects the current limits of the planet and the opportunities of future generations while improving the quality of life for citizens). City administrations need not only to embed climate change mitigation and adaptation in both urban planning and infrastructure development, but to integrate climate mitigation and adaptation measures with the development of urban sustainability and resilience. By definition, resilience includes the ability to withstand disasters arising from climate change. There is no long-term sustainable development without appropriately considering climate change effects.

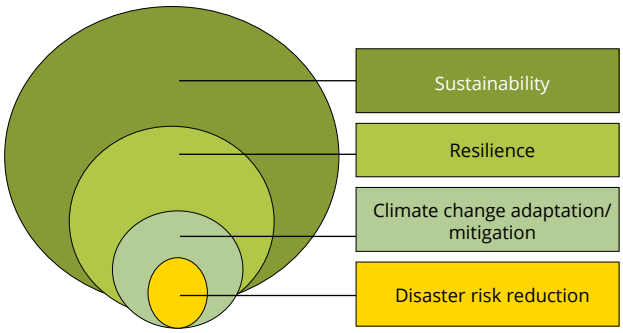
Consequently, although integrated climate change mitigation and adaptation is still a new approach, some cities are already exploring the opportunities

and benefits of linking climate and non-climate policies and establishing multipurpose measures. This is in response to the megatrends and multiple challenges affecting Europe's cities, addressed in Section 2.1. These cities expect to gain most benefit from wider integration and mainstreaming of climate change responses in comprehensive urban development, sometimes under the general heading of, and embedded in, sustainable city development (Figure 3.2).

The above becomes even more evident when considering the narrow 'windows of opportunity' for urban development and transformation programmes. This is because political decision-making, urban planning, infrastructure renewal, and public and private investments all follow different processes and time-lines and have different interests. The decisions taken and investments made mean that, once we have built urban infrastructure or private property, it will last for years, if not decades. For example, a planned urban square may have a great design but, if planners have not considered how the additional sealed surfaces will contribute to urban heat island or water run-off effects, it will worsen the problems rather than provide solutions. An urban project resulting from an integrated approach to planning would design the square differently, considering nature-based solutions such as shading trees, vegetation that drains excess water, cooling water fountains, rain-water sinks or energy-efficient positioning of surrounding buildings. It will also consider how these solutions will create local jobs (e.g. in building and maintaining the green and blue infrastructure) and thus affect the local and regional economy.

You can read more about such transformational actions in this report. Examples include ecosystem-based adaptation and green and blue infrastructure (e.g. sustainable drainage systems, rain gardens, green roofs) that improve the city's environmental and social amenities, disaster risk response plans that enhance social and economic resilience, and measures improving the health of elderly and poor people that also reduce their vulnerability to climate change.

Figure 3.2 **Local adaptation and resilience: embedded in the context of sustainability**



Source: Robrecht and Morchain, 2012.

Profound structural change

As previous examples have shown, a broadly systemic approach that is sustainable and efficient in the long term often requires profound structural changes in the way adaptation managers solve problems. Many conventional measures often try to deal with problems that already exist (end-of-the-pipe solutions). Developing them incrementally is prone to reach limits. In addition to addressing short-term challenges, we need to change production and consumption patterns. This also responds to the sustainability challenge to live well within ecological limits. 'Living well within the limits of our planet' suggests more profound changes in dominant institutions, practices, technologies, policies, lifestyles and thinking. It also requires reconfiguring social relations between local governments, civil society, science and businesses. It does not aim to keep the current urban system functioning under changed climate conditions, but sees change with a positive attitude. This is an opportunity for urban development with the potential to make cities even more attractive places to live and work and put Europe and its cities at the frontier of science and technology.

The approach calls for a greater sense of urgency and more courageous actions (EEA, 2015e). Currently, socio-economic trends seem to offer opportunities for renewal, innovation and transformation in many areas, including climate change response. New digital developments and other technological change also provide new opportunities for solutions, for example related to innovations in communication technologies, new materials or novel multipurpose use of urban space. They influence the roles of citizens, city managers and other urban actors. The same applies to non-technological innovations: social, cultural and institutional. Urban lifestyles (i.e. the way people live, work and move around), interpersonal relationships and urban governance approaches will be different in the future and can be more sustainable and resilient. Environmental policies also have the potential to create economic opportunities and thereby also contribute to political strategies such as Europe 2020, aiming to develop a smart, sustainable and inclusive economy in the EU by 2020 (EC, 2016b).

Table 3.3 provides an idea about the different solutions used by transformational adaptation compared to the conventional approach of incremental adaptation.

Challenges remain: transformational adaptation is a learning process

As stated in the preceding chapter, transformational adaptation also has to deal with certain challenges. Solving problems a different way from in the past can be risky to a certain extent if measures have not been sufficiently tested in practice. Transformational adaptation is a learning process. Monitoring, reporting and evaluation are therefore key. Also, it is helpful to focus on flexible or step-wise solutions that are easy to adjust.

Transaction costs to establish a new approach may be high, as in some cases it is necessary to change mindsets, institutional structures and governance schemes. This can be a lengthy process. In this situation, starting with coping and incremental adaptation (but being careful to avoid possible lock-ins) can be important to gain time to prepare transformational measures in parallel.

Table 3.3 Dealing with climate change challenges: examples of incremental and transformational approaches

Approach / Challenge	Incremental measures: optimising conventional measures	Transformational measures: dealing with the challenge in a different way
Flooding	Build more dikes and floodgates	Create space for water; retention areas
	Reinforce existing dikes	Reduce soil sealing to allow natural drainage
	Pump water out	Place infrastructure on higher grounds
	Floodgates at buildings	Retreat from low-lying, potentially flood-prone areas
		Floating buildings and infrastructure
		Develop infrastructure that can be temporarily flooded without any damage (non-sensitive use of ground floors and basements)
Heat	Improve air conditioning	Change city design: cooling by greening and ventilation corridors
		Change building design: passively cooling by isolation, shadowing, natural ventilation
		Change behaviour: work in the cooler hours, stay in cool places, drink more water, slow down physical activity
Water scarcity and droughts	Serve the demand by getting water from distant regions	Reduce the demand by water-saving appliances in households and buildings
	Water rationing	Reuse water
	Reduce leakages	Establish water-saving behaviours
		Change production using less water
Various	Improve existing governance and behaviour	Changed governance; consumption, behaviour etc.

Further resources

➔ *Transformational adaptation: what it is, why it matters & what is needed* (Lonsdale et al., 2015)

➔ *Adapting to an uncertain climate* (Capela Lourenço et al., 2014)

➔ Chapter 4 Transition management in cities. In: *Urban sustainability issues — Enabling resource-efficient cities* (EEA, 2015f) http://www.eea.europa.eu/publications/enabling-resource-efficient-cities

4 Urban adaptation action to date

Key messages

- Although climate change adaptation is still a novel issue, more cities have started the process over the last few years. Most cities are at early stages of the process, assessing their vulnerability and developing adaptation strategies and plans. The frontrunners have now started to implement adaptation measures and to develop first ideas for monitoring and reporting.
- In the past, cities very often started to adapt after a disaster, because they wanted to avoid such catastrophic events in the future. In recent times, cities that have not suffered such an event had started to take action too. Increasingly, they see climate change adaptation as an opportunity to create a more attractive and vital city.
- Mainstreaming the need to adapt into other policy areas, such as climate change mitigation, water management, biodiversity, disaster risk management or health, can be an effective way to implement adaptation. It is sometimes even the only way decision-makers accept.

In 2012, when the EEA published its report *Urban adaptation to climate change in Europe: Challenges and opportunities* (EEA, 2012b), climate change mitigation was established but adaptation in European cities was a fairly new topic. Cities had mostly reacted to past disasters, such as flooding, droughts or heat waves, as part of water, health or disaster risk management. Such reactions can be a starting point, but not many cities had embarked on adapting to future climate changes. The report stated that 'as the adaptation agenda is relatively new [...], combined with the complex nature of both climate change and the urban areas, the planning process may be fairly complex' (EEA, 2012b, p. 79). It identified both structural and operational challenges for urban adaptation, including jurisdictional, political, economic and budgetary, as well as technical and scientific challenges. It also identified success factors for urban adaption processes.

Since then, among many other initiatives ([8]):

- A number of pilot adaptation processes and measures have been completed, and analysed for potential replication and standard approaches. Many of them are part of EU or nationally funded projects.
- By 2013, a group of 20 pilot cities had completed their adaptation strategies with the EU Cities Adapt project ([9]), the biggest of its kind to that date. In addition, some individual cities (e.g. Greater London, Copenhagen, Rotterdam, Dresden, Birmingham) have prepared adaptation strategies that we can regard as frontrunners for other European cities. Further European and nationally funded projects ([10]) have enabled more cities to start adaptation action.

([8]) Chapter 5 describes more actions and initiatives.
([9]) DG Clima, EU Cities Adapt. http://climate-adapt.eea.europa.eu/viewaceitem?aceitem_id=8724
([10]) For example, as part of the INTERREG and LIFE+ programme, Horizon 2020.

- The first cities have now started to move from planning adaptation to implementing action. A few have embarked on exploring how they can monitor and report.

- Various events ([11]) and platforms ([12]) have provided lessons learned from these processes for other European cities to follow.

- Both the EU and national authorities have further developed the framework for cities to implement adaptation measures. It now also recommends a systematic adaptation methodology, such as the Urban Adaptation Support Tool, and funding opportunities (see Sections 5.1, 5.2 and 5.3).

- Political framework processes are in place. The EU Adaptation Strategy was launched in 2013. It kicked off the Mayors Adapt initiative, which is now a part of the Covenant of Mayors for Climate and Energy and extends to cities beyond Europe.

- At the international level, the action plan defined during COP21 in December 2015 established a global goal for adaptation. Thereby it strengthened the role of cities. The new UN Sustainable Development Goals target climate change and explicitly mention making cities inclusive, safe, resilient and sustainable (SGD 11). Initiatives such as the Durban Adaptation Platform, the Compact of Mayors or the Lima–Paris Action Agenda provide incentives to receive political recognition for embarking on local climate adaptation processes ([13]).

- Bottom-up processes and top-down support have resulted in around one hundred small, medium-sized and large cities starting adaptation processes. As there are no reporting obligations,

Box 4.1 provides some examples. The number of cities that have actually embarked on the process is higher, although the majority of European cities have not yet started.

Drivers and motivation to adapt

Experiences from early adaptation suggest that urban adaptation is more than local action, but needs a supporting framework. Hence, all administrative levels — from city management through regional and national governments to European and global policy bodies — need to interact (EEA, 2012b). The level and type of effort, however, is very different. It depends on political priorities, recent experiences with weather-related events, and locally available knowledge and resources, among other variables (see Section 5.2 for more).

Cities may also have different motivations and driving factors, both push and pull, such as recent weather-related disasters; the consideration that acting now will result in lower costs after future events; and national governments' adaptation strategies and plans (see also Section 2.3). Other cities see opportunities to increase their attractiveness or to brand themselves as resilient and sustainable cities to attract investors (see Box 5.22 for Rotterdam, Box 5.33 for Copenhagen). Finally, city council staff may be enthusiastic or politicians may act as change agents. Of course, a combination of these motivations in one city is possible, and actually likely, to drive adaptation measures forward. Box 4.2 provides some examples for motivation.

Cities' capacity to take action

Europe has more capacity to adapt than other regions of the world (EEA, 2015e). According to the IPCC's Fifth Assessment, most cities in high-income nations, such as European countries, have at least an adequate capacity for adaptation and resilience in terms of bouncing back after a shock to the original state. Some cities, such as London, also have the capacity to 'bounce forward' or transform into a different and better state (see Table 4.1) (Revi et al., 2014).

([11]) For example, European Climate Change Adaptation Conferences (ECCAs) 2013 (http://eccaconf.eu/) and 2015 (http://www.ecca2015.eu/), Bonn Resilient Cities (http://resilient-cities.iclei.org/), Open European Days 2013, 2014 (http://resilient-cities.iclei.org/bonn2014/open-european-day/) and the EU Open Days (http://ec.europa.eu/regional_policy/opendays/).

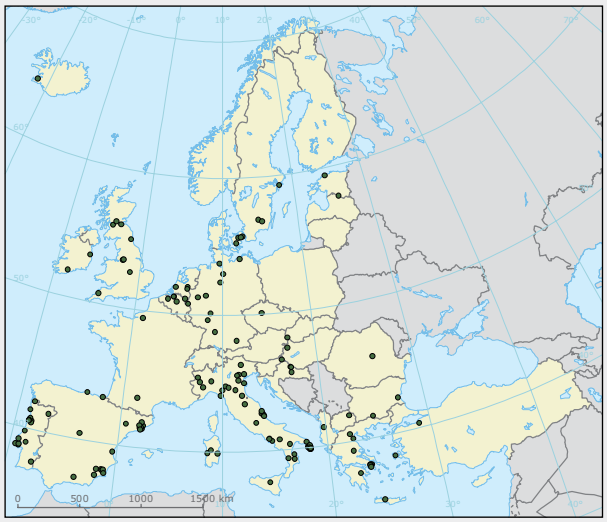
([12]) Including Climate-ADAPT: http://climate-adapt.eea.europa.eu/. For knowledge platforms addressing urban adaptation, see Table 5.3, p. 69: Knowledge platforms addressing urban adaptation.

([13]) http://mayors-adapt.eu; http://www.durbanadaptationcharter.org; http://www.compactofmayors.org.

Box 4.1 State of urban adaptation: information about adaptation-related action in European cities (examples)

The following information from various published studies and data collections provides a partial overview of adaptation activities in European cities.

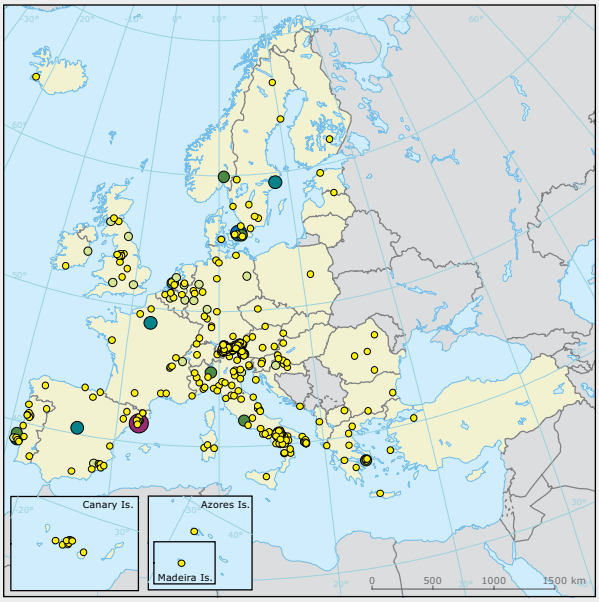
Map 4.1 Cities committed to adaptation action in the Mayors Adapt/Covenant of Mayors Climate and Energy, December 2015



Sources: http://mayors-adapt.eu; http://climate-adapt.eea.europa.eu/tools/urban-adaptation.

Since 2014, around 150 cities have committed to taking adaptation action by signing up to the EU Mayors Adapt initiative. The signatory cities either develop a comprehensive adaptation strategy or integrate climate change adaptation into relevant existing plans. Mayors Adapt follows the model of the Covenant of Mayors, which has become the key European initiative on urban mitigation action, with more than 6 700 signatories. In October 2015, the initiatives merged as a new Covenant of Mayors for Climate and Energy. It is open to non-European cities too.

Map 4.2 Participation of 650 European cities in European and global city initiatives related to adaptation, December 2015



Source: http://climate-adapt.eea.europa.eu/tools/urban-adaptation.

Other European or international initiatives are relevant to adaptation. This adds yet some 500 more cities to those in Map 4.1. Such initiatives beyond the Covenant of Mayors are the Compact of Mayors, C40 with adaptation action, Making Cities Resilient (United Nations Office for Disaster Risk Reduction, UNISDR), the European Green Capital Award, European Green Leaf, Metropolis no regret charter and Rockefeller 100 resilient cities.

Map 4.3 State of urban adaptation plans in Denmark

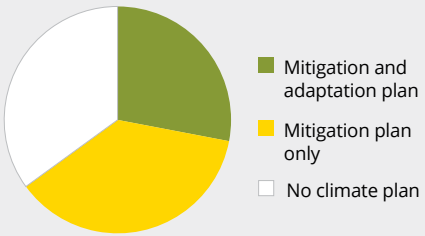
More cities have started adaptation action than are registered in international initiatives. For example, in Denmark, four cities have signed the Covenant, but almost all Danish municipalities have a climate adaptation plan as part of their municipal plan. Cities in other countries may also be active but not represented in European or international initiatives.

Source: http://www.klimatilpasning.dk/kommuner/kortlaegning-til-brug-for-klimatilpasning/kommunekort.aspx.

Box 4.1 State of urban adaptation: information about adaptation-related action in European cities (examples) (cont.)

Figure 4.1 Adaptation steps taken by cities

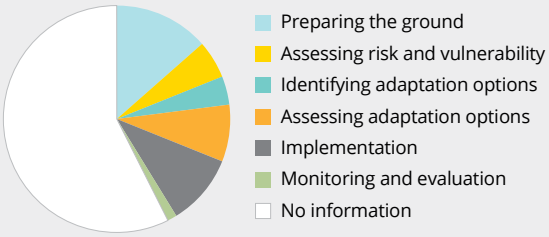
Urban climate plans, 2012



Of 200 European cities in 11 countries, 65 % had a mitigation plan and 28 % had also an adaptation plan in 2012.

Source: Reckien et al., 2014a.

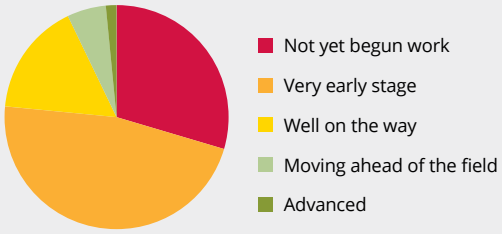
Step reached in the adaptation cycle of 148 Mayors Adapt cities, 2015



A high proportion of Mayors Adapt signatories have not yet developed an adaptation strategy or have not yet provided any information.

Source: www.mayors-adapt.eu.

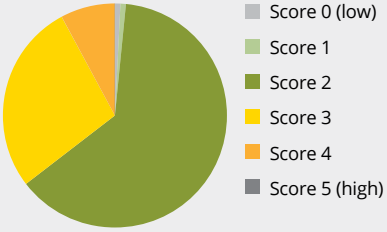
State of adaptation action in 196 European cities, 2011



A self-assessment survey among 196 municipalities in 2011 showed that most had not yet begun the process of adaptation plannning or were at a very early stage.

Source: Ricardo-AEA, 2013.

Preparedness of UNISDR cities, 2015



Of the 470 European cities (EEA member countries) participating in UNISDR's Making Cities Resilient campaign, only 118 have provided a 10 Essentials (*) report. The majority of those score two out of five on their average level of disaster risk preparedness.

If the availability of a report indicates how seriously cities are taking the process, then few regions seem to be particularly active. Cities in a few regions in Italy and Austria are particularly active.

Note: (*) The 10 Essentials describe disaster risk preparedness criteria that are generally relevant to addressing climate change impacts. However, it does not mean that climate change adaptation is systematically considered.

Sources: http://www.unisdr.org/campaign/resilientcities; http://www.preventionweb.net/english/hyogo/progress/reports/local.php?o=pol_year&o2=DESC&ps=50&timeline=Second±Cycle±%28May±2013±-±Oct±2014%29&cid=rid3&x=5&y=10.

Box 4.2 Motivation of cities to take action

'Our main motivation for taking adaptation action is the increasing frequency and magnitude of extreme weather events that inflict increasing damage on socio-economic and natural systems.' San Benedetto del Tronto (Italy).

'Our aim is to offer all citizens, living or visiting this area, a high level of services as well as a clean environment and promote a sustainable way of living and working. The main motivation for taking the adaption action is to solve environmental problems and prove that everyone can have a high quality of life so all future generations can live in a healthy and sustainable environment.' Almyros (Greece).

'Our main motivation for taking adaptation action is the imminent need to lower the risks posed by the consequences of climate change experienced in the area lately and to exchange with other cities from the EU in order to take collective action.' Burgas (Bulgaria).

Source: Mayors Adapt — city profiles, http://mayors-adapt.eu.

The EEA (2012b) groups the adaptive capacity in three dimensions:

1. The awareness dimension highlights the role of knowledge in adaptive capacity. This includes not only education and the provision of and access to information about climate change, but also perception of risks, and human and social capital.

2. The ability dimension reflects a society's potential to design and implement adaptation measures. It is associated with access to technology and infrastructure.

3. The action dimension relates to whether or not the society can put the solutions into practice. It is associated with the economic resources available.

Europe-wide data on cities' adaptive capacity are scarce. They are available only for single factors, such as societal trust in other people (Map 4.4). You can see further maps in the interactive *Urban vulnerability map book* (EEA, 2016a) on response capacity. The maps show a mixed picture, where cities in the same country score differently. The cities where most citizens feel that their administration is committed to fighting climate change are predominantly in north-western and northern Europe. However, over recent years, there has been a positive trend in eastern and south-eastern Europe, among other regions.

The challenge with adaptive capacity is, however, how to mobilise it for adaptation action. Another example is if urban populations are highly educated, they are assumed to be smore aware of climate change impacts and adaptation needs, and hence better able to respond. The link from education through awareness to response capacity is, however, indirect: it increases the ability to comprehend climate change information, but provides no guarantee of how people will use the information. Higher levels of societal trust increase the probability that city residents will work together in emergencies, and will help each other in addressing the consequences.

Integration of adaptation and mitigation and other areas

It appears that cities go through learning phases. Observations from stakeholder events such as the Open European Days Resilient Cities or the Mayors Adapt events have shown that some cities, when they begin to act on climate change, confuse mitigation and adaptation. They do not fully understand the difference between strategies (e.g. Giordano et al., 2014). As they progress, the differences between the two approaches and the associated policy areas and types of measures become clear. This can lead to separate tracks for adaptation and mitigation, but, when cities expect trade-offs and synergies, they need to integrate them again. More advanced cities are now starting to develop joint mitigation and adaptation strategies ([14]). For example, in December 2015, the Senate of Hamburg approved its new climate plan, which also integrates adaptation for the first time. Schmallenberg in Germany (see Box 5.19) had already done so.

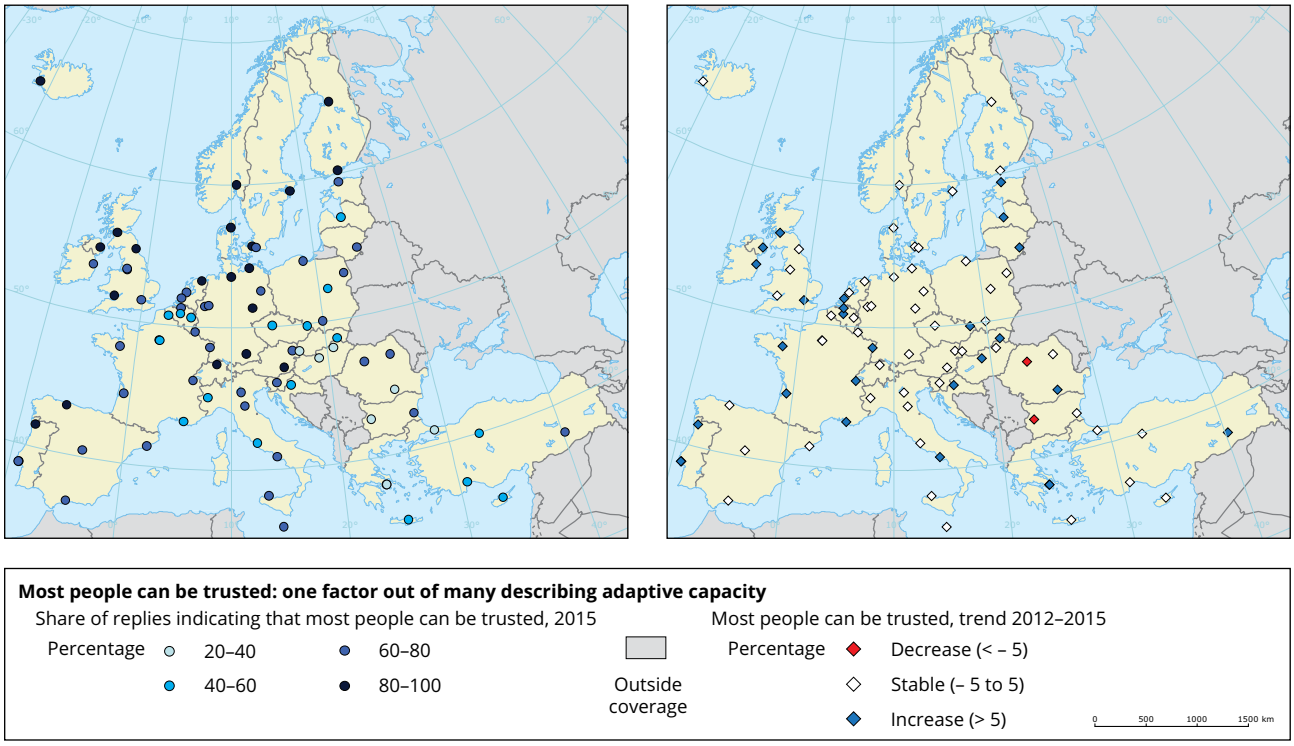
([14]) Communications from cities during the master class on climate change adaptation, Copenhagen, 24 November 2014.

Table 4.1 Cities' capacity to take action

	Cities globally				
			Vast majority of cities in Europe and other developed regions		
Indicator clusters	**Very little adaptive capacity or resilience/ 'bounce-back' capacity**	**Some adaptive capacity and resilience/ 'bounce-back' capacity**	**Adequate capacity for adaptation and resilience/'bounce-back' capacity, but not yet acted on**	**Climate resilience and capacity to bounce forward**	**Transformative adaptation**
The proportion of the population served with risk-reducing infrastructure (paved roads, storm and surface drainage, piped water...) and services relevant to resilience (including health care, emergency services, policing/rule of law) and the institutions needed for such provision	0–30 % of the urban centre's population served; most of those unserved or inadequately served living in informal settlements.	30–80 % of the urban centre's population served; most of those unserved or inadequately served living in informal settlements	80–100 % of the urban centre's population served; most of those unserved or inadequately served living in informal settlements.	Most/all of the urban centre's population with these and with an active adaptation policy identifying current and probable future risks and with an institutional structure to encourage and support action by all sectors and agencies. In many cities, also upgrade ageing infrastructure.	Urban centres that have integrated their development and adaptation policies and investments within an understanding of the need for mitigation and sustainable ecological footprints.
The proportion of the population living in legal housing built with permanent materials (meeting health and safety standards)				Active program to improve conditions, infrastructure, and services to informal settlements and low-income areas. Identify and act on areas with higher/increasing risks. Revise building standards.	Land use planning and management successfully providing safe land for housing, avoiding areas at risk and taking account of mitigation.
Proportion of urban centres covered	Most urban centres in low-income and many in middle-income nations.	Many urban centres in many low-income nations; most urban centres in most middle-income nations.	Virtually all urban centres in high-income nations; many in middle-income nations.	A small proportion of cities in high-income and upper-middle-income nations.	Some innovative city governments thinking of this and taking some initials steps.
Estimated number of people living in such urban centres	1 billion	1.5 billion	1 billion	Very small	
Infrastructure deficit	Much of the built up area lacking infrastructure		Most or all the built up area with infrastructure (paved roads, covered drains, piped water...)		
Local government investment capacity	Very little or no local investment capacity		Substantial local investment capacity		
Occurrence of disasters from extreme weather	Very common		Uncommon (mostly due to risk-reducing infrastructure, services, and good quality buildings available to almost all the population		
Examples	Dar es Salaam, Dhaka	Nairobi, Mumbai	Most cities in high-income nations	Cities such as New York. London, Durban, and Manizales with some progress	
Implications for climate change adaptation	Very limited capacity to adapt. Very large deficits in infrastructure and in institutional capacity. Very large numbers exposed to risk if these are also in locations with high levels of risk from climate change	Some capacity to adapt, especially if this can be combined with development, but difficult to get city governments to act. Particular problems for those urban centres in locations with high levels of risk from climate change	Strong basis for adaptation, but needs to be acted on and to influence city government and many of its sectoral agencies.	City government that is managing land use changes as well as having adaptation integrated into all sectors.	City government with capacity to influence and work with neighbouring local government units. Also with land use changes managed to protect ecosystem services and support mitigation

Source: Revi et al., 2014.

Map 4.4 **'Most people can be trusted': one factor of many describing adaptive capacity**



Sources: http://climate-adapt.eea.europa.eu/tools/urban-adaptation/generic-response; data from Urban Audit perception surveys 2009 and 2012, http://ec.europa.eu/eurostat/web/cities/perception-surveys.

There are relatively few measures planned or in place that can serve both mitigation and adaptation at the same time (Box 4.3). For instance, the former Covenant of Mayors has more than 2 000 Benchmarks of Excellence (Covenant of Mayors Office, 2016). They include examples of mitigation options that could also be relevant for adaptation, such as building design. However, just a handful mention adaptation too. More cities might consider adaptation, but the initiative has not explicitly encouraged integrated solutions so far. It merged with the former Mayors Adapt initiative in autumn 2015 to form the new Covenant of Mayors for Climate and Energy. That may now encourage integration.

Plans and strategies in other policy areas can include adaptation, particularly nature and biodiversity, water management, disaster risk reduction and health. For example, the European Green Capital Award (EGCA) could even more explicitly encourage cities that apply for it to integrate adaptation (see Box 4.4). Cities participating in UNISDR's Making Cities Resilient campaign usually work on extreme events they have already experienced. Some, like Karlstad in Sweden (see Box 4.5), already combine this with adaptation to cope with future extreme events.

Box 4.3 Integrating adaptation and mitigation in design of new and old buildings, Rotterdam in the Netherlands, and Madrid in Spain

Population: 616 294
Biogeographical region: North-western Europe

Renovating the Groot Willemsplein building in Rotterdam

The old office building at Groot Willemsplein in Rotterdam dates back to the 1940s. Renovation gave it a new life with commercial functions on the ground floor and flexible office spaces on the other floors. The main tenant of the offices, the company Joulz, explicitly wanted a sustainable building for its headquarters. Joulz was enthusiastic about the location of the building and saw the potential to transform it to match the company's sustainable business goals.

Photo: © Roel van Dorsten

The project developers kept the parts of the building that were still useable. They insulated the four remaining floors well. They added three new floors on top of the old floors, with triple glazing and highly insulated façades. This measure also helps to keep the air inside the building cool in higher summer temperatures due to climate change. An energy-efficient aquifer thermal energy storage (ATES) system absorbs heat in summer and stores it for use in winter. Finally, a rooftop garden prevents or delays stormwater run-off resulting from more frequent heavy showers. In addition, it is an attractive recreational green space designed with special attention to birds, bats and insects.

Well adapted and energy-efficient, the building consumes 63 % less energy than average office buildings in the Netherlands.

Population: 3 165 235
Biogeographical region: Mediterranean

Integrated design in the new IMDEA building in Madrid

In 2012, the energy department of the Institute for Advanced Studies (IMDEA) took possession of its new building in Madrid. The city expects even more extreme heat in summer, combined with water scarcity but occasional heavy rainfall. The new building incorporates many different integrated solutions to adapt to and mitigate climate change.

For example, white painted roofs reflect solar radiation and the back-ventilated façades have 80 mm of insulation. These and the building's orientation lower the indoor temperature and reduce the energy needed for cooling. Inside, the building uses glass to reduce energy consumption for lighting. At the same time, sunshades outside the building protect against excessive indoor heat from sunshine.

The water cooling system is closed, to minimise losses and maximise energy savings. Sinks, toilets and urinals are very low-consumption models; the saving is over 40 % compared with a conventional building. Rainwater from the roof irrigates the green areas that cover more than 40 % of the total area of the site. They are planted with local trees and plants that contribute to adaptation by cooling and cleaning the air.

To encourage the use of sustainable transport, the parking area has special spaces reserved for electric cars and carpooling. The car park itself has a permeable surface, which discharges water rapidly after heavy rainfall.

Sources: Climate-ADAPT, http://climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=6101; http://climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=6202.

Box 4.4 The European Green Capital Award requires cities to integrate climate change adaptation into sustainable urban development

The EGCA is a European Commission initiative. It recognises and rewards local efforts to improve the environment, the economy and the quality of life in cities. Cities need to report on their current state, progress made and action taken in 12 environmental areas. The EGCA originally did not explicitly include a requirement to report on adaptation to climate change. Therefore, earlier applications generally just consider urban adaptation sporadically, mostly as one of the benefits of green infrastructure, but do not integrate it systematically. It was just recently that adaption became an explicit criterion in the application process.

For example, **Essen**, Germany, the Green Capital 2017, integrates adaptation in planning urban development. It focuses on the heat island effect, and uses synergies with the 'New ways to the water' project as well as green roofs and façades. It is transforming the River Emscher, with many benefits for adaptation, water management and quality of life. This is a good illustration of climate-friendly conversion of the city (see Box 5.27).

Population:
569 884 (Essen)
165 235 (Nijmegen)
Biogeographical region:
North-western Europe

Nijmegen, the Netherlands, was one of the finalists. It is already well known for its adaptation actions, in particular for replacing the Waal dike and constructing a secondary flood channel. That created a unique urban river park in the heart of the city with space for living, recreation, water and nature. Nijmegen has converted challenges into opportunities and broadly integrated adaptation into overall urban development.

The recent developments demonstrate that, as a voluntary instrument, the EGCA can urge cities not only to consider urban adaptation but also to integrate it in overall sustainable urban development and quality of life.

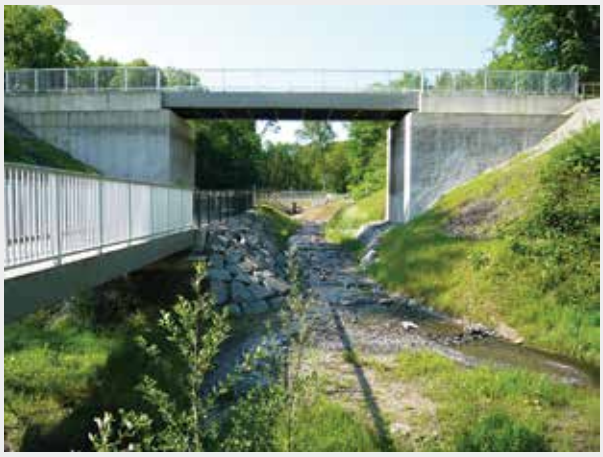
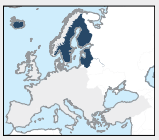


Photo: Steam Kessel (Essen) before (left) and after transformation (right) © Grün und Gruga Essen

Sources: EGCA, 2015; Climate-ADAPT, http://climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=4401.

Box 4.5 Integrating disaster risk management, adaptation and health in Karlstad, Sweden



Population: 89 000
Biogeographical region: Northern Europe

'In our city, we work towards integrating planning for the management of disaster risk, such as flood risk, climate change adaptation, green infrastructure and related health aspects because we think that can save us a significant amount of money. Current and future flood levels are considered in the design of the new levee for the General Hospital with an elevated bicycle path. The levee will integrate both mitigation and adaptation measures and also adds better traffic safety and a more secure environment for people who work at the hospital. Also, looking at climate change mitigation that calls for a dense city development and adaptation that calls for green urban areas at the same time enables us to find better solutions serving both, rather than maximising the benefits for one area now and having to invest a lot to solve the problems with the other area at a later date. Thinking and working across departments opens up new perspectives, better and more cost-effective solutions.' Anna Sjödin, Karlstad City Administration.

Photo: © Mikael Svensson

Karlstad has 89 000 inhabitants. It is on the largest delta in northern Europe, where the River Klarälven flows into Lake Vänern. Its location helps make the city attractive but also puts it at significant risk of flooding, which is expected to increase as the climate changes.

Karlstad has employed a flood risk manager since 2007 and has had a flood risk management plan since 2010. That year, it also became a role model in UNISR's Making Cities Resilient campaign. In contrast to many other risk management plans, Karlstad integrated climate change impacts in its plan. In the meantime, the package is growing: a climate change adaptation plan, a green infrastructure plan and a plan for stormwater management are also under development. Cross-department project teams are developing them, thus ensuring proper integration.

Source: Direct communication from Anna Sjödin, Karlstad City Administration, November 2015.

Further resources

- ➔ **Covenant of Mayors for Climate and Energy — Mayors Adapt: http://mayors-adapt.eu**
- ➔ **Making Cities Resilient: http://www.unisdr.org/campaign/resilientcities**
- ➔ ***Climate change response in Europe: what's the reality? Analysis of adaptation and mitigation plans from 200 urban areas in 11 countries* (Reckien et al., 2014)**
- ➔ ***Adaptation Strategies for European Cities,* EU Cities Adapt project: http://climate-adapt.eea.europa.eu/viewaceitem?aceitem_id=8724**
- ➔ ***National action on urban adaptation in EEA Member states* (Breil and Swart, 2015): http://cca.eionet.europa.eu/reports/Urban%20Adaptation%202016**

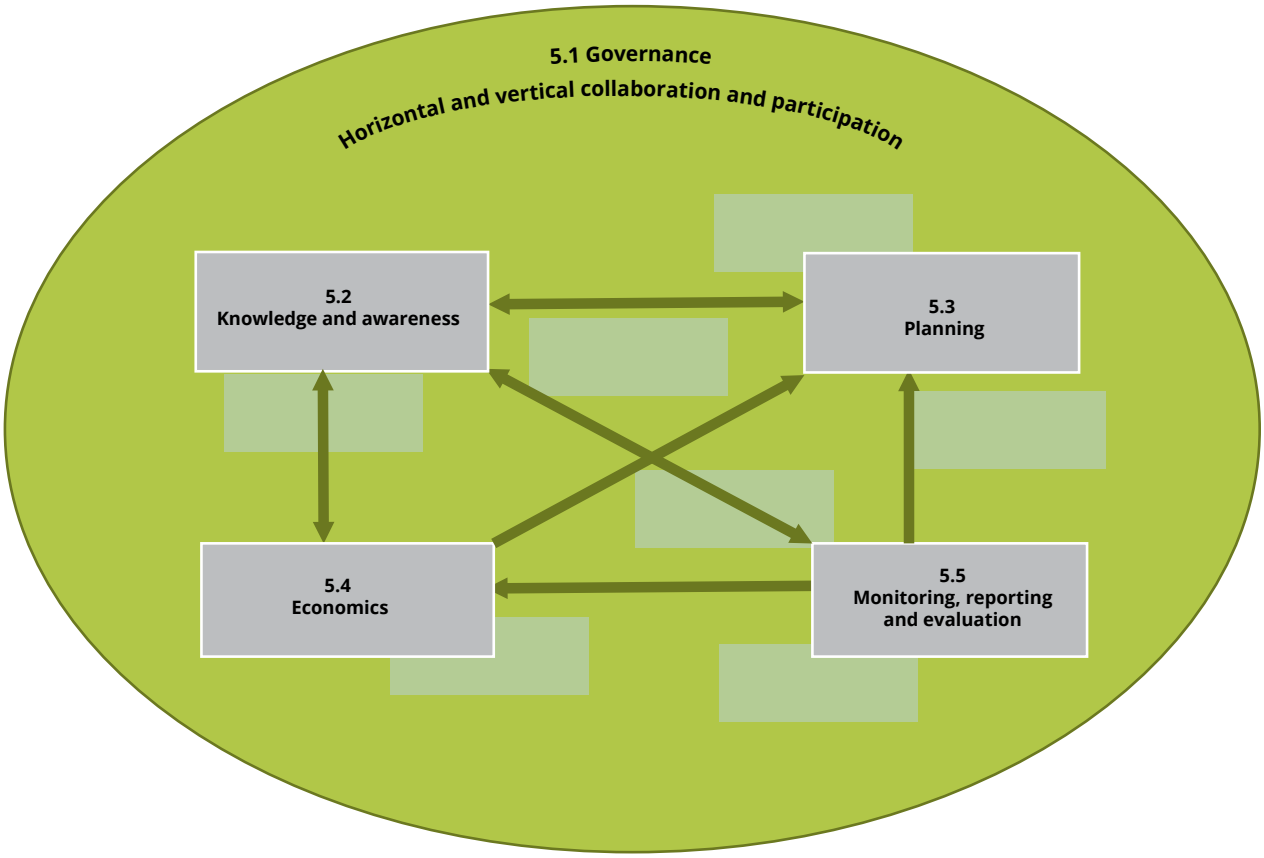
5 Spotlight on selected areas of action: is action effective to meet future climate challenges?

Chapter 4 has shown that cities are starting to act on adaptation. Over the last few years, the frontrunners have moved from developing strategy and planning adaptation to implementing the first parts of these plans. Despite the improvements of recent years, EU cities still face considerable challenges. What can we learn from these early beginners and are they on the right path, considering the enormous challenges ahead?

This chapter selects five key areas in the adaptation process. These are important for implementing effective adaptation action and transforming cities into well-adapted, attractive and vital cities that have used adaptation as an opportunity (Figure 5.1). The selected areas are not exhaustive, nor should you confuse them with the steps of an adaptation planning and implementation cycle. The Urban Adaptation Support Tool (UAST) ([15]) can provide direct guidance on the different steps to take (see Box 5.18 in Section 5.3). Rather, the selected areas serve several of the steps in the adaptation planning and implementation process. They provide them with certain qualities.

Supportive and well-tailored governance needs to engage cities with regions, the state, Europe and each other, and to encourage a broad range of

Figure 5.1 Five selected key areas of the adaptation process and their relation to each other



([15]) http://climate-adapt.eea.europa.eu/tools/urban-ast.

stakeholders and sectors to participate. This is a key to making urban adaptation work in a planned and effective way. When designed well, it enables all steps of the adaptation planning and implementation process. Raising awareness and creating knowledge also help. They reinforce each other. Together with supportive governance, they enable stakeholders to respond to climate challenges. Financial resources support all other capacity-building activities, planning, implementation and monitoring. A persuasive economic case for adaptation supports knowledge creation and thus awareness raising and finally decision-making about what adaptation measures to plan and implement. Monitoring, reporting and evaluation create knowledge of how effective the measures are, as well as of the adaptation process. It thus allows cities to adjust the single steps of the planning and implementation process.

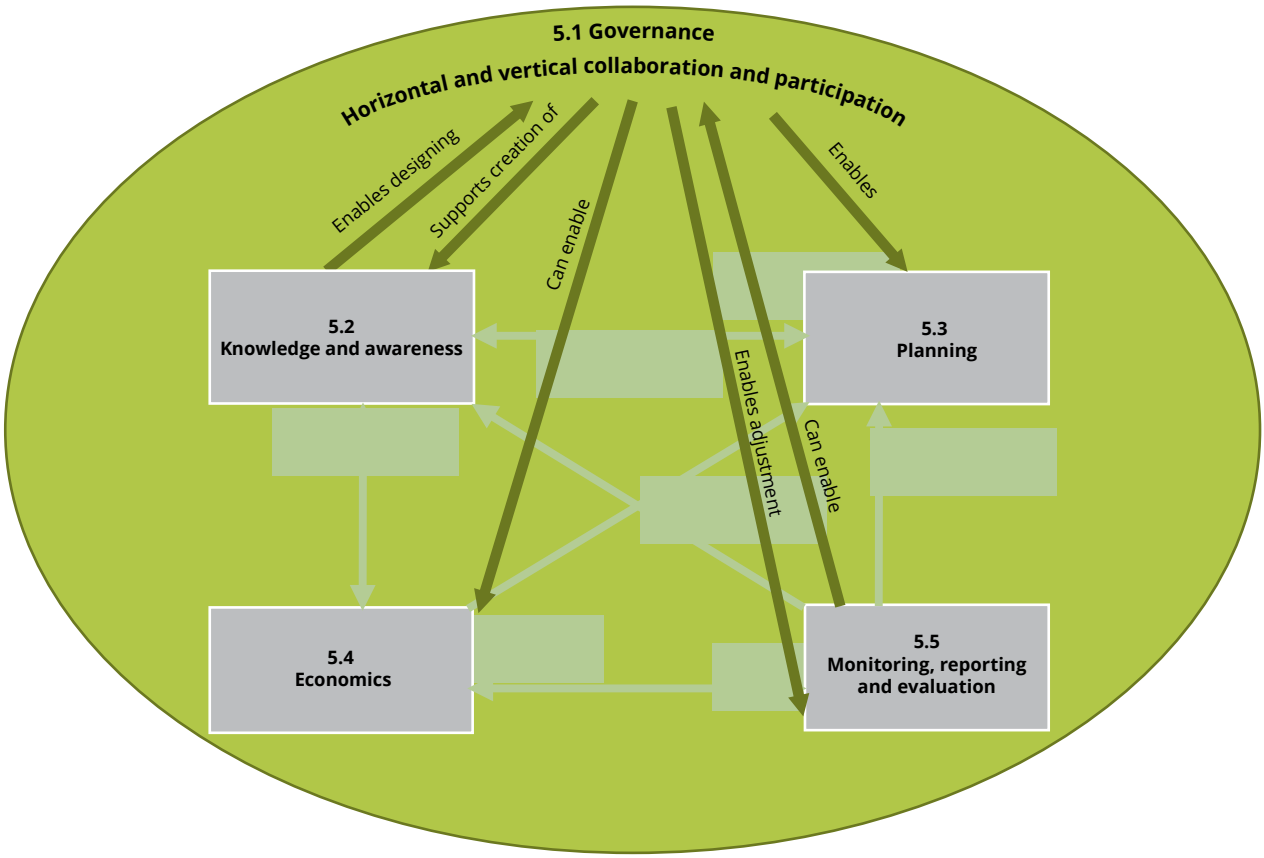
The following sections analyse what different levels of government are doing in these areas. They reflect critically on the approaches and the level of ambition in relation to the challenges cities face and possible approaches as described in Chapter 3.

5.1 Governance for urban adaptation

Key messages

- Good governance, tailored to local adaptation needs, is necessary for effective adaptation activities. These range from creating knowledge and raising awareness, through effective adaptation planning, to implementing green, grey (technological) and soft adaptation measures.
- Urban adaptation to climate change crosses sectors and affects all levels of governance. Different departments and levels of government need to work together, and stakeholders need to get involved actively.
- The EU, international organisations and national organisations support cities by raising awareness, sharing knowledge, providing a legislative framework and funding adaptation action. At the national level, the degree and type of support varies depending on established national frameworks and cultures and traditions of policy-making.
- Regional governments can play a decisive role. In particular, they can serve smaller municipalities that have less capacity, and can thus spread adaptation to more cities and towns.
- Horizontal coordination across sectors and city departments supports synergies, knowledge sharing and coherent adaptation action in cities.
- The current governance of adaptation often lacks ways for local stakeholders to take part systematically and meaningfully. Transformative adaptation calls for new ways of collaboration, and innovations in governing urban adaptation. Cities can develop governance by discovering and testing different business models for implementing adaptation to climate change in urban areas.

Figure 5.2 Governance framework and its relations to other topics



5.1.1 Elements of good governance for urban adaptation

The report *Urban adaptation to climate change in Europe* (EEA, 2012b) describes in detail the characteristics and benefits of a governance system for adaptation, in particular multilevel governance, its challenges, the actors involved and the role they (can) play. This section builds on this previous work and other literature sources to describe current action and the further need for governance to follow an ambitious approach to urban adaptation.

Governance broadly means the interactive processes and decision-making among actors involved in a collective problem and associated institutions. It is key to effective implementation of climate adaptation. Good governance tailored to local adaptation needs can enable and promote different adaptation activities, such as knowledge generation and awareness raising; designing an economic case for adaptation; effective planning and implementation; and setting up a monitoring, reporting and evaluation system. Conversely, new knowledge or insights generated by developing good business cases or monitoring adaptation measures can help adjust governance mechanisms (Figure 5.2).

Urban adaptation takes place primarily at the local level and it is mostly local actors that do it. However, different sectors and levels of government often have decision-making and support responsibilities. Addressing climate impacts at the appropriate level is essential. For example, water management and safeguarding external public services call for regional collaboration, whereas addressing other impacts such as urban heat islands or stormwater management is essentially local. Thus, we need interaction and collaboration with multiple actors and stakeholders across different administrative levels (vertical coordination) and across sectors and departments at city level as well as with other cities (horizontal coordination). Coherence across different levels of governance is important for planning and implementing local adaptation actions.

Transformational adaptation complements coping and incremental adaptation. It may imply fundamental shifts in power and representation of interests and values, presenting new challenges for governance (Lonsdale et al., 2015). The complexity of climate change includes multiple interactions, cascading effects and long-term consequences. Addressing it requires a good institutional fit between the scope of the problem and the scope of decision-making, and effective interplay between governments and other actors (Young, 2003; Young, 2010). Many climate impacts, such as flooding and other water-related impacts, affect whole regions or catchment areas. The adaptation challenge, then, is at the regional or catchment level. Effectively addressing the climate risk involves reaching beyond current governance structures focused on the local level. This means, for instance, exploring new types of partnerships in governance. It needs strong leadership. Participatory mechanisms should expand spheres of responsibility and decision-making (Lonsdale et al., 2015) so that the governance of urban adaptation includes the views and resources of all affected parties.

Good governance supports effective coordination between actors, allocates resources wisely and ensures legitimacy and support for adaptation action. The following elements are among those we know are necessary to govern local adaptation effectively:

- knowing and accepting adaptation needs, and, where appropriate, a strong commitment to integrated and multilevel responses from relevant stakeholders;
- adequate distribution of responsibilities and authority, while decentralising in favour of local autonomy where relevant;
- good coordination between actors;
- combined top-down and bottom-up approaches (Urwin and Jordan, 2008);
- institutional frameworks to addressing the complexity of adaptation challenges across levels of government;
- stable institutional structures so work can continue regardless of electoral cycles and political changes (EEA, 2012b);
- effective organisations with sufficient skills and resources;
- flexible and responsive governance mechanisms;
- accountability and transparency (e.g. Urwin and Jordan, 2008; Tanner et al., 2009);
- equity, through inclusive participation as well as scientific expertise in urban sustainability (Joas et al., 2014) and risk governance (Renn, 2005).

Good governance of urban adaptation demands effective local organisations. The EU Cities Adapt project applied the Performance Acceleration through Capacity-building Tool (PACT) framework. It is one

tool for assessing the capacities of organisations to address climate change adaptation (Ricardo-AEA, 2013). Its elements are nine organisational capacities necessary for adaptation: awareness, agency, leadership, agents of change, working together, learning, managing operations, programme scope and coherence, and expertise and evidence (Table 5.1). These broadly cover the 10 elements of good governance identified above.

The PACT framework accommodates the needs of both incremental and transformational adaptation. Cities can use it as a checklist to assess and reflect on their adaptive capacity over time (Lonsdale et al., 2010). For example, the EU Cities Adapt project has demonstrated its usefulness for 21 cities in very different stages of addressing adaptation needs (Ballard et al., 2013) and it also helped the first UK Climate Change Risk Assessment. PACT and other frameworks have a limitation in assessing the capacity of organisations to respond to climate change: their application to date has largely focused on public sector actors. It is becoming increasingly important for the governance of urban adaptation to include the private sector and civil society.

Good governance includes stakeholder engagement to ensure that urban adaptation policies and actions are transparent and legitimate, and to make sure that local stakeholders are committed to implementing them. Involving stakeholders early may also help to identify and address potential conflicts in a timely manner. Adaptation is paying increasing attention to questions of climate justice and equity. This also calls for better understanding of how climate impacts affect groups with different vulnerabilities in cities. We need to include these perspectives in planning and implementing adaptation.

5.1.2 Current governance structures and approaches

Vertical coordination through multilevel governance

There are multilevel governance frameworks that currently support cities to varying degrees. Different legal and institutional frameworks, as well as different styles and traditions of policymaking, enable various types of city–state relations in European countries. The level of decentralisation largely determines how local governments can act. In some countries, cities and other levels of government understand that they depend on each other, and act accordingly. In others, state structures may be so centralised that they do not allow local and regional authorities to make their own decisions, so there is no concept of multilevel governance (Keskitalo, 2010). For example, in federal countries such as Germany, regional governance has a strong role in urban planning, whereas in unitary states the focus of power varies from strong national guidance (e.g. France) to strong local autonomy (e.g. Finland and Sweden). Figure 5.3 provides an overview of regional, national and European support to urban climate change adaptation action.

Table 5.1 The PACT framework for analysing organisational capacities

1. Awareness	Grasp of what climate change means for society, for the organisation and its mission, and for particular areas of responsibility, now and into the future
2. Agency	Capacity to spot, prioritise and develop opportunities for meaningful and timely action on climate change
3. Leadership	Extent to which a formal leadership team has developed a strategic vision and engages with, supports and legitimises its implementation
4. Agents of change	How to identify, develop, empower and support a network or group of champions so that they can be effective agents of change
5. Working together	Capacity to participate in, learn from and act in collaborative partnerships with internal and external groups
6. Learning	Extent to which the organisation generates and responds to feedback from innovation, even on a small scale, and makes sense of and communicates new information to improve procedures, strategies and mission
7. Managing operations	Embedding of procedures to get to grips with climate change in a systematic way to ensure that intentions and policies turn into action
8. Programme scope and coherence	How far projects sit within a strategic programme of action suited to the scope of what the organisation is trying to achieve
9. Expertise and evidence	Ability to identify, access and deploy the necessary technical and change 'know-how' and information to make the biggest difference

Source: Lonsdale et al., 2010.

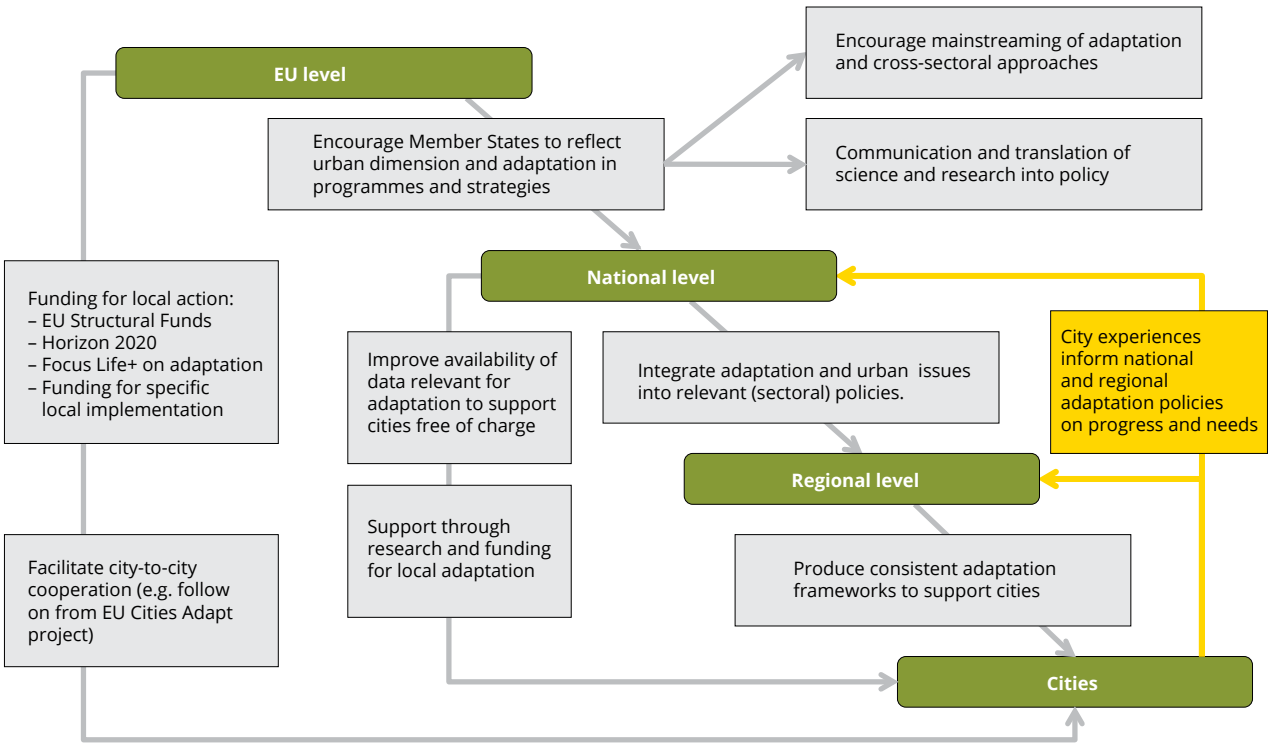
EU-level support for local adaptation action comes in various forms of soft law and economic incentives. The EU Adaptation Strategy reflects it. So does the commitment to dedicate at least 20 % of the overall EU budget for 2014–2020 to climate action (EC, 2016c). The EU Adaptation Strategy sets a specific focus on urban adaptation, in particular with the Mayors Adapt initiative, now merged into the Covenant of Mayors for Climate and Energy, which covers both mitigation and adaptation to climate change. This initiative has created broad awareness of the importance of urban adaptation action and helped cities to get local political support for climate action across Europe. Peer networks established through such initiatives also form a platform for learning and knowledge transfer.

The EU Adaptation Strategy also includes developing systems to handle local adaptation in the same way, including monitoring and impact assessment. Another pillar of the EU Adaptation Strategy is policy coherence and making urban adaptation a standard part of other policy areas such as structural funds. There are also specific initiatives such as the European Green Capital Award, an award for a European city based on its environmental record that encourages cities to strive for low-carbon and climate-resilient futures. The Green Leaf Award is a similar award for smaller cities (between 20 000 and 100 000 residents).

The many European initiatives related to cities also have much unused potential ([16]). The European Local Transport Information Service (ELTIS) is Europe's main portal on urban mobility. It supports the creation of sustainable urban transport systems. Transport infrastructure is vulnerable to climate change and at the same time is a key service for cities to ensure resilience and quality of life. However, to date ELTIS has hardly included any adaptation action. URBACT, a European exchange and learning programme that promotes sustainable urban development, has operated for more than 10 years but only recently added its first project related to resilience, including climate risks.

The European Commission coordinated the *Cities of Tomorrow* report (EC, 2011). It presents a strong and inspiring vision of the future of European cities, calling for social, inclusive and green cities that provide a high quality of life, including under future conditions. It can unite all the scattered urban initiatives. The EU Urban

Figure 5.3 Making cities climate resilient typically requires support from higher levels of government



Source: Adapted from Kazmierczak et al., 2013.

([16]) http://ec.europa.eu/regional_policy/index.cfm/en/policy/themes/urban-development/portal.

Agenda process (EC — Regional Policy, 2016b), a joint approach with EU institutions and cities, promotes better coherence and more effective implementation of the numerous EU regulations and initiatives concerning cities (EC, 2014b, 2015b).

Designing effective governance for urban adaptation needs to consider these different set-ups. Integrating climate change into infrastructure standards may be an effective international framework to support adaptation at the local level. For Europe, the European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC) are currently exploring the possibilities of this for the energy, transport and construction sectors (CEN—CENELEC, 2016). The EU working programme for standardisation analyses the potential role of standards for deploying green infrastructure and nature-based solutions. The analysis also contains the adaptation component (EC, 2016a).

National-level support can greatly help urban adaptation action. National adaptation strategies and plans can make it legitimate to attend to and focus on adaptation action. This supports local governments. They may not be perfect in providing effective guidance for local adaptation efforts, but the lack of national-level support for local action and inappropriate multilevel governance structures is clearly a barrier to local adaptation action (ICLEI and CEPS, 2013). Involving local authorities in developing national adaptation strategies informs the national strategy by providing local knowledge and experiences. It also helps to raise awareness among local authorities and get them to take responsibility for developing and implementing local strategies and action (see Box 5.1 on Cyprus).

In national adaptation strategies across Europe, spatial and urban planning is fifth in the order of priorities, after water, agriculture, forestry and human health (EEA, 2014). Twenty-one EEA member countries have a national adaptation strategy or plan (or a national climate strategy covering both mitigation and adaptation). Three of them devote a specific chapter to urban adaptation or the built environment. Many national adaptation strategies are structured according to policy sectors, and often they address urban issues under several sectors rather than in their own right. Urban adaptation mostly crops up in sectoral strategies, such as health, spatial planning, water management, transport, buildings or disaster risk response. Other countries do not explicitly address urban issues in their national adaptation policy framework. See Table 5.2 and Breil and Swart (2015).

Overall, national adaptation policies are better at coordinating across sectors (horizontally) than between levels of government (vertically) (EEA, 2014). National adaptation strategies often consider problems that have little relevance to local action. Their policy level is too distant from local realities. National guidance often comes in the form of top-down regulation that may not be effective if it is not matched with sufficient support and enabling actions. See the French example in Box 5.4. Furthermore, national and local/regional adaptation strategies may not be consistent with each other, which can hinder effective urban adaptation.

The mere existence of a national plan does not guarantee that it helps cities adapt. For instance, when Spain had a national strategy and Italy did not, a study found that neither country had supported the local level enough through national and regional frameworks. In both countries, proactive cities had taken voluntary action because of their environmental awareness and/or involvement in national and international networks rather than because of top-down steering from the national government (De Gregorio Hurtado et al., 2014). See Box 5.2 for further information on action that Italian cities have taken in the absence of a national-level adaptation framework.

Box 5.1 Defining adaptation options together with local authorities, Cyprus

In Cyprus, a National Adaptation Steering Committee took part in the adaptation process from the very beginning. Besides governmental departments, academic and research institutions, NGOs, special interest groups and consumer groups, the committee included local authorities. The stakeholders evaluated various pre-identified adaptation measures against defined environmental, social, technical and economic criteria. The process resulted in prioritising the most appropriate adaptation measures for Cyprus.

Biogeographical region: Mediterranean

Source: LIFE+ co-financed project CYPADAPT, http://uest.ntua.gr/cypadapt/?page_id=106.

Table 5.2 Urban adaptation in national climate strategies and plans of 21 EEA member countries

Integration of urban adaptation in national policies	Countries
Urban issues included in a specific part of the national adaptation strategy	Austria, Italy, United Kingdom
Urban issues mainstreamed throughout the national adaptation strategy	Bulgaria, Denmark, France, Turkey
Urban issues mainstreamed thematically into:	
– building and construction	Finland, Spain, Turkey
– spatial planning	Czech Republic, Finland, Germany, Portugal, Spain, Switzerland, Turkey
– health	Belgium, Czech Republic, Finland, Germany, Portugal, Spain, Switzerland
– transport	Belgium, Czech Republic, Finland, Portugal, Spain
– disaster risk management	Czech Republic, Portugal, Turkey
– water management	Netherlands, Portugal, Turkey

Source: Breil and Swart, 2015.

Box 5.2 What if national action is not available? Example of Italy

Photo: © Francesca Giordano

Biogeographical region: Mediterranean

National strategies and plans can encourage and enable cities to prepare for climate risks. However, many cities that are aware of the risks adapt without such a national framework. Until recently, Italy had no national adaptation strategy. At that time, a survey on adaptation in 38 Italian cities explored whether they had initiatives addressing the health and safety of their citizens, protecting the urban environment from the threats posed by climate change, and identifying future perspectives and potential barriers to adaptation. Approximately two thirds of the cities had experienced consequences of weather-related extreme events in recent decades (floods, landslides, heat-related health problems, damage to infrastructure and agriculture). Of these cities, only one third thought climate change posed a high risk, about half considered themselves highly vulnerable, more than half thought their adaptive capacity was medium and one third thought it low. More than 75 % had adopted measures to cope with extreme weather events and their consequences. These mainly included repairing infrastructure to treat wastewater, strengthening pipelines and setting up monitoring and early warning systems for hydrogeological risk areas. About half of these measures were not labelled as adaptation, but one third actually took a climate risk perspective in planning. Damage from extreme weather events has triggered action; so have European funding schemes. It helps that Italy had a long tradition of city networks even before it adopted a national framework.

Source: Giordano et al., 2014.

National legal frameworks can help cities take action on climate change, and can provide incentives for them to do so. Like developing and implementing national adaptation strategies, integrating adaptation into legal frameworks depends on the political and governance context of the country. For example, France has arguably the strictest legally binding delegation of responsibilities to the local level (see Box 5.4). Some countries have non-binding or weakly binding legal frameworks to encourage local actors to take action, often supported by financial incentives (e.g. Denmark). Other countries have integrated climate change adaptation into legal frameworks for specific sectors, such as water management, spatial planning, building regulations or disaster risk response (e.g. Austria, Finland, Germany, the Netherlands, Norway (Box 5.3), Slovakia, Sweden (Breil and Swart, 2015). Beyond legally binding obligations, factors such as capacity building and funding can get many local actors to plan adaptation. In Denmark, although the legislation is not binding, nearly all municipalities have adopted adaptation plans (see Box 5.4).

In most countries, relationships between local authorities and national governments follow the principle of subsidiarity: assigning tasks to the lowest suitable level of administration, to keep decision-making close to citizens. On this principle, local administrations generally handle urban planning in Europe. However, they have some responsibilities less often, for instance disaster risk management and civil protection. Regional or national governments normally manage these, to make the best use of resources and ensure effective coordination. In some countries, sectoral institutions have special responsibilities, such as water agencies in the Netherlands and Portugal, and health institutions in Switzerland (Breil and Swart, 2015). They have a special focus on functional aspects (management of watersheds) or their spatial scale is different (health authorities). This adds further levels of governance to coordinate or use for coordination.

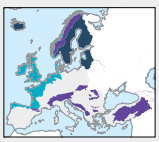
Regions have different levels of self-rule, including fiscal autonomy. These shape their role in multilevel governance frameworks for adaptation. This level of self-rule in regions varies considerably across Europe. In many parts of Europe, the authority of regions is growing (EC, 2014a). Regions can play a two-fold role in supporting urban adaptation.

On one hand, cities and rural areas interact at the regional scale. Certain adaptation measures, such as dealing with flood prevention, water scarcity or providing cool air to cities, need to take that into account. Governance is typically fragmented in peri-urban areas. By encompassing them, regional governance can help coordination across municipalities (see further in Section 5.3). However, such cases can also demonstrate the challenges that arise when administrative boundaries do not match geographical regions.

Naturally, regional authorities do more to adapt in countries with federal systems and regional autonomy, such as Belgium, Germany or Spain, or where regional authorities are responsible for urban

Box 5.3 Supporting cities in mainstreaming adaptation in Norway

Photo: © Tore Meek/NTB scanpix



Biogeographical region: North-western/ Northern Europe/ Mountain areas

The Norwegian government appointed a special committee to evaluate current legislation on urban run-off water. It proposed amendments so that the municipalities responsible for managing urban run-off water would have a better framework for dealing with the increasing challenges of urban flooding. A website has practical tools, case studies and information on climate change adaptation. The resources are tailored to meet the needs of those responsible for spatial planning in the municipalities, and include a guide to adapting to climate change. The guide covers, for example, how to consider adaptation in various planning processes connected to the Planning and Building Act and the Civil Protection Act.

Source: http://www.klimatilpasning.no.

Box 5.4 Interplay of national frameworks and local adaptation in Denmark, France and the United Kingdom

Biogeographical region:
North-western/
Central and eastern Europe

France: legal obligations do not immediately trigger local action

According to the French law on climate action — 'lois Grenelle' (Law 2010-788 of 12 July 2010) — territorial climate-energy plans (PCETs) codify local climate action. They consider all forms of climate action for both mitigating and adapting to climate change (EEA and EC, 2015). Furthermore, several national plans have identified specific local action related to drought and flash floods and provided funding for it (Ministère du Développement Durable, 2011).

The French Environment and Energy Agency (ADEME) organises a national observatory where local authorities register PCETs on a voluntary basis. Despite the legal obligation, only half of them integrate climate change adaptation 'in one way or another'. 'The majority of local authorities are still waiting for more information about adaptation or have just started adaptation planning or demonstration projects. Regional strategic guidelines have been elaborated by regional authorities and the state is responsible for compliance control of risk management planning and climate planning. Risk management planning does not currently consider potential future changes of climate conditions beyond sea-level rise, as prevailing uncertainties in climate projections make it difficult to include risks such as intense rainfall. Beyond these plans, a number of cities have moved with adaptation measures addressing single risks (for example heat) or integrating adaptation measures in their local urban planning instruments.'

National monitoring of local adaptation provided momentum for municipalities in the United Kingdom

The UK's national monitoring of adaptation used to include local adaptation planning. This provided momentum for municipalities. UKCIP surveyed cities at the end of 2010, and more than three quarters of the 100 respondents indicated that they would not have done any adaptation work if they had not needed to report against the national performance indicator NI188 'planning to adapt to climate change' and without the guidance that came with it. The national government abolished the indicator in October 2010, aiming to let local authorities make their own decisions taking local needs into account. Consequently, 40 % of the survey respondents assumed that they would do less or nothing on adaptation in the future. There is no recent survey that could confirm if these assumptions turned into reality. Support from the UK Government's Climate Ready Support Service may have increased awareness about the need for action, which may or may not have kept local authorities taking action even without national monitoring.

Coherent national legal frameworks and dedicated support for municipalities enable local adaptation in Denmark

Integrating adaptation into legal frameworks requires coherence at the national level to avoid conflicting signals and barriers to action. Denmark amended its planning act in 2012, so that municipalities could include climate change adaptation directly in their development plans. Municipalities and the central government agreed to invest DKK 2.5 billion more in adapting wastewater treatment for climate change, according to risk assessment and municipal climate change adaptation plans. Around the same time, an amendment to the Danish water sector act clarified that wastewater companies may invest in climate change adaptation. All municipalities have an adaptation plan and many have already implemented the first grey, green and soft measures. By the end of 2015, nearly all Danish municipalities had approved adaptation plans and the remaining few were preparing them. In preparing the plans, the municipalities used guidelines from the government and a 'mobile team' within the National Task Force on Climate Change Adaptation at the Danish Ministry of the Environment. Municipalities can call upon the mobile team, free of charge, for guidance and, for example, help in coordinating between municipal authorities and other stakeholders.

Photo: © www.klimatilpasning.dk

Sources: http://www.klimatilpasning.dk/kommuner.aspx; Climate Adapt, France (EEA and EC, 2015), Ministère du Développement Durable (2011); direct communication with Celine Phillips, ADEME, October 2015; UKCIP, 2011.

planning legislation, such as Italy. Several countries have regional plans at the level of states, provinces or areas around large cities. For example, in Finland, the Helsinki metropolitan region adopted an intermunicipal adaptation strategy in 2012, which the regional environmental authority coordinated (Peltonen et al., 2014).

On the other hand, regional frameworks can also enable local action similarly to national and European frameworks, although to date, regional coordination seems to have played a limited role in devising local adaption strategies (ICLEI and CEPS, 2013). Some encouraging examples do exist, for instance from the Province of Barcelona in Spain (Box 5.5). In Sweden, the country administrative boards are responsible for adaptation at the regional level and they collaborate with a broad range of both public and private stakeholders within the county, including municipal authorities ([17]). The Covenant of Mayors for Climate and Energy builds on the support of regional bodies that officially commit to providing strategic guidance, and financial and technical support to participating cities.

Furthermore, regional climate change adaptation partnerships are emerging, for example in the United Kingdom and Canada. They are new models of coordination that operate horizontally, but also facilitate vertical coordination (Bauer and Steurer, 2014). These partnerships are examples of 'network governance', which complex issues, such as sustainability or climate change, often call for. Governments may lead them from the top down or they may be bottom-up initiatives by businesses or other actors. They can build shared adaptive capacity at the local and regional levels by bringing together actors from both the public and private spheres and thus pooling capacities and resources.

Horizontal coordination within and between cities

Cities follow a range of approaches to adaptation. They may implement specific adaptation policies and programmes or integrate adaptation with the mainstream (Uittenbroek et al., 2014). Regardless of the type of approach, the cross-cutting nature of adaptation calls for broad collaboration by different parts of city administrations.

A mainstreaming approach integrates adaptation into existing networks and processes around vital city functions such as spatial planning, health and rescue services, or transport. This enables the use of existing governance mechanisms and institutional structures to support urban adaptation. Traditional methods of collaboration within cities may not, however, be enough to address adaptation needs. If action is not coordinated, it may be incoherent and even badly adapted. Institutional structures in cities tend to be in separate silos that are often not best suited to tackling cross-sectoral adaptation. Likewise, a lack of political commitment and leadership creates barriers to mainstreaming adaptation in cities (Uittenbroek et al., 2014).

The findings of a recent survey on governance of urban adaptation (Aylett, 2015) show that different municipal services engage in adaptation efforts to very different extents. Only environment and planning agencies are actively engaged in planning adaptation. Other departments are still largely on the margins. According to the study, the most effective strategies for mainstreaming adaptation that cities have applied to date focus on building internal (both formal and informal) networks between departments, such as 'creating informal channels of communication' and 'cultivating personal contacts and societal trust'. On the other hand, formal education and training programmes, for example, were relatively ineffective but were also the least commonly applied strategies for mainstreaming. How much different strategies for mainstreaming are used, and how effective they are, are both likely to reflect the level of attention, mandates, resources and support that leadership gives to planning adaptation.

People are paying increasing attention to equity in adaptation. This highlights the importance of understanding social vulnerability to climate impacts in cities. Experiences from Newcastle, north-east England, show that adaptation planning and decision-making easily marginalises the most vulnerable groups of people (e.g. low-income single-parent families, pensioners, homeless people and migrants) or excludes them outright when sectoral policies do not fully integrate adaptation needs (Wilson et al., 2014). Budgetary pressures and competition for scarce resources are increasing, and we urgently need to integrate adaptation considerations better in sectoral policies and actions to ensure that they pay sufficient attention to both the short-term and long-term needs of the most vulnerable groups.

([17]) National adaptation portal page (Roles for government actors at different levels) (Swedish National Knowledge Centre for Climate Change Adaptation, 2014).

Box 5.5 Diputació de Barcelona: 'We actively support our municipalities to cope with climate change'

Population: municipalities between 390 and 64 999 and Barcelona with 5 522 565
Biogeographical region: Mediterranean

On the map of EU city initiatives that cope with climate change, the area near Barcelona appears to be very active. What are the reasons for this high level of engagement?

The provincial council, Diputació de Barcelona, explains:
'We have a long tradition to support our municipalities on sustainable urban development. This started with the Local Agenda 21 process in the nineties, and continued with the Covenant of Mayors and now the Mayors Adapt initiative. We think it is important to achieve a balanced situation in the province.

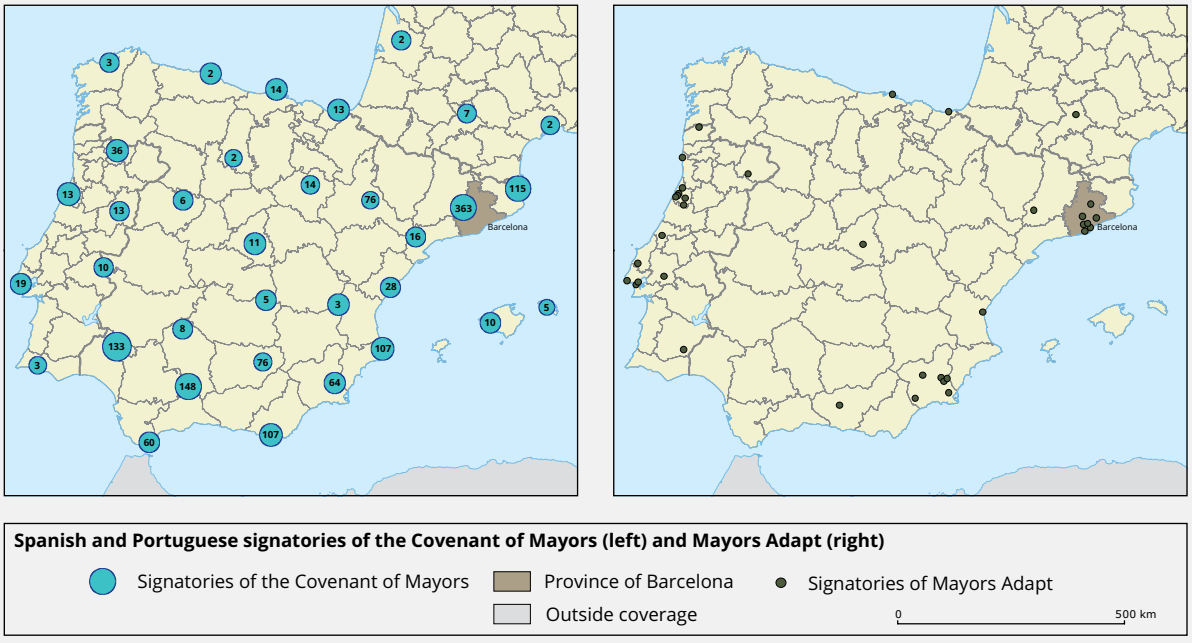
'In the region, we have the big city of Barcelona that is very active, but many smaller municipalities as well. These smaller municipalities face particular challenges. Often, they do not have the expertise and capacities to develop climate action on their own. Neither are they able to participate and thus benefit from European initiatives. In this situation, the provincial council functions as coordinator and service provider. We develop and fund the local climate strategies, plans and actions and provide the necessary competences and technical support. For example, we searched Climate-ADAPT for available tools to develop adaptation strategies. These were, however, often developed for bigger cities and do not necessarily relate to the Spanish circumstances. Based on others' experiences, we have therefore developed a standard methodology and a tailored tool for our municipalities. It is a simpler scheme with checklists and is already partially prefilled with provincial data.

'Another success factor of working effectively and efficiently, I see in our close cooperation with the Catalonian government as well as with the metropolitan region of Barcelona, so we can share experiences and methodology issues, we optimise resources and we avoid overlapping. We are also the coordinator for EU initiatives such as the Covenant of Mayors and Mayors Adapt. In this way, we enable our municipalities to competently participate in these initiatives, we make knowledge accessible, e.g. from Catalonia, the city of Barcelona, Spain or the EU.

'Beyond our competences, we see trust as a major success factor. We have built it up over many years' work. Together with the strong and long-term political back-up to invest in environmental issues across all parties in the region, it made it easier to convince our municipalities to engage.'

The result of this supportive action by the provincial council is outstanding local engagement. Of the 311 municipalities in the region, 213 participate in the Covenant of Mayors, representing 96 % of the population. Seven municipalities have joined Mayors Adapt, which comprises 120 European cities. An active regional coordinator, such as a province, can make a difference.

Map 5.1 Spanish and Portuguese signatories of the Covenant of Mayors (left) and Mayors Adapt (right)



Sources: http://www.diba.cat/en/web/mediambient/canviclimisost; direct communication with Carme Melcion, Climate Change and Sustainability Office of Diputació de Barcelona, July 2015.

Cities around Europe have begun to actively integrate adaptation needs in coastal zone management. They are bringing together sectors and interests that have traditionally operated separately, for example in Lithuania, Northern Ireland and Spain. Bologna, Italy, provides an example of a broad range of public and private stakeholders collaborating in urban planning to support resilience (Box 5.17). In many instances, however, officials from different city organisations occupy separate administrative silos, and involving them in adaptation is difficult enough, without adding large numbers of other stakeholders. In the Helsinki region, authorities specifically sought to engage officials from local government organisations first, leaving future efforts to tackle broader coordination and engagement of other actors and the general public (Peltonen et al., 2014).

Another important element of governing urban adaptation is collaboration with other cities. That can be both informal and through organised city networks. Cities engage directly with other cities to exchange experiences and knowledge, benefit from peer-to-peer learning, increase the awareness and visibility of their actions, and generate momentum for lobbying national and European institutions. Networks focusing on specific topics, such as ICLEI, C40 and Climate Alliance, as well as European initiatives such as the Covenant of Mayors for Climate and Energy, focus increasingly on climate change adaptation. These networks tend to provide collaborative platforms predominantly for large and medium-sized cities, as small municipalities often lack the capacities and resources to actively pursue networking opportunities (e.g. the German KoBe project; see Box 5.14) (Reckien et al., 2014b). Especially when there are no clear national frameworks to support local adaptation, international networks can provide much-needed support for cities in their adaptation work. Peer networks and other new types of partnerships in governing urban adaptation can complement traditional governance mechanisms. Collaboration on single projects can also provide a platform for coordination between cities. The Climate-Proof City (ILKKA) project in Finland (ILKKA-project, 2016) brought together four medium-sized cities to develop tools and procedures for climate-proof urban planning. The project received some of its funding from the European Regional Development Fund; this demonstrates the use of European funding instruments to support urban adaptation. Czech cities (Box 5.9) and Bratislava (Box 5.15) have also put forward positive experiences of networking with other cities through projects. Exchange and learning between cities is also an integral part of Horizon 2020's new call for projects to demonstrate innovative nature-based solutions in cities; it applies the concept of frontrunner and follower cities (EC — Research and Innovation, 2015).

Box 5.6 GRaBS participation approach

The GRaBS participation approach is a tool that can ensure participation in adaptation processes. It presents a sequence of actions that need to be transparent to ensure that the process of participation connects the inputs and proposals of all participants with the final decision about adaptation measures and strategies.

Source: Holstein, 2010.

Ways to participate in governing urban adaptation

Although there is broad agreement that adaptation needs to engage residents and local communities, organising timely, informed and meaningful participation processes is not straightforward. There is still not much evidence about good practices in participating in urban adaptation, and adaptation planning has not yet applied participatory approaches systematically. The German Federal Environment Agency has compiled lessons and experiences from participatory approaches in preparing national adaptation policies, which are also relevant to urban adaptation (Rotter et al., 2013).

It is clear from experience that involving private sector actors is challenging. Still, involving them is very important for successful local adaptation, as the private sector holds the key resources that it needs. Private landowners are important actors in cities and manage other resources that could be useful alongside public resources. Box 5.33 provides an example from Copenhagen: the city and the water utility company collaborated in implementing adaptation projects and complementing public measures, for instance in addressing the residual risks that cannot be covered by public interventions.

To motivate residents to participate, it is crucial that they be aware of climate change impacts and the need to act, the EU Cities Adapt project found. For example, communication of risks should be sensitive, and map-based interfaces (such as global information systems) are effective in communication. Social networking and external experts or organisations can help deliver messages effectively. Technical terms such as 'adaptation' may be a barrier; using local terms and local examples instead is good practice (Ricardo-AEA, 2013). Even established mechanisms for participation may not be equally accessible to all groups of people in cities, for various reasons such as language, educational level or time (Wilson et al., 2014).

Some guidance for participation exists. For instance, the Green and Blue Space Adaptation for Urban Areas and Eco Towns (GRaBS) project (2009–2011) developed the GRaBS principles for participation (Holstein, 2010). As one of the first EU-funded urban adaptation projects, it focused on helping people exchange their knowledge and experience, and transferring good practice in climate change adaptation strategies to local and regional authorities. The guidance includes ways to apply the principles more systematically in local adaptation processes, along with recommendations for local and regional authorities, professional planners, NGOs, community groups and other stakeholders (see Box 5.6).

German experience confirms an important lesson learned in research on participatory processes: information on the impacts of climate change does not automatically trigger adaptive action (Rotter et al., 2013). In the EU Cities Adapt project, the urban residents' awareness of climate change impacts and the need to act was crucial to motivate them to participate (Ricardo-AEA, 2013). This underlines that simply informing the public and decision-makers about climate change impacts is not enough.

Further resources

- ➔ ***Urban adaptation to climate change in Europe*** **(EEA, 2012b), Chapter 4, Multi-level governance: http://www.eea.europa.eu/publications/urban-adaptation-to-climate-change**
- ➔ **Urban Adaptation Support Tool, step 1: Preparing the ground: http://climate-adapt.eea.europa.eu/tools/urban-ast**
- ➔ **GRaBS project: http://www.grabs-eu.org**
- ➔ **Adaptation Strategies for European Cities — EU Cities Adapt project: http://climate-adapt.eea.europa.eu/viewaceitem?aceitem_id=8724**
- ➔ **Chapter 4 Transition management in cities. In:** ***Urban sustainability issues — Enabling resource-efficient cities*** **(EEA, 2015f) http://www.eea.europa.eu/publications/enabling-resource-efficient-cities**
- ➔ ***National action on urban adaptation in EEA Member states*** **(Breil and Swart, 2015): http://cca.eionet.europa.eu/reports/Urban%20Adaptation%202016**

5.1.3 Towards developing governance for effective urban adaptation

Current governance of adaptation often lacks ways for local stakeholders to take part systematically and meaningfully. To adapt effectively, we need new ways to link actors and stakeholders who represent different fields and parts of city administrations and who may have little previous experience of working together in areas such as infrastructure or service provision. Synergy between adaptation and mitigation can also improve efficiency. Engaging stakeholders more deeply than just providing information is necessary. Co-creation of knowledge and plans, and joint decision-making integrate stakeholder perspectives in urban adaptation. Making engagement processes more stable than one-off events and temporary arrangements can help build trust in society and the capacity of stakeholder groups to adapt. Improving stakeholder engagement and participation processes can also make urban adaptation more equitable and just, as it takes in the views of the most vulnerable communities when designing and implementing adaptation responses. When making adaptation decisions, we need to pay careful attention to ensure equal opportunities for all citizens to participate and/or make their views known.

Effective multilevel governance frameworks enable simultaneous and complementary actions at different levels. In particular, interplay and coherence between different levels of governance are important, along with finding suitable scales to address different risks at the local, regional or national level. This requires systematically identifying and addressing gaps in existing governance frameworks. For example, France has a strict legal requirement to address urban adaptation, but lacks support for their implementation (Box 5.4).

Can cities, especially smaller cities, engage in multilevel frameworks as well as partnerships and peer networks? That is a key to ensure that such frameworks provide effective support for cities' adaptation needs. The province of Barcelona has found an effective approach (Box 5.5).

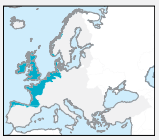
International commitments can even help cities overcome the short-term nature of electoral cycles and support the long-term perspective needed for adaptation (e.g. in Barcelona). Targeted support for smaller cities, including partnership and exchange in networks, can help overcoming their shortage of resources and capacities (Reckien et al., 2015).

> *We see the commitment in longer-lasting international initiatives as a way to ensure continuity in our work. Even if the local government changes, the commitment goes on*.
>
> Toni Pujol Vidal, Barcelona City Council

Supporting learning is a key element in improving the governance of urban adaptation. The experience of Bilbao (Box 5.7.) highlights how governing urban resilience can benefit from reflecting on and adopting lessons learned in past transformational processes. Mechanisms for institutional learning, such as monitoring and evaluation of adaptation policies and measures (see Section 5.5), can improve feedback processes and help cities to recognise emerging threats and increase their ability to respond to them.

Existing governance mechanisms and institutional structures have limitations. Transformational adaptation calls for new ways of collaboration and innovations in governing urban adaptation. We need to discover and test different business models for adaptation, for example through innovative partnerships with private sector and civil society actors. The Danish example (see Box 5.4) demonstrates how regulation coupled with dedicated support mechanisms can promote local adaptation planning. Innovative collaboration and engagement with key stakeholders can further enhance the capacities of cities to address the climate challenge.

Box 5.7 Efficient engagement of stakeholders in transformation: lessons for urban adaptation and resilience from Bilbao, Spain



Population: 346 574
Biogeographical region: North-western Europe

Heavy industry in Bilbao faced an economic crisis. The city needed to start a transformation strategy in response to social conflicts and economic decline. This strategy resulted in two decades of tremendous transformation of the city, in both urban development and economic change. The revitalisation plan included environmental restoration of the heavily polluted waters of the Nervion River and estuary, massive regeneration of urban public space and development of social housing as well as construction of symbolic buildings and architecture. The Guggenheim Museum is an outstanding landmark.

This was possible thanks to a combination of different mechanisms and the active involvement of various stakeholders. The governance approach stretched across sectors and levels. A good example is the creation of an ad hoc public company to manage land and urban regeneration — Bilbao Ria 2000. National, regional, provincial and municipal administrations took part. They gave the company land they no longer needed for infrastructure or industry. The governance of the process, agreement among all those institutions and cooperation with the private sector were crucial factors for the success of the strategy. This was one of the key lessons learned for upcoming ambitious interventions in the city.

Photo: Zorrotzaurre peninsula today (left) and future simulation (right) © Ayuntamiento de Bilbao, Bilboko Udala

Years later, the municipality incorporated open public participation, with help from external professionals, as a key component of planning. A tangible result is the regeneration of the Zorrotzaurre peninsula. A renowned architect designed it and it substantially improves flood protection. This intervention contributes a lot to Bilbao's climate proofing and resilience. The lessons learned from the previous post-industrial transformation and the social participation processes are also crucial for managing this new urban intervention. This approach will certainly be a reference framework when addressing a holistic and integrated climate adaptation strategy.

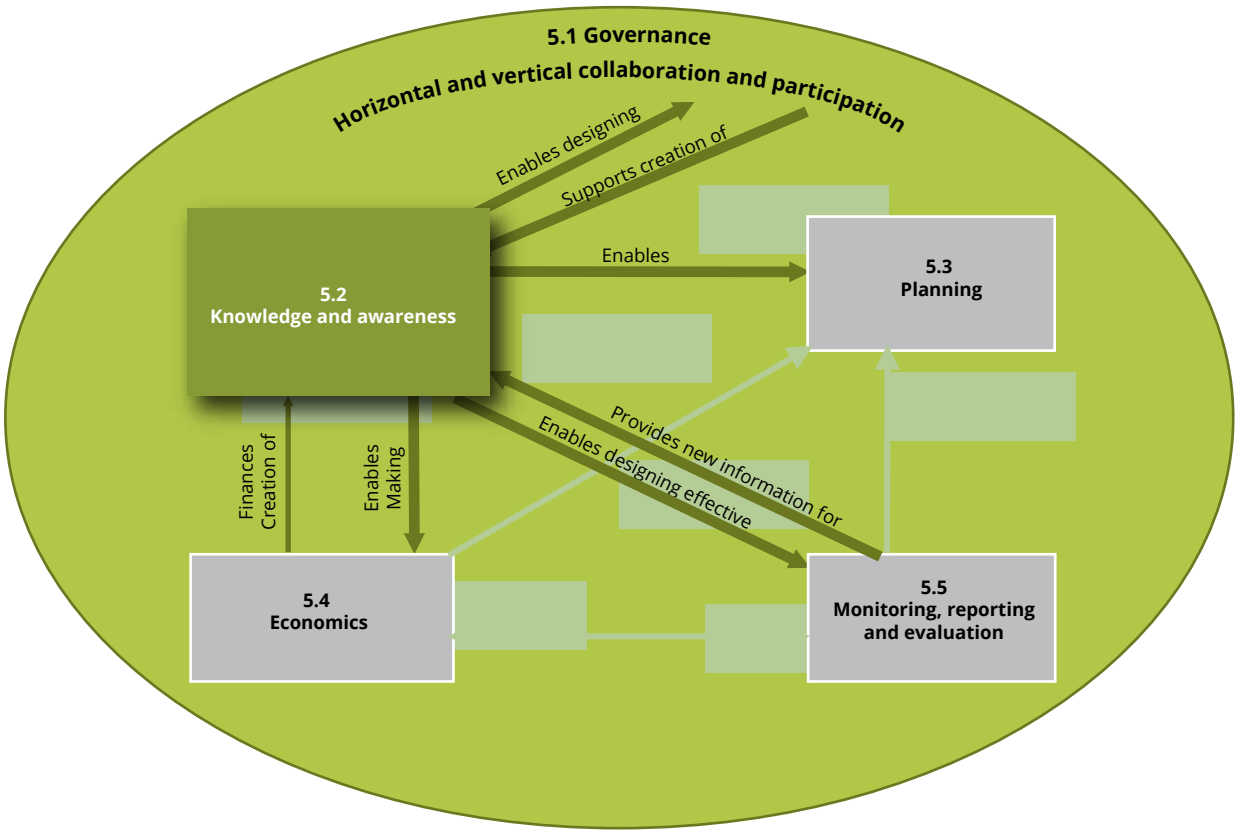
Source: Direct communication from Efrén Feliu, Tecnalia, January 2016.

5.2 Building the adaptation knowledge base and awareness

Key messages

- Awareness is crucial for continuous urban adaptation. It demands scientific, technical and local knowledge about climate change implications and options for action.
- Awareness of adaptation has grown in recent years. European institutions, many national governments, city networks, NGOs and initiatives such as Mayors Adapt have increasingly drawn local attention to the need for climate action. The level of awareness still needs to be improved.
- Cities, especially smaller ones, often lack the capacity or resources to access knowledge and select the most appropriate tools already available. The know-how for initiating urban adaptation is already available, although some gaps exist, especially in specific local information. Practitioners and scientists may be able to fill these gaps by managing the interaction and producing knowledge together. They can determine what knowledge cities need and translate scientific results into useful information for planning adaptation in local contexts.
- However, we do not yet know enough to deal with the systemic and long-term challenges of climate change together with demographic and other socio-economic change. They require fundamental changes in the way cities, and the stakeholders that support them, approach adaptation.

Figure 5.4 Awareness and knowledge and its relation to other topics



5.2.1 The knowledge base needed to create awareness and action for urban adaptation

Anticipating climate change requires awareness and knowledge. Awareness of climate challenges, or understanding what climate change means for the urban context, can come from scientific knowledge or direct experience of climate change impacts. Knowledge can also provide insight into available options for action and form a basis for developing meaningful actions locally. It is essential for all steps in an adaptation cycle. Actors need to know about the impacts of climate change on the urban area, the necessary planning steps in the process and possible coping options as well as how to oversee and finance those options in practice (Martins and Ferreira, 2011). The necessary knowledge includes the city region's characteristics, so they can determine how vulnerable services from the region are, such as food, transport (e.g. evacuation), energy, water and ecosystem services, but also potential impacts from the surrounding area, such as (flash) floods, mud slides, forest fires and avalanches.

Knowledge is necessary for systemic and long-term planning as well as dealing with the many uncertainties. Ultimately, we need knowledge and awareness to develop and support transformational adaptation (Lonsdale et al., 2015). Awareness comes with knowledge, but politicians and decision-makers can often become aware from direct experience such as actual disasters.

Several groups of actors need to have the right knowledge and awareness:

- Local adaptation planners, mostly local administrative staff, but also private sector parties and experts involved in local planning, need to be aware of and know about impacts, vulnerabilities, interconnectedness with other environmental and socio-economic developments, possible adaptation options and how to implement them. This requires the right awareness among politicians so that they will provide back-up and resources such as staff and funding. Colleagues in other policy areas need to be aware of the interlinkages between their area and climate change and know how to tackle them.

- Regional adaptation planners, mostly regional administrative staff, need to consider how the region is interconnected with the urban areas. This includes climate change impacts and vulnerability, as well as ecosystem services, such as flood retention areas, which are useful for adaptation.

- National governments and the EU need awareness and knowledge of the climate change adaptation challenges for cities as well as the region, so they can support them effectively. This includes information on how cities have adapted so far, area by area, and what barriers exist to urban adaptation.

Climate change concerns business as well as everybody's life. Water companies, network managers, urban asset managers, businesses, insurance, individual citizens, etc. all need to be aware of the challenges they will face, and to know how to act or support insight and understanding.

There are different sources of knowledge. The majority of formal climate information comes from expert knowledge. Knowledge about urban adaptation is dynamic. It depends on future conditions that are not all certain yet and is continuously developing. We do not have all of the answers so we cannot go straight from knowledge to awareness. Knowledge about adaptation is also often context specific. What we know about how to adapt in one city will not match another. This increases the emphasis on learning. A key means of learning is practice and experience. Thus, interactive and bilateral exchange processes between practitioners and scientists, aiming to create knowledge jointly, can be an innovative strategy for improving expertise and scientific evidence (Frantzeskaki and Kabisch, 2016). Monitoring, reporting and evaluation (MRE) is a valuable way of making experience from past and present action available. It provides additional knowledge of the effectiveness and efficiency of adaptation action (see Section 5.5). That turns adaptation into the result of a continuous learning process.

People's everyday knowledge is another source of information. It can be very sophisticated and detailed and it may be very diverse as well (Birkmann et al., 2010). Nolmark et al. (2009) refer to the 'urban knowledge arena', which draws on a mix of expertise from government, industry, academia and citizens. Both expert and local knowledge help to develop a shared understanding of risks, issues and outcomes, which can increase the chance that a project will succeed. Such co-creation, combining expert and local knowledge, requires integration, participation and broad stakeholder involvement (Cloutier et al., 2015; Solecki et al., 2011). To co-create knowledge requires mutual respect and trust among the partners (Rob Swart et al., 2014).

To adapt an urban environment to climate change, municipalities need enough suitably qualified staff to interpret future impacts, identify potential options, make projections more precise and act in the face of uncertainty. They also need general research targeted

on urban adaptation, which requires sufficient funding by national and European institutions. Finally, the right structures and communication channels need to be in place to distribute and tailor knowledge and create awareness (Rob Swart et al., 2014).

5.2.2 Current state of awareness, knowledge creation, accessibility and take-up

Stakeholders in many EU Member States, as well as at the European and international levels, are well aware of the need to adapt cities. In particular, the EU adaptation strategy has focused on cities and increased political awareness with the Mayors Adapt initiative. Several European and international city networks specifically raise awareness of climate change mitigation and adaptation, among others ICLEI, EUROCITIES and Climate Alliance.

At the international level, global city networks and the United Nations Human Settlement Programme (UN-Habitat) create awareness and knowledge by means of the Compact of Mayors. Other initiatives are Making Cities Resilient (UNISDR), PROVIA (United Nations Environment Programme), European Healthy Cities Network (World Health Organization) and Cities and Climate Change Initiative (CCCI, UN-Habitat). Bottom-up initiatives of global city networks include the C40 cities, ICLEI's Resilient Cities and the 100 Resilient Cities network, which the Rockefeller Foundation supports.

Many cities believe that the mere existence of a national policy can make local and regional actors more aware of the need for action at urban level (Heidrich et al., 2013). Of the 21 EEA member countries that have a national adaptation strategy or plan, 15 devote a specific chapter to urban adaptation or address it explicitly under several sectors.

Cities are undertaking more and more adaptation actions. That indicates that awareness is growing at this level. However, compared with cities taking climate mitigation action, the number is still small. Before the two initiatives joined forces as the Covenant of Mayors for Climate and Energy, Mayors Adapt had 132 effective signatories (Mayors Adapt, 2015) and the Covenant of Mayors had 6 496 signatories (Covenant of Mayors Office, 2015). Olazabal et al. (2014) sampled 200 large and medium-sized cities in EU Member States ([18]) and found that the proportion of cities that have a mitigation plan varies between countries. At the end of 2012, only 7 out of 26 Spanish and 11 out of 32 Italian cities in the same sample had developed some form of plan or strategy for adaptation. According to the authors, this might be because they had a 'limited level of understanding, know-how and technical knowledge'. The problem was especially knowledge of specific local future climate conditions, and the 'difficulty of translating best adaptation practices from one city to another' (Olazabal et al., 2014, p. 10). Many investments in mitigation plans pay off in reduced energy expenditure. In comparison, many local authorities do not invest in adaptation strategies and measures because they do not yet know how useful it is to fill these knowledge gaps. Moreover, the authors conclude that the lack of EU and national initiatives can make a difference to local awareness and knowledge generation.

Adaptation action by cities such as Copenhagen, Dresden and Paris used to be particularly in response to disasters, such as flooding, droughts or heatwaves. However, the awareness created by extreme events can drop relatively quickly and the perception of risk can soon return to original levels (Bornschein and Pohl, 2012, p. 76). Additionally, after the River Elbe in Germany flooded, the authorities took protection measures. Knowing that, individuals perceived the risk as lower and, as a consequence, were less concerned about protection measures only a few years later (Bornschein and Pohl, 2012). To avoid losing momentum, administrations therefore need to use windows of opportunity immediately when decision-makers and citizens become more aware.

Recently a few cities, such as Rotterdam and Bologna, took action without the impetus of a recent disaster. This shows that knowledgeable and motivated administrative staff can create awareness and retain political support. EU, national and regional initiatives create awareness and increasingly trigger action. Extreme weather events and EU policies that promote and finance urban adaptation currently appear to be the main triggers to raise awareness and prompt action among national and local policymakers (EEA, 2014, p. 24; Breil and Swart, 2015).

Non-governmental organisations, local environmental groups and individuals raise awareness and lobby. These are also important in triggering local action on climate mitigation and urban sustainability (Bulkeley and Betsill, 2013). Many NGOs are fostering climate

([18]) The research analysed plans and strategies from cities included in the Urban Audit. The Urban Audit regularly collects data from 200 large and medium-sized European cities, which are home to approximately 20 % of the population in each country (http://ec.europa.eu/eurostat/web/cities).

change mitigation action at both local and national levels, but so far few are raising awareness of the need for urban resilience. The EU supports NGOs so that it receives input for policies, and also uses their capacities to raise awareness of climate policies. For instance, the EU provides operating grants to environmental and/or climate NGOs and explicitly requests a focus on climate change adaptation. Several of the NGOs selected for this programme aim to raise awareness and support local authorities that are building local resilience (EC, 2015a; EC Environment, 2016). For an example of an NGO that has used this funding to publicise the need for action on climate change resilience, see Box 5.8.

At national and local levels, many organisations advocating environmental sustainability and climate mitigation also act for urban resilience. For example, the Czech Environmental Partnership Foundation is again benefiting from the LIFE+ finance for NGOs and is supporting Czech cities as they start to adapt (EPA, 2016).

Knowledge creation

Numerous initiatives at EU, international and national levels support knowledge creation. They develop, collect and disseminate the available information and knowledge on urban adaptation. Moreover, many initiatives provide guidelines or handbooks on how to adapt.

To support development of urban adaptation knowledge, the EU has a range of research and knowledge-sharing programmes, such as Horizon 2020, the 7th Environment Action Programme (EAP), the Joint Programming Initiative (JPI) Urban Europe, JPI Climate, the Interreg programme and the LIFE+ programme. They analyse impacts, in particular putting money values on direct and indirect impacts. They also design innovative strategies, tools and solutions. Most projects use case studies, generally choosing major cities (e.g. London, Copenhagen, Rotterdam, Barcelona). Some of these cities appear more often than others. This raises the question of whether multiple case studies in one city have created added value for that city. The experience of Bratislava confirms that participating in different international research projects helped the city assess knowledge and exchange experiences with partner cities (see Box 5.15). There is less focus on smaller cities or less densely populated urban areas. Studies may investigate only one impact (e.g. flooding). The scope of the studies is also somewhat limited, with flooding the impact most often addressed. Among adaptation measures, studies investigate technical and nature-based solutions more than management or behaviour (e.g. combining public and private efforts). According to information from Mayors Adapt/Covenant of Mayors for Climate and Energy, the issue of financing is also not well developed and studies rarely look into market-based instruments for urban adaptation.

Various initiatives make knowledge available to cities. At the international level, the Urban Climate Change Research Network (UCCRN) provides the C40 cities and other urban decision-makers with the knowledge they need to make better policies based on climate science.

Box 5.8 An NGO raising awareness about the needs of local authorities

'Underfunded, underprepared, underwater?' asks the report by Nick Mabey, Rosalind Cook, Sabrina Schulz and Julian Schwarzkopff from E3G (Mabey et al., 2014). They point to the need to enable cities to prepare for climate change. They aim to raise national governments' awareness of the need to support local authorities in dealing with climate change impacts. Their analysis points to the need for action at national level, showing how unclear responsibilities and lack of funding leave cities unprepared. Government inaction could lead to damage costing billions of euros each year in areas that are crucial hubs for national economies. This threatens the well-being of citizens and the existence of businesses. The report strongly advocates the creation of comprehensive climate risk management frameworks. The EU should act further to support and guide cities and governments in making decisions about adaptation and resilience in the face of uncertainty.

Nick Mabey, one of the authors, underlines the potential consequences of inaction: 'Most businesses don't include climate risks in business strategy — but if risks are not disclosed they cannot be properly managed. It's time for an honest dialogue on what climate risks mean for business and how governments and cities can assist in managing them.'

Source: E3G.

Sources: Mabey et al., 2014; E3G, 2016.

Box 5.9 Research supporting Czech cities to prepare for climate risks

Population: 1 259 079 (Prague)/
377 440 (Brno)/
169 033 (Pilsen)
Biogeographical region:
Central and eastern Europe

'Czech cities are currently not very advanced in their adaptation to climate change for several reasons. Climate change adaptation was so far not so high on the political agenda; cities to some extent lack awareness, knowledge, and governance structures. In this situation, the Global Change Research Institute (CzechGlobe) together with partners from the cities, NGOs and universities created the UrbanAdapt project focusing on the development of urban adaptation strategies using ecosystem-based approaches to adaptation. Within this project we aim at initiating the process of development urban adaptation strategies in Prague, Brno and Pilsen.' David Vačkář, project coordinator, Global Change Research Institute.

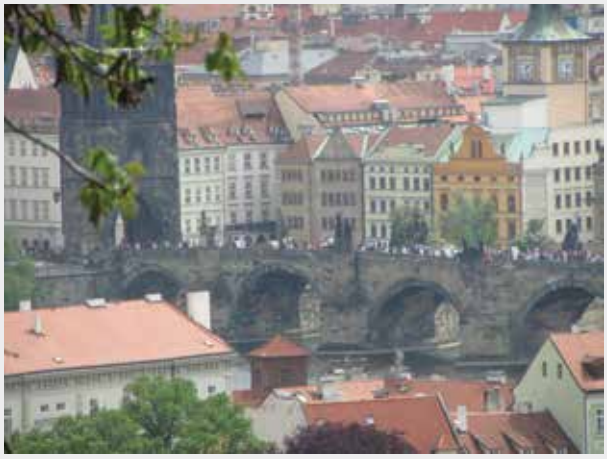


Photo: © Pia Schmidt

The Global Change Research Institute provides Prague, Brno and Pilsen with access to scientific knowledge and information from international experiences. It helps translate them into information needed for the local context, especially for suitable ecosystem-based adaptation measures and actions. Within the project the consortium organised two rounds of stakeholder workshops in each of the three cities in 2015. Participants came from city administrations, regional authorities, the ministry of the environment, the private sector, NGOs and research institutions. They discussed the current problems of the city related to climate change impacts and jointly defined a strategic vision and future goals for 2030 that the city could follow. Some of the problems in the three cities are quite similar, such as urban heat island effects (especially in the city centres), the lack, or low quality of green areas and insufficient rainwater retention. Other problems were specific to each city. For instance, in Pilsen, scarcity of drinking water will be a major challenge in future, because the city has only one source. For these specific challenges, CzechGlobe proposed suitable adaptation measures based on the ecosystem approach, and the group sessions discussed their relevance for each city. In a second round of workshops, the discussions focused on the process of developing the urban adaptation strategy, particularly using ecosystem-based adaptation. The focus was also on how to raise awareness in the cities and mainstream adaptation into ongoing decision-making processes in the cities.

'We can see that the situation starts to change. The discussions in the cities are moving towards broader integration of climate change adaptation issues into the local policies, and strategic and spatial planning of the cities.' Eliška Krkoška Lorencová, CzechGlobe.

The project will go on to evaluate adaptation measures in Prague, Pilsen and Brno and the development of their adaptation strategies.

Sources: http://urbanadapt.cz/en; direct communication from Eliška Krkoška Lorencová, CzechGlobe, January 2016.

It develops projections and assessments, as well as tools and guidance. LIFE-ACT ([19]) helps local authorities develop a local adaptation strategy that takes into account environmental, social and economic impacts of climate change, to increase the city's resilience. The strategy derives from collaboration between local authorities, the research world and all the local stakeholders. The process is inclusive and participatory.

Knowledge sharing

Internet platforms also share knowledge. The European Commission's European Climate Adaptation Platform, Climate-ADAPT, includes a specific urban section (Box 5.11). At national and transnational levels, further knowledge platforms exist, several of them directly connected to national adaptation strategies and plans

([19]) www.actlife.eu/EN/index.html.

Box 5.10 Examples of knowledge from EU-financed research

The Reconciling Adaptation, Mitigation and Sustainable Development for Cities (RAMSES) project (2012–2017) receives money from the European Union's seventh framework programme for research, technological development and demonstration. It aims to provide quantified evidence of impacts of climate change in urban areas and assesses costs and benefits of a wide range of adaptation measures, focusing on cities. This quantitative knowledge is essential for designing and implementing adaptation strategies in the EU and beyond.

Source: http://www.ramses-cities.eu.

The bottom-up Climate Adaptation Strategies towards a Sustainable Europe (BASE) (2012–2016) also receives funding from the European Union's seventh framework programme for research, technological development and demonstration. It focuses on integrating knowledge derived from bottom-up and top-down assessments of effectiveness, costs and benefits of adaptation strategies at different scales and in different adaptation sectors. Several of the case studies (Prague, Madrid, Venice, Copenhagen, Leeds) cover urban adaptation issues, focusing on different adaptation challenges (heat and drought, river and coastal flooding).

Source: http://base-adaptation.eu.

Climate Resilient Cities and Infrastructures (RESIN) receives funding from the European Union's Horizon 2020 research and innovation programme. It focuses on creating knowledge about climate resilience jointly and spreading it among European cities. It engages cities and researchers to develop practical and applicable tools for designing and implementing strategies for local contexts. The project aims to compare and evaluate ways of planning for climate adaptation, to standardise adaptation strategies formally.

Source: http://www.resin-cities.eu.

Other frameworks for research include LIFE+, INTERREG and JPI Urban Europe. The 2016 work programme contained a number of calls stressing different aspects of integrating nature-based solutions for urban sustainability.

Box 5.11 Climate-ADAPT enables access to adaptation information across Europe

Climate-ADAPT is the European Climate Adaptation Platform. It aims to support Europe in adapting to climate change. It is an initiative of the European Commission and helps users to access and share information on:

- expected climate change in Europe;
- current and future vulnerability of regions and sectors;
- national and transnational adaptation strategies;
- adaptation case studies and potential adaptation options;
- tools for adaptation planning.

The platform has a section on cities, which presents information relevant to cities and offers specific support tools such as the Urban Adaptation Support Tool and an interactive map book on urban vulnerability.

Sources: http://climate-adapt.eea.europa.eu/cities; http://climate-adapt.eea.europa.eu/tools/urban-ast; http://climate-adapt.eea.europa.eu/tools/urban-adaptation.

(EEA, 2015c). According to the EEA (2015c), if users are to take up the information successfully, it must be relevant and the platforms must be usable. Thus knowledge platforms need to interact with users to grasp what knowledge they require and to take into account their different levels of knowledge and capabilities. Some platforms provide interactive features that can promote bottom-up information and knowledge exchange among users, and hence engage them in the further development of the platform. Interactive features can also provide helpful ways to check if a platform is meeting its objectives (EEA, 2015c).

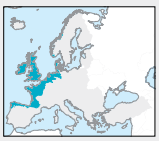
An example of a bottom-up knowledge platform is weADAPT. It is designed as an online 'open space' about climate adaptation and its synergies with mitigation. It allows practitioners, researchers and policymakers to access credible, high-quality information and to share experiences and lessons learned. The platform has a specific section on urban adaptation ([20]).

Many countries have their own mix of initiatives to help municipalities develop and implement adaptation strategies. For example, Austria has an extensive research programme that includes several projects in which selected cities participate. Flanders, Belgium, has organised a think tank of experts to advise on climate change adaptation and spatial planning (Box 5.12). The Netherlands and Germany have funded large programmes on research that cross disciplines between academics and (urban) stakeholders. The Swiss Federal Office for the Environment, together with major Swiss cities, has assessed climate change impacts and vulnerabilities of Swiss cities to identify the need for adaptation. The Turkish Ministry for Environment and Urbanisation, through the UK Foreign and Commonwealth Office's Prosperity Fund, has supported a pilot project for building capacity to prepare city-level plans for climate change adaptation in Turkey. In 2013, it trained the Bursa municipality to build capacity. Breil and Swart (2015) give more examples of such national initiatives.

Several countries have developed guidance and tools and have or are developing a national information platform specifically addressing adaptation. Breil and Swart (2015) provide a comprehensive overview. At the national level, such knowledge platforms sometimes target climate change adaptation in general ([21]), with attention to urban adaptation ([22]), and sometimes they specifically target cities ([23]) (see Table 5.3). However, especially in the newer

Box 5.12 A think tank in Flanders, Belgium, developing a climate resilience strategy

Photo: © Vincent Grond



Biogeographical region: North-western Europe

Flanders, Belgium, is working towards becoming climate resilient. The Flemish Department of Spatial Planning has started a study to develop a plan looking at national and international developments.
As dealing with climate change needs to be at both regional and local levels, the department organised two think tanks in which stakeholders gathered to discuss what measures they could take to become more climate resilient. The discussions focused around two specific regions for which they developed desirable spatial transformations to deal with climate change. By engaging in conversation with each other, they structured the climate issue. A guiding model, maps and a moderator enabled them to agree relatively quickly on the design of future scenarios at different scales. This approach proved very successful in dealing with the complexity of a spatial transition process. From the discussions at the two meetings, future solutions came into being.

Source: Coninx et al., 2012.

([20]) https://weadapt.org/initiative/urban-adaptation-to-climate-change.
([21]) E.g. Klimanetz (Austria): http://www.klimanetz.at.
([22]) E.g. Preparedness for Climate Change (UK): http://www.ukcip.org.uk/preparedness-for-climate-change-uk-urban-areas/.
([23]) E.g. Club ViTECC (France): http://www.cdcclimat.com/Cities-Local-Governments-Energy.html.

Table 5.3 Knowledge platforms addressing urban adaptation

Country	Platform name	Focus	Description	URL
Czech Republic	Adaptation of Residential Areas to Climate Changes	Adaptation	Knowledge base, case studies (under construction)	http://www.adaptacesidel.cz/en
Denmark	Climate Change Adaptation	Adaptation	Knowledge base, case studies	http://en.klimatilpasning.dk
France	Club ViTECC	Economics of adaptation	Science–policy interface	http://www.i4ce.org/go_project/club-villes-territoires-energie-et-changement-climatique-vitecc-3
	WIKLIMAT	Adaptation	Knowledge base, best practice	http://wiklimat.developpement-durable.gouv.fr/index.php/Wiklimat:Accueil
Germany	KomPass	Adaptation	Guidance, project and best-practice database	http://www.umweltbundesamt.de/themen/klima-energie/klimafolgen-anpassung/kompas
Netherlands	Spatial Adaptation Knowledge Portal	Adaptation	Guidance, best practice, knowledge	http://www.ruimtelijkeadaptatie.nl/en
	Klimaatactieve Stad	Adaptation and mitigation	Guidance and knowledge base	http://stedelijkwaterbeheer.stowa.nl/Achtergronden/Klimaatactieve_stad_verbindt_.aspx
Norway	Norwegian portal for climate change adaptation	Adaptation	Guidance, best practice	www.klimatilpasning.no
Poland	KLIMADA	Adaptation	Knowledge base (under construction)	http://klimada.mos.gov.pl/?p=136
Spain	AdapteCCa	Adaptation	Overview on regional climate action (no specific urban contents)	http://adaptecca.es/en/regional-local-administration/autonomous-communities
	Redciudadesclima	Mitigation, sustainability, adaptation	Best practice	http://www.redciudadesclima.es
United Kingdom	UKCIP	Adaptation	Guidance, best practice	http://www.ukcip.org.uk

Source: Breil and Swart, 2015.

EU Member States, national support or a national framework to facilitate action is missing, according to information from Mayors Adapt/Covenant of Mayors for Climate and Energy. Among the newer EU Member States, only Romania and Lithuania declared that they were developing some form of general or sector-specific guidance for cities or the building sector. Poland is preparing specific guidance for urban areas, which builds on Warsaw's ongoing experiences with adaptation, as well as other inputs.

Several countries have used climate platforms to transmit knowledge to local administrations, citizens or business. They face several challenges in their attempt to provide appropriate and useful information to their users. Some use different entry points for different user groups (municipalities, citizens, business) or have a hierarchical system: a landing page addresses more generic knowledge needs and the user can proceed to increasingly specialist information. Many of these knowledge portals explicitly address what municipalities need to know about urban adaptation (EEA, 2015c).

A pitfall of these portals and tools is that urban stakeholders do not know them well, so they do not use them widely, as Mayors Adapt/Covenant of Mayors for Climate and Energy found out. Getting users to take this information on board requires more than just presenting the information online. Providers have to interact directly with the potential users.

Often this requires a certain level of resources. For example, the European Economic Area Grants and the Portuguese Carbon Fund (FPC) provided the resources

Box 5.13 Making the UKCIP Adaptation Wizard useful for Portuguese cities

Population:
between 3 407 and 547 733
Biogeographical region:
Mediterranean

'In Portugal, under the scope of the ClimAdaPT.Local project, we adapted the UKCIP Adaptation Wizard (UK) and used it as a support tool for developing 26 Municipal Climate Adaptation Strategies', says Tiago Capela Lourenço, a researcher from the University of Lisbon, who supported the 'translation' of the UKCIP. He continues: 'we translated the Wizard into Portuguese and adapted it to the context of Portuguese local authorities (which include both urban and rural areas). The tool was renamed ADAM (which stands for Apoio à Decisão em Adaptação Municipal). Our project includes a specific training course to guide and support practitioners (such as urban planners, municipal engineers, geographers and other technicians involved in local planning) from all involved municipalities. So we adapted the guidance provided by the UKCIP Wizard and connected the material to each of the steps in the adaptation planning cycle (for example: getting started, assessing current vulnerabilities, identifying future vulnerabilities, selecting and appraising adaptation options and planning for monitoring and evaluation) to fit it to our training modules and delivered them in the form of training manuals. The guidance material provided during the training course contained, furthermore, additional and specific information such as, for example, updated climate projections and scenarios for Portugal. By the end of the project we expect that the tool and all material will be revised based on the outcomes and lessons learned during this first experience, and prior to making it available to all other Portuguese local authorities.'

Photo: © FFCUL

Among the participants in the project are three municipalities that had already developed and adopted a climate or climate adaptation strategy (Sintra, Cascais and Almada). During the training course, planners and other practitioners from these three cities not only supported the development of the training material, but also shared their experiences with their peers and worked on further updating their own strategies.

The European Economic Area Grants, the Portuguese Environment Agency and the FPC made the training course possible, and the Faculty of Sciences of the University of Lisbon coordinates it.

For further information, see: http://climadapt-local.pt/en.

Source: Direct communication from Tiago Capela Lourenço, University of Lisbon, February 2016.

to adapt the UKCIP Adaptation Wizard for use by Portuguese municipalities (see Box 5.13).

Generating expert knowledge through research is the business of national and European institutions. Boundary organisations are bodies that transform these scientific results into policy-relevant information, raising awareness and tailoring them towards practical recommendations to act (Groot et al., 2015). Examples are the EEA reports on urban adaptation or the numerous materials and tools from UKCIP. UKCIP also directly addresses public opinion, attempting to gain public support for adaptive action ([24]). According to Dannevig and Aall (2015), local authorities prefer referring to knowledge published by governments or governmental organisations. They regard it as 'more credible in terms of scientific integrity and legitimate' than more up-to-date or locally specific information provided by independent research institutions (Dannevig and Aall, 2015). Other experiences confirm this tendency. Regional authorities provide the necessary competences and technical support to city administrations, for instance in the province of Barcelona (see Box 5.5). Experience from Norway also points to the important potential role regional authorities could have as boundary organisations. By supervising local planning activities, they are able to trigger knowledge exchange with local authorities (Dannevig and Aall, 2015).

([24]) See, for instance, this blog post by Roger Street and Kay Jenkinson, on the UKCIP website: http://www.ukcip.org.uk/preparing-society-for-future-weather-impacts (Street and Jenkinson, 2015).

Knowledge exchange and networking

Helping knowledge providers network with users is an important way to get more stakeholders to use the available knowledge. The many adaptation or resilience initiatives mentioned before enable cities to exchange experience and knowledge. So do particular events such as the Open European Days Resilient Cities 2013 and 2014 (Breil et al., 2014) and other stakeholder meetings. The various city networks dedicated to climate change adaptation and resilience offer excellent platforms for direct exchange. These initiatives help to spread knowledge, raise awareness, release funding for research and steer it in the direction of urban adaptation.

Countries have dedicated projects for knowledge exchange and for enabling municipalities to plan adaptation. For example, Enabling Municipalities (KoBe) in Germany targets small cities in particular. In Denmark, the national authorities created a specific expert group that travelled to all bigger and smaller cities and helped them plan adaptation (Box 5.14). As one result, this helped all cities in Denmark to include adaptation plans in their municipal plans.

There are, however, underused resources. The European Commission's URBACT programme ([25]) supports the exchange and spread of knowledge between cities, for sustainable integrated urban development. However, despite very successful activities, the programme has not yet addressed adaptation to climate change. In summer 2015, a call included a specific thematic objective 'Promoting climate change adaptation, risk prevention and management', but it resulted in only one adaptation-related activity among 21 approved activities (EC, 2015c).

If there is not enough national support, city networking can be a way forward. For example, the five major cities in Slovakia formed an informal network because they lacked support from the national level (direct communication from Z. Hudekova, City of Bratislava, May 2015).

City twinning is another tool to enable mutual learning. In the EU Cities Adapt project ([26]), three peer cities partnered with 18 cities that were just starting to plan adaptation. Several of these beginners, such as Bratislava, Almada or Burgas, have themselves become role models. The project stopped in 2013 but the cities still maintain their network relationships. Mayors Adapt has recently launched a city-twinning initiative.

Sharing knowledge and experience across Europe is inspiring, but transferring it into good practice often fails. Different cities face different climate hazards and have different levels of vulnerability and capacity to adapt to them. They also have different institutional and socio-economic circumstances. As a first step, networking and twinning help to identify success factors, barriers and solutions. Then, cities can more easily adjust good practice to local circumstances. Often this requires a certain level of resources. For example, the European Economic Area Grants and FPC provided the resources to adapt the UKCIP Adaptation Wizard for use by Portuguese municipalities (see Box 5.13).

Scaling good practices up

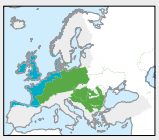
An important question is how to scale up experiences from frontrunner cities to cover the majority of cities in Europe, which are not yet active. Large cities can muster more knowledge, staff and financial resources, so it is no surprise that many of the frontrunner cities are large metropolitan areas. Many small and medium-sized cities are not yet actively working on climate resilience. However, there are several examples of small and medium-sized cities working very actively towards increasing their resilience. They demonstrate that these smaller urban areas can also take action. An advantage of smaller administrations is that it is easier to integrate policy areas. Often, cities that took early steps to lower energy consumption and associated GHG emissions also tend to be the first ones to work on adaptation, possibly because they are more aware of climate change risks in general.

Local knowledge

Administrations, businesses and citizens have practical experience at the local level. The additional local knowledge this generates is important. Local and regional governments have very local information on, for example, sensitivities to climate change impacts. This could be information on the terrain or demographics. They can add it to the climate impact information from research or from national or European sources. Cities that want to develop their own vulnerability assessments may, however, face problems because, in general, there are few local data on climate change scenarios (Martins and Ferreira, 2011). Nevertheless, cities can use predictions of global climate change or they can downscale predictions made at a continental, national or even regional

([25]) http://urbact.eu.
([26]) http://climate-adapt.eea.europa.eu/viewaceitem?aceitem_id=8724.

Box 5.14 Enabling smaller cities to plan for adaptation: KoBe project, Germany



Population:
between 9 411 and 120 988
Biogeographical region:
Central and eastern Europe/
North-western Europe

What are the challenges facing smaller municipalities trying to adapt and what is the best way to support them? The KoBe project of the German Federal Environment Agency and the Wuppertal Institute focused on the question of which factors and conditions determine the adaptive capacity of, in particular, smaller municipalities in Germany. The project team had discussions with the 11 participating municipalities and the participants of different workshops. These led to proposals to develop conditions to effectively enable municipalities to plan and implement adaptation.

Andreas Vetter from the Federal Environment Agency explains: 'We learned that small municipalities, like bigger ones, lack financial and personal resources to plan and implement adaptation action. The situation in small municipalities is, however, much more pronounced. Often, one person in the administration is responsible for several areas, among them adaptation. This results in little capacity left to even search for knowledge, to access funding, to network with other cities or with knowledge providers or participate in technical conferences and meetings — all together steps that we consider as preconditions to start planning urban adaptation. Therefore, coaching as part of this project has proven an effective way to start the process.

Photo: © Jörg Hempel

Such projects can unfortunately only support a limited number of actors. In this situation, the district level could play a decisive role in providing tailored and targeted knowledge, because our participants felt there is not a lack of knowledge but a lack of capacities to find and select the most appropriate pieces of information.

The participants considered also a legislative commitment for local adaptation planning as a push factor that could increase the political awareness and strengthen adaptation action in the competition with other municipal topics. Such measure could, however, only work if sufficient resources and capacities are provided.'

Source: http://www.umweltbundesamt.de/themen/klima-energie/klimafolgen-anpassung/anpassung-auf-kommunaler-ebene/kommunen-befaehigen; direct communication from Andreas Vetter, Federal Environment Agency, Germany, December 2015.

Box 5.15 The benefits of peer learning and city networking for adaptation in Bratislava, Slovak Republic

Population: 491 061
Biogeographical region: Central and eastern Europe

Photo: © Pavel Šťastný

'In Bratislava, we started working on adaptation thanks to some NGOs raising the issue of urban adaptation for our city, and promoting participation in international research projects', Zuzana Hudekova reports. 'In this way, our city was able to exchange experiences with other cities and learn from them. In particular, the combination of workshops, visits and the coaching adopted in the EU Cities Adapt project provided us with useful and tailored inputs for our work. The network among all cities and the contacts between our twinning cities (Birmingham, Dresden and Sfantu Gheorghe) are still alive and provide us with new occasions for continuing our adaptation planning. We also continue participating in research projects, as we can continuously learn from partner cities and receive new ideas and suggestions. For example, the city of Barcelona recently approached us proposing a joint participation in an EU project.'

Source: Direct communication from Z. Hudekova, City of Bratislava, January 2016.

scale, where available. Cities with sufficient time, skills and financial resources may choose to do their own downscaling of climate models, using publicly available data (ICLEI, 2011a). Partnering with local universities or participating in research projects can be a way forward, as shown in the Horizon 2020 projects RESIN and SmartMatureResilience ([27]).

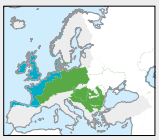
A limitation for many cities is that they often have limited budgets and staff to set up an adaptation programme that includes a broad range of stakeholders, and the staff usually do not know enough to start the process (CoR, 2011). Smaller cities, in particular, often lack sufficient technical capacities. Past events may already have reduced vulnerable cities' resources. This limits their capacity to prepare future action (Reckien et al., 2015). City networks and twinning can support them. Still, many cities derive their action from data about past disasters because they lack the capacity to develop the right knowledge about long-term risk levels from climate change (see, for example, Vác, described in Box 3.4). Another barrier is that society may not trust the knowledge that other stakeholders have created and promoted (Rob Swart et al., 2014) (Box 5.14).

Other local stakeholders, such as emergency services, business or citizens, also have valuable information. Municipalities include local knowledge in the adaptation process by mapping stakeholders and surveying them. For example, Frederiksberg, Denmark, decided to use citizens' knowledge to develop its adaptation strategy. During a well-attended meeting, participants discussed the major cloudburst of summer 2011 and mapped what they had observed in their gardens or neighbourhoods. They wrote possible solutions on post-its.

This suggests that knowledge about urban adaptation is best if all stakeholders cooperate to create it. Events such as the Open European Day Resilient Cities enable such an exchange and can be a starting point for further collaborations. Many EU projects, such as RAMSES or BASE, include local stakeholder events to co-create knowledge and tailor results to needs ([28]). Cities are often part of Interreg and LIFE+ projects and they benefit strongly. Approaches and guidance developed with this practical experience can also benefit cities that do not participate in them, for example the Adaptation Compass of the Future Cities project ([29]).

([27]) Resin Project, http://www.resin-cities.eu; SmartMatureResilience, http://ciem.uia.no/project/smart-mature-resilience.
([28]) For a report on one of these events, see http://base-adaptation.eu/event-report-base-case-study-workshop.
([29]) http://www.future-cities.eu/project/adaptation-compass.

Box 5.16 Adaptation action in German municipalities

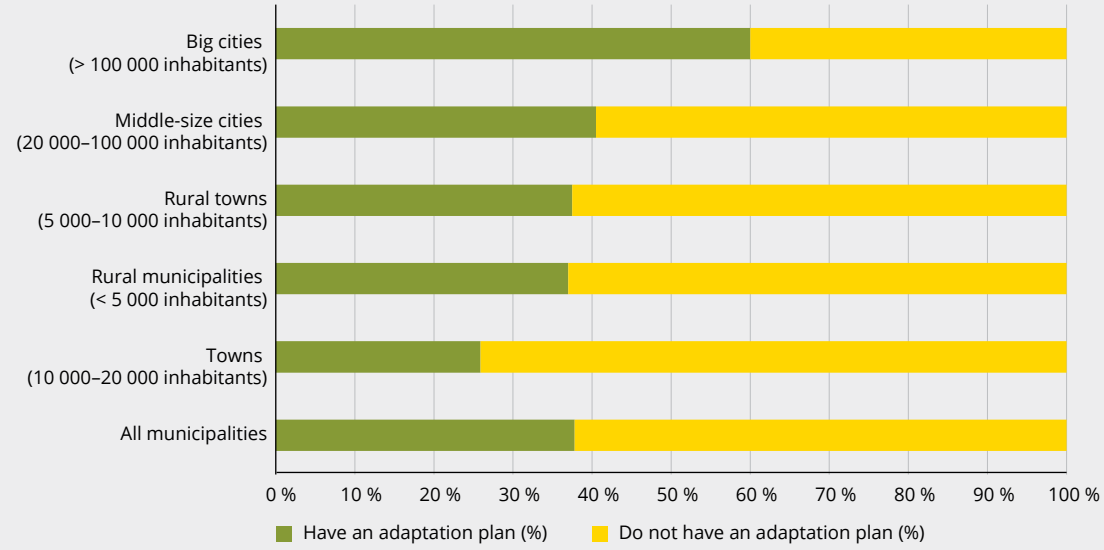


Biogeographical region: Central and eastern/ North-western Europe

In Germany in 2011, 38 % of all municipalities had developed adaptation activities. These included 60 % of big cities and 40 % of middle-sized cities. However, only between 26 % and 38 % of the smaller towns have so far developed activities. The northern regions of Schleswig-Holstein and Mecklenburg-Western Pomerania were in the lead, with 73 % and 67 % coverage.

Interestingly, more small cities than big ones claim to have implemented adaptation measures. Obviously, a systematic assessment of risks and vulnerabilities is not necessarily a precondition for cities to act. Their smaller scale and less complex structures might enable smal cities to define adaptation measures intuitively, in particular as ad hoc reactions to extreme events. Presumably, the bigger the city, the greater the capacity to follow a more systematic approach by starting with an assessment of vulnerability and adaptation options.

Figure 5.5 State of climate change adaptation planning according to the size of municipalities in Germany, 2011



Source: Mahammadzadeh et al., 2013.

Box 5.17 Bologna plan for resilience, Italy

Population: 384 202
Biogeographical region: Mediterranean

Stakeholder participation in the design of urban plans has a long tradition in Bologna. So, when the local administration started considering the local adaptation plan, it involved stakeholders as a matter of course. The LIFE+ programme financed the Bologna Local Urban Environment Adaptation Plan for a Resilient City (BlueAp) project to design the plan. The city made great efforts to select appropriate stakeholders to involve in design the plan for a resilient city. It was to take into account the expected impacts from a changing climate and the potential roles of stakeholders in increasing urban resilience.

Stakeholders met in plenary sessions. Their main goal was to create a shared knowledge base about climate projections for the city, expected impacts and envisaged strategies for resilience. They were also to provide an overall view of climate adaptation and resilience plans and policies. In fact, whereas everybody had some idea of what climate mitigation and energy efficiency strategies entail, stakeholders and many local policy-makers turned out to be much less familiar with climate adaptation and urban resilience, and had trouble grasping the concepts.

Photo: © Comune di Bologna

Following an initial plenary meeting, stakeholders met regularly in groups according to their potential role in the implementation process (politicians, citizens, representatives of the production sector) and according to areas of intervention (greening, urban gardening and agriculture, urban water management, spatial development).

'These meetings were crucial', states Giovanni Fini from the Bologna local authority, 'as they helped us design feasible and useful actions and compose an adaptation plan that can be implemented, but they furthermore generated an increasing awareness among participants about climate change adaptation and about the importance of resilience.'

In addition, the BlueAp project started a public awareness campaign targeting local schools. It offered them scientific information, lectures and interventions informing students about climate change. They were a terrific success. For the general public, it plans more targeted workshops, which will focus on the particular contribution individuals can make to increase urban resilience, for instance in urban greening.

For more information on the BlueAp project: www.blueap.eu.

Source: Direct communication from Giovanni Fini, City of Bologna, November 2015.

Further resources

- ➔ **Climate-ADAPT/cities: http://climate-adapt.eea.europa.eu/cities**
- ➔ **Urban Adaptation Support Tool: http://climate-adapt.eea.europa.eu/tools/urban-ast**
- ➔ **Resilience Resource Point: http://resilient-cities.iclei.org/resilient-cities-hub-site/resilience-resource-point/**
- ➔ ***Learning through collaboration*** **(Swart et al., 2014)**
- ➔ ***Overview of climate change adaptation platforms in Europe*** **(EEA, 2015c): http://www.eea.europa.eu/publications/overview-of-climate-change-adaptation**
- ➔ ***National action on urban adaptation in EEA Member states*** **(Breil and Swart, 2015): http://cca.eionet.europa.eu/reports/Urban%20Adaptation%202016**

5.2.3 Towards implementing a knowledge base for effective urban adaptation

Much knowledge on urban adaptation is available and is increasingly shared. It will grow as stakeholders use it. Monitoring and reporting on the implementation of adaptation action (see Section 5.5) will deliver new knowledge on the effectiveness of the measures taken. Urban adaptation is a constant learning process. But what are the current gaps and future knowledge needs?

At the European level, it is difficult to get an overview on the state of urban adaptation action. Information is patchy, as there are no reporting obligations. This is true of many European countries too. Only a few countries have comprehensive and up-to-date overview.

Mayors Adapt/Covenant of Mayors for Climate and Energy has analysed urban knowledge gaps in Europe by a survey among its member cities. It found that cities feel there are too many uncoordinated initiatives, reflecting a lack of coherent direction at EU level. The survey further identified a range of knowledge gaps, including:

- economic costs and social impacts (impacts on society) of climate change as well as costs and effectiveness of adaptation measures;
- impacts of climate change on essential services at city level, including supply chains in general and interdependencies between sectors that converge at the city level;
- downscaling and interpreting impacts at a city scale;
- how to develop, select and apply adaptation indicators and the appropriate monitoring system to assess the progress and effectiveness of adaptation as well as safeguard against maladaptation and lock-in;
- securing funding for adaptation;
- the implementation and monitoring steps of the adaptation cycle.

Comparing what we know with what we need to know delivers the following insights.

The problem is not so much knowledge itself but access to knowledge for policymakers. Frequently, those who produced the knowledge had other purposes than adaptation in mind. It is usually not on adaptation platforms but in other sources, where practitioners seldom access it (Kirchhoff et al., 2013). There are only a few attempts to integrate knowledge of adaptation and mitigation with other subject areas (Payne and Shepardon, 2015). Furthermore, there are not enough studies of some cross-sectoral aspects of climate impacts, for instance cascading impacts of climate change on urban services such as transport, electricity supplies, water, food and health services. In a survey among cities participating in the RAMSES project, 10 out of the 14 representatives from cities of different sizes stated that, 'although the departments that are working closely on the topic in their municipality are well aware of the adaptation issues, many other departments still do not acknowledge the issue and how this affects their daily work' (Terenzi and Wigström Westerlind, 2014, p. 58). A systemic approach would make it easier to overcome this problem.

Chapter 3 describes the need for a profound structural change (transformational adaptation). Cities seldom recognise it, partly because they do not understand the problem well enough and partly because they lack funding and administrative support. Even if knowledge about options is available, often cities do not know how to implement such 'out of the box' solutions in the current institutional, political and legislative framework (see Box 5.26 on floating houses).

A long-term perspective is a challenge for municipalities because the future is highly uncertain. Policy agendas deal with only the next few years, so they prefer measures that take effect in the short term, but can be insufficient to tackle the long-term changes or may even hamper efforts. Especially where recent disasters trigger awareness, this can contribute to concentrating on short-term solutions instead of a long-term perspective. We can usually predict local impacts for the next two or three decades. Beyond that, the uncertainties increase greatly. This is also true of socio-economic trends that are intertwined with climate change impacts, in particular at the local scale. This uncertainty requires knowledge of ways to deal with them to avoid being locked in to unsustainable approaches. Adaptation measures have to be flexible or robust.

To date, only a few cities have grasped the need to adapt, not only as a challenge but also as an opportunity to create attractive cities with a high quality of life. The *Cities of tomorrow* report of the European Commission (2011) has formulated just such a holistic vision for European cities that embraces change as an opportunity for new development rather than seeing it as a limitation. It can be used to inspire analogous vision-building processes with a focus on

urban adaptation. Another way to take a wider view and create awareness of the need to change systems is participatory scenario and vision exercises. They move beyond linear and narrowly focused interpretations of how cities and urban areas should adapt (Carter et al., 2015).

This change in perspective towards preparing transformational adaptation generates specific needs for awareness and knowledge:

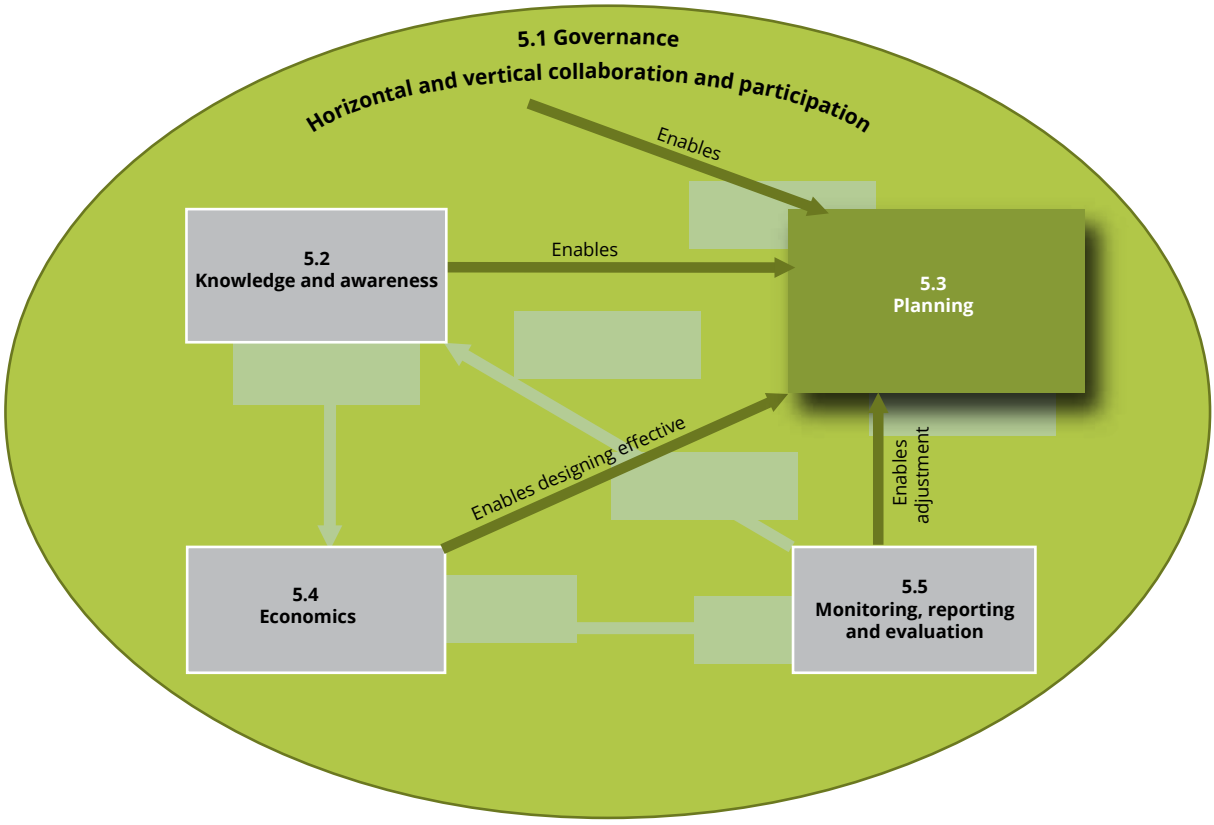
- To understand how the present city can transform into a more resilient place, knowledge of how it has evolved can help us understand how it works now and how it can be changed (or how transition to a new urban system can happen).
- Transition requires a form of leadership able to seize the chances for change offered by windows of opportunity: 'Good leadership for transformational change prepares the system for change by supporting the emergence of shadow networks, effectively navigating the transition, and charting a new direction for management' (Lonsdale et al., 2015). Therefore, each city will need stakeholders who know that transformational action is necessary, how systems work and how to trigger change.

5.3 Planning adaptation action to lead to implementation

Key messages

- Many cities across Europe have started adaptation action in recent years. Experience has increased but is still limited. A range of factors constrain local authorities, including the boundaries between sectors and limited expertise, financial, technical and human resources.
- Cities consider that an effective way to implement adaptation measures is to make them part of the mainstream and integrate them with mitigation and activities in other policy areas. Nevertheless, they seldom develop strategic adaptation documents enabling systematic and appropriate integration.
- The commonest actions in cities' adaptation strategies include individual construction measures, promoting research projects to improve knowledge and developing specific plans, such as for managing the risk of floods or heatwaves. They also pay increasing attention to the potentials of green and blue infrastructure, which provide multiple benefits beyond adaptation.
- Systemic and integrated adaptation planning with a long-term perspective is still rare among European cities. A few leading cities have started transformational adaptation and embrace change as an opportunity to increase the overall sustainability, quality of life and attractiveness of the city.

Figure 5.6 Planning and implementation, and its relations to other topics



5.3.1 Planning and implementing approaches for urban adaptation

This report understands planning adaptation as comprising the identification, assessment and selection of adaptation options, often based on vulnerability assessments and adaptation strategies. It is therefore a primary task for local and regional governments and for businesses, private service providers and citizens, as it concerns their own assets and behaviour.

Adaptation options aim to deal with climate challenges to help specific vulnerabilities and needs. They may also take advantage of any positive opportunities that arise from climate change and from working together with mitigation or non-climate objectives. Adaptation options can range from actions that build adaptive capacity or establish management systems and supportive mechanisms (also called 'soft measures') to physical adaptation measures, often referred to as 'grey' (e.g. infrastructure development) or 'green' (i.e. nature-based) measures. Systematically considering a wide range of different types of adaptation options, technological, informational, organisational, behavioural, ecosystem-based and socio-economic, as well as both sectoral and cross-sectoral measures, has proven to be most successful.

Planning and implementing adaptation builds on awareness and knowledge of climate change impacts (see Section 5.2), existing adaptation options and the possibilities of implementing them. It conducts vulnerability assessments or prioritises different adaptation options. Appropriate governance structures, securing political support in the long run, staff capacities and sufficient funding are crucial as well (see Section 5.1) (Figure 5.6).

Adaptation is iterative: the process goes in cycles, and the outcomes of one lead into the next. Any adaptation action will benefit from close monitoring and regular review to ensure it remains effective and to enable adjustments if necessary.

A systemic, integrated and cyclical approach to managing climate change responses provides an efficient and effective framework for cities to plan and implement adaptation action. The Urban Adaptation Support Tool (Urban AST), among others, provides guidance on how to approach urban adaptation in such a way. It applies six regularly repeating steps. The EEA's previous report on urban adaptation (EEA, 2012b) presents several success factors for urban adaptation processes (see Box 5.18).

Systemic and integrated adaptation planning is a key condition for effective adaptation in urban areas, rather than developing and implementing adaptation measures in isolation. Planning adaption includes defining how different adaptation measures can best complement each other as well as the right timing and sequence for implementing them. It needs a comprehensive and holistic adaptation strategy that also considers interrelationships with socio-economic trends, a broad range of stakeholder needs and objectives, and the cascading effects of climate change. A coping or incremental adaptation approach would restore or improve existing infrastructures and ways of functioning and carry on with business as usual.

A systemic approach can help define innovative solutions that go further. For many cities, transformational adaptation is novel. Thinking outside the box can help find new solutions, including innovative and effective use of funding, and identify the best economic case for adaptation. As well as economic considerations it includes social ones such as health and equity. Finally, a systemic approach enables adaptation measures that create additional benefits in other areas. Taking a long-term perspective makes it easier to consider transformational solutions and integrate them with other policy areas and administrative levels. This includes dealing with long-term uncertainties by establishing flexible or robust adaptation options and avoids getting locked in to unsustainable approaches. Adaptation can be taken into account relatively easily at the planning stage for the design and location of new infrastructure and buildings, saving costs. Given the structure of most European cities, however, the main challenge is to adapt existing buildings and infrastructure, including cultural heritage.

Who implements adaptation strategies and how depends on the options selected and responsibilities allocated. To implement a framework, it is in any case necessary to cooperate closely with all relevant stakeholders. This includes the public sector (e.g. local, regional and national planning authorities, water authorities, health services, social services, housing authorities and agencies concerned with disaster risk management), the private sector (e.g. urban service and utility providers, businesses, investors, private homeowners and consultants) and other stakeholders (e.g. citizen initiatives and community organisations).

Ideally, city authorities start to involve stakeholders as soon as they begin considering adaptation to develop a strategy and implementation plan. This produces well-informed policies and creates ownership among stakeholders. The various stakeholders have different roles:

- City administrations are key to the overall planning and implementation process, especially

as planning is context-specific and unique to each city. This process needs to be systemic and integrated, with collaboration across many different city departments and sectors, for example, the ones responsible for adaptation, mitigation, risk management, water management, nature, health and service providers. It can lay the ground for individual actors, such as business and citizens, to act on adaptation. It also has to connect with the relevant regional and national adaptation activities.

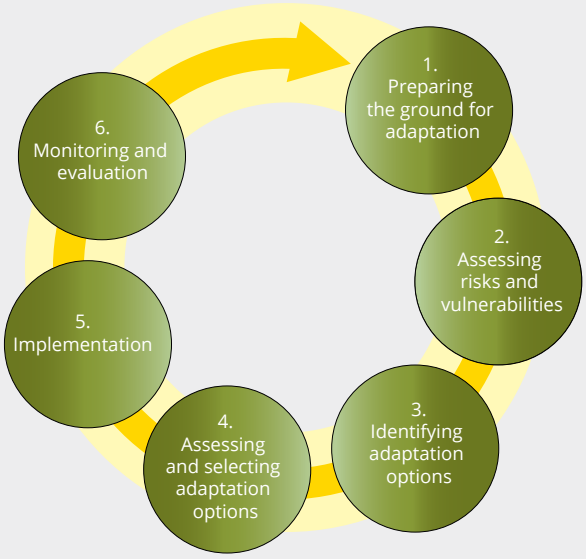
- Regional authorities are involved in two ways. Regional adaptation plans and measures need to consider urban areas that are part of the region. In particular, river floods, storm surges and water scarcity pose challenges that cities cannot solve on their own. They require urban–rural collaboration. Regional governments, together with national governments and the EU, are also part of the institutional framework in which municipalities can act (see Section 5.1).
- National governments and the EU provide the legal and financial framework and promote knowledge generation. These set the conditions under which cities can plan and implement adaptation (EEA, 2012b) (see Sections 5.1 and 5.2).
- Researchers and knowledge providers can support local planning and implementation by tailoring knowledge (see Section 5.2).
- Businesses and citizens need to implement further specific measures and change their behaviour to make their properties and activities climate-proof. These actions need to connect with those of public bodies.

Box 5.18 Guidance on planning and implementing urban adaptation

Urban Adaptation Support Tool (AST)

To support adaptation action in European cities and towns, the European Commission developed Urban AST as part of its Mayors Adapt Initiative. The tool provides urban adaptation decision-makers, practitioners and interested stakeholders with quick-start step-by-step guidance through the adaptation planning and implementation cycles. It gives easy access to in-depth, expert information and data by providing a comprehensive up-to-date database of literature and information sources for each step of the urban adaptation cycle. The tool complements guidance provided by EU Member States.

➔ **http://climate-adapt.eea.europa.eu/tools/urban-ast**



Urban adaptation to climate change in Europe

The EEA's 2012 report provides guidance on capacities to act, planning steps, success factors and multilevel governance approaches.

➔ **http://www.eea.europa.eu/publications/urban-adaptation-to-climate-change**

Success factors

- Raising awareness of climate change and the need to adapt.
- Cutting across different sectors and levels.
- Utilising the additional benefits of adaptive actions.
- Dealing with uncertainty and long timeframes.
- Working with nature, not against it.
- Securing resources for adaptation.

5.3.2 Current planning and implementation action

Climate change adaptation is still relatively new on the agenda of many decision-makers: EU, national and local. There is still no comprehensive inventory of adaptation in cities. Thus, it is hard to give precise answers on the current state of planning. Nonetheless, some data from various initiatives, projects and studies are available, along with expert judgement derived from exchanges with the stakeholders involved. They allow a preliminary overview.

Action at the local and regional levels

European cities have taken different approaches to moving forward with their adaptation agendas. Many cities adapting in a strategic way have developed strategies or action plans. These include metropolitan areas that are frontrunners in this field, such as London, Rotterdam and Copenhagen, but also smaller and medium-sized cities, among others Kalamaria (Greece), Hannover (Germany), Murcia and Bullas (Spain), Bologna, Ancona, Padua and Alba (Italy), Edinburgh and Stirling (UK) and Växjö (Sweden). In several cases, national or European projects, such as EU Cities Adapt ([30]) or KLIMZUG ([31]), have supported the development of local adaptation strategies (see also Section 5.2).

Adaptation plans systematically identify adaptation options on the basis of a strategy, as opposed to autonomous action without any strategy. The introduction or executive summary often includes general aims and objectives. Some cities, for example Copenhagen, London and Kalamaria, provide a political statement by the mayor at the beginning of the document to emphasise the importance of adaptation and/or devote a separate chapter to describing the aims and objectives. A major component of urban adaptation strategies is developing an evidence base. It usually provides general information regarding climate change, (local) climate projections on the basis of different emissions scenarios and a risk or vulnerability assessment. Some cities keep this section relatively short and refer to, or summarise, external studies and reports. This happens in the strategies of small towns or cities such as Schmallenberg, Brno (Box 5.19), Kalamaria and Malmö. Other cities, such as Copenhagen and London, present this section very prominently, being able to rely on specific local climate projections (Ricardo-AEA, 2013).

However, they do not always prepare a separate strategic document. Some cities have developed integrated strategies addressing both climate mitigation and adaptation. These are complementary strategies for addressing climate change. Particular projects can also pursue synergies (see Chapter 4). Some cities take it even further and have started to explore integrating adaptation into other policies more widely and systematically. Sometimes this happens under the umbrella of sustainable development. Another way is reviewing and eventually modifying instruments for other purposes that are relevant to adaptation. Bologna, for example, did that (Box 5.21).

Mainstreaming is an effective way to implement adaptation (Boxes 5.19 and 5.20). It is nevertheless advisable to develop a strategic/planning document outlining the key impacts, sectors of action and policies for integrating aspects of adaptation. This gives an overview and helps coordinate mainstreaming activities. Cities have seldom taken this approach.

Many cities take adaptation action to avoid negative impacts of climate change. Some cities, however, state that their main motivation is to take advantage of the opportunities arising from the need to act. In addition to incremental approaches they initiate profound changes, for example in dealing with stormwater or increasing heat. Transforming the city thus improves the quality of life (Box 5.22). Such plans for transformational adaptation are often based on a long-term vision for the future design of the city. It can motivate a broad range of city departments and stakeholders to engage. They would be less interested in adaptation if it were a standalone task that would lead to additional burdens and responsibilities.

Integration and collaboration are necessary not only among different departments and stakeholders in municipalities, but, for many climate risks, also at regional scale. A city may be able to address some problems, such as heat stress or local stormwater discharge, at the city level, but cannot solve others, such as river flooding, on its own. Hence, Dresden, on the River Elbe in Germany, is collaborating with the rest of the region in Germany and even across national borders to tackle the flooding challenges more effectively. This provides an example of how a wider region can collaborate to tackle challenges even at transnational levels (see Box 5.23).

([30]) http://climate-adapt.eea.europa.eu/viewaceitem?aceitem_id=8724.
([31]) www.klimzug.de/en/94.php.

Box 5.19 Developing integrated climate mitigation and adaptation plans in Schmallenberg, Germany, and Brno, Czech Republic

Population:
25 236 (Schmallenberg)/
377 440 (Brno)
Biogeographical region:
Central and eastern Europe

'In the city of Schmallenberg we started to think about the potential impacts of climate change already a few years ago. Our main concern has been to reduce negative impacts on the sectors which are key to our economy, such as forestry and tourism. We came to the conclusion that adaptation strategies should not be implemented in isolation, but rather developed in close interrelation with mitigation measures. An integrated approach is indeed what seems to suit our needs best. We have therefore developed an integrated climate mitigation and adaptation strategy that outlines diverse and efficient options for action', says Holger Entian from the city of Schmallenberg. He goes on:

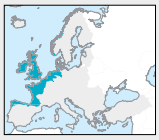
Source: City of Schmallenberg.

'By seeking to create synergies among climate mitigation and adaptation we aim to contribute to our overall goals of improving the living conditions of all our citizens, enhance the city's capacity to attract investments and develop in a sustainable way. The success of the initiatives that we implement strongly relies on the active involvement of a wide range of stakeholders. Therefore, our strategy includes actions of and cooperation between the administration, the private sector, research institutes and citizens. As climate mitigation and adaptation have been pursued partly separately from each other, we also decided to establish the position of a project manager for the integrated concept, who has been responsible for the coordination and implementation of the integrated concept.'

The UrbanAdapt project in the Czech Republic organised the first participator workshop in Brno in spring 2015. Local stakeholders perceived urban heat islands as the most pressing climate change problem the city would experience in the next few decades. The city is currently preparing its new Strategy for 2050, which is to replace the current Strategy for Brno. The new document will include the greater metropolitan area and emphasise a more holistic approach to strategic planning, taking into account the need to adapt to climate change impacts. Mr Holeček, a representative of the City Strategy Office in Brno, noted during the second participatory workshop in Brno, in winter 2015: 'In Brno, we have focused mostly on mitigation measures so far, which is also evident in the Strategy for Brno. However, with the continuing discussions on integration of adaptation measures, the city should respond at all levels — on the conceptual level as well as with concrete steps and local projects.'

Sources: http://www.schmallenberg.de/rathaus/leben-in-schmallenberg/klimaschutz/klimakonzept-der-stadt-schmallenberg.html; direct communication with Holger Entian, City of Schmallenberg, February 2016; UrbanAdapt Project press release 3 December 2015, http://urbanadapt.cz/en.

Box 5.20 Combining mitigation and adaptation in the Rouen Ecodistrict, France



Population: 488 706
Biogeographical region: North-western Europe

A consortium of public and private actors is collaborating on redeveloping an old industrial area close to the city centre of Rouen. They are creating an inner-city residential and commercial area. It integrates sustainable urban water management with efficient and sustainable energy generation. The plan should help avoid further urban sprawl and tackle impacts from climate change such as extreme precipitation and heat.

Photo: © Agence Devillers et Associés

The Rouen Ecodistrict Luciline is situated on the banks of the River Seine. The constant temperature of river water will be used for heating. Cooling vegetation in open spaces provides shade. Rainwater cools public areas where it is stored, and then runs into the river, avoiding flooding. The Luciline River used to run under the site but the development will uncover it. This will give room for biodiversity and attractive open spaces inside the district. Geothermal energy for heating and cooling will give the residential area a high standard of energy efficiency and sustainability. As well as reducing energy consumption, this provides an alternative to developing new areas on the periphery of the city. Developing the centre rather than expanding the urban area further creates potential benefits, such as better use of existing urban services and networks.

Source: ONERC, 2010.

Box 5.21 Integrating adaptation into existing instruments in Bologna, Italy

Population: 165 235
Biogeographical region: Mediterranean

'We started the BlueAp project (Bologna Local Urban Environment Adaptation Plan for a Resilient City) aiming at an Adaptation Plan to Climate Change for our municipality; this implied providing for some concrete local measures to test, in order to make the city more resilient and able to meet the climate change challenges. The realisation of measures foreseen in the Adaptation Plan will happen also through the review and adaptation of regulatory and planning instruments of the municipality. A first analysis suggests that we might need to modify the following instruments:

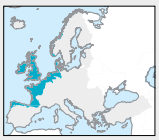
- civil protection plan
- guidelines for key infrastructures at risk
- bylaw for green areas
- bylaw for hydrogeologic protection areas
- urban planning instruments: structural plan (PSC), implementation or operative plan (POC), municipal building code.

'We also included adaptation measures in the city's building code (RUE). In this way, measures for adaptation and for a more efficient management of climate change effects will be explicitly foreseen for new buildings and reconstruction.'

Photo: © Lorenzoclick

Sources: http://www.blueap.eu; http://www.blueap.eu/site/wp-content/uploads/2013/09/BLUEAP_Strategia_adattamento_locale.pdf; interview with Giovanni Fini, City of Bologna, November 2015.

Box 5.22 Rotterdam in the Netherlands seizes adaptation as an opportunity to promote innovative city development



Population: 384 202
Biogeographical region: North-western Europe

'In 2042, Rotterdam will be an attractive city which offers high-quality living, working and mobility.' Alexandra van Huffelen, Vice Mayor for Sustainability, the City Centre and Public Space.

Rotterdam has water on all sides and around 90 % of the city is below sea level. Some areas are 5–6 m below sea level. Not surprisingly, the consequences of climate change, such as excess water and flooding, affect it greatly. In the longer run, it will also face rising sea levels and rising temperatures, which will affect increasing numbers of people. Adapting to climate change is therefore a necessity for Rotterdam. More importantly, it is an opportunity to make Rotterdam a more attractive city in which to live, work, relax and invest. For this purpose, and to tackle the situation for the benefit of its citizens, it has taken a series of innovative measures.

Photo: © Rick Ligthelm

In 2007, the city founded the Rotterdam Climate Initiative, a movement in which the government, companies, knowledge institutions and citizens collaborate to reduce carbon dioxide emissions by 50 % by 2025 and fully adapt to climate change by the same year, while stimulating the economy. To deal with the challenge of climate change as an opportunity rather than a threat, the city set up the Rotterdam Climate Proof programme and developed the Rotterdam Climate Adaptation Strategy. The city implements them proactively and can adjust to changing circumstances. Rotterdam has actively sought collaboration with various partners to become a leading centre for water knowledge and climate change expertise; enhance the attractiveness of the city and port for residents, companies and knowledge institutes; and develop and market adaptation innovation and knowledge as an export product.

A number of innovative measures have taken place in recent years. They include the building of facilities to absorb water, improvements to the city's drainage system and the creation of a 'water plaza' and floating buildings. Green infrastructure provides multiple benefits in urban areas, so one of the aims is to plant more trees and create more green areas in the city. Additional urban parks, green roofs and roof gardens are good for public health. They reduce stress and mask noise, save energy, store water, improve urban biodiversity, stimulate leisure and recreation activities, and can be used to produce healthy and sustainable food. To achieve all these, the city is promoting the construction of green roofs. It offers a subsidy scheme and puts green roofs on municipal buildings where possible.

Sources: http://www.iclei-europe.org/members/member-in-the-spotlight/archive/rotterdam; http://www.c40.org/case_studies/climate-proof-adaptation-strategy-2010; direct communication with Arnoud Molenaar and Corjan Gebraad, December 2015.

Box 5.23 A regional and transnational approach to address flooding in Dresden, Germany

Population: 530 754
Biogeographical region: Central and eastern Europe

'Global climate change is already having a real impact in the Dresden region. Today we already experience changes in average temperatures, rainfall and the frequency of extreme weather events. The Elbe valley and adjacent areas are the most strongly affected by climate change. In the past years, several severe flooding events have caused huge damage in our region and for our city. In 2002, more than 30 000 people had to leave their homes in various neighbourhoods throughout the city of Dresden (Kirchbach et al., 2002). The flood destroyed much of the (restoration) work that had been done throughout the country since German unification in 1990, damaging also some of the city's cultural landmarks, such as Dresden's Zwinger Palace, which is home to a significant collection of Europe's artistic treasures, or the Semper Opera House.

Photo: © querbeet

Dresden is only some 50 km away from the border with the Czech Republic; thus the river and flood management across the border upstream is of immediate importance for Dresden. Since 2002, we are therefore in close contact with Czech institutions involved in flood protection and forecasting. We also exchange experiences regarding flood prevention and the city of Dresden has been included in the Czech information network, which allows us to follow meteorological and hydrological developments across the border in real time and get better prepared in our city.

In 2013, Dresden again faced a severe flooding event. Though the damage caused by this event was large as well, the city was this time much better prepared, to a large extent also because of the increased level of information.'

Sources: Direct communication from Wolfgang Socher, City of Dresden, December 2015; Kirchbach et al., 2002.

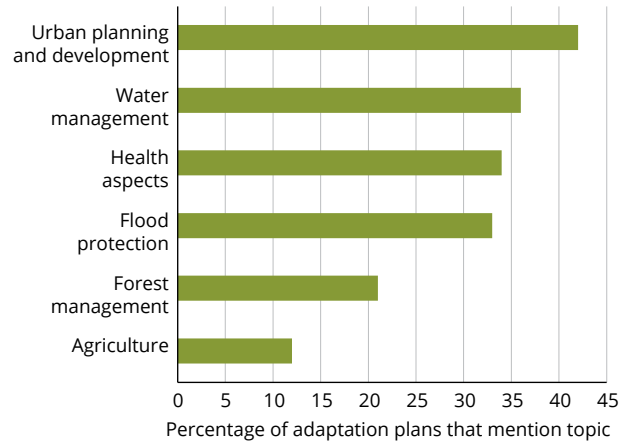
State of identifying, assessing and selecting adaptation options

Authorities are likely to select options for adaptation in the areas that strategies specifically identify. The content of existing adaptation strategies varies. Urban planning and development, water management, addressing flood risks and addressing heat-related health risks are usually the most prominent climate adaptation actions (Reckien et al., 2014a) (Figure 5.7). Other issues tend to receive less attention, such as reducing vulnerability to water scarcity, droughts, forest fires, and damage to external services and communication and transportation systems.

The adaptation actions most often in cities' strategies are, according to the EU Cities Adapt project (Ricardo-AEA, 2013):

- individual construction measures, for example flood barriers, improvement of the drainage system;
- promoting research projects to improve city staff's knowledge;
- specific risk management or heatwave plans or changes in certain (planning) standards;
- increasing public communication;
- strategic design and use of green and blue infrastructure (green spaces and water bodies).

Figure 5.7 Adaptation topics that cities address



Source: Reckien et al., 2014a.

Cities identify adaptation options mainly through literature review and databases, working with scientific experts or consultants. Sometimes they also have support from colleagues from other departments or authorities, through stakeholder involvement or by applying a combination of methods.

Usually, a planning document prioritises the identified adaptation actions. It uses various criteria to assess the suitability of possible options in terms of time, economic and social costs and benefits, and how these costs and benefits are spread over time and across society. Stakeholder feedback indicates that important criteria for choosing measures are how effectively they reduce vulnerability or enhance resilience. However, systemic monitoring to measure the contribution of adaptation efforts to these objectives has only recently begun (see Section 5.5).

Depending on their specific objectives, some cities also included wider aspects such as synergies or trade-offs with other urban policies such as water management, biodiversity or climate change mitigation. They also considered the wider impact of the adaptation measures on sustainability. They use windows of opportunity by integrating adaptation into regular maintenance, or upgrading infrastructure or planning documents. Vulnerability is not distributed evenly across society, and social and economic disadvantages often go along with higher levels of vulnerability (Lindley et al., 2011; Brisley et al., 2012; Wilson et al., 2014). Becoming aware of that, local policy and practice are beginning to recognise the importance of embedding social justice in adaptation. For example, in the United Kingdom the ClimateJust portal ([32]) collects and exchanges experience on social vulnerability (see the example of Newcastle in Box 5.24). However, so far the distribution of costs and benefits across society and aspects of equity and social justice have not received due consideration in the assessment of adaptation options (Brisley et al., 2012). Very few cities have assessed costs and benefits of different adaptation options in a systematic way (see also Section 5.4). Even if they have, decision-makers may have used other criteria to prioritise options (Breil et al., 2014).

> *Our politicians like green urban areas for adaptation as they make the city more attractive. They want an attractive and safe city.*
>
> Lykke Leonardsen, Head of Climate Unit, Copenhagen

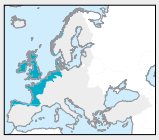
Overall, stakeholder feedback suggests that, to date, cities seldom assess adaptation options systematically. Many cities start with the easy jobs. They are mainly based on soft measures or are relatively easy and inexpensive to establish. Examples are heat management plans and integrating adaptation into spatial planning and communication. Afterwards they turn to more cost-intensive infrastructure measures. However, protecting, modifying and increasing green and blue infrastructures are popular measures to adapt cities (Box 5.25). They attract increasing attention because they have great potential to provide multiple benefits, such as recreation, beauty and biodiversity, which are immediately visible. Vegetation modifies the urban microclimate by providing cooling through shade and transpiration. It can prevent possible flooding by helping to reduce the amount of stormwater run-off (Box 5.27). Green and blue infrastructure is usually of low regret and reduces several risks, such as those from heatwaves or cloudbursts.

Cities often assign the development of adaptation action — strategies, plans and measures — to an internal sustainability, climate or adaptation team. This suggests it is important for city administrations to have enough staff to plan adaptation. However, it does not necessarily require city staff working specifically on adaptation. Cities can already integrate adaptation planning into existing structures at the strategy and planning stages. It can link to urban visions/strategies, local plans and municipal guidelines for designing streets and public spaces. Feedback from stakeholders in different projects suggests that the departments dealing with adaptation are most often the environmental, civil protection or planning departments. Some cities have more than 10 employees plus consultants working on adaptation planning, such as Copenhagen. Others have only one person who is responsible for adaptation, among other tasks. That is a potential problem for smaller cities; however, it may have the advantage of easier integration with other policy areas.

Local governments lead the process of planning, but experts or consultants can support it technically or mediate between different stakeholders. When cities involved external experts and consultants in planning adaptation, it was mainly as part of larger projects that provided external funding, such as EU Cities Adapt ([33]). Bigger cities often have an advantage because they host universities and other institutions that can support planning. Smaller authorities generally have more difficulty obtaining support in terms of expertise.

([32]) http://www.climatejust.org.uk.
([33]) DG Clima, EU Cities-ADAPT, http://climate-adapt.eea.europa.eu/viewaceitem?aceitem_id=8724.

Box 5.24 Social vulnerability to flooding in Newcastle upon Tyne, the United Kingdom



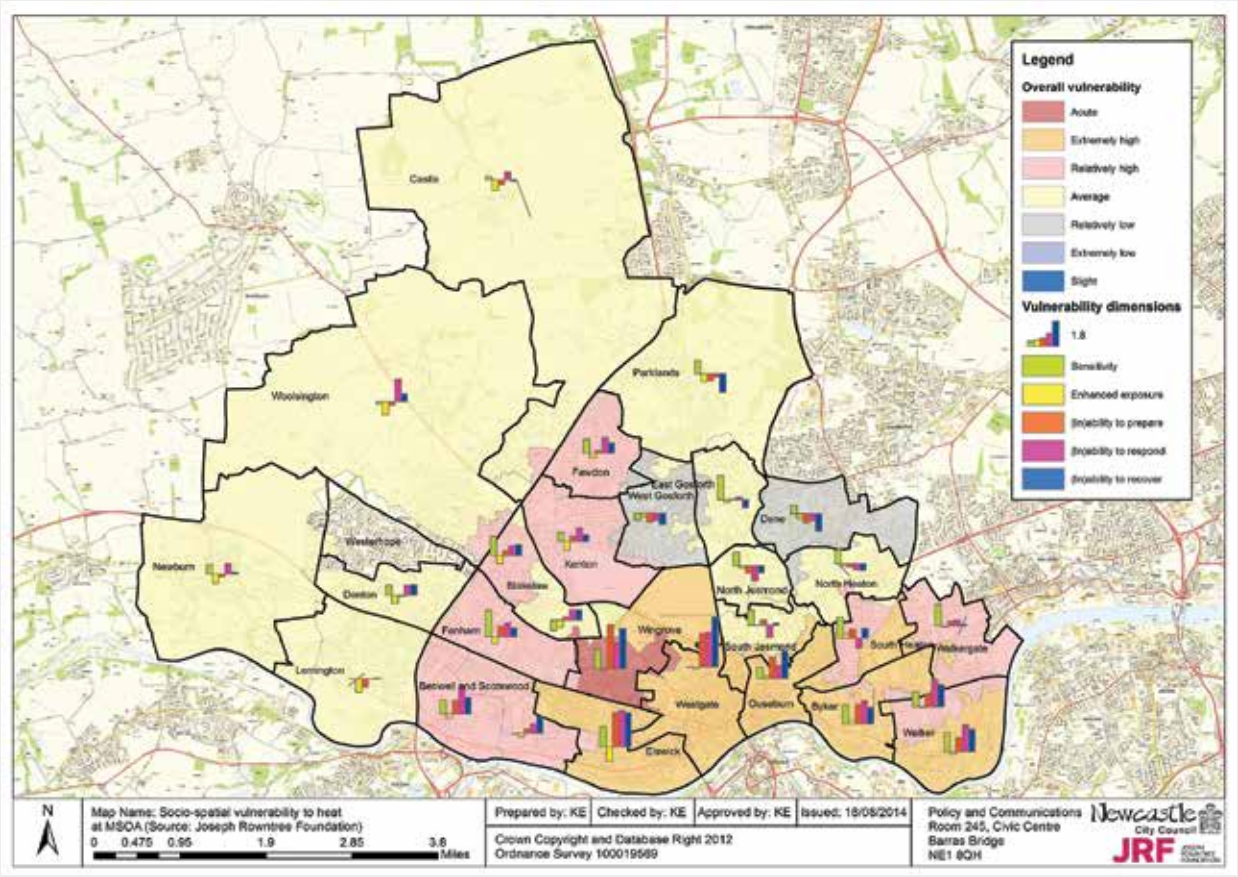
Population: 279 100
Biogeographical region: North-western Europe

In 2014, Newcastle worked with the Joseph Rowntree Foundation to trial ClimateJust. This is the foundation's new set of maps to help municipalities understand how socio-economic factors affect citizens' ability to prepare for, respond to and recover from extreme weather and climate change. Based around the IPCC's fourth assessment report framework on vulnerability, it shows how the vulnerability of communities to flooding and heat varies across Newcastle upon Tyne, accounting for factors such as age, income and access to insurance or green space. The city's evidence for service planning and delivery includes these factors.

Kit England, Policy and Communications Business Partner at Newcastle City Council, said 'the value of the maps is that they help us understand the differential impacts that climate change and extreme weather events could have on our residents and communities. The maps are at a fairly low geography, and highlight key differences which have implications for the way that we are developing adaptation approaches and responses. In some parts of the city, it might mean prioritising housing retrofit options to deal with heat issues for older people, whilst in others it may mean looking at providing alternative solutions to residents to help access insurance for those on low incomes. It also helps us better understand the kinds of demands on public services that we may see in future from extreme weather events if we do not implement effective adaptive responses'.

The key learning from this project is that adaptation responses must acknowledge that residents could experience profoundly different impacts from weather events and climate change as a result of their socio-economic situation. The council is now using the maps to inform its approach in a number of areas, including flood investment, community resilience and emergency planning, and public health.

Sources: Mayors Adapt city profile for Newcastle upon Tyne, http://mayors-adapt.eu/wp-content/uploads/2015/09/Newcastle-upon-Tyne.pdf; ClimateJust, www.climatejust.org.uk; direct communication from Kit England, Policy and Communications Business Partner, Newcastle City Council, March 2016.



Source: Newcastle City Council.

Box 5.25 Barcelona: trees temper the Mediterranean urban climate

Population: 1 615 448
Biogeographical region: Mediterranean

Photo: © Barcelona City Council

'Our city is one of the densest in Europe, which enables high resource efficiency but leaves little space for green urban areas. Despite this situation, we have over 200 000 trees lining the streets of Barcelona, which means approximately one tree for every 10 m of street in addition to the trees in parks and forest areas. This is more than in most other European cities and new trees are being planted every year. These trees help us to cool down our city, which faces already high temperatures, and heat waves and expects more heat and droughts in the future. Our Tree Master Plan foresees to plant more trees and improve their management', says Xavier Hernández from the Barcelona city administration.

The Barcelona Green Infrastructure and Biodiversity Plan 2020 (BGIBP) already include the management of street trees. It is an 'umbrella' strategic plan. It provides a model for an urban green network and a city where green elements are not ornamental accessories but rather genuine green infrastructures. The Trees Master Plan 2015–2035 will become the strategic document giving the city council guidance for future planning, management and conservation of the arboreal city. With the BGIBP and the Trees Master Plan, the city has the vision to create a well-managed, healthy and biodiverse city, with the trees as a real and integrated infrastructure connected to both the urban and the natural environment. The city will become more resilient and adapted to climate and global change, for the benefit of the people, who will appreciate its value.

Managing trees in a hot and dry climate is challenging. Climate projections predict even higher average temperatures and much less rainfall for Barcelona. Also, there is limited space in the ground for the roots. There is very little organic material and the soil is compact. Therefore, streets should provide scope for transforming individual tree pits into continuous pits. In the remaining areas with street trees, the city is to improve tree pit conditions. In response to water and heat stress, Barcelona increasingly uses run-off water, and it plants species that are more resilient to water and heat stress. Irrigation depends on their biology and where and when they are planted. Automatic systems provide irrigation and control leaks.

Sources: Climate-ADAPT, http://climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=5901.

Support from the regional, national and European authorities

Cities planning and implementing adaptation can benefit from the knowledge and funding that higher-level authorities and other stakeholders supply, as well as a supportive legislative and institutional framework, territorial governance and policy coherence (EEA, 2012b). The example of amphibious houses in Maasbommel in the Netherlands shows that ill-fitting legislation can hamper innovative adaptation approaches (Box 5.26). In recent years, policy support for local governments from regional, national and EU-level institutions has increased. Sections 5.1, 5.2, 5.4 and 5.5 describe that in detail and illustrate it with examples.

Box 5.26 Amphibious houses in Maasbommel, the Netherlands: a solution to scale up?

Population: 1 343
Biogeographical region: North-western Europe

The Netherlands has a long history of mitigating flood damage and adapting to flood risk as much as 60 % of the country is below sea level. Also, rivers pose a risk of flooding that climate change increases. In 1993 and 1995 two major river floods occurred as a result of exceptionally heavy rainfall in Belgium, France and the Netherlands. These two incidents led to a tightening of legislation and the implementation of a new government programme, Ruimte voor de Rivier (room for the river), in 1997. It included developing natural flood areas, which could store water temporarily if water levels rose. This had significant consequences for urban development, as building permanent constructions in these areas, for example in Maasbommel, was no longer allowed.

As a way out of this situation, Maasbommel became the first site with amphibious houses in 2005. This solution demonstrates a transformative approach to adaptation, in contrast to the conventional flood-resilient infrastructure. Amphibious houses are based on floating foundations. Four poles keep houses from drifting off while they move up and down with changing water levels.

Photo: © Factor Architecten b.v.

Although the technology of amphibious houses proved safe during a flood in 2011, there is only moderate take-up of this concept in the Netherlands. Amphibious houses are defined as 'water houses'. In 2012, the estimated total number in the Netherlands was a few hundred.

Maasbommel had both adequate technology and an interested developer. There were two main difficulties. Potential house owners were hesitant to build in areas that they considered dangerous. The building regulations did not cover amphibious houses, so people could not obtain building permits. When the developer and architect contacted the government to obtain permission to develop them, the authorities did not respond with immediate enthusiasm. The government had several concerns about the safety of the future residents. Defining the type of housing would have consequences for approving the permits. For example, it would affect the rights and duties of the future residents. This slow uptake is in contrast to an increasing shortage of building land in areas not at risk of flooding.

Sources: Climate-ADAPT; http://climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=6302.

Further resources

- ➔ *Urban adaptation to climate change in Europe* (EEA, 2012b): http://www.eea.europa.eu/publications/urban-adaptation-to-climate-change
- ➔ Urban Adaptation Support Tool: http://climate-adapt.eea.europa.eu/tools/urban-ast
- ➔ Climate-ADAPT/cities: http://climate-adapt.eea.europa.eu/cities

5.3.3 Towards establishing better planning for effective urban adaptation

As discussed above, experience in local adaptation planning has increased since 2012 and many cities across Europe have started their adaptation action. However, climate adaptation is still rather new on the agenda. Local authorities have a key role in delivering space-specific adaptation measures, but they are constrained by a range of factors. These include the boundaries between sectors that have their own objectives, internal working processes and timescales; limited expertise; and insufficient financial, technical and human resources (Carter et al., 2015).

Adaptation planning ranges from single measures, through mainstreaming potential action into other policies, up to comprehensive strategic planning. Still, the prevailing approach is to prioritise easy options: low-cost and soft measures; low-regret measures such as boosting green infrastructure; or well-known measures that are easy to establish. London is installing white panels on top of buses to reflect the rays of the summer sun and keep the vehicles cooler (Morales, 2014). Kassel has set up a 'heatwave telephone' for volunteers to call elderly people to warn them about health risks during a heatwave and suggest possible measures. Paris encourages solidarity networks in neighbourhoods, for neighbours to look after each other during heatwaves. These measures are certainly useful, and reduce the risk from current impacts of climate change. However, they are probably not enough for the expected impacts, especially in the long run. Still, options for transformational adaptation in particular have a vast potential to reduce that risk substantially (Revi et al., 2014).

Many cities that have started to plan and implement adaptation action are aiming to restore the current way of life after a disaster. They mostly use coping or incremental adaptation (see Section 3.1). So far, it appears that adaptation planning has considered either the current risk levels or a short to medium time horizon. The flood prevention approach of Vác, Hungary (Box 3.4) is typical of many other cities. It shows well the risks of strategies based on local and short-term solutions, which are not able to address the long-term character and root causes of the problem. Many causes of flooding and other climate impacts need to be addressed at a regional level, as Dresden, Germany, has tried (see Box 5.23).

To move beyond the short/medium term and a sector-bound approach, we need to look at potential consequences of scenarios with more than 2 °C global warming, long-term climate impacts and the uncertainties and cascading effects on services and other sectors. Copenhagen has started this process by checking its 2011 climate adaptation plan to identify what it needs to adjust. Many of the implemented and planned solutions (the cloudburst plan includes around 300 projects) look as if they will also be highly effective in more severe scenarios. Thus, they prepare the city for an uncertain future. This is also because the chosen approach combines coping, incremental adaptation and transformational adaptation (Box 5.33).

Few European cities' adaptation plans are highly systemic and integrated yet. The most frequently used measures are green infrastructures. They are integrative, as they also provide benefits beyond adaptation. Basel, Switzerland, has the largest area of green roofs per capita in the world. It increased them initially to save energy, and subsequently to conserve biodiversity and serve adaptation as well ([34]). Other options are less in use so far, such as the Covenant of Mayors' collection of Benchmarks of Excellence (see Chapter 4). Many current disaster risk management plans also deal only with current risks and underrepresent climate change (UNISDR, 2015). Stakeholder feedback, for example from the Open European Day Resilient Cities or projects such as RAMSES and RESIN, confirms that many cities still appear to have trouble integrating climate adaptation into environmental and socio-economic sectors.

Rotterdam, Copenhagen and the Emscher valley region (Boxes 5.22, 5.27 and 5.33) are leading examples of embracing change as an opportunity to increase the overall sustainability, quality of life and attractiveness of the city, foster innovation and thus create jobs. Copenhagen has already taken many steps and keeps appearing at or near the top of quality of life surveys. It exports its cloudburst solutions to cities such as New York.

Some urban areas in Europe are still expanding into low-lying and potentially flood-prone areas. They depend on technical infrastructures such as dikes, dams or pumps working properly. They are locked into this approach because it takes a lot of effort to change. Only exceptional cases use profound structural change, such as relocation, which is a very sensitive issue.

([34]) See, for instance, the green roof policy implemented in Basel, Switzerland: http://climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=5801.

Nevertheless, sometimes it is the most economically viable option (Section 5.4). Most examples are on a small scale, such as relocating five houses in Sanderum, close to Odense, to make way for rainwater basins (DANVA, 2009). Bigger relocation projects such as in Eferding, Austria (Box 5.29), or Röderau, Germany, which moved 86 residential buildings and some commercial buildings from a floodplain to higher areas (Thieken and DKKV, 2015), are exceptions. Building in safe places would help avoid such drastic measures, but constructors are still placing new buildings and infrastructure in flood-risk areas (Seifert, 2012).

Other options for risk-prone areas are innovative solutions and thus transformational approaches, such as amphibious infrastructures (Box 5.26), or flexible solutions, such as using green infrastructure to manage very different precipitation levels instead of enlarging the underground sewerage pipes (see Box 5.27). Such examples indicate that moving towards transformational adaptation does not necessarily require a radical departure from existing structures and mechanisms. From a more strategic perspective, cities could consider adaptation a core element of a progressive vision (Carter et al., 2015).

Box 5.27 Green and blue infrastructure as a transformational approach to deal with different water levels and heat in the Emscher valley, Germany

Population: around 2 200 000
Biogeographical region: North-western Europe

Over a century ago, the Emscher valley developed into an industrial conurbation as part of the German Ruhr area. This development turned the River Emscher into a man-made system of open waste waterways that quickly and completely drained all the area's wastewater and run-off. This resulted in extreme fluctuations in water levels during downpours, on one hand, and very dry and hot periods, on the other. Climate forecasts project more extreme weather in both directions.

To prepare for future climatic conditions, a traditional approach would use grey engineering solutions such as higher dikes and bigger sewers or the enhancement of pumping stations. However, the Emschergenossenschaft (water board) has decided to establish a new, more flexible, nature-based solution. It became feasible after the industrial decline of the area and the closure of the mines in the last decades of the 20th century. The water board, together with city administrations, regional development boards and all relevant stakeholders, developed a long-term strategy. It channels wastewater into closed sewers, and has revitalised the river and its tributaries to manage the run-off and strengthen the water cycle.

Photo: © Emschergenossenschaft

The starting point for this development was the attempt to revitalise the area after the decline of industry and to improve its environmental and recreational qualities. At the same time, the green infrastructure helps adapt to floods, dry spells and heat. The river, returned to its natural condition, retains floodwater and supplies the denser urban areas with fresh air. The continuous green spaces along the river have cycle paths and recreational facilities. These contribute to transforming the image of the region.

The integrated, long-term concept triggered different single projects that form part of this system. For example, a new residential estate in Gelsenkirchen combines sustainable stormwater management with architecture and design. The main feature of the green public space is an infiltration trench that takes the stormwater from 80 % of the buildings in the 7.5-ha area. A regional zoo, landscaped to resemble an African lake and surrounding wetlands, serves as a retention basin with a volume of 165 000 m³ for the nearby watercourse connected to the Emscher.

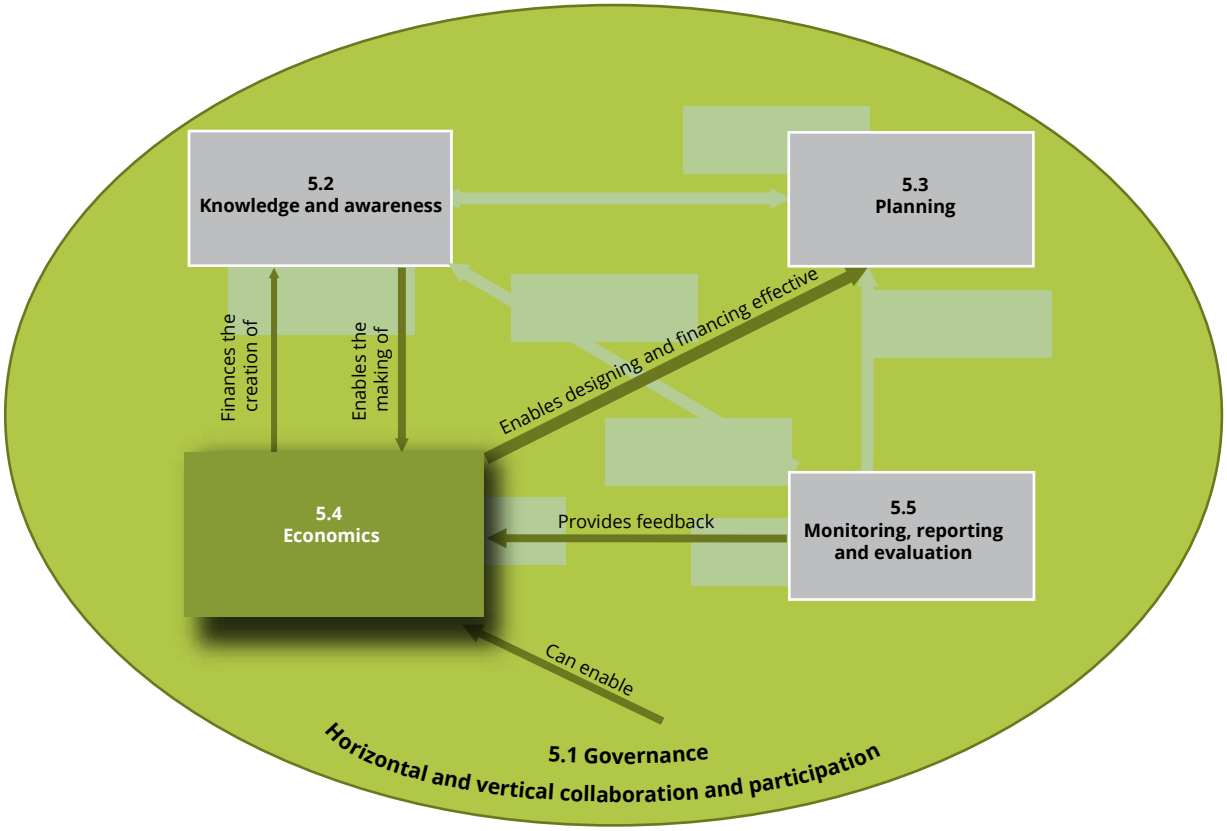
Sources: Climate-ADAPT, http://climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=6201.

5.4 Economics of urban adaptation

Key messages

- An economic case for adaptation can improve decision-making and reduce the risk of spending too much. It evaluates different options and approaches — coping, incremental or transformational — to identify which makes most economic sense.
- In practice, cities have not yet widely developed economic cases. Selecting the right scope and finding the necessary data for the analysis are still challenging. Not all aspects are quantifiable.
- Neither do cities use economic cases widely as decision criteria. They often use other criteria, such as short-term benefits, available funding and easy implementation: the low-hanging fruits.
- Currently, the economic focus is primarily on financing adaptation measures, and especially on funding opportunities. Few cities yet include adaptation as a standard part of municipal budgets or have developed new, innovative financing schemes.

Figure 5.8 The economic case for adaptation and how it relates to other topics



5.4.1 Adaptation economics for decision-making

Urban decision-makers frequently discuss the economics of adaptation in terms of finding enough resources or funding for investments in adaptation measures. However, the economic case is broader than the question of funding. It is useful for decision-making because it provides insights into the economic consequences of different possible adaptation measures and approaches before cities select a financing scheme. The critical question is whether or not investing in projects to adapt to climate change is economically efficient. That means estimating if the benefits that adaptation measures will generate for society will outweigh their implementation and opportunity costs (Rosenzweig et al., 2015). Economic analysis gives information about costs and benefits of adaptation plans and options, so it is one useful basis for making decisions about adaptation measures and financing them (UNFCCC, 2011). It is particularly important where financial needs compete with each other. Adaptation economics form one important element in decision-making by delivering a baseline for evidence-based decision-making and creating awareness of the financial consequences of a decision. However, some benefits of adaptation do not have monetary values (ECONADAPT, 2015). Decision-making needs to include non-monetary criteria too, such as health, well-being, equity, urgency and conservation of natural resources.

Establishing an economic case needs sufficient information from monitoring (ADEME, 2013) as well as political willingness for action. The governance framework and, in particular, national and EU policies influence the economic case by providing intentional or unintentional economic incentives (positive as well as negative ones), financing mechanisms and funding.

Consequently, planners and decision-makers at local and regional levels need the economic case to analyse different adaptation approaches and options and finally to decide which action to implement (Figure 5.8). They need to be aware of the economic implications of their selection. National governments and the EU need to be aware which options and directions make economic sense and use legislation, awareness, incentives and finance to support them. They can also be a strong stimulus for transformational adaptation. Individual investors such as homeowners or owners of commercial buildings, when deciding between investment options, may find it useful to have economic assessments of the long-term costs and benefits of investments in their premises (e.g. green roofs).

Developing and using the economic case for urban adaptation, however, faces different challenges:

- It is harder to develop a good economic case if knowledge of climate impact costs at local scale is scarce and the cost-effectiveness of various adaptation options under a systemic perspective is difficult to assess; if one does not know how to evaluate financial and non-monetary assets and draw up accounts consistently to compare the options better; and if one lacks knowledge about how economic instruments in the private and public sectors influence the behaviour of businesses and individuals. It also needs sufficient staff or expert capacities to put these methodologies into practice and build the economic cases for different adaptation options.

- It is not possible to put money values on all benefits and joint benefits of adaptation measures, such as saved lives or the value of a park for recreation or biodiversity (ECONADAPT, 2015).

- Needing to solve a certain problem urgently, for example after an extreme event, can force decision-makers to act with measures that, from a broader perspective, are less economically sound.

- The local impacts of climate change, as well as of socio-economic changes such as population movement or urban sprawl, are uncertain and time horizons are long. That makes it difficult to evaluate what damage will happen or one will avoid (Hallegatte et al., 2008). On the one hand, the cost of adapting after a future event is uncertain because the impact of the event is unknown. It is mostly the cost of restoring the status quo and lessening vulnerability. On the other hand, the cost of adapting after a change is difficult to estimate because the impacts of climate change in urban areas are uncertain. In other words, decisions and economic investments assume how a city and the climate might develop over the next 50 to 100 years, although climate change will continue beyond then and most cities are expected to function after 2100.

- The cost or burdens and the benefits of an adaptation solution may not be distributed equally. Some may bear the costs and others may have the benefits (UNFCCC, 2011). A provider of public transport services might conclude that it is more efficient to cope with interruptions during and after an extreme event than to adapt in advance, even if that takes down the service temporarily. Landowners benefit most from flood protection, but damage from storm surges and cloudbursts go much further than a single property and spread across the whole city and the wider territory. From a wider socio-economic perspective, the economic benefit of a well-functioning city or territory needs

to take into account knock-on effects too, so that proactive adaptation becomes economically viable. Thus, the chosen scope of the economic assessment can lead to different conclusions, including about the distribution of costs and burdens between public and private sectors and across governance levels (Section 5.1).

- In this context it is important to take an integrative, systemic and long-term perspective. It needs ideally to include all related costs, including in the social and economic area, and knock-on effects. Broadening the issues (from adaptation to sustainable development, from neighbourhood to wider areas) may make the situation more complex but also offers more opportunities for a more attractive economic case. For instance, rather than expanding the underground sewerage system, stormwater drainage capacity can increase by using open canals, lakes, green infrastructure, etc. Considering that such structures have different functions — serving as recreational areas, helping cool the city and increasing biodiversity — they provide more benefits than just avoiding flood damage. Swart et al. (2014) analysed 100 Dutch spatial/water projects and clearly showed that focusing on more objectives than only defence against rising water levels reduces the risk of poor investments or maladaptation.

The economic case can also help broaden the perspective beyond business as usual, if it adopts long enough timeframes and a broad enough perspective on costs and benefits. As Section 3.1 describes, different approaches — coping, incremental and transformational — offer different ranges of benefits. Each of them can be economically viable, depending on the nature of the impacts and vulnerabilities. Coping by repairing after each event might cost a lot but can be economically reasonable if events are unlikely or when used in combination with the other approaches. Incremental adaptation can be very effective and easy to establish, but can limit future options and/or be expensive to maintain. It can also lock cities into unsustainable and expensive pathways in the long term. Transformational adaptation that changes the way cities develop and function can take more effort at the beginning but usually leads to much lower maintenance costs in the long run (see Section 3.1) and can provide greater additional benefits. If cities explore these options and start to implement them now, for example by changing spatial plans to avoid building or rebuilding in risk-prone areas or they include the necessary changes in regular maintenance or upgrading of infrastructure it may cost less than if they act later. Then, low-cost options might no longer be available or the city might be locked in to an outdated solution. A sensitive economic case would, therefore, analyse all three approaches and possible combinations. It can help identify low-regret solutions, or solutions with more side benefits than just avoiding uncertain damage from future climate impacts.

5.4.2 Current state of using economics in urban adaptation

Economic issues are among the biggest challenges facing urban adaptation, as it sometimes requires large investments. Yet decision-makers use adaptation economics less than financing for adaptation measures, as 'decision makers often follow different arguments, like immediately visible benefits of a measure that fits into their political agenda rather than long term economic viability' (Breil et al., 2014, p. 5).

Using the economic case for decision-making

In recent years several tools and methods to assess the damage of a catastrophic event and to assess different adaptation options have come into play. The UNFCCC (2002) has identified three main techniques to apply in the economic assessment of climate change adaptation options:

- Cost–benefit analysis can help predict if the benefit from an adaptation measure or a comprehensive strategy can outweigh the cost. It can provide a criterion for ranking alternatives. One can use it where one can quantify all costs and benefits in monetary terms. It should possibly also include calculation of cash flows to be more realistic. The limits of the approach and one reason for not employing it so frequently is that it is not good at qualitative values (Breil et al., 2014).

- Cost-effectiveness analysis is useful when one of the criteria for decision-making can have no monetary value. It compares options on the basis of the question 'which option obtains the desired outcome at the lowest cost?' It is easier to compute but requires precise information on how each option contributes to the objective and about potential desired or undesired side effects.

- Multicriteria analysis is the best choice if several factors have values that are impossible to translate into money, for instance equity, justice or, as a local representative put it in a meeting on urban adaptation, 'the value of hearing a bird singing' (Breil et al., 2014, p. 5). In these cases, one can assess options using a set of criteria to score their performance against different objectives (ensure social justice, enhance biodiversity, protect rare species and cultural values, etc.).

A more comprehensive list of tools and guidance for choosing the appropriate assessment strategy is in the Urban Adaptation Support Tool on the Climate-ADAPT website ([35]), and on the MEDIATION platform ([36]).

> *Decision-makers often follow different arguments, like immediate visible benefits of a measure that fits into their political agenda rather than long-term economic viability.*
>
> A participant in the Open European Day Resilient Cities 2014

These tools are often very complex to use and require good data sets to deliver credible results. Further, when talking to city representatives in the context of the European Open Day Resilient Cities 2014, it became clear that cost–benefit analyses are quite controversial. While all participants recognised the need to consider economic criteria for prioritising and monitoring adaptation measures, some raised doubts about the possibility of quantifying non-monetary benefits, such as behavioural changes or ecosystem services. Furthermore, they considered it very difficult to quantify and monetise damage precisely, beyond flooding or heatwaves (Breil et al., 2014). Critics of the cost–benefit approach also argue that discounting poses problems for equity between generations because it underestimates the costs to future generations. In reality, decision-makers also use other decision criteria such as social issues, short-term economic considerations and achieving short-term results. That sometimes leads to less sound economic decisions (Breil et al., 2014), and favours a focus on finding external funding sources for adaptation measures that are more visible.

In general, cities have made little progress on using economics in adaptation. It remains a big challenge for most cities, according to the information from Mayors Adapt/Covenant of Mayors for Climate and Energy. Nevertheless, economic considerations in decision-making can add value, as the following case study on Hamburg (Box 5.28) shows, even if the outcomes are not always clear cut.

Box 5.28 Using cost–benefit analysis to assess green roofs in Hamburg, Germany

Population: 1 746 342
Biogeographical region: North-western Europe

It is mostly private homeowners that need to pay for green roofs, so the cost–benefit analysis of this investment is particularly important. The city of Hamburg has decided to subsidise private investments in green roofs after analysing costs and benefits from the point of view of private investors.

Visualisation: © TH Treibhaus Landschaftsarchitektur, photo: Matthias Friedel

Senator Jens Kerstan explains: 'Considering a lifetime of 40 years, according to this study, the slightly higher initial costs of green roofs with respect to traditional roofs pay off and bring enormous benefits for the city. They allow the abating of maintenance costs and reduction of duties to the sewerage system and they are a good answer to climate change as they can improve the microclimate and enhance rainwater retention. In a growing metropolis, green roofs are also a centrepiece to maintain the quality of life. Considering the high co-benefits beside climate-related aspects from green roofs, Hamburg decided to take forward this measure and create a positive incentive for private owners.'

The city estimates that the cost of adapting the urban sewage system will be in the tens of billions of EUR. It expects the retention capacity green roofs provide will contribute to reducing the need for investment in future rainwater drainage. Since mid-2015, private owners who decide to install a green roof between 20 and 100 square metres in size have received a one-off grant of 40 % of the cost of the roof planting. They do not have to pay it back. Further subsidies are possible. For bigger rooftops and commercial owners, there is extra funding for each additional measure. Furthermore, the scheme reduces sewerage charges by 50 %, recognising the contribution green roofs make to urban run-off. Also thanks to these measures, the city plans to increase the area of green roofs to 100 hectares by 2020.

Sources: http://www.hamburg-news.hamburg/en/cluster/renewable-energy/hamburg-supports-green-roofs; Müller, 2015; Ansel, 2011; direct communication with Hanna Bornholdt, city of Hamburg, January 2016.

([35]) http://climate-adapt.eea.europa.eu/tools/urban-ast/step-4-0.
([36]) http://www.mediation-project.eu/platform.

Box 5.29 Transformational adaptation makes economic sense: relocating houses in the Eferdinger Becken, Austria

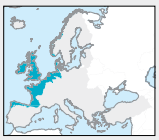
Biogeographical region: Central and eastern Europe

Photo: © Landespolizeidirektion OÖ

The region of the Eferdinger Becken, Upper Austria, lies on the Danube. It has no protection against floods with a 100-year probability and no projects are planned. The flood-prone area covers 24 hectares. About 130 houses there flood regularly. Expert judgements on the costs and benefits suggest that relocating these houses is cheaper than designing and implementing flood protection. Homeowners needed to decide by the end of 2015. The federal and the regional government compensate citizens for 80 % of the value of the house if they move. Currently 29 homeowners have decided to move.

Sources: http://derstandard.at/2000011527317/Eferdinger-Becken-Hochwasseropfer-stimmen-Absiedlung-zu; http://www.startclim.at/startclim2015.

Box 5.30 Moving from business as usual towards innovative solutions: Dawlish railway line, the United Kingdom



Population: 11 312
Biogeographical region: North-western Europe

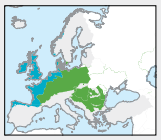
The British railway connecting Cornwall and the west of Devon with the centre of the United Kingdom runs along a sea cliff. At Dawlish, a sea wall protects both the railway and the town. The railway line is very vulnerable to coastal storms. Heavy storms have already damaged it several times. It is evident that rising sea levels and storm surges will increase the erosion problems on this part of the coastline. The most damaging event happened in February 2014, when the seawall broke during a winter storm. The railway was closed for two months of repair works, cutting off the railway connection to Cornwall, and nearby houses had to be evacuated. Until this, consideration of alternative, more cost-effective options had not led to action, essentially because the operator of the railway line had no mandate to modify the rail network in the name of climate change adaptation. Estimates of the economic consequences for the region are very high (in the millions of pounds), because of the knock-on effects of tourists and commuters being unable to travel for two months.

Photo: © Roos M. den Uyl

After that event, public debate triggered the discussion of alternative solutions. The institution responsible for the railway line (Network Rail) developed alternative solutions that would allow it to reroute the railway line away from this vulnerable tract of coast. That economically more sound solution might leave the area of Dawlish with less protection, as there would be less incentive to maintain the Dawlish sea wall. Currently Network Rail manages the wall as part of the railway network. Consequently, the residential area would require new protection measures.

Sources: BASE project case study, http://base-adaptation.eu/united-kingdom-what-do-south-devon-coast; direct communication with Roos M. Den Uyl, Exeter University, February 2016.

Box 5.31 Different framing leads to different economic perceptions: financing coastal protection in the Netherlands and in Denmark



Biogeographical region: North-western/ Central eastern Europe

Different strategies have been adopted for distributing the costs of adaptation measures to protect coasts. Some countries, such as the Netherlands, consider that coastal protection provides benefits for society as a whole and finance these measures as national infrastructure. Other countries, such as Denmark, see coastal protection measures as providing benefits mainly to private landowners, and request private individuals to contribute to the cost of coastal protection measures.

Photo: © Jørgen Madsen, Danish Board of Technology Foundation

Large parts of the Netherlands, and especially the economically most vital areas, are already below sea level. Therefore, the country considers coastal protection a national challenge and distributes the cost of coastal protection across the whole society. In particular, the Delta programme is changing the system of flood risk management. According to the estimates, meeting the new standards of the flood protection programme will cost approximately EUR 15 billion (Delta Programme Commissioner, 2014).

In Denmark, coastal authorities organise coastal protection. They rely on the municipalities to coordinate and collect the contributions from landowners who benefit directly from the protection measures. Municipal authorities may request contributions from landowners who benefit indirectly and are not situated in flood-prone areas. National support has begun only recently: a fund provides support for victims of damage from storm surges. In some cases, local coastal authorities can authorise landowners to implement their own coastal protection measures. Sea levels keep rising and the climate adaptation plan requires very expensive measures. For example, securing Copenhagen against a sea-level rise of 2.55 m, which corresponds to a 70-years-return storm surge under a sea-level rise scenario in 2110, would cost about EUR 308 million. In this context, there has been considerable debate on how to maintain or adapt this system. Integrated measures for coastal protection would have provided extra benefits by improving the landscape (broader beaches) but the authorities could not implement them, as private land owners refused to contribute.

Sources: http://base-adaptation.eu/adaptation-storm-surges-denmark-who-pays; http://english.deltacommissaris.nl/delta-programme/documents/publications/2014/09/16/delta-programme-2015; City of Copenhagen, 2011.

Authorities make even less use of economic cases to decide between incremental and transformational adaptation approaches. There have been only a few instances. An example of a drastic transformational adaptation measure is the relocation of buildings from flood-prone areas. A cost–benefit analysis has led Austrian authorities, to do this in the basin of Eferdingen (Box 5.29). Copenhagen (Box 5.33) provides another example of cost–benefit analysis for a long-term and systemic approach.

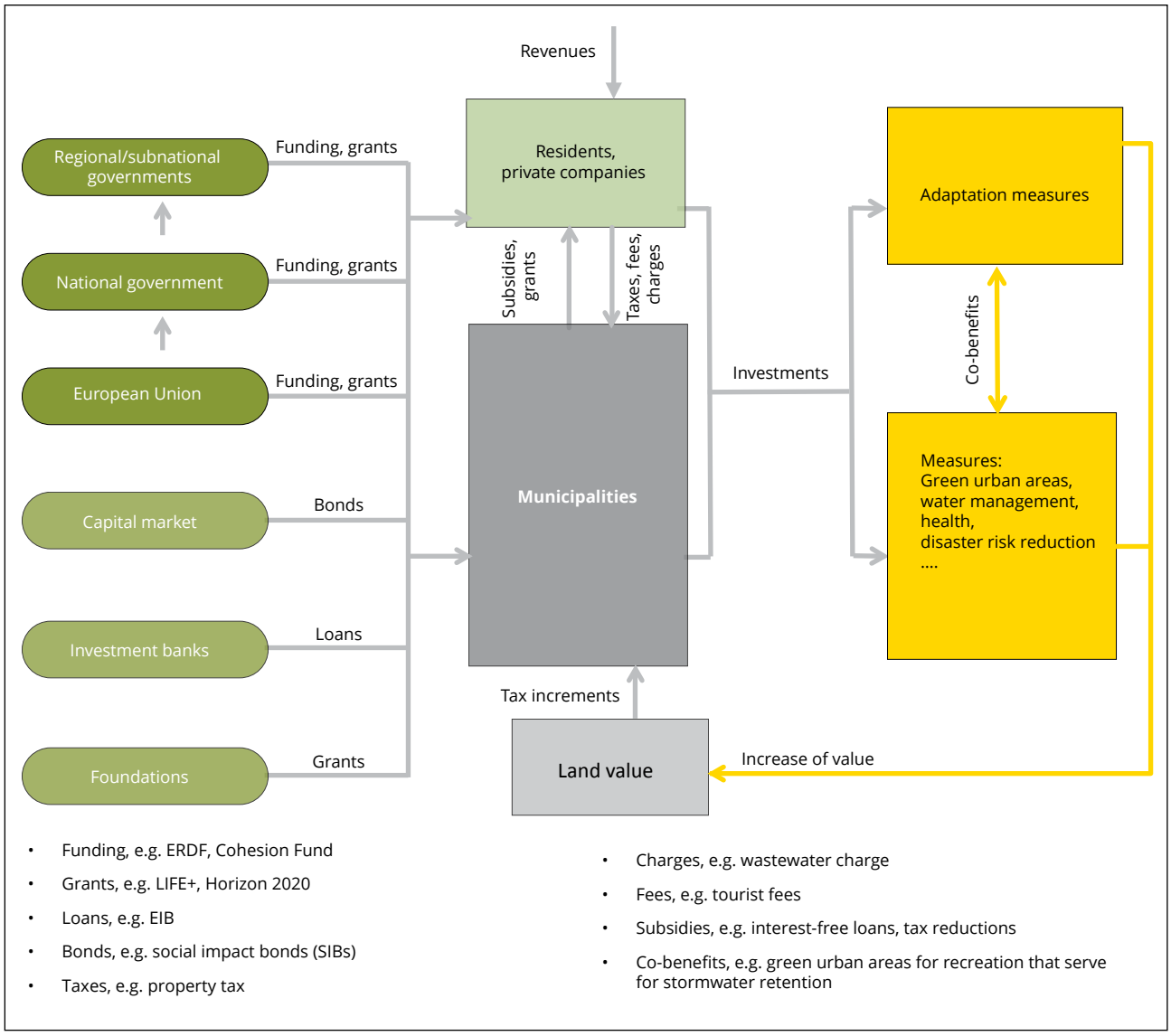
As mentioned above, often decision-makers do not use cost–benefit considerations or they choose a narrow temporal or social scope. The example of the South Devon railway line in the United Kingdom (Box 5.30) and the issue of coastal protection (Box 5.31) show that people see protection from storm surges as a benefit only for individual owners of buildings.

Financing urban adaptation measures

Funding for local adaptation measures is available through several EU funding instruments, national, regional and local funds, international financing institutions and private donor organisations (The World Bank, 2011). Moreover, other sectoral funding mechanisms or budgets from other policy areas, such as water management, biodiversity or health, offer funding relevant to urban adaptation. They may not necessarily label it as 'funding for adaptation'; however, such funds may still contribute to adaptation policy aims.

Figure 5.9 shows how financing from the public sector can also facilitate private sector action and how one can use it to generate investment by the private sector.

Figure 5.9 Opportunities for financing climate change adaptation in municipalities



Notes: EIB, European Investment Bank; ERDF, European Rural Development Fund.

Source: EEA, adapted from Rosenzweig et al., 2015.

The municipal budget and finance system consists of the actors and institutions responsible for decisions regarding tax revenues and public expenditures at the local level, including financial transfers from higher levels of government and new forms of public–private partnership (PPP). The city of Gothenburg, for instance, has decided to collect private resources by issuing green bonds, providing investors with transparent information about the use of their money ([37]). Integrating adaptation concerns into revenue mechanisms can make new resources available for adaptation. For example, one could use water charges not only for maintenance but also for enhancing network capacities to adapt to the challenges of climate change. So can including adaptation in budgets for measures in other policy areas (e.g. health, nature) Beyond creative solutions such as this, the type of financial mechanism and how donors or local governments earmark funds can influence the range of policy choices available for adaptation. For instance, if local finance relies heavily on property taxes that may encourage local governments to make investments

([37]) http://www.covenantofmayors.eu/about/signatories_en.html?city_id=312&benchmarks=586.

that increase the value of local property. So the mix of existing financing mechanisms (e.g. local taxes and charges) and their earmarking constrains the scope of local government action on adaptation.

The picture that emerges from many stakeholder events, such as the EU RAMSES and RESIN projects or the Open European Day Resilient Cities, is that hardly any municipality has a specific climate change adaptation budget. If measures do not have external funding, they are mainstreamed into other policy areas. For example, Copenhagen finances all water-related adaptation measures, including green infrastructure for water retention or natural drainage, using water charges and in cooperation with the water utility company, HOFOR (Box 5.33). Basel, Switzerland, has put 5 % of all customers' energy bills in the Basel canton into an Energy Saving Fund. It is used for energy-saving measures such as extending the area of green roofs, which also help to conserve biodiversity and adapt to climate change (EEA, 2016b).

First, one can develop integrated adaptation options. Then, as a second step, one can identify potential sources of funding that fit the purpose, from multiple sectors. That offers the opportunity to choose adaptation options independently from earmarked funding and allows the pooling of funds from different sources. However, this approach might be more challenging than mainstreaming adaptation into the existing budget. In other words, the better existing budgets incorporate climate change as standard, the more likely they are to finance adaptation measures, even if they might consider adaptation only as a co-benefit. To ensure mainstreaming, the relevant financing departments need to discuss the results from the vulnerability assessments with the planning departments. In the short run, this will allow them to pay for incremental and transformational adaptation measures.

Cities finance most adaptation planning, at least initially, by external funding in the form of research projects or specific support programmes. A variety of support exists at national and European levels (see Section 5.2).

The Multiannual Financial Framework 2014–2020 of the EU ensures that at least 20 % of the EU's budget is climate-related expenditure. European funds such as LIFE+ or the European Structural and Investment Funds (ESIF) offer ample opportunities for supporting interventions in urban areas. For example, the Cohesion Policy funds (ERDF, Cohesion Fund and European Social Fund, as part of ESIF) provide more than EUR 56 billion for actions related to climate change (EC — Regional Policy, 2016a). This includes EUR 8 billion for climate change adaptation and risk prevention. About EUR 15 billion of the ERDF is specifically for sustainable urban development, for cities to manage directly (EC European Structural and Investment Funds, n.d.). Although climate change adaptation is not a major focus in this, the support for green infrastructure might be considerable, as a major emphasis is on urban rejuvenation and brown field regeneration. LIFE+ aims to catalyse changes in developing and implementing environmental policy by providing and disseminating solutions and best practices to achieve environmental and climate goals, and by promoting innovative environmental and climate change technologies. The LIFE+ Multiannual Work Programme 2014–2017 sets out the priorities for implementation in the first four years, with a budget of EUR 449 million. EUR 190 million from the LIFE+ budget could be spent on adaptation action across the EU in 2014–2020 (EC Environment, 2016).

Other European institutions, such as the European Investment Bank and its JESSICA programme, offer additional funding opportunities. Under Step 1.4 of UAST ([38]), one can find a list of EU-level potential funding mechanisms relevant to the urban environment.

Specific national financing and research programmes mainly target knowledge generation and capacity building at local level, promoting pilot actions in selected cities. This is crucially important. Besides favouring knowledge exchange, these initiatives contribute to the development of new and integrated approaches. Breil and Swart (2015) give a broader overview of the many national-level funding activities. Box 5.32 presents a few examples.

([38]) http://climate-adapt.eea.europa.eu/tools/urban-ast/step-1-4.

Box 5.32 Examples of national activities to provide financial support for urban adaptation

The **German** Ministry of Education and Research has initiated and financed a series of regionally focused projects for climate change adaptation, called KLIMZUG. It aims to enhance knowledge and capacities for the 'development of innovative strategies for adaptation to climate change'. In addition, the same institution has financed a sector-oriented research project on climate change adaptation under the KFM/Klimazwei programme. It focuses on, inter alia, climate effects in the metropolitan areas of Hannover–Braunschweig–Göttingen–Wolfsburg and the region of Starkenburg, Lower Saxony.

The Ministry of Environment and Building has financed adaptation action with a focus on urban areas, namely programmes called ExWoSt and KlimaMoro. Both programmes foster climate change-proof urban development. They develop ideas for cities to counteract the causes and impact of climate change, and aim to produce new evidence for fresh conceptual approaches.

The **Netherlands** has set up a specific capacity-building and mainstreaming programme. It aims to engage regional and local policymakers, institutes and businesses in promoting climate-proof and water-resilient cities for 2020. It provides funding for participants to implement programmes (Breil and Swart, 2015). Furthermore, the Watergraafsmeer project, which ended in 2014, took an integrated and participative approach to designing a way for an urban settlement to adapt to climate change. The Spatial Adaptation Knowledge Portal showcases examples of good practice.

The **Norwegian** government has financed a collaborative project with the 13 largest cities in Norway called Cities of the Future (*Framtidens byer*). It aims to reduce GHG emissions and adapt to a changing climate. The project ran from 2008 to 2014. The 13 cities were Oslo, Bærum, Drammen, Sarpsborg, Fredrikstad, Porsgrunn, Skien, Kristiansand, Sandnes, Stavanger, Bergen, Trondheim and Tromsø. Cities of the Future was an important driving force for climate change adaptation in Norway. The cities' work has helped to speed up the planning process in other municipalities.

Sources: Breil and Swart, 2015; http://www.klimzug.de/en/160.php; http://www.klimafolgenmanagement.de/?pgid=119; www.klimaexwost.de; www.klimamoro.de. https://www.regjeringen.no/globalassets/upload/subnettsteder/framtidens_byer/samlinger/london2010/fbclimatadaption131210.pdf.

Further resources

➔ **MEDIATION platform: http://mediation-project.eu/platform**

➔ **Urban Adaptation Support Tool, Step 1.4 and Step 4: http://climate-adapt.eea.europa.eu/tools/urban-ast**

➔ **EU Adaptation Funding on Climate-ADAPT: http://climate-adapt.eea.europa.eu/eu-adaptation-policy/funding**

➔ **ECONADAPT project: http://econadapt.eu**

5.4.3 Towards making better economic cases as the basis for effective urban adaptation

A couple of cities have started to explore the economic case for adaptation, on their own or with the support of external experts. Experience is still scarce and fragmented. The use of that information in practical planning and decision-making about adaptation seems to be even more limited. Project financing by national or EU sources, such as LIFE+ or the cohesion policy (in particular Interreg), where cities participated in projects, has had the most impact so far and has been important on preparing plans and strategies, as Bologna, Bratislava and Ancona have demonstrated. Some cities have, however, already started to implement adaptation measures and use locally available budgets, often from other policy areas.

> *We need to prioritise. If we can get money from the ERDF we would prefer rather other areas such as climate change mitigation or transport to be funded*.
>
> Stakeholder from a city administration at the Green Cities workshop of DG REGIO, 22 September 2015

According to information from Mayors Adapt/ Covenant of Mayors for Climate and Energy, cities see the following as the main challenges related to the economic case for adaptation:

- The lack of knowledge about economic assessment methods and tools. This refers in particular to assessing the cost of direct and indirect damage, but also to methods such as cost–benefit assessments that support decision-making. Even if they apply such tools, the financial and non-financial benefits of adaptation measures often play only a minor role in overall decision-making processes, as these investments normally have long pay-back times well beyond political mandates.
- The lack of qualified staff. Several cities do not have environmental or resource economists in their administration or in the department that leads adaptation. They lack the budgets to close this gap even by using consultants.
- Insufficient or incomplete information about national or European adaptation funding schemes.
- The lack of examples of good practice to learn from.
- Restrictive legislation (e.g. existing labour rules might limit the ability to adjust working hours to cooler hours of the day or cooler days).
- The lack of awareness.
- The lack of action on adaptation.

Cities do not yet use adaptation economics enough to support adequate and ambitious urban adaptation that also considers transformational approaches. Cities would have to start considering economics more broadly and deeply, seeing adaptation as a systemic challenge involving other environmental areas, social and economic concerns, and knock-on effects, as well as taking a long-term perspective. Action to support local authorities should not just provide information on how to finance adaptation measures. It should also cover how to determine the economic sustainability of different approaches to adaptation (incremental or transformational) and of single adaptation measures. This also needs to be part of the mainstream thinking of all relevant departments of a city administration.

A more transformational adaptation approach in cities will require more than just mainstreaming adaptation activities. Transformational adaptation needs strong local leadership to start it. Sustaining it probably requires supportive social contexts and acceptable options and resources for action (Kates et al., 2012).

An important element for preparing the ground for local transformative action would be to improve knowledge of what long-term adaptation to climate change requires (see Section 5.2). Another would be to provide sufficient staff for planning adaptation action and mainstreaming it into local planning and policy activities. Sufficiently informed staff would potentially also enable local authorities to explore opportunities that existing national and European funding schemes offer.

Creating resources for action will require redesigning the financial mechanisms at regional, national and EU levels. They must provide positive incentives to change behaviour, and take into account social costs and benefits of individual behaviours and investment decisions (e.g. introducing grants for establishing new green areas or roofs as in Hamburg (Box 5.28). That will share the burden of financing adaptation to climate change (Box 5.31). Badly designed sources of finance may hinder transformative adaptation by focusing too much on the status quo instead of triggering such a change. Currently, little work has been done on this topic and even fewer practical examples exist.

For an appropriate economic assessment, cities need to define the borders of the system carefully to attribute costs and benefits properly. They have to identify the various interlinkages and improve data sets. A careful selection considers criteria and information such as the interlinkages of different policy areas inside the city, the interconnections of the city with the region, the spatial scale of the climate impact, the scale and scope of different approaches and options, and the long-term horizon. A first step can be defining what relevant data the assessment needs and, if existing monitoring does not give the required information, what additional data it needs. These activities require specific capacities and staff, inside the municipalities or from external consultants. Developing the economic case needs external expertise or capacity building for relevant staff. Assessments support a systemic, integrated approach that helps introduce long-term perspectives and long-term thinking into situations that need profound changes.

One way to finance adaptation measures can be the continual and increasing integration of adaptation into the work of other administrative areas, such as water management, biodiversity and city planning. However, establishing the necessary adaptation measures in these other areas will require a systemic and strategic approach, as described in Section 5.3, rather than waiting passively for opportunities. Budgets also need to consider the long-term planning perspective of adaptation. As the example of Copenhagen shows, considering alternative frameworks and changing

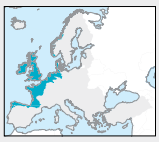
existing rules can give access to additional resources, for instance getting private property owners to contribute, or creating dedicated national funding for adaptation measures as part of the ordinary budget.

Governing and planning sustainable urban futures increasingly takes the perspective of innovative value creation and new financing models. Those who see 'their' value increased may also have a motive to invest.

A couple of examples have explored the economic case for transformational versus incremental adaptation. They can provide inspiration. For example, Upper Austria is looking afresh at flood protection by aiming to relocate 130 houses instead of building conventional flood protection measures (Box 5.29). Copenhagen found that it is most beneficial to combine incremental and transformational adaptation with coping with the remaining risk (see Box 5.33).

Transnational and national initiatives often aim explicitly at innovative actions. They can be useful for exploring innovative and transformational approaches, theoretically and as pilot projects. The Urban Innovative Action ([39]) of the cohesion policy finances up to 80 % of the costs of transformational action that goes beyond business as usual and explores other possibilities. This represents an opportunity for innovative action.

Box 5.33 Copenhagen, Denmark, combines incremental and transformational adaptation in a systemic approach based on an economic assessment



Population: 559 440
Biogeographical region: North-western Europe

'On 2 July 2011, our city was flooded. During a 2-hour period over 150 mm of rain fell in the city centre and the sewers were unable to handle all of that water. It flooded streets, houses and basements. The emergency services were within minutes of having to evacuate the city's two biggest hospitals because of flooding and power cuts. This single event cost us more than EUR 0.8 billion and many more of these events are predicted. An economic assessment of the costs of damage to Copenhagen, if nothing is done to adapt the runoff and sewage system, estimates around EUR 2.1 billion over 100 years,' says Lykke Leonardsen, Head of the Climate Unit in Copenhagen.

'How can we protect our city that such damage never happens again? We started to develop a cloudburst plan. An obvious action was to extend the sewer system. However, to handle such an amount of water, the costs would be tremendous, if that is possible at all, as an economic assessment had shown. Based on this assessment, we decided to combine conventional sewer-based solutions with surface solutions including redesigning and extending our green infrastructure that can naturally drain and retain storm water all over the city. We also found out that it is more cost-effective to allow for a residual risk, accepting pavements to be flooded up to a level of 10 cm under a 100-year cloudburst event and cope with its (minor) consequences with protection measures for buildings, rather than aiming at "total" protection of the city even against any flooding levels.

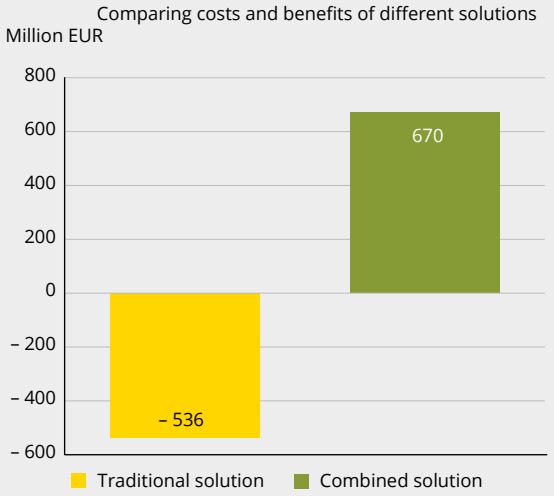
Photo: © EVM Landskab

Photo: © EVM Landskab

([39]) http://ec.europa.eu/regional_policy/en/policy/themes/urban-development/portal.

Box 5.33 Copenhagen, Denmark, combines incremental and transformational adaptation in a systemic approach based on an economic assessment (cont.)

Realising the combined solution, we expect to incur lower costs for construction and management than for a traditional approach. Indeed, an assessment of social costs and benefits shows that under current conditions we can expect that benefits in terms of avoided costs of damages will exceed our investment costs by EUR 670 million in a period of 100 years, compared with the option of the traditional sewer-based solution, which would lead to an economic loss of EUR 536 million over the same period. This leaves us with a socio-economic benefit of around EUR 1.2 billion, which does not even include the additional benefits of the improved green infrastructures and design of public places that make the city nice, safe and highly attractive for people and business. The calculations of costs include the private investments house owners will need to bear like anti-flood backflow valves and private share of costs for connection and disconnection to the network.



In 2015, the municipality adapted a holistic action plan combining 300 different projects to be implemented stepwise over 20 years. The first projects, like Tåsinge Plads, were just implemented. Furthermore we checked our plan also against long-term climate change impacts and came to the conclusion that it also holds in the long-term future. We will further build monitoring to measure implementation and success, but also to learn over time and adjust our plan where necessary. The charm of the many green infrastructure solutions is that they are much more flexible and easier to adjust than grey infrastructures, which is important considering the uncertainties of climate change impacts.

The implementation of the plan is financed with public and private stakeholders in association. In Denmark, the water utility companies can also co-finance surface projects to manage storm water and these are financed by water charges. In fact, as almost all our projects are water related, they are financed this way. Money for additional improvements of green space needs to come from municipal budget, but the city, therefore, gets highly attractive public space with relatively little municipal budget used. On private land, homeowners and business have to take care for their own property to withstand high soil moisture and cope with temporarily 10-cm water level on pavements.'

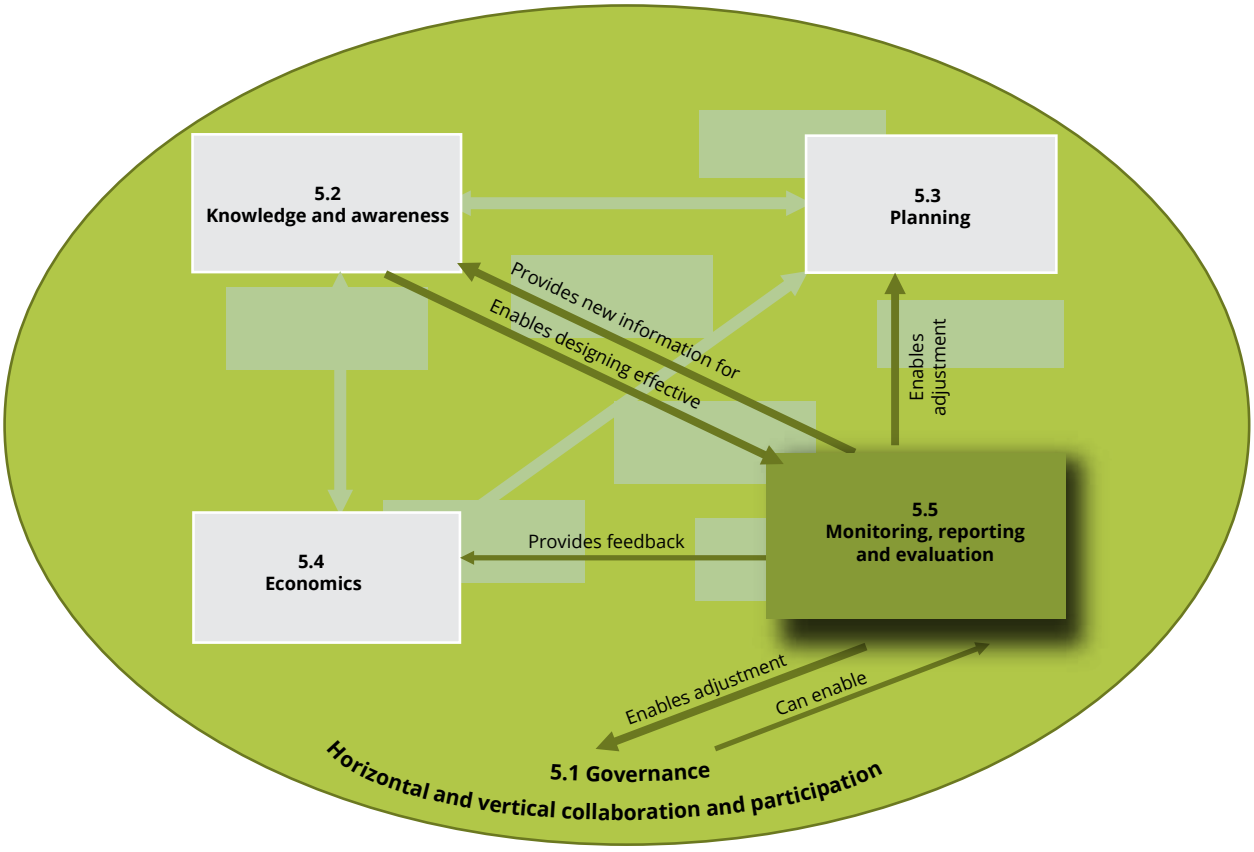
Sources: City of Copenhagen (2015); Climate Adapt, http://climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=5501; direct communication from Lykke Leonardsen, City of Copenhagen, January 2016.

5.5 Monitoring, reporting and evaluation

Key messages

- Monitoring, reporting and evaluation (MRE) provides feedback on the effectiveness of adaptation action taken and progress achieved. Thus, it enables gaps to be discovered, necessary adjustments made and future decision-making improved.
- The last couple of years, interest in MRE for adaptation has increased, particularly at national level and at project and programme levels. While there has been a push to promote city-level adaptation planning, to date examples of that are rare.
- The level of work undertaken suggests that cities have little capacity to set up MRE. They are short of know-how and of technical, human and financial resources, and they seldom apply adaptation indicators.
- A few cities have used MRE for adaptation. Their experience is valuable for followers. Learning and the continuous development of monitoring activities (e.g. through development of indicators) are important to better understand the effectiveness of adaptation action.

Figure 5.10 Monitoring, reporting and evaluation and its relation to other topics



5.5.1 Monitoring, reporting and evaluation of urban adaptation

The last couple of years, interest in MRE for adaptation has increased dramatically. This has resulted in a variety of literature on the subject, including reports, guidance and frameworks (Bours et al., 2014a). A growing number of adaptation plans, projects, policies and strategies have been developed. Consequently, planers and decision-makers want to understand whether or not adaptation policies and actions work, in which contexts and why (Pringle, 2011). Monitoring, reporting and evaluation provides vital feedback on the effectiveness of the different elements of the adaptation process (Figure 5.10). This can improve future decision-making.

Interest in MRE has tended to focus on the project and programme levels and, more recently, the national level (EEA, 2015b).

While there has been a push to promote city-level adaptation planning, to date there has been limited focus on city-level MRE of adaptation. As work commences on implementing these strategies, it is reasonable to expect attention to turn to how we might go about monitoring and evaluating progress and performance. Indeed, anecdotal evidence suggests that a number of larger European cities are beginning to grapple with how to monitor and evaluate adaptation efforts. This section of the report reflects on the limited number of available examples of city-focused approaches to MRE. It considers what we can learn from MRE of adaptation at other levels. Thus, it aims to provide a timely contribution for cities that are starting to develop MRE and for cities that have already begun the MRE process and are now considering it in more detail.

Much of the literature on MRE of adaptation refers to 'monitoring and evaluation'. Box 5.34 explores these two terms and explains the addition of 'reporting'.

Many cities are still at an early stage in understanding how best to adapt to climate change, how to reduce vulnerability most effectively and enhance resilience, and what the characteristics of a well-adapting society might be. Learning what works well in which circumstances, and why, is critical. As cities develop adaptation strategies, MRE will play a vital role in examining if these strategies are effective and if they contribute to reducing vulnerability and enhancing resilience. The complex and long-term nature of climate change makes it important to incorporate MRE as a continuous and flexible process (UNFCCC, 2010). The Urban Adaptation Support Tool reflects that (see Box 5.18, Section 5.3 of this report). Such an approach can support a process of ongoing improvement, helping cities to understand adaptation from different perspectives, including those of highly vulnerable communities.

Monitoring, reporting and evaluation has many benefits. The EEA report on MRE at national level (EEA, 2015b) identified a number of drivers and purposes ([40]) that

Box 5.34 Monitoring, reporting and evaluation are distinct yet closely linked processes

Monitoring is a continuous process of examining progress made in planning and implementing climate adaptation. This might also include monitoring the context and environment within which adaptation occurs, or drivers that shape resilience and vulnerability. The objective of monitoring can be described as 'to keep track of progress made in implementing an adaptation intervention by using systematic collection of data on specified indicators and reviewing the measure in relation to its objectives and inputs, including financial resources' (EEA, 2014).

Reporting is the process by which monitoring and evaluation information is formally communicated, often across different levels of governance. It can allow users to assess how adaptation is performing. It can facilitate learning on different scales, for example by providing an overview of progress across the EU. Reporting on adaptation can be voluntary or a legal requirement, depending on the governance context or the reporting mechanism used.

Evaluation is a systematic and objective assessment of the effectiveness of climate adaptation plans, policies and actions. It is often framed in terms of reducing vulnerability and increasing resilience. Evaluations usually draw upon a range of quantitative and qualitative data, including those gathered through monitoring processes. Evaluations happen at a defined point in the project or policy cycle. Ex ante and mid-term evaluations focus on ways of improving a project or programme while it is still happening. An ex post evaluation seeks to judge the overall effectiveness of an intervention, usually after a project or programme is complete (EEA, 2014).

Source: EEA, 2015b.

([40]) 'Purpose' refers to the overarching aims as well as the more specific objectives. 'Drivers' are the reasons and motivating factors behind MRE action. These terms are in some ways interchangeable. They can be similar or in some cases overlap (EEA, 2015b).

appear to have catalysed efforts to develop MRE of adaptation at a range of scales. Many of these are also relevant to cities and highlight both the objectives behind MRE efforts and some of the benefits effective MRE can bring (Box 5.35).

As well as bringing benefits, MRE faces challenges. A number of studies on MRE set out the key challenges associated with it in the context of climate adaptation (Bours et al., 2014b; Silva Villanueva, 2011; Spearman and McGray, 2011). It is useful to understand some of these issues to realise why it may be necessary to adjust approaches to MRE, and to be aware of some specific pitfalls.

The following section draws upon recent literature, including the EEA report on *National monitoring, reporting and evaluation of climate change adaptation* (EEA, 2015b), to identify some of the most significant challenges associated with MRE for adaptation. These challenges are highly relevant to those cities that are beginning to consider MRE:

Uncertainties: There are inevitable uncertainties surrounding adaptation. Experts often describe them in terms of our understanding of the climate system. However, uncertainties also relate to the social, economic and environmental drivers that influence the extent and nature of climate impacts, where they

Box 5.35 Drivers and purpose of MRE at city level

Learning: There is a growing emphasis on ensuring that learning is placed at the heart of MRE. Many European cities have undertaken some form of adaptation planning, but only a modest number have begun implementing it systematically. This means that they have not sufficiently developed knowledge and experience of how best to adapt to future climate change, how vulnerability can be most effectively reduced and resilience enhanced, and what the characteristics of a well-adapting city might be. Monitoring, reporting and evaluation has the potential to be a key means of enhancing learning within and between cities, and can inform more effective adaptation policy and practice.

Accountability: Adaptation in urban areas often requires dedicated finance from both public and private sources. Monitoring, reporting and evaluation helps make actors accountable to funders, governments or the tax-paying public. This can lead to a particular focus on ensuring that adaptation meets policy commitments, expectations, expenditure targets and standards (Spearman and McGray, 2011). For this purpose, there are often formal monitoring and reporting requirements.

Transparency: Transparency is linked closely to accountability. Monitoring, reporting and evaluation can help to ensure transparency of allocation, use and results achieved through adaptation policies (Pringle, 2011; OECD, 2015).

Effectiveness and efficiency: Monitoring, reporting and evaluation can play an important role in helping to understand if a policy or set of interventions has been effective in achieving its objectives at city level (e.g. avoiding loss of life or increasing resilience). It also helps determine if the implementation was efficient. For example, did the plan choose the most appropriate means of achieving that objective and how could it be better in the future? Assessing efficiency may include weighing up the costs and benefits (including value for money), the risks involved and the timeliness of actions.

Outcomes: Assessment of outcomes is a common objective of MRE in most policy areas. It can be difficult in the context of climate change adaptation. Outcomes are results that contribute to positive improvement(s) that a policy or programme is supposed to achieve. For example, an outcome could be fewer homes affected by flooding. That, in turn, could be considered an aspect of reduced vulnerability. Long timescales, uncertainty and establishing what did not happen (adverse outcomes avoided) are all methodological challenges for the MRE of adaptation. Nevertheless, MRE systems should at least determine progress made towards outcomes such as increased resilience and reduced vulnerability to climate change.

Equity: Climate change will have uneven effects on people. These vary in both space and time. The impacts on different communities will vary, often because they differ in vulnerability. As a result, equity and justice are important considerations (Pringle, 2011). They raise questions such as whose voice the adaptation planning process should hear and how it addresses the needs of socially vulnerable groups being addressed. The issue of equity can be particularly pertinent in cities where extremes of wealth and poverty can exist within a relatively small area. This means that climate change can mean very different things to different people. For example, the urban heat island effect may be relatively trivial to a healthy, young executive living in an air-conditioned apartment, while in the next block it might threaten the life of an elderly person with weak social networks who lives in a block of poorly designed flats.

Source: Adapted from EEA, 2015a.

happen and whom they affect (see Wilby and Dessai, 2010). Given the dynamic and uncertain nature of these factors, it can often be difficult to evaluate how appropriate adaptation policies and actions are.

Long timescales: Climate change is a long-term process that stretches beyond the span of programme management cycles or political terms of office. Consequently, we may not truly understand if our adaptation decisions were optimal or appropriate for many years.

Establishing baselines: The combination of long timescales, uncertainty and a complex array of climate and non-climate drivers creates a dynamic context for adaptation. It might be ideal to measure progress on adaptation against specific reference points, but they change over time (the 'shifting baseline' problem).

Attribution: Given this uncertainty and long timescales, it can be very difficult to attribute changes in resilience to a given intervention or policy. A range of factors that do not relate directly to our adaptation efforts can also shape resilience.

Lack of a universal objective: Climate mitigation MRE typically tracks changes in GHG emissions or in what emissions the use of carbon sinks avoids. Carbon dioxide equivalent emissions provide an interchangeable and quantifiable unit and, consequently, common ground for MRE. It is not possible, or necessarily desirable, to establish a universal set of objectives or indicators for adaptation. As a result, what exactly we should be monitoring, evaluating and reporting is more varied, diffuse and subjective.

Diversity of key concepts and definitions: Adaptation can mean specific actions, the process of which they are a part, or the outcome, which is a reduction in risk (Bours et al., 2014b). It might comprise capacity building, planning, actions or a combination thereof. Sometimes experts frame it in terms of increasing resilience, reducing vulnerability or altering risk levels. All of these can offer slightly different ways of viewing adaptation and therefore what we should be seeking to measure and understand.

Data availability: Data for indicators should be scalable and applicable in a wide range of areas to allow comparison. However, data are not always available in the same format, on the same scale or over a comparable timescale.

Resource constraints: Cities often have limited resources to collect and analyse information. This means that they must make compromises regarding what to monitor and evaluate, who can take part in the process, and how, with whom and in what format they can share the findings.

If these are common factors for those designing and implementing MRE for adaptation, the next consideration is what they might mean for policymakers and practitioners who are working in an urban context. Table 5.4 considers the relevance of each of these challenges to the urban context, and gives examples.

5.5.2 Current state of MRE activities for urban adaptation

City level

Adaptation MRE has made less progress at city level than at other scales, especially project and national levels. This is perhaps understandable given that adaptation is a relatively new focus for many cities. While the planning process can, and should, consider MRE, it is not at all surprising that cities often identify it as a pertinent issue only when considering implementation in detail.

Mayors Adapt/Covenant of Mayors for Climate and Energy recently surveyed European cities. It found that cities do perceive monitoring and evaluation as critical for implementing adaptation. However, they either lack the know-how and the technical, human and financial resources or are not convinced about the indicators so far available. This highlights that cities recognise MRE as important, but it may also help to explain the limited progress to date.

Adaptation MRE is increasingly on the agenda of larger European cities, especially members of the C40 cities Climate Leadership Group. That is a network of the world's megacities, committed to addressing climate change. However, even in this global network, MRE of adaptation is still an emerging, rather than established, topic.

Broader adaptation guidance has considered MRE of adaptation, but support aimed at the regional or municipal level is often fairly general. This is because such guidance tends to reflect the stages on which most cities currently focus: planning and the early stages of implementation. The French Environment and Energy Management Agency has produced one of the few detailed adaptation MRE resources targeting the local and regional levels (ADEME, 2013). It reviews international practice on adaptation MRE. The agency prepared it as an aid for local authorities in France, especially directors in charge of cross-cutting policies, evaluation managers and technical managers.

Table 5.4 Challenges and strategies for city-level MRE

Challenge	Relevance to cities	Managing challenges
Uncertainties	In urban areas, social, economic and physical changes can be rapid. The result is an ever-changing context within which to adapt to climate change. Those living and working in urban areas are often used to a dynamic environment and to making decisions in the context of uncertainty	Consider risk-based approaches to decision-making that acknowledge uncertainty rather than attempt to simplify it
Long timescales	Urban landscapes often reflect a wide range of timescales. Some historical buildings and infrastructure have remained for centuries; other areas have seen a rapid turnover in land use and buildings. Increasing urbanisation is likely to increase the pace of change and present opportunities to increase urban resilience	Use MRE to understand and test assumptions about how long you expect an adaptation investment to last. Theory of change approaches can be useful for this. You can align MRE outputs to specific 'windows of opportunity' to adapt infrastructure, buildings and public spaces. For example, if you need to rebuild a road, consider the drainage specification given possible climate impacts. This often requires careful planning of policy cycles to ensure that MRE outputs (especially evaluation outputs) are able to inform long-term decisions
Establishing baselines	Urban areas are associated with rapid change. This can make it difficult to establish baselines. For example, if a city uses mortality rates as a measure of heatwave management processes over time, should it use historical rates as a baseline? Would this accurately reflect changes in heatwave occurrence or changes in the underlying health of the population?	Understand the assumptions that are made, especially when using individual indicators. Identify and discuss when a baseline may no longer be useful (especially where this relates to public attitudes and acceptability, which can change quickly and in response to single events)
Attribution	A range of climatic and non-climatic drivers shape urban adaptation, making it hard to attribute outcomes to policies and actions. For example, reduced building on flood plains may result from adaptive planning policies or from changing property market conditions. Separating the two factors may be difficult. If cities emphasise mainstreaming adaptation into existing programmes, it helps adaptation to become part of 'business as usual' (e.g. in Rotterdam, Box 5.38). However, it can make it harder to attribute specific adaptation benefits from wider programmes	Consider focusing on the broader contribution of an adaptation measure or policy rather than trying to relate it to specific outcomes. Use approaches that enable you to track causality or that encourage reflection on assumptions about causality (such as theory of change and process tracing)
Diversity of key concepts and definitions	At all spatial scales it is important to be clear about what adaptation means and what the long-term objectives are. It is often not easy to agree what to monitor and evaluate	Ensure you are using consistent terms when discussing issues with partner organisations, stakeholders and citizens. If you put adaptation or resilience in the context of a long-term vision for a better city with improved quality of life for citizens, that can place adaptation at the heart of broader decision-making processes
Data availability	Conditions vary in a relatively small area. For example, one street may be much more vulnerable than the next. This means that authorities often need data about very precise areas. Many different agencies may hold data and use them for other purposes	Cities often have an advantage over the national level. Adaptation planning and data sources often reflect a well-defined administrative area, making it more likely that cities can find coherent data. Understand as early as possible where the useful data are held, who holds them and any restrictions on access
Resource constraints	Adaptation MRE can be everybody's responsibility but nobody's budget. It raises capacity issues. Cities have limited money and time. Adaptation MRE requires input from a range of policy officers as well as stakeholders, including citizens	Let all stakeholders know the benefits (and efficiency savings) of understanding adaptation performance through MRE. This includes city departments, utility providers and others. This may help to increase resources, through either budgets or in-kind support

Other scales and levels

Progress on MRE of adaptation at city level has so far been limited. This does not mean that it is not happening within cities. Approaches to MRE are evolving at other scales and levels of governance. They can inform and influence city-level MRE.

The most common scale at which cities have assessed adaptation progress and performance to date is at the project or programme level. This is partly because monitoring and evaluation is a well-established element of the project management cycle and is usually expected and necessary in any project or programme, irrespective of field or sector. These MRE efforts may include assessing projects focused partly or entirely on adaptation within urban systems. However, such efforts are likely to be limited to the scope of the project or programme in question. This results in MRE findings designed to examine a specific theme (e.g. adaptation to extreme heat); a specific group or community (e.g. adaptation to support the elderly during heatwaves); or a specific location or building (e.g. adaptation of care homes in a specific district of a city). Furthermore, they are also likely to be limited to the time period of the project in question, whereas city-level MRE is likely to be ongoing and take a medium- or longer-term view. Outputs from project- or programme-based MRE systems can therefore provide valuable sources of information for broader city-wide MRE systems, but they serve different needs.

National systems for adaptation MRE appear to be slightly more advanced than city-level approaches. A recent study found that 14 European countries had established or were in the process of establishing such a system (EEA, 2014). National-level MRE approaches must draw upon multiple sources of information across a range of sectors and spatial levels. They require an understanding of the complex web of decisions and policies that can enable and block effective adaptation. In many ways, city-level MRE has many of the traits of national-level MRE, albeit on a smaller scale. It must provide a clear understanding of adaptation progress and performance, across multiple projects and programmes; in different funding regimes; across multiple sectors; and at different spatial scales. Like the national level, a coherent city-level adaptation plan can provide a valuable framework for monitoring and evaluating progress on adaptation. In most cases, the city administration or municipality is likely to lead a broader city-level approach to MRE of adaptation.

City-level MRE results can help inform national-level assessments of adaptation progress. The national level can provide useful information that allows a city to compare, and learn from, adaptation happening elsewhere. As both systems develop, they should consider possible synergies in methodologies (e.g. indicators) and data. It may not be possible to nest one approach within the other. However, careful coordination could improve the flow of information and the timing of MRE outputs.

At the European level, Mayors Adapt is developing a monitoring and reporting scheme with its members, for them to report on progress. Climate-ADAPT offers an interactive map book on urban vulnerability ([41]) that harvests relevant city data available from European institutions such as Eurostat, the EEA or the Joint Research Council. It presents them in the context of urban vulnerability to heatwaves, water scarcity and droughts, floods, and forest fires. The map book provides a European-level overview of key elements of urban vulnerability, its current state and trends. It points local stakeholders to areas that might be critical and require closer analysis.

Monitoring, reporting and evaluation capacity

There has been no comprehensive assessment of the capacity of cities to design and implement effective systems and approaches to MRE of adaptation. Given the level of work undertaken in this area, it would be fair to assume capacity is generally low. The recent survey of the Mayors Adapt/Covenant of Mayors for Climate and Energy initiative supports that assumption. However, city administrations tend to work in similar ways and have certain characteristics in common. These may provide a sound base upon which to further develop capacity for MRE of adaptation.

First, in most cities the policy cycle is a critical way to conceptualise and manage policies and associated projects and programmes. Monitoring, reporting and evaluation plays a key role in providing evidence for this process. This means that, unlike other aspects of adaptation, policymakers and project managers will be familiar with the MRE process and understand. The challenge is now to ensure that they understand the distinct characteristics of MRE for adaptation and reflect them in practice.

Second, another characteristic that may help cities to cope with the challenges of adaptation MRE is that urban systems are dynamic, complex and inherently

([41]) http://climate-adapt.eea.europa.eu/tools/urban-adaptation.

uncertain. City administrations that already recognise these traits and acknowledge them in their working practices are likely to be well placed to develop MRE systems that take such factors into consideration. In this context, MRE can play an important role in providing evidence to support the political legitimacy of adaptation action and illustrate the benefits for an array of stakeholders.

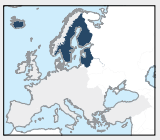
Progress on MRE for adaptation at city level

It is within those more advanced cities, which have progressed to implementing adaptation, that the 'green shoots' of progress in MRE are now emerging. Helsinki and Rotterdam illustrate how MRE for adaptation is progressing in cities, specifically in terms of governance, methods, stakeholder engagement and the dissemination and communication of results (Boxes 5.36 and 5.38). The example of New York illustrates how cities outside Europe are tackling the challenge of MRE. In so doing, they are identifying relevant transferable lessons (Box 5.37). In addition to these, other cities are beginning to explore the topic. For example, London held a workshop on adaptation indicators in 2015 but as of November 2015 had not yet decided how it will take the work forward.

One of the most complete examples of city-level MRE available comes from New York City. This example provides practical experience in selecting indicators and quantifying results. Bigger European cities are already using it, for example those in the C40 network.

While Rotterdam's approach to MRE is still being refined, it is an interesting example, as it has established a clear link to its adaptation strategy while seeking to monitor and evaluate the broader resilience and vulnerability context. It will achieve this through a clearly structured approach based on critical climate risks/impacts and five key themes or dimensions. The mainstreaming approach raises challenges for MRE. The many other cities that plan to mainstream adaptation across local government functions will undoubtedly face them. A particular challenge is attribution: to what extent can we link adaptation outcomes to specific actions and policies? This tends to lead to MRE approaches that focus less on attribution and more on outcomes, such as changing resilience and vulnerability.

Box 5.36 Monitoring, reporting and evaluation approach in Helsinki Metropolitan Area



Population:1 090 616
Biogeographical region: Northern Europe

The Helsinki Metropolitan Area adopted its adaptation strategy in 2012. It focuses on measures that address cross-sectoral or cross-municipal impacts of climate change and can produce synergies or efficiency gains through broader collaboration. The strategy covers the following areas: land use; transport and technical infrastructure; building and climate resilience of the built environment; water and waste management; rescue services and safety; health care and social services; knowledge generation and dissemination. The strategy did not cover flood protection, because that comes under regional flood risk management planning (following the EU Floods Directive (EC, 2007). One of the actions in the strategy is creating a system to monitor annually the implementation of measures, changes in the operational environment and reporting of implementation and changes.

Helsinki Region Environmental Services (HSY) coordinates the strategy work. Susanna Kankaanpää, climate specialist for HSY, describes the start of the monitoring efforts in 2013: 'We first set up a monitoring group to steer the monitoring efforts, with representatives from the cities in the metropolitan area, HSY as well as Helsinki Region Transport (HSL). The group has met twice a year and in early 2015 we published the first monitoring report covering the period 2012–2014. We assessed the status of implementation of the strategy's measures primarily by collecting expert views from the cities and regional organisations. We also used available information from environmental reporting of cities; for example the City of Vantaa reports on some adaptation measures as part of its environmental reporting. Overall, our ambition is to integrate monitoring of adaptation as much as possible with other existing monitoring efforts'.

Source: HSY.

A qualitative indicator describes the status of implementation for each measure. There are four categories: excellent (for successfully implemented and completed actions), good (for ongoing actions and processes), requiring additional efforts (for actions that have not yet started or are delayed) and poor. For ease of communication, the categories have matching Oiva smiley face icons. Helsinki Region Environmental Services originally developed them to communicate food safety monitoring and inspection results in restaurants and food outlets in Finland (see Evira, 2013). 'We selected the Oiva smiley faces for our first indicator report for their familiarity among residents and decision-makers in our cities', Kankaanpää explains. Helsinki Region Environmental Services has disseminated the results in the published report as well as on its website and at stakeholder events, including an annual regional adaptation seminar that brings together hundreds of local stakeholders.

Learning, improving policies and actions and raising awareness are the main purposes of engaging in monitoring activities in the Helsinki region: 'We want to put strong focus on learning and improving our adaptation actions and policies. It is thus important to identify gaps and emerging adaptation needs in addition to tracking progress in implementing existing measures. For example at HSY we have recently prepared a monitoring report focusing on the measures specifically assigned to our organisation, that includes updated measures for the remaining period of the current strategy (2015–2016) and proposes new policies from 2016 onwards. This year [2015] we also made an effort to ask for data and information for monitoring from the health and social services sector. We did not expect to find many adaptation actions implemented, but it is important to get them thinking and raise awareness about adaptation, as they are not yet very active in adaptation', Kankaanpää says.

In addition to improving adaptation policies and actions, the Helsinki Metropolitan Area is actively developing monitoring efforts. 'In 2015 we (HSY) started collaboration with the University of Helsinki and the University of Manchester, after I learned about work done around social vulnerability to climate change in the United Kingdom. We are now in the process of carrying out a vulnerability mapping exercise and developing spatial indicators for vulnerability. This work is intended to eventually lead to improved indicators for monitoring progress on adaptation, but at first we are just trying to better understand the current situation. Identification of particular areas at risk and vulnerable groups in the area can also help us direct our adaptation efforts better in the future. We have good-quality spatial data in the Helsinki region, which facilitates data collection for the indicators', Kankaanpää explains. By November 2015, the work had progressed to checking data availability, after identifying suitable indicators that reflect the socio-economic structure and characteristics of the area. It has also started integrating flood risk maps with local spatial databases and software.

Sources: Direct communication from Susanna Kankaanpää, climate specialist, Helsinki Region Environmental Services (HSY), February 2016.

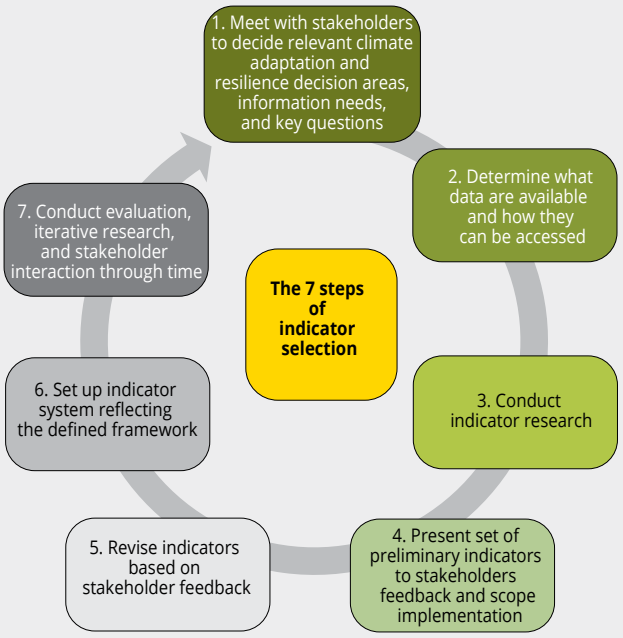
Box 5.37 MRE in New York: lessons to learn for Europe as well

Population: 8 175 133
Region: outside Europe

In 2010, the New York City Panel on Climate Change (NPCC) issued a report proposing the development of indicators and a monitoring system (Jacob et al., 2010). It recommended that the system cover a range of quantifiable indicators relating to physical climate change variables; risk exposure, vulnerability and impacts; adaptation measures; and new research in the previous three categories. This implies an active learning element and interest in benefiting from research findings and best practices from elsewhere. It defined three requirements for the choice of criteria to be used as indicators: policy relevance, analytical soundness and measurability. It emphasised that it is important for different actors (scientists, engineers, city officials) to collaborate in defining and selecting indicators. The overall goal of the indicators and monitoring system was to support the development of flexible adaptation approaches that contribute to the sustainability and climate resilience of the New York City region as a whole. It identified four distinct benefits to monitor: the efficiency of public and private spending, the effectiveness of adaptation measures, whether or not practices are improving over time and whether or not vulnerabilities are reducing. Practical uses of the monitoring results can inform decision-makers and stakeholders, engage stakeholders and communities to make adaptation an ongoing activity, alert stakeholders to trigger points and thresholds, and initiate necessary course corrections. Overall, it emphasised the importance of well-coordinated and sustained monitoring, complete with finance.

In 2015, the NPCC2 monitoring framework came out (Solecki et al., 2015). It builds on work and developments since 2010. It offers a seven-step process to develop indicators, with a strong element of stakeholder participation.

Figure 5.11 Steps of indicator selection



The NPCC2 proposes a range of indicators including climate, impact, social vulnerability and resilience. Tables in the report give examples of all types. Ideally the city's planned Climate Resiliency Indicators and Monitoring System should include them. Key elements of establishing such a comprehensive system include regional and multi-institutional integration and collaboration. The currently monitored indicators have a strong focus on physical climate change and some impact variables (coastal zones and sea-level rise, water resources and quality, and biodiversity and ecosystems). The framework also emphasises the need for indicators of adaptation measures. Monitoring needs to track indicators over time, to provide information on the effectiveness of current and future responses to climate change.

A concrete example of monitoring implemented adaptation measures in New York is the Cool Roofs programme. It aims to alleviate the urban heat island effect in the city. It applies seven monitoring metrics that cover elements of both adaptation and mitigation outputs as well as community engagement in the process:

- electricity usage, in wattage and money spent, in selected buildings that have received an NYC Cool Roof coating;
- number of square feet of rooftop coated;
- amount of carbon reduced, calculated from the square footage of roofs coated;
- number of volunteers engaged;
- number of buildings coated;
- number of green workforce participants; and
- number of green workforce participants who secure jobs and/or further their education.

Source: Solecki et al., 2015.

Box 5.38 Monitoring, reporting and evaluation approach in Rotterdam

Population: 616 294
Biogeographical region: North-western Europe

The city of Rotterdam established the Rotterdam Climate Proof Programme (RCP) in 2008 to lead the development and implementation of the Rotterdam Climate Adaptation Strategy and to implement associated adaptation projects. As part of its role in implementing the strategy, the programme is also responsible for developing appropriate monitoring and evaluation approaches. Chantal Oudkerk Pool is senior advisor for climate change adaptation at the city of Rotterdam and explained more about the approach it is developing:

'In 2008, RCP was established within the water management section of the Public Works Department. Soon after, in 2009, it was incorporated in the newly established Rotterdam Climate Office. This office combined the two existing climate programmes RCP and RCI (Rotterdam Climate Initiative focusing on mitigation). The climate office became a distinct entity residing under the Mayor's office. In late 2014, the governance of the RCP was changed to reflect the mainstreaming concept that is central to the approach to adaptation in Rotterdam; adaption needs to become part of everyday decision-making. This meant that the Rotterdam Climate Proof Programme was no longer led by a separate entity, but by sustainability staff embedded in the wider organisation. Even though most sustainability staff and activities (including adaptation) are covered by resources from across all city departments, there is still a separate Municipal Sustainability Programme (2015–2018) with dedicated staff and funding. The programme members are assigned to oversee and facilitate the incorporation of sustainability in municipal plans and processes; and to stimulate innovations and pilot projects. By 2018 it is expected that adaptation will have become fully mainstreamed in decision-making and there will no longer be a need for a distinct set of climate proofing activities so the formal programme is expected to end.

'The main reasons for developing an MRE system for Rotterdam are to track progress and learn. More specifically we want to report to citizens, our political leaders and the media (thus fulfilling an accountability role) and learn where, and how effectively, climate change adaptation has been integrated (assessing the aforementioned mainstreaming approach).'

Rotterdam is still at an early stage in developing its approach to MRE, but it has established the structure and key building blocks of the system. So far, it has identified five dimensions that underpin the MRE system. Table 5.5 describes these.

Table 5.5 Five dimensions of MRE systems

Dimension	Level at which monitoring and evaluation will occur	Frequency
Risks (probability × consequence)	City	10 years
Targets (how much is enough?)	District	4 years (a political term)
Effort (how many m^2/m^3 etc. added)	Project level/across project levels	Annually
Effect (of implemented measures)	Project	Annually
Speed (are we adapting fast enough?)	City	10 years

As Chantal Oudkerk Pool explained, in addition to these dimensions, indicators will also form an important part of the system:

'Indicators will be developed for four critical impacts identified in the Rotterdam City Adaptation Plan (flooding from sea and river both in inner-dyke as well as outer-dyke areas; flooding from rain (stormwater); and heat). These impact-based "packages" of indicators will span the five dimensions (as shown in Table 5.5). For example, indicators for flooding will aim to provide information on changing flood risk; the appropriateness of targets and priorities; the effort made in terms of inputs and outputs; the effectiveness of flood prevention and management measures; and the scale and speed of action on flood risk versus the changing risk and vulnerability. At this stage, they envisage many of the indicators will be process indicators'. For example, is there a flood risk plan?

Sources: Direct communication from Chantal Oudkerk Pool, senior sustainability advisor, City of Rotterdam, October 2015.

Further resources

- ➔ **AdaptME Toolkit: http://www.ukcip.org.uk/wizard/adaptme-toolkit/#.Vk7nVGfouUk**
- ➔ **Future Cities Adaptation Compass: A guidance tool for developing climate-proof city regions: http://www.future-cities.eu/project/adaptation-compass.html**
- ➔ **'Monitoring & evaluating climate change adaptation at local and regional levels: Learning from international experience to develop an M&E methodology' (ADEME, 2013)**
- ➔ ***National monitoring, reporting and evaluation of climate change adaptation in Europe* (EEA, 2015b)**
- ➔ ***National climate change adaptation* (OECD, 2015)**
- ➔ ***Monitoring and evaluation of climate change adaptation* (Dinshaw et al., 2014)**
- ➔ ***Monitoring and evaluation for climate change adaptation and resilience: A synthesis of tools, frameworks and approaches* (Bours et al., 2014a)**
- ➔ **BASE Evaluation Criteria for Climate Change Adaptation (Weiland, and Tröltzsch, 2014)**

5.5.3 Innovative aspects and emerging practice from MRE supporting effective urban adaptation

Relatively few cities have developed MRE of adaptation. Those that have are 'innovators', or at least 'early movers'. Their experience may be limited, but it is possible to draw out innovative actions and insights for those developing adaptation-focused MRE systems at city level. These include the following:

- A regional or city-level adaptation strategy can drive the set-up of MRE.
- Tracking progress in implementing a city-level adaptation strategy is an important aspect of MRE. Helsinki, for example, has developed relatively simple qualitative indicators to start tracking progress, but continuous development of monitoring activities (e.g. by developing indicators) is important to improve our understanding of how effective adaptation measures are.
- A strong focus on learning and improving adaptation actions and policies can be important (e.g. Helsinki and Rotterdam, Boxes 5.36 and 5.38), especially given the challenges of long timescales and uncertainties. Identifying gaps and emerging adaptation needs can help (see Helsinki).
- In urban areas, climate impacts and adaptation responses often cross sectors and municipalities. Therefore, MRE needs to track how effective cross-sectoral approaches are and assess how much they have identified and exploited synergies.
- Monitoring and evaluating vulnerability and resilience takes MRE beyond answering the question 'did we do what we said we will do?' It provides a critical understanding of the context of adaptation policies, and can link strategies to longer-term outcomes. The universities of Helsinki, Manchester and Cardiff are collaborating to map vulnerability and develop spatial indicators of vulnerability; that is an innovative example of such work in action. In Rotterdam, considering the question 'are we adapting fast enough?' requires an understanding of changing risks and vulnerabilities.
- Quantitative (and qualitative) indicators play an important role in MRE. Establishing robust criteria for choosing them is important (e.g. New York, Box 5.37).
- Tracking the integration of climate change adaptation into existing policy and practice is an important aspect of the approach taken in

Rotterdam. This presents a potentially valuable example to others seeking to mainstream adaptation into their activities and track progress.

- Monitoring activities can also help raise awareness by engaging sectors and actors that are less active in adaptation.

There has been relatively limited attention to MRE of urban adaptation to date. It is perhaps not surprising that little distinction is made between MRE of incremental and transformation adaptation processes. Yet it is worth noting that literature on transformation and transitions acknowledges the significant role of MRE. For example, Rotmans and Loorbach (2009) emphasise that monitoring and evaluating the transition process is important, and the importance of MRE for learning lessons from transition experiments. In the context of transformational adaptation, MRE can play a critical role both in tracking change processes and in learning and sharing lessons that may facilitate systemic change. As MRE of urban adaptation becomes more sophisticated, there is likely to be a growing demand to ensure that MRE approaches connect to ambitious transformational objectives, including by developing appropriate indicators. This is already evident in the International Climate Fund's key performance indicators. They include the 'Extent to which ICF intervention is likely to have a transformational impact' (Lamhauge, 2013). Those cities that are actively pursuing transformational goals and objectives will need to consider how best to assess them over time.

6. Conclusions from a stakeholder perspective

6.1 A local perspective: connecting global long-term change with action here and now

Climate change adaptation: investing in a finer urban future

The local level is where people can really embrace change and incorporate adaptation into positive plans and investments in the future, rather than see adaptation as a problem that may lead to additional costs. Cities such as Copenhagen, London, Paris, Hamburg and Rotterdam have all shifted perspective from risk to an opportunity to make the city more attractive, safe and economically sound. Learning from these examples, other cities may go through this transition faster.

Expanding urban planning horizons in space and time

While this report does not give city managers systematic guidance on how to adapt to climate change, it does identify a large number of lessons learned from cities that are at a relatively advanced stage of the process. It also summarises relevant findings from international city networks, and from the academic and professional literature. One of the most important lessons is to expand decision-making horizons in space and time. Cities are at the centre of changes resulting from a number of megatrends, which pose ever-changing challenges to urban planners and managers. Cities are not self-contained units. They face the impacts of changes elsewhere, for example the impacts of the climate on services from outside the city limits. At the same time, cities can find options to make them more resilient not only within their boundaries, but often also outside. For example, external areas can accommodate flood waters before they reach the city.

Reshaping urban environments

Coping strategies (such as emergency planning) and incremental solutions can help to remove vulnerable local hotspots, correct local policies that climate change may affect, and avoid or reduce damage from extreme weather events. Addressing climate risks or turning climate change into a longer-term opportunity needs a complementary perspective on transformational action. Conventional solutions might reach their limits and fail under future climate conditions. Engaging citizens, local businesses and other stakeholders to develop joint, attractive visions of urban futures can connect long-term challenges to daily lives and short-term urban planning. Avoiding lock-ins and addressing adaptation in tandem with mitigation and other urban aims can help bring multiple functions together in one place.

Tailoring the design of stakeholder engagement processes to local conditions

Stakeholder engagement and public participation are important, but in Europe it is still rare to include them meaningfully. We need different ways to engage stakeholders in local, long- and short-term adaptive action, depending on the scope, objectives and role of stakeholders. They can address specific local problems, conditions and objectives, and also capitalise on the potential of social innovation. One lesson learned is that we need special attention to integrate science-intensive issues such as climate change in participatory processes. In other words, effective communication and translation of scientific information is essential. At the same time, many citizens and businesses may give priority to other local affairs. Putting climate change in that context can help make engagement broader, more effective and sustained.

Developing sound business cases for urban adaptation

Cities often still consider finance an obstacle to urban adaptation. Often this does not need to be so. Building a sound economic case early in the process can speed up decision-making and can avoid measures being expensive. The focus should not be solely on how to finance an adaptation measure. It also needs to be on which measure, or combination

of measures, makes economic sense. It costs less to adapt urban infrastructure in the process of renewing, maintaining and expanding it. That also helps integrate adaptation funding into regular city finance streams. Besides using dedicated EU or national adaptation funds, cities should explore how to fund adaptation within existing local budgets. For example, they can use multi-objective solutions: mitigation, health, economy, social cohesion, etc. This requires effective coordination across city departments and between public and private stakeholders. While transformational adaptation may appear to be more costly than incremental adaptation, the opposite may be true. First, incremental solutions may not be enough, so cities may require more costly measures later. Second and maybe more importantly, transformational adaptation solves problems across a wider space and for a longer time and involves a larger and more diverse set of stakeholders. This can open up novel and shared finance opportunities and at the same time lead to far-reaching and diversified environmental, social and economic benefits.

6.2 National, regional and international perspectives: creating an enabling environment for cities to act

Transforming cities, transforming Europe

In a changing world, the EU aims to become a smart, sustainable and inclusive economy, delivering high levels of employment, productivity and social cohesion. Europe can achieve these goals only if its economy is also environmentally sustainable. As urbanisation continues, attractive and resilient cities will necessarily be the engines of such development. This requires national and European governments to support sustainable urbanisation even more than today. Cities need to transform, without higher administrative levels restricting their choice of ways to do so. Lack of incentives can also frustrate transformation.

Upscaling and knowledge transfer

Early initiatives of frontrunner cities show that urban adaptation action is possible without regional, national or international regulation or other policy frameworks. Cities do not have to wait until governments formally require them to act. Of course, cities do not operate in a vacuum. When developing adaptation measures, they should learn from successes and failures of others, take into account solutions outside the city boundaries, and avoid measures that may harm areas outside the city. Some frameworks are tailored to help a broad spectrum of cities take the most effective and efficient action in the short and long terms. They can help other cities to follow the example of the frontrunners. The popularity of networks such as Mayors Adapt shows that small, medium-sized and large cities are increasingly interested in embarking upon adaptation. To prepare European cities in time for the risks of climate change, they need upscaled and transferred knowledge. Communities of practice around specific urban adaptation questions can mobilise cities that have similar challenges. National governments or the EU can support the long-term viability of national and international networks.

Developing and harvesting an urban adaptation knowledge base

Multilevel governance frameworks can benefit local adaptation efforts, so can support from national adaptation strategies and plans. Such frameworks need maintenance over time and can be generic (e.g. guidance on risk assessment and adaptation planning) or sector-specific (e.g. policies or guidelines focusing on health or energy). Higher levels of government need to ensure access to relevant knowledge and fill gaps. The climate services currently in development may do this, provided that they address users' needs rather than just report the science, and include information about adaptation as well as about the climate and its impacts. Uploading data and case studies to the internet is not enough. It is difficult for cities to take decisions based on such information alone. City twinning and intermediary organisations that facilitate exchange between science and policy are important to build capacity. Sufficient time and resources for this translation process are essential to build societal trust, which is important for the uptake of knowledge.

6.3 A researcher's perspective: filling knowledge gaps and co-creating new solutions

Science for urban adaptation: co-creation of knowledge

Adaptation to climate change is a relatively new issue for cities. It entered the political and scientific agendas only recently. In many cases, lack of capacity rather than lack of knowledge slows down adaptation. In many other cases, knowledge does play a role. Because urban adaptation is local and adaptation research began only recently, the knowledge base is still relatively weak and fragmented in several aspects,

but it is growing rapidly. The knowledge base has to develop from a focus on risk assessment to the next stages of the policy cycle: how to identify, prioritise and implement measures; and how to monitor their effectiveness and feed the lessons learned back into the process. One common challenge is to develop a knowledge base that is really relevant to local priorities. It requires cities to connect researchers, knowledge providers and public and private sector users for a long time. The knowledge that urban adaptation needs are context-specific; the variety of characteristics of cities implies that they need tailored knowledge. Creating solutions jointly crosses boundaries between disciplines, and translating existing knowledge into the language of local stakeholders and matching their perspectives is key.

Filling knowledge gaps

It is important for researchers and stakeholders to create effective solutions jointly that are economically feasible and have public support. In parallel, they need reflection and need to fill the gaps in knowledge between academic disciplines. There are some emerging issues: the equity aspects of risk and adaptation; a better understanding of the nature of decision-making processes; the economics of urban adaptation; the dependency of city services on impacts elsewhere; and the transferability of knowledge taking into account a diversity of approaches for different contexts, such as small and large, northern, southern, eastern and western, rich and poor, expanding and shrinking cities.

Glossary

Adaptation to climate change is the process of adjusting to actual or expected changes in the climate and its effects. In human systems (e.g. urban areas), adaptation seeks to moderate or avoid harm or exploit beneficial opportunities (IPCC, 2014a).

Adaptation actions are measures considered for implementation. Adaptation action comprises protection against negative impacts of climate change, but also creating resilience, reducing vulnerability to both current and future variation in climate, and taking advantage of consequences of climatic events. There are various types of adaptation action, including anticipatory, autonomous and planned adaptation. They can be clustered in four main types:

- 'Green' adaptation actions make use of nature. Examples include introducing new crop and tree varieties, allowing room for rivers to flood naturally onto floodplains, and restoring wetlands.
- 'Grey' adaptation actions use artificial infrastructure to reduce vulnerability to climate change and create resilience. Examples include building dykes and restoring beaches to prevent coastal erosion.
- 'Soft' adaptation actions are managerial, legal and policy approaches that alter human behaviour and styles of governance. Examples include early warning systems and insurance against damage from natural disasters.
- 'Combined' actions use all of the above three types. The best results often come from combining actions. For example, a combination of 'green' and 'grey' actions, or 'grey' and 'soft' actions, can address flood risk in a particular area (EEA, 2013; EEA, 2014).

Adaptation needs are the circumstances requiring action to ensure the safety of populations and security of assets in response to climate impacts (IPCC, 2014a).

Adaptation options are the array of strategies and measures that are available and appropriate for addressing adaptation needs. They include a wide range of actions that can be categorised as structural, institutional or social (IPCC, 2014a).

Adaptive capacity is the ability of systems (e.g. a city), institutions and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to consequences (IPCC, 2014a).

Awareness of the need for adaptation has a public dimension. It means that the public at large, including communities, businesses and organisations, understand climate change and the need for adaptation. It also has a political dimension when adaptation reaches the national agenda and policymakers are willing to take action. In addition, awareness of the need for adaptation relates to the provision of scientific evidence, and the public's and policymakers' need for it (EEA, 2014).

Boundary organisations are bridging institutions, social arrangements like learning spaces, or networks that act as an intermediary between science and policy. (IPCC, 2014a).

Capacity building is the practice of enhancing the strengths and attributes of, and resources available to, an individual, community, society or organisation to respond to change (IPCC, 2014a).

City and **town** have no uniform definition across EU Member Countries. Each country has its own definition based on population size, density, functions and/or historic factors. 'Cities' can even include municipalities with fewer than 2 000 inhabitants. The OECD Organisation for Economic Co-operation and Development (OECD) and the European Commission (EC) have recently provided a harmonised definition for statistical purposes. It is based on population density (at least 1 500 inhabitants/km^2), population size (at least 50 000 inhabitants), population distribution and a link to the political level. These cities comprise around 40 % of the EU population. Another 30 % live in towns and suburban areas (Dijkstra and Poelman, 2012). Servillo (2014) follows a similar approach for small and medium-sized towns — which he defines as areas with an average density between 300 and 1 500 inhabitants/km^2 and a population of between 5 000 and 50 000 inhabitants — and very small towns — settlements with more than 300 inhabitants/km^2 but fewer than 5 000 inhabitants. This report refers to cities as well as smaller towns and suburban areas.

Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system.(IPCC, 2014a).

Climate change refers to a change in the state of the climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use. The Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.' The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes (IPCC, 2014a).

Co-benefits are the positive effects that a policy or measure with one objective might have on other objectives, irrespective of the net effect on overall social welfare. Co-benefits are often subject to uncertainty and depend on local circumstances and implementation practices, among other factors. Another name for them is ancillary benefits (IPCC, 2014a).

Co-creation refers in this report to adaptation actions and policy solutions that is based on reciprocal knowledge exchange, involving all actors (policymakers and stakeholders) in mutual learning and knowledge generation.

Coordination can be horizontal or vertical. Horizontal coordination is provided by institutions and processes that support integration of adaptation into policies for specific sectors. Staff responsible for different policy areas at the same administrative level (e.g. national government) have to exchange information and adjust their activities to ensure that adaptation efforts result in coherent action responding to the unavoidable impacts of climate change and, where possible, benefiting from it. Vertical coordination mechanisms are institutions and processes that support integration of adaptation between multiple administrative levels (e.g. European, national, provincial, regional and local or city level). This entails transferring information on, and approaches to, adaptation and exchanging them effectively within each policy area from the European to the national to the subnational levels and vice versa (EEA, 2014).

Coping is the use of available skills, resources and opportunities to address, manage and overcome adverse conditions, so that people, institutions, organisations and systems can function (IPCC, 2014a). In the present report, coping strategies for adaptation are those that focus principally on short- to medium-term responses aiming to repair damage from a disaster and to promote recovery afterwards. Like incremental adaptation strategies, this approach aims to maintain or restore the city's current functions. It usually uses experience gained over decades, for example in disaster risk management.

Disaster risk is the likelihood of a disaster within a specified time. A disaster means severe alterations in the normal functioning of a community or society when hazardous physical events collide with vulnerable social conditions. They lead to widespread human, material, economic or environmental effects that require an immediate emergency response to satisfy critical human needs. Those affected may require external support for recovery (IPCC, 2014a).

An **extreme weather event** is an event that is rare at a particular place and time of year. Definitions of 'rare' vary, but an extreme weather event would normally has a probability of occurring 10 % or less. By definition, what weather counts as extreme varies from place to place. When a pattern of extreme weather persists for some time, such as a season, one may class it as an extreme climate event, especially if its average or total is itself extreme (e.g. drought or heavy rainfall over a season) (IPCC, 2014a).

Financing instruments supporting adaptation action are of four types.

- Project-based public support: Public funding helps implement adaptation projects. For example, research projects may include test cases that carry out implementation; they finance adaptation measures for regional or local use.

- Explicit budgetary allocations: A dedicated part of public finance is earmarked to finance adaptation implementation. This may lead to project-based

adaptation, so in some cases it may overlap with project-based public support.

- Insurance mechanisms: To transfer the risk of a loss equitably, insurance helps to avoid or minimise human and economic losses following events related to climate change.

- Public–private partnership: A partnership can fund and operate a joint venture between a government service and the private sector. It can be a useful tool to combine financial and knowledge resources from the public and private sectors on specific projects, in order to foster adaptation implementation (EEA, 2014).

Governance is the way in which government hierarchies and structures are organised to allocate resources, and to exercise control and coordination (Rhodes, 1996). Modern governance systems are thus not centralised, vertical 'command and control' but consist of dispersed networks across multiple centres of authority (Hooghe and Marks, 2003). Coordination needs to be both vertical and horizontal.

Green and blue areas, in this report, are green urban areas, sports and leisure facilities, agricultural surfaces and forests in urban areas, semi-natural areas and wetlands, and water bodies and low density areas with private gardens (EEA, 2012b). Green roofs, facades and trees in streets are also considered as part of urban green.

Green infrastructure is a 'strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services' (EC, 2013). The European Commission's definition emphasises the ecosystem services provided, and the purposeful land designation and management, made with the aim of delivering a range of environmental benefits, including maintaining and improving ecological functions. 'Smart' conservation addresses impacts of urban sprawl and fragmentation, builds connectivity in ecological networks and promotes green spaces in the urban environment (including through adaptation and retrofitting) (EEA, 2015a).

Grey infrastructure means construction measures such as buildings, technical and transport infrastructure, dikes and other technical protection using engineering (EEA, 2012b).

Incremental adaptation is less radical. It is the extension of actions that are normally taken to reduce losses or enhance benefits from climate variability and extreme events. These can include increasing existing flood defences; modifying extreme weather warning systems; augmenting water supply by increasing the size or number of reservoirs or decreasing demand; and ecosystem and forest management measures. Incremental adaptation measures are what people have already tried and are familiar with in a region or system — doing more of the same to deal with current climate variability and extremes (EEA, 2013) and adapted from (Lonsdale et al., 2015)

Knowledge, in the context of this report, refers mainly to scientific and technical evidence that is relevant to risk, vulnerability and adaptation to climate change. Knowledge generation means the production of scientific and technical evidence relevant to climate change adaptation, such as research programmes and risk/vulnerability assessments (based on Edelenbos et al., 2011). Knowledge use is the application of scientific and technical evidence relevant to climate change adaptation in support of well-informed policy decision-making (EEA, 2014).

Locked-in describes a situation in which past decisions have determined a present-day situation where one form of action has become predominant. The occurrence of a lock-in potentially leads to inefficient solutions, as it is no longer possible to adopt better alternatives (Sydow et al., 2009).

Mitigation (of climate change) is a human intervention to reduce the sources of GHGs or trap more of them in sinks (IPCC, 2014a).

Monitoring refers to a continuous process of examining progress made in planning and implementing climate adaptation. This might also include monitoring the context and environment within which adaptation occurs, or drivers that shape resilience and vulnerability. One description of the objective of monitoring is 'to keep track of progress made in implementing an adaptation intervention by using systematic collection of data on specified indicators and reviewing the measure in relation to its objectives and inputs, including financial resources' (EEA, 2015b).

Multilevel governance, as this report understands it, means nonhierarchical forms of policymaking, involving public authorities as well as private actors, who operate at different territorial levels, and who acknowledge their interdependence (EEA, 2012b).

National adaptation policies can provide important guidance for urban adaptation. National adaptation strategies can flag the importance of urban adaptation by including it among the priorities of the national strategic vision. National action plans can articulate,

among the measures, specific responsibilities, resources and guidelines for adaptation in urban areas.

Planning adaptation activities, in the context of this report, includes the following tasks

- identifying possible adaptation options: collecting and describing a wide spectrum of possible adaptation options, including 'soft', 'green', 'grey' and 'combined' measures;
- assessing adaptation options: appraising options regarding their effectiveness in addressing potential impacts from climate change, their implementation timeframe, direct and indirect effects to the environment, society and economy, costs and benefits, and other criteria;
- prioritising adaptation options: choosing specific actions to implement, given that identifying and assessing adaptation options typically detect more adaptation options than it is feasible to implement, especially in the short term and taking financial limitations into consideration (EEA, 2014).

Regions are the term in this report for subnational administrative units. They can have different names, dimensions and degrees of relevance for local activities, depending on the specific national administrative and governance settings. These intermediate levels are relevant for urban adaptation activities because they represent a level where more specific forms of support can be given, as it is supposed to be closer to local situations, and they present a spatial unit at which to address issues that require collaboration beyond the borders of national administrations.

Resilience is the capacity of social, economic and environmental systems to cope with a hazardous event or trend, responding or reorganising in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation (IPCC, 2014a).

Risk describes the potential for consequences where something of value is at stake and where the outcome is uncertain, recognising the diversity of values. A common representation of risk is the probability of the occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure and hazard (IPCC, 2014a).

Risk assessment (climate change) is, in general, the qualitative or quantitative scientific estimation of risks. It includes the use of climate scenarios to assess the projected climate change impacts to a system; the estimation of the probability of these impacts; and then the final estimation of the climate risk to this system. It can use both quantitative and qualitative techniques to describe and assess risks. Quantitative assessments assign a numerical value to the probability of an event occurring, while qualitative assessments use general description of the magnitude of potential consequences and the likelihood that they will occur (EEA, 2014; IPCC, 2014a).

'Soft' adaptation actions are managerial, legal and policy approaches that alter human behaviour and styles of governance. Examples include early warning systems or financial infrastructure that can insure against damage from natural disasters (EEA, 2014).

Stakeholder involvement in urban adaptation planning and implementation entails engaging representatives of local (and regional) actors whose interests that may be affected by future climate impacts and/or planned adaptation measures. Therefore, besides representatives of public authorities, relevant stakeholders include local business and the private sector, specific interest groups (e.g. NGOs), scientists/researchers and the general public. There are different levels of stakeholder involvement, ranging from providing information (e.g. websites, newsletters, reports and meetings) or collecting information (e.g. online surveys) and feedback on draft proposals; through active forms of involvement in policymaking that provide stakeholders opportunities to shape decision-making (e.g. on advisory committees) or partnerships between responsible authorities and stakeholders; to, finally, empowerment, where the final decision-making is in the hands of the stakeholders. This report considers active involvement, partnerships and empowerment 'deeper' forms of stakeholder involvement. Recently, co-creation has emerged as a term to describe forms of involvement whereby multiple public and private sector stakeholders work together and share responsibility for developing knowledge, options and solutions. There are elements of co-creation in both partnerships and empowerment (adapted from EEA, 2014).

State of adaptation, in this report, relates to a scale of different policy decisions or actions performed in the country or the single city (adapted from EEA, 2014) such as:

- need for adaptation not recognised and no measures implemented yet;
- coordination activities for adaptation started;

- some adaptation measures identified but not yet implemented;
- adaptation measures identified and implementation (of some) launched;
- adaptation measures implemented;
- adaptation measures in place and monitored/ evaluated.

Systemic approaches to adaptation in this report is understood as focussing on interlinkages of climate change impacts and adaptation measures with socio-economic structures and regional and global trends. These approaches require climate scenarios to incorporate socio-economic projections progressively and explore other analytical approaches, for example those of social sciences or arts. Hence, it is necessary to consider adaptation and mitigation options not only together but also from this even broader perspective. They can be sector-oriented, but in particular integrative, for example in urban design or citizens' behavioural patterns.

Transformational adaptation measures are ways of using behaviour and technology to change the biophysical, social or economic components of a system fundamentally but not necessarily irreversibly. It includes planned and responsive measures using a different approach from the standard method; they include innovation or shifting certain activities to new locations. Transformational adaptation looks forward to the long term and takes a systemic approach to planning and implementation. It can result from single initiatives or a series of rapid incremental changes in a particular direction. Transformational adaptation may be positive, in terms of gains, or negative, in terms of losses or reaching the limits of adaptation (EEA, 2013) and adapted from (Lonsdale et al., 2015).

Uncertainty is a state of incomplete knowledge that can result from a lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from imprecision in the data to ambiguously defined concepts or terminology, or uncertain projections of human behaviour. One can therefore represent uncertainty by quantitative measures (e.g. a probability density function) or by qualitative statements (e.g. reflecting the judgement of a team of experts) (IPCC, 2014a).

Urban, in this report, is a generic term to fit with the definitions of cities and towns (see above) and their various minimum thresholds for density and size.

Vulnerability has a variety of definitions depending on the specific context. The United Nations International Strategy for Disaster Reduction, for example, defines vulnerability as the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard (UNISDR, 2009). The Intergovernmental Panel on Climate Change defines vulnerability to climate change as the propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2014a). While being aware of the different definitions and concepts of vulnerability, the present report does not use a specific definition or concept stringently but rather refers to the term in a more generic way.

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