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Urban adaptation to climate change in Europe

Challenges and opportunities for cities together with supportive national and European policies

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European Environment Agency

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Contents

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Key messages

Climate change — the risk to cities and Europe

Climate change is happening, projected to continue and poses serious challenges for cities. Extreme weather events resulting in hazards such as heatwaves, floods and droughts are expected to happen more frequently in many parts of Europe.

The impacts are stark: flooding can damage or wash away homes, businesses and infrastructure. Jobs and vital services will be lost. Heatwaves can compromise public health, reduce productivity and constrain the functionality of infrastructure. Water scarcity will place cities in competition for water with a wide variety of other sectors, including agriculture, energy generation and tourism.

Cities drive Europe's economy and generate substantial wealth. If important economic hubs such as London, Paris or Rotterdam experience climate related problems Europe's economy and quality of life will be under threat.

Urbanisation, population ageing and other socio-economic trends interact with climate change

Climate change is strongly intertwined with other socio-economic changes. Demographic trends such as on-going urbanisation and competing demand for water from the public and sectors such as industry and agriculture leads to regional water scarcity. An ageing population increases the share of people vulnerable to heatwaves. Urbanisation also reduces the area available for natural flood management or increases the number of homes and businesses actually in flood-prone areas. These socio-economic changes increase the vulnerability of people, property and ecosystems under current climate conditions as long as no adaptation measures are taken. Climate change is projected to exacerbate these problems.

Photo: © ESA

Cities face specific climate change challenges ...

Three quarters of the population of Europe live in urban areas and this is where climate change will be most apparent in everyday life.

While urban areas will generally experience the same exposures to climate change as surrounding regions, the urban setting can alter this as well as any potential local impacts. The replacement of natural vegetation with artificial surfaces and buildings creates unique microclimates altering temperature, moisture, wind direction and rainfall patterns. Differences in urban design and management make cities vulnerable in different ways, even those situated in the same geographic region. Excessive amounts of rain water cannot drain into the ground where a high share of the city's area is imperviously sealed and thus generate or worsen floods. A high amount of artificial surfaces stores heat and cause raised temperatures in cities compared to the surrounding region.

... and depend highly on other regions in Europe and beyond

Cities depend heavily on other cities and regions to provide them with indispensable services such as food, water and energy and the infrastructure to deliver them. Ecosystem services from surrounding regions provide fresh air, store or drain flood water as well as drinking water.

Climate change challenges: from risk management to opportunity seizing

The challenges of climate change force drastic changes in city and regional management so innovative solutions are required alongside traditional measures. Establishing strong spatial planning which stops placing homes, businesses and infrastructure into current but also future risk-prone areas or providing more room for rivers can be an effective and sustainable way to deal with risks complementary to building higher dikes. Keeping public space and buildings cool by using green roofs or walls and providing more shade, rather than air conditioning, saves energy and can make cities even more attractive.

Adaptation to climate change offers the opportunity for developing new jobs and promoting innovation and, at the same time, for implementing the profound changes needed in managing Europe's cities and regions. This will lead the way towards a more sustainable and resilient future for people, the economy and nature.

Acting now ensures adaptation in time and at lower cost

Cities cannot profess being unaware about climate change. Now is the time to act. Delaying adaptation action will most probably increase costs at a later stage or measures will come too late. Infrastructure, such as buildings, roads, railways, energy grids and sewage systems, lasts for decades and is expensive to replace. Building infrastructure ready for future climate conditions and not in risk prone areas (such as floodplains) will result in lower costs and increased effectiveness.

Long-term planning is crucial but has often been lacking. Some positive examples can, however, be found in other areas such as insurance and pension planning. The Norwegian Government Pension Fund is one such example as it intends to ensure pensions in the future via a long-term strategy, despite the trend of an ageing population. Thereby it increasingly considers the climate change-related risks of its investments. A similar long-term approach is needed for infrastructure investments.

Maintaining the functioning of urban infrastructure requires massive investments

Existing and future buildings and infrastructure need huge investments, alongside those for climate-proofing, over the coming decades in order to keep them functioning and delivering their services. It means incorporating climate change adaptation concerns into building standards and retrofitting activities, such as ensuring that sewage systems can cope with heavier precipitation, reviewing building designs to better insulate against heat and adapting the energy and transport systems to cope with higher temperatures, low water availability or flooding.

Large financial resources are needed irrespective of financial constraints. The Multi-annual Financial Framework (MFF), in particular the cohesion funds, is a key European Union instrument which supports local and regional adaptation. The MMF proposal for the period 2014–2020 foresees using a much higher share of the budget for climate change (20 %) than in the current period. However, the proposed 20 % will support both climate change mitigation and adaptation. Current political discussions seem very much focused on mitigation rather than adaptation.

Investment goes beyond 'grey' infrastructure

Adaptation also relates strongly to using and expanding green infrastructure such as parks, forests, wetlands, green walls and roofs, wherever feasible and sustainable. Such infrastructure serves to provide a cooling effect on cities as well as playing a role in managing floods. Measures which combine grey and green infrastructures ([1]) have the potential to deliver robust and flexible solutions over a long period. In addition they can deliver

([1]) Grey infrastructure: construction measures using engineering services.
Green infrastructure: vegetated areas and elements such parks, gardens, wetlands, natural areas, green roofs and walls, trees etc. contributing to the increase of ecosystems resilience and delivery of ecosystem services.

benefits such as higher energy efficiency due to lower cooling needs, or attractive areas for nature, wildlife and recreation.

'Soft' measures ([2]) are another option and can often be implemented at less cost. Such measures include behavioural changes, emergency systems and the adequate provision of information to vulnerable groups. They can reduce health impacts in the event of heatwaves or flooding. While such systems are generally well-established in disaster risk management programmes they often do not include additional risks related to climate change. Investments in capacity building and planning processes are required to fully develop the potential of these soft measures. This would involve:

- sharing information and building knowledge for citizens, administrations, politicians and business;
- enabling and promoting innovation;
- enabling a broad participation in planning and implementation thereby taking up local knowledge and educating people and decision-makers;
- changing long-term planning and implementation approaches across sectors and governmental levels;
- providing the appropriate institutional structures and capacities for mainstreaming and cooperation across sectors and levels.

Urban adaptation relies on action beyond cities' borders

Events outside of cities can have major effects on urban areas. Certain cities, for example, face flooding due to inappropriate land use and flood management in upstream regions. In water scarce regions cities compete for water with agriculture and other users. Urban adaptation to climate change therefore requires regional, national and European approaches.

Support from a national and European framework is crucial in assisting cities to adapt

Cities and regional administrations need to establish grey and green infrastructures and soft local measures themselves. National and European policy frameworks can enable or speed up local adaptation thus making it more efficient. Supportive frameworks could comprise of:

- sufficient and tailored funding of local action;
- mainstreaming adaptation and local concerns into different policy areas to ensure coherence;
- making the legal framework and budgets climate-proof;
- setting an institutional framework to facilitate cooperation between stakeholders across sectors and levels;
- providing suitable knowledge and capacities for local action.

Few European regulations refer to adaptation, but a higher potential exists. One proposal linked to the European Union's structural funds for the period 2014–2020 states that project spending requires the existence of disaster risk assessments taking into account climate change adaptation as conditionality. It will ensure that expensive and long-lasting infrastructures are able to cope with future climate changes. In addition the proposal for the MFF 2014–2020 requests that the budget for climate change is sourced from different policy sectors forcing policy mainstreaming and coherence.

Europe's future depends on strong and resilient cities — towards a joint, multi-level approach to cope with climate change

Europe needs to build climate change resilience in its cities. Cities and regions are connected on multiple levels with cities being key for the economy

([2]) Soft measures: policies, plans, programmes, procedures.

and wealth generation for Europe. This requires a joint and comprehensive approach combining dialogue and partnerships which crosses sectors and governmental levels.

The development and implementation of the European climate change adaptation strategy for 2013 offers a unique opportunity to create this joint approach and reflects efforts cities have made in recent years to be part of related EU policy. Prominent examples, in which the European Commission directly works with cities and city networks, are the Sustainable Cities and Towns Campaign and the Covenant of Mayors initiative. The latter initiative sees more than 3 000 municipalities committing themselves to reduce their greenhouse gas emissions. An extension of this model towards the inclusion of adaptation is in discussion. Moreover, the European Commission started a project in 2011 to support urban adaptation strategies.

This report …

… provides information to facilitate this multi-level European process and the effective participation of local governments. It complements a range of other studies and information sources, such as the European Climate Adaptation Information Platform CLIMATE-ADAPT, the forthcoming EEA reports on climate change impacts and on adaptation (due in autumn 2012), the handbook on Climate-Friendly Cities (2011), published under the Hungarian EU presidency, among others listed later in the report.

1 What is this report about and who should read it?

The need for an urban focus on climate change adaptation in Europe

Climate change leading to higher temperatures, changing precipitation patterns and sea level rise, is a reality in Europe. Climate change mitigation measures will limit the magnitude and rate of related events in the future, but they will not prevent them. Pro-active adaptation to climate change is therefore imperative (EEA, 2010a).

Around three quarters of Europe's population live in urban areas (EEA, 2006; EEA, 2010b). Urban areas are the places in Europe where most people will be vulnerable to the effects of climate change. At the same time cities are Europe's economic centres. Innovation and major economic assets are concentrated here (EC, 2009a). Urban areas adapted to climate change are key for Europe's future. The large and growing size of the urban population, cities' economic assets and the complexity of city systems to provide and manage energy, water, waste, food and other services make urban areas highly vulnerable to both current climate variability and future climate change. Urban areas need focused attention across Europe and a specific approach.

While urban adaptation to climate change at a first glance may seem to be purely a local governance issue, the strong connections between European cities and their surrounding regions, or countries, warrant a broader perspective.

Box 1.1 Key terms used in this report

Urban areas, cities and towns: Due to a lack of European definitions these terms are used in the report depending on the particular context. The indicators in this report generally consider cities with more than 100 000 inhabitants. Results and guidance from this report are nevertheless relevant for cities and towns below that population threshold. The report uses 'urban areas' as a collective term to fit with the different country specific definitions of cities and towns.

Adaptation to climate change is the adjustment in natural or human systems (e.g. urban areas) in response to actual or expected climatic stimuli or their effects. It moderates harm or exploits beneficial opportunities of climate change.

Adaptive capacity is the ability of a system, such as urban areas, to adjust to climate change to moderate potential damages, to take advantage of opportunities or to cope with the consequences.

Vulnerability: Many definitions exist according to the context. For example, the United Nations International Strategy for Disaster Reduction (UNISDR, 2009) defines vulnerability as the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. The Intergovernmental Panel on Climate Change defines vulnerability to climate change as the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (CoR, 2011a; IPCC, 2007). While being aware of the different definitions and concepts of vulnerability, we do not use a specific definition or concept stringently in this report but rather use the term in a more generic way.

Mitigation of climate change is an anthropogenic intervention to reduce the anthropogenic forcing of the climate system. It includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.

More terms can be found in the glossary at the end of this report.

Focus and target audience of this report

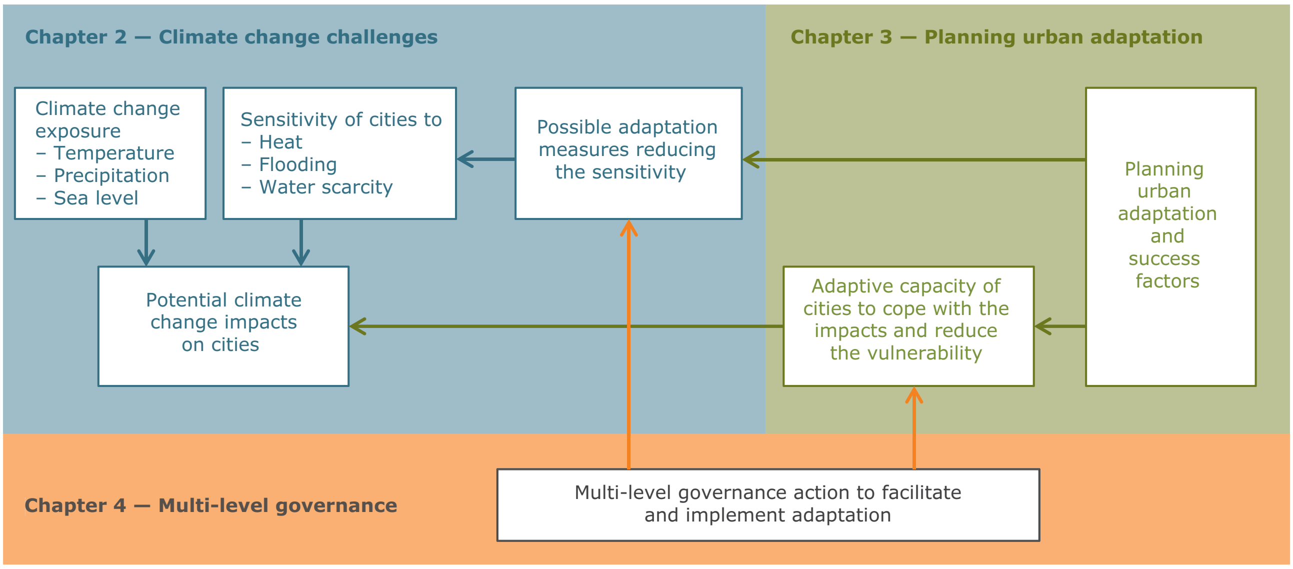
From a European perspective, this report informs about the key challenges that climate change poses to cities and the need for urban adaptation. It positions the urban challenges in the larger policy frameworks provided by regional, national and European institutions and it gives a summary overview of opportunities for solutions.

As such, the report addresses stakeholders involved in urban development at local and city level as well as at regional, national and European level. It aims to support policy development and decision-making across all these levels. This report takes key policy questions for specific climate-related problems, which are common for groups of cities, as the starting point of the assessment. It presents:

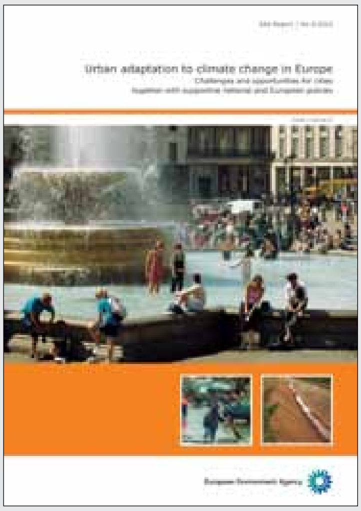
- the most important potential impacts of climate change on cities in Europe: it characterises cities interms of their vulnerability or adaptive capacity to climate change due to factors such as geographic position, urban design, size, wealth or governance system;
- a range of adaptation responses for different spatial levels;
- the challenges and opportunities for multi-level governance in the relevant policy frameworks.

Because of its question-guided approach, the report does not provide a comprehensive scientific assessment of all possible potential climate change impacts and associated adaptation options across all European urban areas. It synthesises existing data and research results around selected key climate challenges for cities and focuses at providing the information needed by European and national and to some extent by regional and local decision-makers to decrease the vulnerability of cities across Europe in a multi-level policy framework (Figure 1.1).

Figure 1.1 Framework of the report



Box 1.2 Examples of what stakeholders can expect from the report



Stakeholders in all governments, communities and networks, the private sector and research:

- support towards a better understanding of their own position and role in the overall European context in enabling urban adaptation to climate change, such as developing coherent policies towards adaptation, implementing effective adaptation or closing research and information gaps;
- an overview of the differences and similarities between cities and regions encouraging mutual learning;
- a cross-sectoral and multi-level perspective that encourages 'out-of-the-box' thinking, challenges creativity and reveals the many cross-benefits of good adaptation.

European and national level stakeholders:

- information to create awareness about urban vulnerability to climate change and the awareness that several types of impacts as well as solutions depend on action at national and European level;
- information on the opportunities to mainstream urban adaptation into the different European and national policy areas in order to identify potentially adverse impacts and opportunities, overcome barriers and thus enable effective local adaptation;
- information on European patterns of urban vulnerability as input into the development of more targeted funding programmes, such as the EU's structural funds and for research.

City and regional governments:

- in a European context, provide information to raise awareness of future climate change challenges for urban areas and their related regions and potential options for adaptation action;
- the ability to start comparing one's vulnerability and response options with other cities, exploring the reasons behind and ways to reduce this vulnerability;
- an understandable methodological framework, facilitating the transition between awareness of cities' climate challenges and the development of targeted adaptation actions;
- a suggestion about the potential and benefits of active participation of local governments in a multi-level governance approach and in the development and implementation of the 2013 EU adaptation strategy and national strategies;
- the report does not provide guidance for detailed local adaptation planning due to the high number and diversity of local situations and the report's focus on the European perspective of the urban challenges.

Building on earlier efforts in support of the 2013 EU adaptation strategy

This report builds on a number of other reports such as the Committee of the Regions' study Adaptation to Climate Change (CoR, 2011a), the handbook Climate-friendly Cities (VÁTI, 2011), the scoping study Urban Regions — Vulnerabilities, Vulnerability Assessments by Indicators and Adaptation Options for Climate Change Impacts (Schauser et al., 2010), a variety of local studies and initiatives such as the Resilient Cities conferences. It provides a European overview of the challenges and opportunities of urban adaptation to climate change and links them with these other initiatives that provide more detailed information on local climate change impacts, and good practice guidance. As such it facilitates the debate on European and national support for urban adaptation, feeds into the European Climate Adaptation Platform Climate-ADAPT, and supports an effective participation of local governments in the development and implementation of the 2013 EU adaptation strategy (EC, 2009b) by providing supportive information.

2 Climate change challenges and response options

Weather and climate strongly influence human life in cities. While exposure to weather and climate is important in the present climate, climate change may exacerbate or ameliorate any potential exposure and subsequent impacts.

Cities and towns, just as the rest of Europe, will be affected by the impacts of climate change. Current observations of change are well in line with projections of the average climate change (Van Engelen et al., 2008), which suggest:

- an increase of the annual mean temperature across Europe between 2 and 5 °C by the end of this century, relative to the present-day climate;
- a change of precipitation patterns with drier summer conditions in the Mediterranean area and wetter winter conditions in Northern Europe;
- a rise of the sea level (Christensen et al., 2007; Van der Linden and Mitchell, 2009; Greiving et al., 2011).

Apart from the changes in average climate, the number, intensity and duration of heatwaves, extreme precipitation events and drought is expected to increase (Barriopedro et al., 2011; Giorgi et al., 2011; Hoerling et al., 2012).

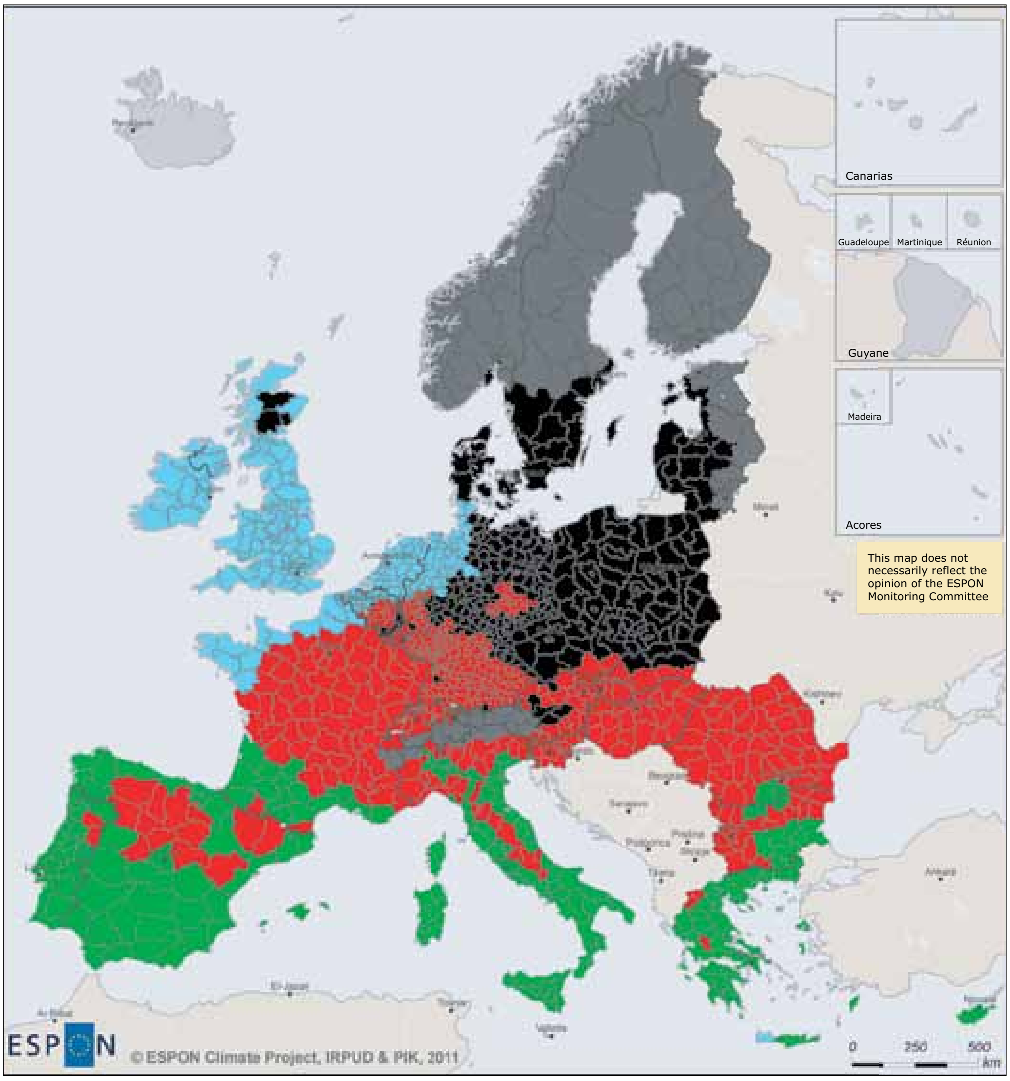
Climate change and its impacts will not appear uniformly in Europe. Different regions will experience varying intensities of change. Map 2.1 identifies five European regions facing similar climate change issues. It is based on a cluster analysis of eight climate change variables which were calculated on the basis of a comparison of 1961–1990 and 2071–2100 climate projections from the IPCC SRES scenario A1B ([3]) scenario (Greiving et al., 2011). The map illustrates that different regions can have similar climate change characteristics, and that in one EU Member State, its regions can have very different climate characteristics. Those working on climate change adaptation in some regions may find regions with similar climate challenges in other countries rather than within their own.

While urban areas will generally experience the same exposures to climate as their surrounding region, the urban setting — its form and socio-economic activity — can alter exposures as well as impacts at the local scale. Built-up areas in the cities create unique microclimates due to the replacement of natural vegetation with artificial surfaces. This affects air temperature, wind direction and precipitation patterns, amongst others. Climate change will affect all of these components, exacerbating some of them and lessening others.

Beyond direct climate change impacts, such as health problems due to heat or damages to buildings and infrastructure due to flooding, the indirect impacts on cities can be much broader. In a world where every city and every region is connected in a multitude of ways to other cities and regions, the failure of one strand of this complex web will create a knock-on effect. Floods can destroy homes, business sites and infrastructure as well as contributing indirectly to loss of jobs and income sources, for example. People and businesses will be cut off from vital services such as energy, transport and clean water. Heatwaves can compromise public health, reduce the ability to work and result in lower productivity thus shortening or delaying 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. High temperatures can put infrastructure at risk — deformed roads and rail tracks can hamper the supply of goods and commuters or, in particular in

([3]) SRES refers to the scenarios described in the IPCC Special Report on Emissions Scenarios (IPCC, 2000). The SRES scenarios are grouped into four scenario families (A1, A2, B1 and B2) that explore alternative development pathways (see further explanation in the glossary).

Map 2.1 European regions clustered according to projected climate changes



Cluster/stimuli	**Northern-central Europe**	**Northern–western Europe**	**Northern Europe**	**Southern–central Europe**	**Mediterranean Europe**
Change in annual mean temperature	+	+	++	++	++
Decrease in number of frost days	––	–	––	––	–
Change in annual mean number of summer days	+	+	0	++	++
Relative change in annual mean precipitation in winter months	+	+	++	0	–
Relative change in annual mean precipitation in summer months	–	–	0	––	––
Change in annual mean number of days with heavy rainfall	0	+	+	0	–
Relative change in annual mean evaporation	+	0	+	0	–
Change in annual mean number of days with snow cover CDSC	–	0	––	0	0

Note: Key: ++ Strong increase; + Increase;
0 Insignificant stimulus for the characterisation of the cluster;
– Decrease; –– Strong decrease.

The map is based on a cluster analysis and represents aggregated data. Therefore in some areas a specific climate factor might point in a different or even opposite direction than indicated in the cluster.

Source: Greiving et al., 2011; © ESPON, 2013.

combination with droughts, power stations might not get sufficient cooling water and thus fail to deliver energy. Potential drops in the production of food, goods and services outside the cities will constrain services in the cities. Water scarcity places cities into a water competition with other sectors such as agriculture and tourism and poses higher economic pressures on the city or individuals to access sufficient water thereby challenging social equity. These indirect impacts challenge in a much broader way the economy and quality of life in cities and in Europe as a whole (response options in Box 2.1).

While these indirect impacts are extremely important their analysis is complex and requires different data as well as analysis above and beyond that usually used for climate change vulnerability assessments. This goes beyond the scope of this report which concentrates, as an initial step, on more direct climate change impacts and vulnerabilities in cities. Sections 2.1–2.3 focus on a selection of climate challenges which are of particular relevance for urban areas:

- heat;
- flooding;
- water scarcity and droughts.

Although a large number of subjects with an urban component, such as storms, forest fires, landslides and erosion, can be defined, this selection is intended to illustrate why and how the specific urban context comes into play when considering climate change issues in cities and towns. The assessment of these direct impacts can then serve as the input to future broader assessments of the secondary and tertiary effects on the economy, social equity and quality of life in cities and in Europe as a whole.

In this report, the assessment builds on European climate change projections and relates them to several key indicators of cities' sensitivity related to urban design and socio-economic structure. The assessment follows, in general, the scheme in Figure 2.1. However, quantitative, Europe-wide data for cities are scarce and do not allow for a fully-fledged assessment. The report considers up to 576 cities with more than 100 000 inhabitants and in a few cases below that population number. For these larger cities, data were available in the urban audit database (Eurostat, 2012) although this is not complete for every indicator. The analysis of potential climate change impacts is therefore rather descriptive as it uses additional qualitative information and illustrative examples.

Box 2.1 Reducing cities' dependency on external services

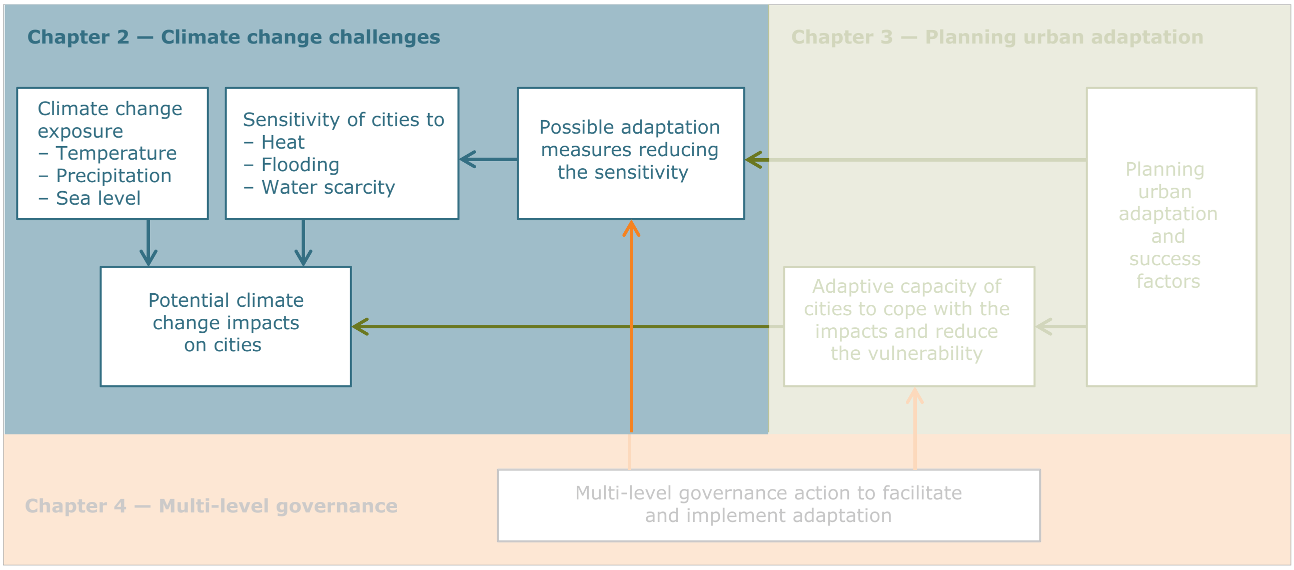
Cities are highly dependent on vulnerable external services but can strategically plan to ensure service provision under future climate conditions.

Firstly, they can take action to reduce supply system vulnerability e.g. by locating power and communication lines underground or creating multiple supply lines. This approach involves measures going beyond city boundaries requiring cooperation, coordination, lobbying and policy agreements on a regional, national and sometimes European level (see Section 3.2) (OECD, 2010).

Photo: © Ian Britton

Secondly, cities can take measures to become more independent of external services and can prepare for something as extreme as a system failure (CAP, 2007). This requires action at all levels. It can include measures to reduce energy demand or to generate energy locally, e.g. building of passive houses (ultra-low energy houses), solar panels on roofs and promotion of district cooling and heating systems. Municipalities can relocate vulnerable urban transport infrastructure and make it climate-proof, improve water use efficiency, reduce losses from the water supply systems and build local water storage facilities and other back-up systems (CAP, 2007). Green infrastructure approaches can consider the capture and use of rainwater as well as recharging groundwater through rain and grey water infiltration. Interconnection between regional water and energy supply systems can serve as a back-up, reducing the likelihood of a failure. Measures towards greater independence may well be considered on a metropolitan or regional scale instead of at a uniquely city level (VÁTI, 2011; CoR, 2011a; CAP, 2007; Greater London Authority, 2010).

Figure 2.1 Placing Chapter 2 within the framework of the report



Box 2.2 Classification of adaptation options as applied in the report

Adaptation options can be categorised in different ways. This report builds on the classifications used in the EU's White Paper on adapting to climate change (EC, 2009b):

- **'Grey' infrastructure approaches** correspond to 'physical interventions or construction measures and using engineering services to make buildings and infrastructure essential for the social and economic well-being of society more capable of withstanding extreme events.'
- **'Green' infrastructure approaches** contribute to the increase of ecosystems resilience and can halt biodiversity loss, degradation of ecosystem and restore water cycles. At the same time, green infrastructure uses the functions and services provided by the ecosystems to achieve a more cost effective and sometimes more feasible adaptation solution than grey infrastructure.
- **'Soft' approaches** correspond to 'design and application of policies and procedures and employing, inter alia, land-use controls, information dissemination and economic incentives to reduce vulnerability, encourage adaptive behaviour or avoid maladaptations. They require careful management of the underlying human systems'. Some of these measures can facilitate the implementation of grey or green measures (e.g. funding, integration of climate change into regulations). Many types of soft measures are particularly relevant when uncertainties about the expected changes are large, since they enhance the adaptive capacity (UNECE, 2009).

Measures in general can be of a preventive character and improve resilience yet they can also offer preparative support when dealing with the anticipated effects of climate change and extreme events. They can also provide responses to direct effects or aim to assist in the recovery of economic, societal and natural systems following an extreme event (UNECE, 2009).

Finally, Chapter 2 lists a range of possible adaptation measures per climate challenge. The options presented do not pretend to be comprehensive since the most appropriate solutions are tailor-made to account for local urban characteristics, which are very different for different regions in Europe. Chapter 3 provides, in addition, an overview of generic ways to increase resilience to climate change.

There are a number of ways to adapt to climate variability and change and various methods to then classify them. This report follows the EU's White Paper 'Adapting to climate change' classification, distinguishing between 'grey' and 'green' infrastructure and 'soft' approaches (see Box 2.2). Other classifications relate to the options for response in terms of their timing in view of prevention, preparation and response choices (EC, 2009b; UNECE, 2009).

Further reading

- EEA, JRC and WHO, 2008, *Impacts of Europe's changing climate: 2008 indicator-based assessment*, EEA Report No 4/2008, European Environment Agency (http://www.eea.europa.eu/publications/eea_report_2008_4).
- IPCC, 2007, *Climate change 2007: Synthesis report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge, United Kingdom (http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf).

2.1 Heat

Key messages

- In Europe, of those natural disasters occurring in recent decades, heatwaves have caused the most human fatalities. During the summer of 2003 the heatwave in Central and Western Europe was estimated to have caused up to 70 000 excess deaths over a four-month period.
- It is highly likely that the length, frequency and/or intensity of heatwaves will increase.
- Present day design of many cities with few green urban areas but many artificial surfaces aggravates the impact of heatwaves within cities, in particular by increasing night-time temperatures.
- Based on the indicators used in this chapter, there are larger numbers of sensitive cities across Europe, with the exception of northern Europe and parts of eastern Europe. A large build-up of heat in Southern and Eastern Europe and its northward shift in the future will have a huge impact on many cities in Europe.
- Local city characteristics tend to be highly important in terms of sensitivity to heat. The results suggest that cities designed in such a way that makes them susceptible to heat are not unique to one particular region. There are sensitive cities in high heat regions which need specific consideration but there are also northern European cities which need consideration.
- City governments have a range of options at their disposal to be better prepared for future heat conditions, including 'grey', 'green' and variety of 'soft' solutions.

2.1.1 *Why are heatwaves an important urban challenge?*

In Europe, of those natural disasters occurring in recent decades, heatwaves [4] have caused the most human fatalities (EEA, 2010c). The European heatwave during the summer of 2003 was estimated to have caused up to 70 000 excess deaths during a four month period in Central and Western Europe (Brücker, 2005; Robine et al., 2008; Sardon, 2007) (see also Box 2.3). This heatwave demonstrated that this issue was not unique to southern Europe. Cities

Box 2.3 Recent major heatwaves in Europe

The summer 2003 European heatwave caused up to 70 000 excess deaths over four months in Central and Western Europe (Brücker, 2005; Robine et al., 2008; Sardon, 2007). It struck the elderly disproportionately hard: the daily mortality rate of the population over 65 years old rose by 36 % in Barcelona, 44 % in London and 105 % in Paris. Moreover the impact of heat on the daily mortality rate clearly increased with age (D'Ippoliti et al., 2010). Note that on specific days and for specific age and gender groups the daily mortality rates may rise far beyond these numbers, with excess mortality rates up to a factor of three and more (see, e.g. Hémon and Jougla, 2004).

The intense heatwave in Eastern Europe in the year 2010 led to an estimated death toll of 55 000 (Barriopedro et al., 2011).

Photo: © iStockphoto

The EuroHeat project analysed the cities of Athens, Barcelona, Budapest, London, Milan, Munich, Paris, Rome and Valencia. The study estimated that during the consecutive summer months of June to August for the period 1990–2004 mortality rates increased when heatwaves occurred. The increase ranged from 7.6 % to 33.6 % depending on the city in question (D'Ippoliti et al., 2010).

(4) There is no generally accepted definition of 'heatwave' with the definition differing per country (WHO, 2004) and even per sector. In general, a heatwave is a prolonged period of unusually hot weather. 'Unusually hot' obviously depends on the background climate.

worse affected were those where heatwave episodes had traditionally been rare or where temperatures strongly exceeded the usual seasonal conditions (D'Ippoliti et al., 2010) such as in Belgium, Germany, the Netherlands, Switzerland and, the United Kingdom. The example of Botkyrka, Sweden shows the combination of a low heatwave threshold for northern European countries and how the sensitivity can be reduced by raising awareness, changing behaviour and appropriate building design (Box 2.4).

Box 2.4 Heatwaves a problem for the south…

While preparing their local adaptation strategy the town of Cascais in Portugal studied the potential adverse health impacts of climate change in the municipality. The results show that an increase of 1 °C above the threshold of 30 °C led to a 4.7 % increase of the risk of mortality. Since all future climate scenarios for Cascais indicate significant increases in days with temperatures above this threshold, the risk of dying from heat stress will rise.

Cascais is now implementing a number of adaptation measures. One project, called the 'Local Green Structure', restructures and links several ecological corridors, such as gardens, valleys and streams, both in natural and urban areas. This structure shall, at the same time, protect and restore local biodiversity and reduce vulnerability to floods.

A special contingency plan uses socio-demographic variables to map sensitive groups in the municipality, e.g. elderly people, people with chronic diseases, children. In the event of an alert for a heatwave, local hospitals, health centres and civil protection services will be called out to support those identified as vulnerable.

Source: Casimiro et al., 2010; http://www.siam.fc.ul.pt/PECAC.

Photo: © Stelosa

… as well as the north

One would be surprised to learn that heatwaves are considered to be one of the biggest threats to public health connected to climate change in Sweden.

Researchers at the University of Umeå in Sweden have found that death rates rose significantly when the average temperature stayed over 22–23 °C for more than two consecutive days.

During July 2010, the mean temperature stayed above 22 °C for nearly two weeks in most parts of Sweden including in Botkyrka in the Stockholm region. Botkyrka was the only Swedish municipality that was prepared for heatwaves. Researchers, in conjunction with the municipality, had been collaborating on mapping risks and the vulnerable. With the help of Geographic Information Systems (GIS) and using national registers and local information, levels of risk and preparedness emerged during the project period of 2008–2010. One fourth of the population was deemed to be vulnerable.

In March 2010, a workshop on heatwaves and health was arranged for all middle management working in the social care department of Botkyrka and those involved with responding to emergencies and representatives from central office. The social care department then distributed advice and instructions on dealing with heatwaves for all relevant municipal services. As a result people that were assisted by the municipal care sector were better prepared in Botkyrka during the 2010 heatwave.

Advice is now published on the municipality's homepage and was personally communicated to people in care homes (see Box 2.8). Nevertheless, awareness still needs to be raised for the general public. Furthermore, a map marking public 'cool spaces' is in production.

The project concluded that municipalities have to be more aware and take precautions within the administration as a whole. City planning, risk management, the care sector and city leaders will have to take the threat of heatwaves into consideration on a more active basis in the future.

Source: Ingrid Molander, Botkyrka municipality, Christofer Åström and Joacim Rocklöv, Umeå University, personal communication, 2011; http://www.botkyrka.se/Nyheter/Sidor/Värmebölja-.aspx.

Heatwaves and human health

An increase in the mortality rate is the most dramatic impact of heatwaves. Exposure to hot weather can also have other negative impacts on human health and well-being.

Humans depend on the body's capability to maintain internal temperature at around 37 °C. The principle mechanisms to prevent thermal stress are sweat production, increased cardiac output and redirection of blood flow to the skin (Hajat et al., 2010). Diminished or delayed physiological responses cause people to be extra sensitive to heat exposure. In particular the elderly, young children and those using certain medication are sensitive to heat (Kovats and Shakoor Hajat, 2008) as well as pregnant women.

In addition, socio-economic and behavioural factors enhance sensitivity to heat at the community level. Such factors include gender, social isolation, homelessness, lack of mobility, alcohol use, being dressed inappropriately, intensive outdoor labour and low income or poverty (Kovats and Hajat, 2008; Hajat et al., 2010; Wilhelmi and Hayden, 2010). In many cases, in particular in cities, a number of these factors act together. For example in low income groups people are more likely to be obese and have inadequate housing (Kovats and Hajat, 2008; Reid et al., 2009). Elderly people are more likely to be socially isolated, to be less mobile and to suffer from chronic disease while also having reduced physiological responses (Luber and McGeehin, 2008; Martens, 1998; Hajat and Kosatky, 2009).

People can, nevertheless, acclimatise to heat to a certain extent. Initial physiological acclimatisation is fairly fast and may occur after several days through increased sweating (Martens, 1998; Haines et al., 2006). However, even with more comprehensive and long term acclimatisation and change of habits, temperature and humidity above certain local and individual thresholds can place stress on people with health implications.

Since geographic location and average temperature are closely linked, mortality related to heat seems to be linked with geographic position (Keatinge et al., 2000; Baccini et al., 2008; Martiello and Giacchi, 2010). The comfort temperature ([5]) or heat thresholds at which the mortality rate is minimal, is associated with the average temperature that communities experience (Martens, 1998) and is indeed higher in areas closer to the equator (Baccini et al., 2008; Hajat and Kosatky, 2009). This is also generally shown in Table 2.1, where the comfort temperatures of a number of European cities are compared. However, there is no clear relation between geographic location and the rate of increase of mortality once the comfort temperature is exceeded. Reasons could include the proportion of elderly residents, the gross domestic product, population density and behaviour.

High temperatures during the night play a decisive role for the serious health effects during heatwaves. Hot days without the relief of cool nights and subsequent exhaustion increase the effects (Grize et al., 2005; Kovats and Hajat, 2008; Dousset et al., 2011).

Table 2.1 City specific temperature threshold (°C) — index describing the relative discomfort due to combined heat and high humidity

Athens	32.7	**Ljubljana**	21.5	**Rome**	30.3
Barcelona	22.4	**London**	23.9	**Stockholm**	21.7
Budapest	22.8	**Milan**	31.8	**Turin**	27.0
Dublin	23.9	**Paris**	24.1	**Valencia**	28.2
Helsinki	23.6	**Prague**	22.0	**Zurich**	21.8

Note: An increase in mortality rates was reported when temperatures passed this threshold.

City-specific estimates of the relevant parameters were obtained from the period 1990–2004.

Source: Baccini et al., 2008.

([5]) Whether or not citizens feel comfortable with the urban micro climate they encounter depends on a complex interaction between physical, physiological, behavioural and psychological factors. Apart from the physical and biological factors perception plays an important role.

Beyond the direct health impacts of thermal stress, other potential effects of heat on health, socio-economic and environmental impacts include:

- impacts on well-being (psychological impacts, increased violence and social unrest);
- impacts on water resources (water pollution caused by a combination of low water flow and heat; water shortages; changes in patterns of vector-borne diseases);
- impacts on economy and infrastructure (reduced productivity of workers in conditions of extreme heat; increased hospital admissions and pressure on care services in summer; increased failure of transport networks in summer, but less in winter; increased demand for cooling in summer, but decreased demand for heating in winter; Failure of power supplies (Wilby, 2008; Schauser et al., 2010; EEA et al., 2008; Oke, 1982);
- changes in patterns of vector-borne diseases.

The Urban Heat Island effect

The impact of heatwaves is particularly strong in cities and towns. The so-called 'Urban Heat Island' (UHI) describes the increased temperature of the urban air compared to its rural surroundings. The temperature difference can be up to 10 °C or more (Oke, 1982). The difference is particularly stark at night. Even relatively small towns can experience a considerable UHI (Steeneveld et al., 2011). Factors determining the strength of the UHI are summarised in Table 2.2.

Urbanisation and human activities essentially alter the balance between the energy from the sun absorbed by the surface, then stored in the building mass and later released to the surrounding air. Most notably, the cooling effect of vegetated surfaces is replaced by the storage of heat in surfaces such as concrete, asphalt and stone. The effect of this alteration is clearly visible in Map 2.2, which reveals much higher surface temperatures in areas of Budapest with a higher degree of soil sealing.

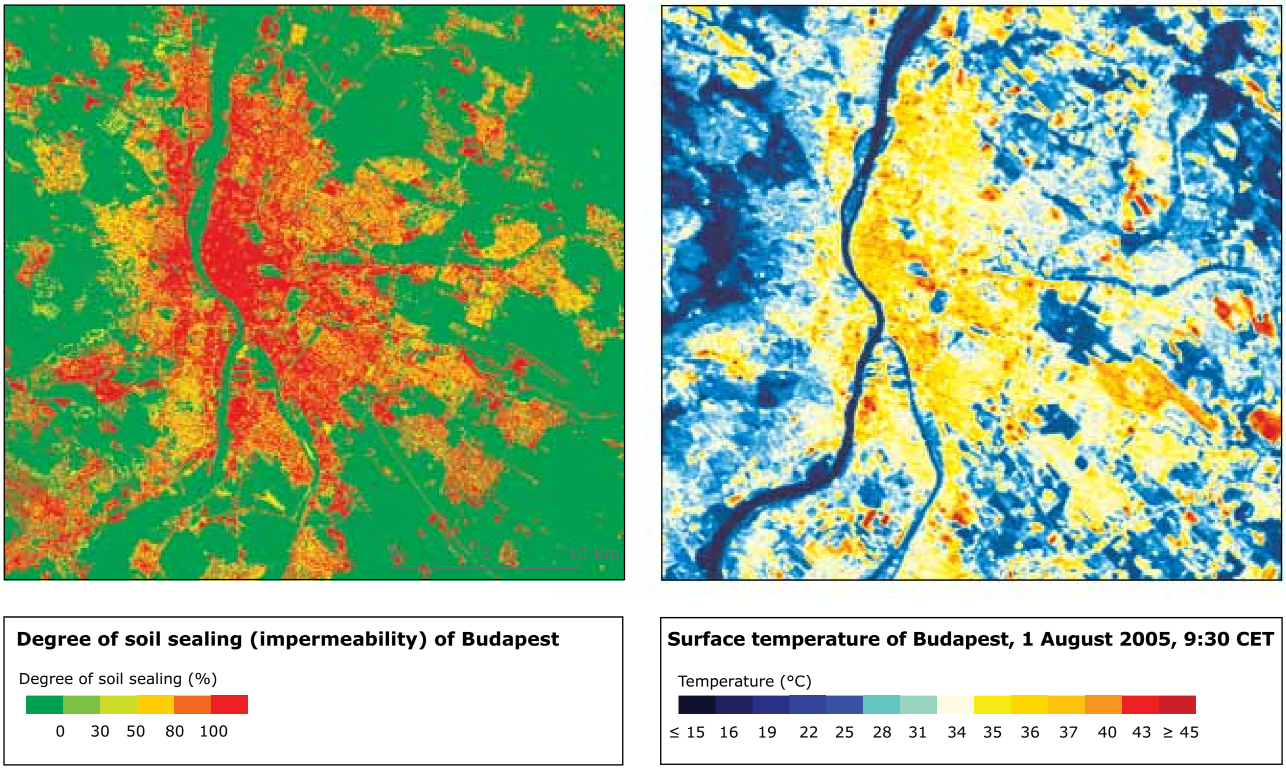
Thus, the intensity of heatwaves in towns and cities is influenced by the urban fabric and design (Oke, 1982; Arnfield, 2003; Wilhelmi et al., 2004). Since the urban fabric shows large amounts of variation the intensity of the UHI would reflect this. This can cause spatial variations of heat effects within cities as well as between cities (Smargiassi et al., 2009; Heusinkveld et al., 2010; Dousset et al., 2011; Knight et al., 2010). The hottest parts in cities and towns are generally those with numerous tall buildings, without green spaces and including areas generating large amounts of anthropogenic heat (EEA et al., 2008).

Wind plays a special role in the interaction between the urban fabric and weather, not only because reduced wind speed generally increases UHI strength (Oke, 1987; Wilby, 2008), but also because so-called 'wind-paths' may offer opportunities to ventilate cities. Streets, oriented in the same direction as wind flow, tend to channel the air into

Table 2.2 Factors determining the strength of the urban heat island effect (UHI) and its impacts

Meteorological factors	Morphological factors	Human factors aggravating heat impacts
Radiation Temperature Wind speed	Geographical location and topography Vegetation and water areas High building mass Presence of impervious cover Structure that hinders ventilation	Urbanisation with a high share of built-up land and impervious areas Population density Little shadowing Insufficient building insulation Additional heat production due to production processes, transport, heating etc.

Map 2.2 Degree of soil sealing (left) and observed surface temperature (right) in Budapest, Hungary



Note: The lower surface temperature in areas with urban green and water can clearly be seen. Although surface temperature does not equal air temperature, surface temperature is often used to detect the UHI, in the form of the so-called surface UHI.

Source: EEA, 2010b; Ongjerth et al., 2007; Gábor et al., 2008.

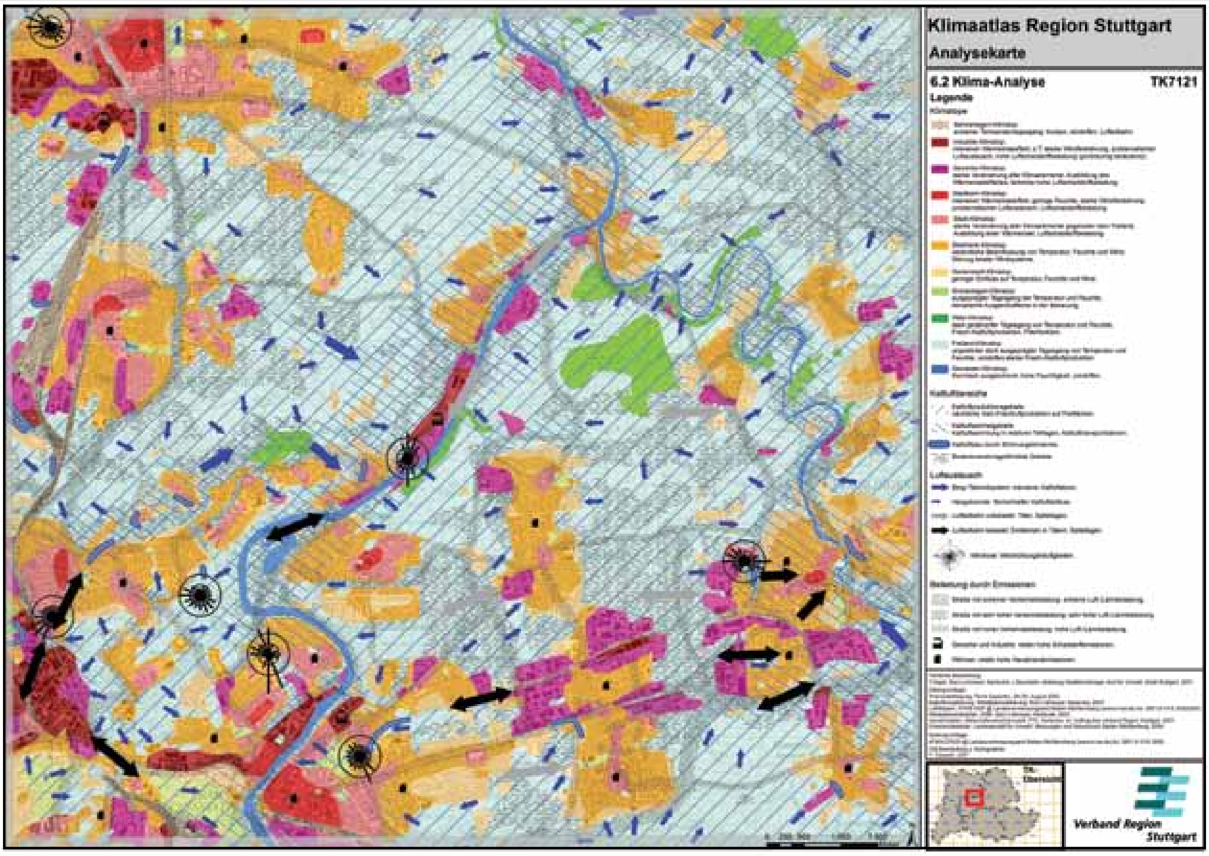
jets called urban wind canyons. During calm and clear nights associated with a strong UHI level, air rises over the city and induces a horizontal flow of air from the rural environment into the city (Oke, 1987; Kuttler, 2008) (see the Stuttgart example in Box 2.5).

Climate change essentially increases the number of hot days by a similar amount for both urban and rural situations. However, the number of additional hot nights is larger in cities than in the countryside. Urban areas store more heat during the day than greener rural areas and release this heat during the night.

Box 2.5 Stuttgart managing urban heat island effects

Stuttgart's climate planning strategy is an excellent example of urban heat island management. The city of Stuttgart has been designed to not only respect and protect nature, but to exploit how natural wind patterns and dense vegetation can actively help the city to reduce its problems of overheating and air pollution. At night cool air sweeps down from the surrounding hills and runs through a series of 'ventilation-corridors' which have been kept open as wide, tree-flanked arteries within the city's street infrastructure.

Map 2.3 Climate analysis map for the Stuttgart region, also showing so-called ventilation paths along with other climate related features



Areas of cold air

- Areas of production of cold air
- Areas of collection of cold air
- Barrier for the flow of cold air

Air exchange

- Mountain/valley wind system
- Downhill flow of cool air
- Clean air ventilation corridor
- Polluted air ventilation corridor

Source: Baumüller and Verband Region Stuttgart, 2008; Klimaatlas Region Stuttgart; http://www.stadtklima-stuttgart.de/index.php?klima_klimaatlas_region.

2.1.2 *What are the potential impacts of heat on Europe's cities?*

Future exposure to heat in European cities

Europe has seen an increase in temperature of 0.3 °C per decade since the 1970s and has experienced an increase in the number of heat incidents in the past two decades (Klein Tank and Können, 2003). At least two summers in the last decade (2003 and 2010) have in all likelihood been the warmest of the last 500 years in Europe (Barriopedro et al., 2011). Climate change scenarios indicate that there will be an increasing probability of mega heatwaves (prolonged heatwaves over large areas such as those observed in 2003 and 2010) over highly populated areas of Europe (Barriopedro et al., 2011). It is very likely that the length, frequency and/or intensity of warm spells, or heatwaves, will increase (Fischer and Schär, 2010; IPCC, 2012).

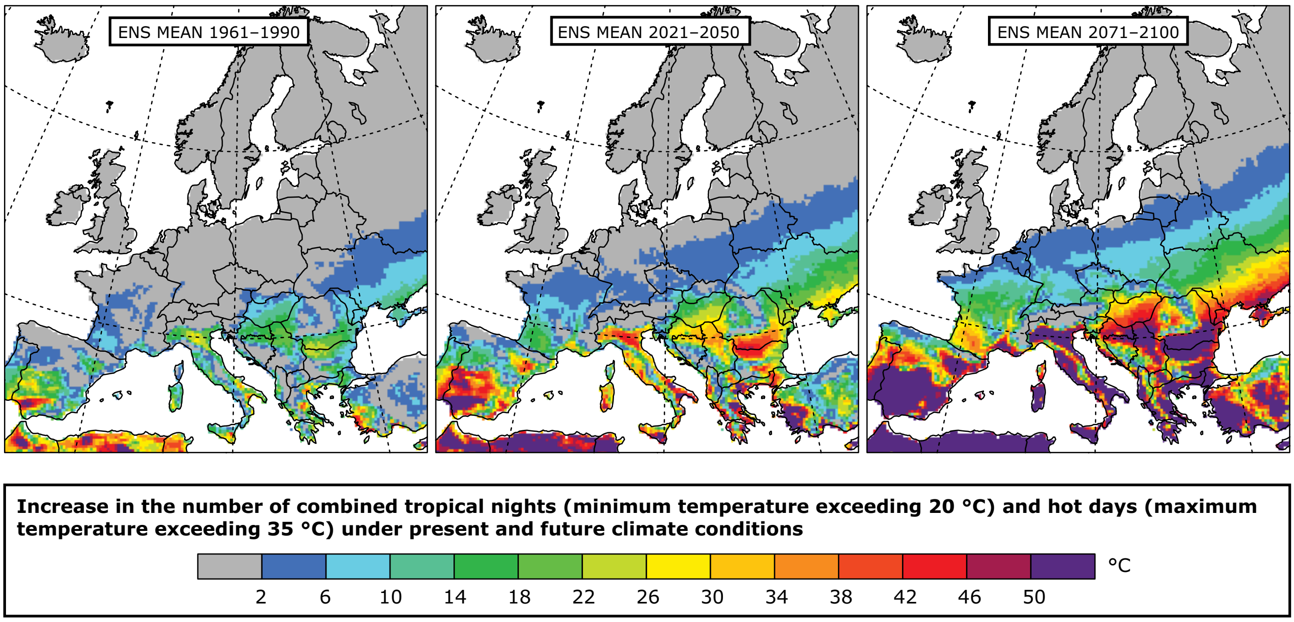
Southern Europe in particular is affected by hot summer days and tropical nights. Projections in Map 2.4 indicate an increase in the number of combined tropical nights and hot days in the future and also a clear northward expansion of the affected regions (Fischer and Schär, 2010). Temperature extremes as well as the duration of heatwaves are expected to increase further (Sterl et al., 2008; Barriopedro et al., 2011). The exceptional summer of 2003 may be viewed as normal in the mid-21st century (Fischer and Schär, 2010; Schär et al., 2004).

Cities' sensitivity to heat

The scenario above notes the increase in regional heatwave days. However, it does not take into account the impact on the urban fabric and the resulting exacerbated heatwave effect in cities. The scenario underestimates in particular the number of tropical nights in cities, which are decisive for health impacts.

Map 2.5 provides a first assessment of the possible future heat impacts on European cities. Here the scenario map for the period 2071–2100 is overlaid with population density and the percentage share of green and blue areas in major European cities. Both provide a proxy to the urban heat island effect. Population density is associated with variables such as building density, green/blue area share and anthropogenic heat production (Steeneveld et al., 2011). The influence of green and blue urban areas has been explained in Section 2.1.1.

Map 2.4 **Increase in the number of combined tropical nights (minimum temperature exceeding 20 °C) and hot days (maximum temperature exceeding 35 °C) under present and future climate conditions**



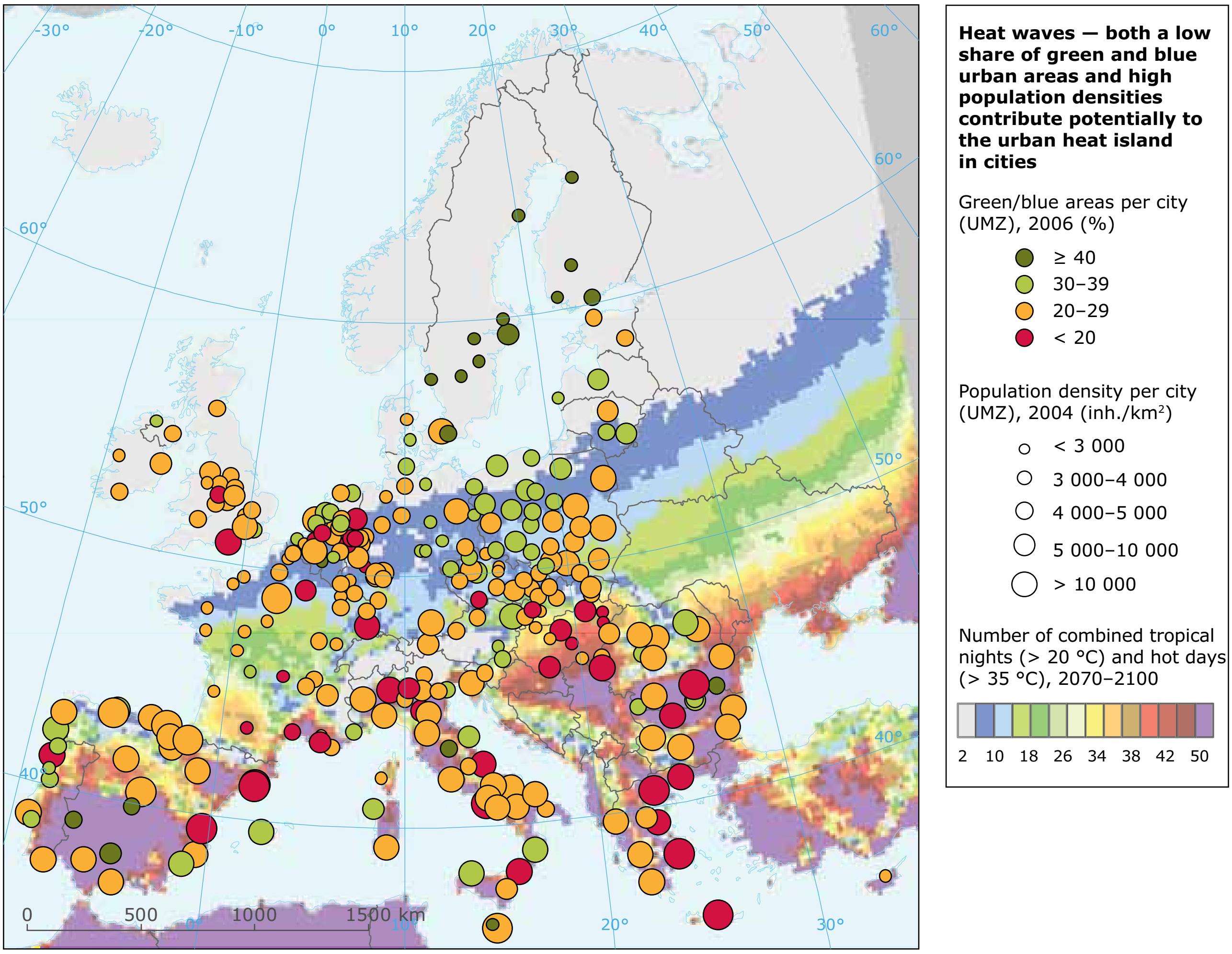
Source: Fischer and Schär, 2010.

The map indicates a large number of cities with large UHI potential in the north-west due to low shares of green and blue urban areas and in particular south-eastern of Europe where, in addition, population densities are higher. In the western part of the Mediterranean area, the UHI potential seems to be quite variable, with a mix of cities with both strong and weak UHI potential.

Comparing expected heat exposure changes with the UHI potential reveals that a large share of cities in eastern and southern Europe will experience relatively strong increases in heat load in the future. If the heatwave intensity expands more to the north-west than expected from the results shown here (see other indicators used by Fischer and Schär, 2010), cities in the Benelux countries and the United Kingdom would also be more affected.

These results suggest that those cities physically sensitive to heat impacts do not cluster in one region only. There are indeed highly sensitive cities in regions with an expected high heat load which need specific consideration but northern cities are also sensitive and deserve consideration. At the same time some cities in southern Europe seem to be less physically sensitive than others. Local city characteristics tend to be more important than similar regional characteristics. The share of cities in a country which has relatively little green and blue

Map 2.5 Heatwaves — both a low share of green and blue urban areas and high population densities can contribute to the urban heat island effect in cities



Note: The background map presents the projection for the period 2071-2100. Values for the earlier periods are presented in Map 2.4.

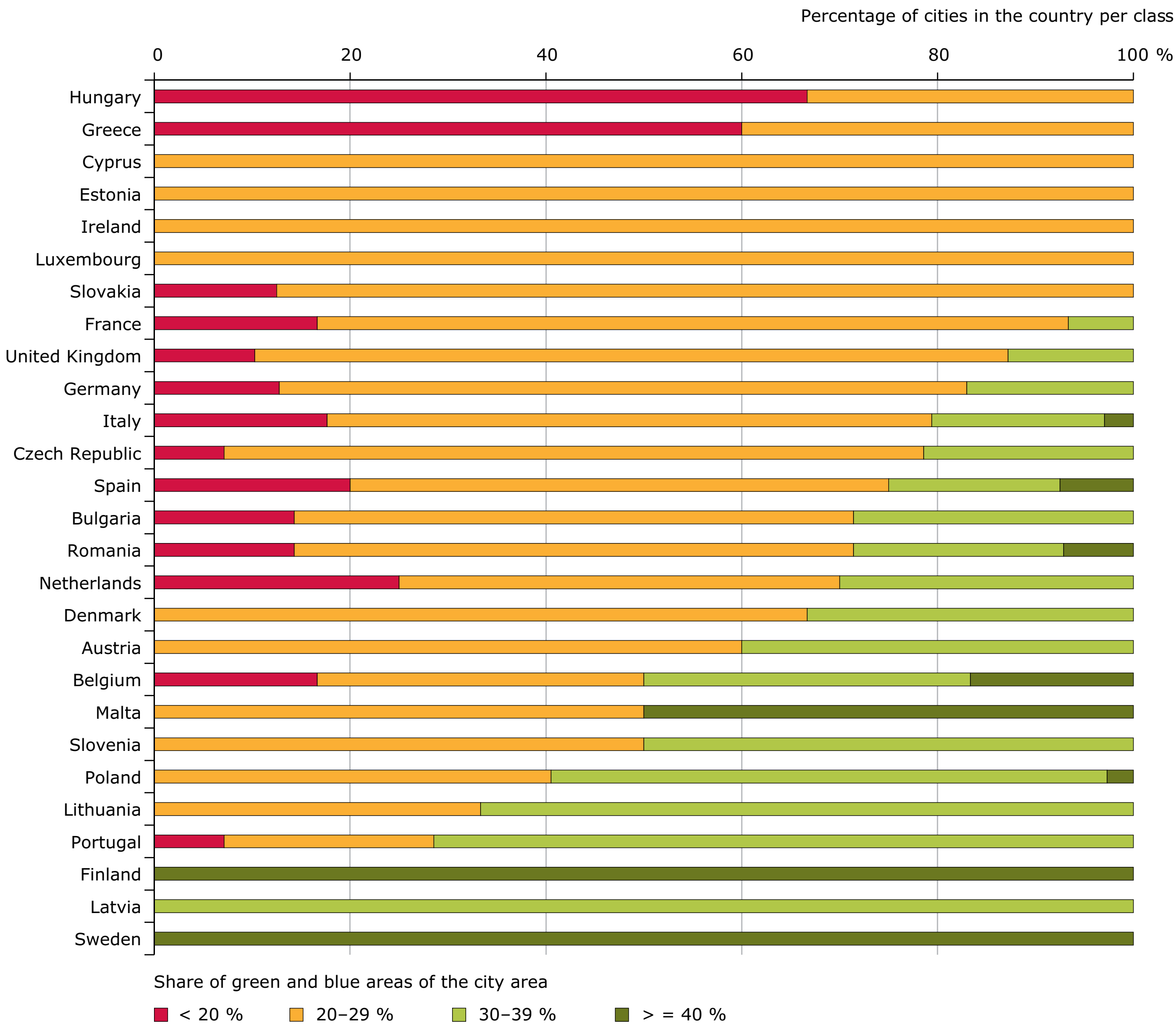
City data for Bulgaria and Ireland are from 2001; the concept of city is defined uniquely by the urban land-use areas within its administrative boundary.

Source: Eurostat, Urban Audit database, 2004; EEA Urban Atlas, 2006.

areas is particularly high in Hungary and Greece as well as Cyprus, Estonia, Ireland, Luxemburg and Slovakia (Figure 2.2).

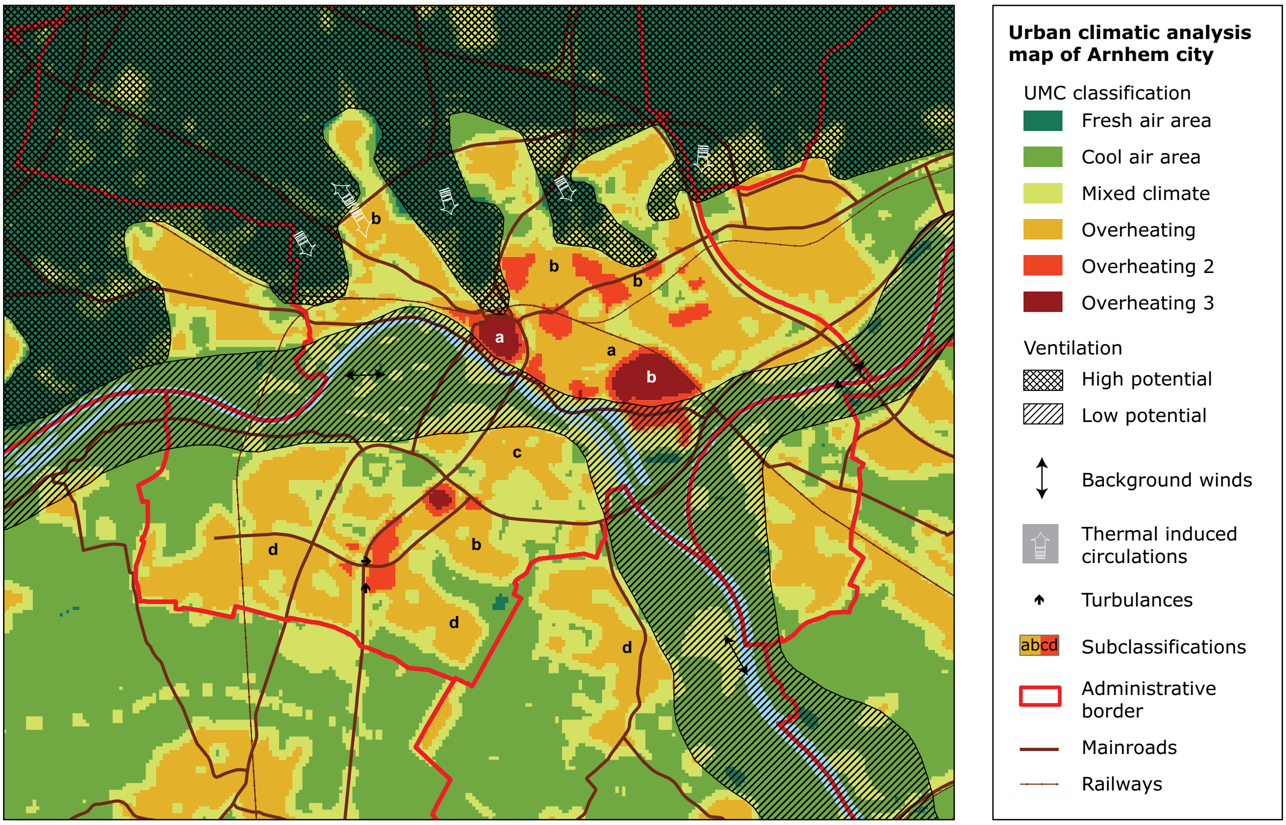
Population density and the share of green/blue urban areas provide a reasonable initial estimate for UHI at the city level and can also serve as a European overview on potential hotspots. For more complex city planning it is clearly too simplistic. Additional factors and variations with the city need to be taken into account. Regarding the cities' sensitivity to heat not only is the share of green and blue areas important, but also their distribution, green facades and roofs as well as shadowing and ventilation. Climate analysis of the city of Arnhem in the Netherlands shows such an example (Map 2.6). The map clearly shows the variability of the risk related to heat in the city with red areas indicating the warmest city parts. The potential for ventilation (marked in black) is related to natural air flow along rivers and on downwards trajectories.

Figure 2.2 Percentage of green and blue urban areas — share of cities per class per country (based on Map 2.5)



Note: Generally, only cities with more than 100 000 inhabitants are considered.

Map 2.6 Urban climate analysis map for the city of Arnhem, the Netherlands



Source: www.future-cities.eu.

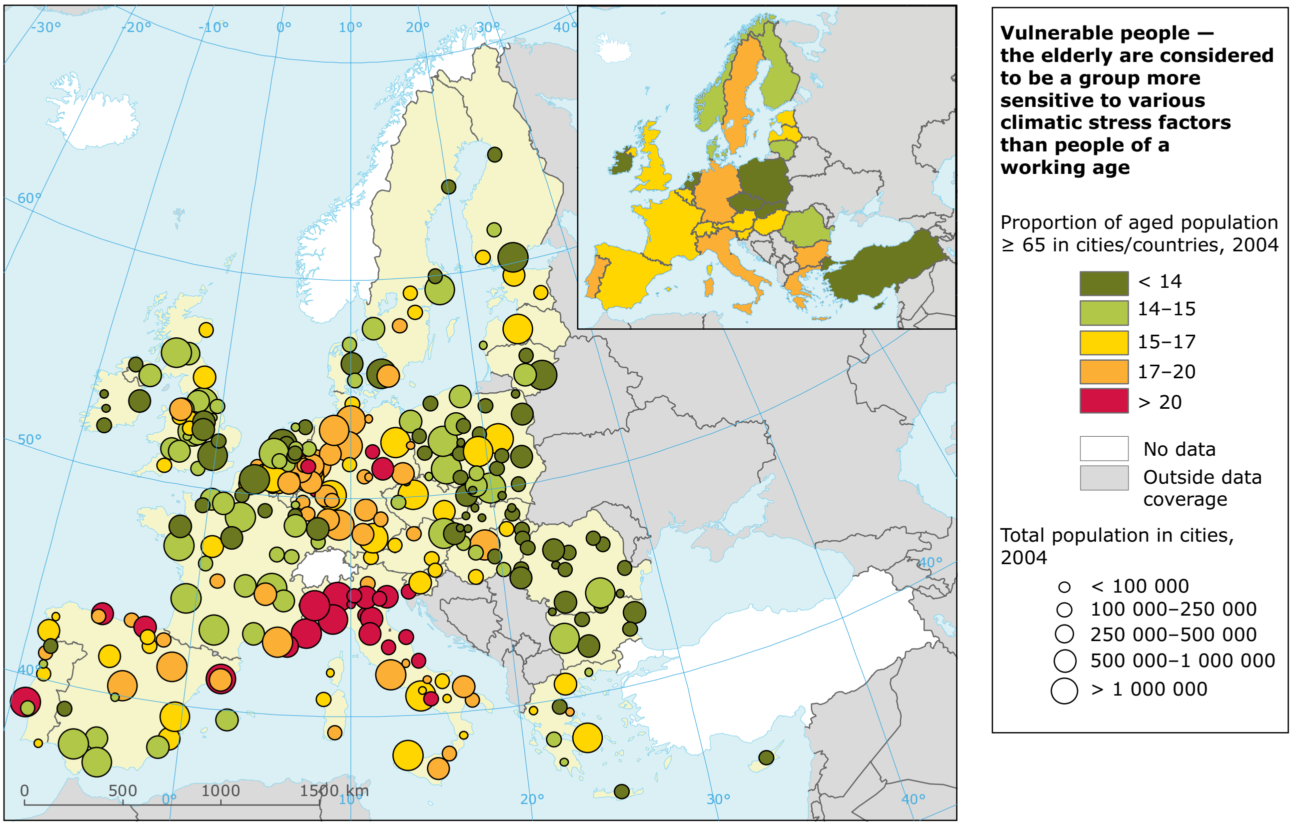
Social sensitivity

The majority of people in Europe live in urban areas and high population densities are already present in European cities. The number of urban dwellers will further increase in the near future (UN, 2010). As explained previously, some population groups are more sensitive to heat than others. Of special importance in terms of sensitivity to heat are senior citizens aged 65 years and over. This population group currently constitutes about 17.1 % of the total population of Europe, but this share is expected to rise to 30 % by the year 2060. The share of people aged 80 years or older (4.4 % in 2008) will nearly triple by 2060 (Schauser et al., 2010; Eurostat, 2008). This demographic trend will naturally bring increased heat-related mortality rates even without climate change if no adaptation measures are taken. However, demographic development in cities does not necessarily follow regional trends. There are at present no European wide demographic projections available at the city level.

Bearing in mind the many uncertainties sketched above, Map 2.7 and Figure 2.3 provide a first impression of European wide differences regarding the social sensitivity of cities to heat. The map shows the total population in 2004 and the share of elderly people as a proportion of population within the major European cities in Europe. The proportion of elderly people in cities is higher in countries in the area of Europe stretching from Italy to Germany and in northern Spain. In Belgium and Germany this proportion usually follows the country average. Cities in northern Italy, meanwhile, tend to have values above the country average. For other countries such as Bulgaria, France, Romania, southern Spain and the United Kingdom the share of elderly people in most cities is lower than in rural areas.

The composition regarding age is not the only factor that determines social sensitivity. Those on low incomes, the disabled and sick, young children and ethnic minorities are classified as vulnerable

Map 2.7 **Vulnerable people — the elderly are considered to be a group more sensitive to various climatic stress factors than people of a working age**



Note: Total population in cities; proportion of population aged ≥ 65.

Data for Bulgaria, Cyprus, Czech Republic, Finland, France, Ireland and Latvia are from 2001.

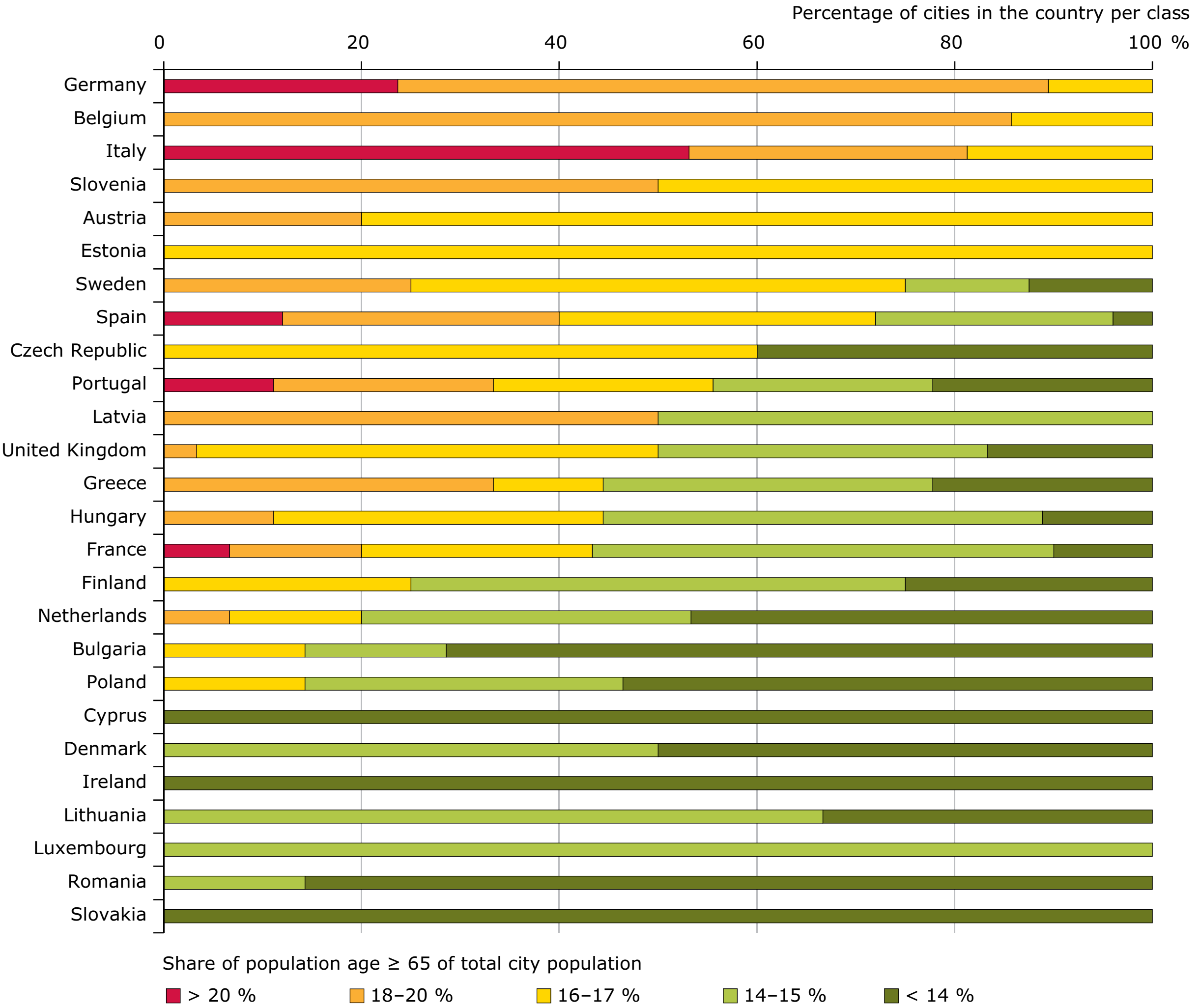
Source: Eurostat, Urban Audit database, 2004.

(Schauser et al., 2010). Further influences include such varied socio-economic characteristics as the quality of the health care system, availability of heat-health warning systems as well as cultural and behavioural aspects. Such factors are also intertwined with physical factors such as the quality of the buildings (thickness of walls, isolation, or availability of air-conditioning), application of green structures in roofs and facades and accessibility of public green and blue spaces (Harlan et al., 2006; Uejio et al., 2011).

Potential future impacts

Climate change projections indicate a rise in the number of heat-related deaths. The PESETA study projected almost 86 000 additional deaths per year in 2071–2100 in the EU-27 Member States compared to the 1961–1990 EU-25 average — albeit under a much more severe climate change scenario (EEA et al., 2008). Koppe et al., 2004 project a rise by up to 20 % until the year 2050 in Germany and Dessai (2003) by 35 % to six fold in Lisbon, Portugal. These

Figure 2.3 Percentage of population aged ≥ 65 — share of cities per class per country (based on Map 2.7)



Note: Generally, only cities with more than 100 000 inhabitants are considered.

deaths can be mainly expected in urban areas where the effects culminate. There are several intertwined trends — climatic and non-climatic — which make population in cities more vulnerable to climate change: global warming, increased urbanisation and population ageing.

Besides the impacts on health, a number of socio-economic and environmental impacts resulting from higher temperatures and heatwaves, such as problems in energy supply and maintaining transport services or water supply, will occur (Schauser et al., 2010). These can trigger additional socio-economic challenges in the form of lower productivity, failure of services, higher energy demand for cooling etc. There is currently not enough information available to assess these future impacts in cities across Europe.

In addition, higher temperatures trigger certain air quality problems in cities. Part of the health effects and increased rate of mortality resulting from heatwaves may be caused by decreased air quality in the urban environment (Box 2.6).

Box 2.6 Air quality problems due to higher temperatures

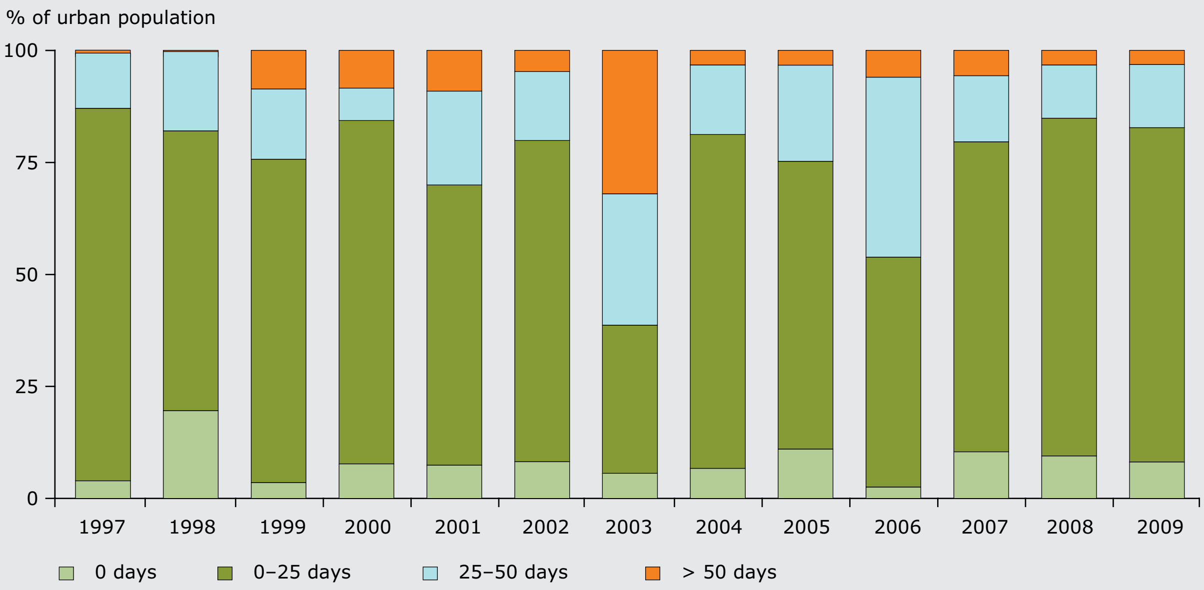
Air pollution in urban areas not only places additional stress on humans, but some pollutants have synergies with heat (Nawrot et al., 2007). Hot weather exacerbates air pollution through increased formation of ground-level ozone and, because hot periods usually coincide with dry periods, more particulate matter remains in the air (EEA, 2010d). Evidence for a synergistic effect on the mortality rate due to high temperatures and ozone-levels is increasing (Bell et al., 2005; Medina-Ramón et al., 2006; Stedman et al., 1997). Hence, part of the health effects and increased mortality during heatwaves may therefore be caused by decreased air quality (Filleul et al., 2006).

Previously, hot, dry summers with long-lasting periods of high air pressure over large parts of Europe led to elevated concentrations of ozone which exceeded the minimum threshold values for health risks. Analysis on a number of cities in the United Kingdom showed that between 21 to 38 % of those affected were not caused by heat, but by smog and particulate matter (Stedman, 2004). A study of a severe heatwave in Greece in 1987 showed that the effects in Athens were much stronger than in other, less polluted Greek cities (Katsouyanni, 1995)). Figure 2.4 shows a high percentage of the urban population affected by high ozone levels in 2003. This was a year when large parts of Europe were affected by a heatwave (EEA, 2011a; EEA, 2011b). Increasing temperatures and heatwaves in the future are expected to exacerbate the existing ozone problem. Forsberg et al., 2011 projects an increase of ozone-related deaths over the next 60 years in Europe, with 10 to 14 % increase being marked for Belgium, France, Portugal and Spain.

Temperature is clearly not the only predictor of ground-level ozone concentrations. The main drivers are the concentrations of ozone precursors: NO_x and volatile organic compounds (VOCs). NO_x are emitted during fuel combustion for example by road transport and industrial facilities. VOC are emitted from a large number of sources including paint, road transport, refineries, dry-cleaning and other solvent uses. Biogenic VOC are emitted by vegetation, with amounts released dependent on temperature. Methane (CH_4), also a VOC, is released from coal mining, natural gas extraction and distribution, landfills, wastewater, ruminants, rice cultivation and biomass burning (EEA, 2011b). Further reducing the emissions of ozone precursors is therefore an option to reducing periods with high ozone levels and adopting adaptation measures to more frequent heatwaves and warm weather periods in the future. NO_x and VOC emissions also need to be reduced in order to protect the population against the resulting direct health impacts.

Typical measures to improve air quality are therefore also supportive when coping with higher temperatures and heatwaves. These include the promotion of walking, cycling and the use of public transport; restrictions for road traffic; use of cleaner emission technology for transport, heating and cooling systems; creation of green areas, such as parks, can absorb and filter dust and other pollutants; and awareness raising and educating vulnerable groups to avoid certain activities during events of high air pollutant concentrations (CoR, 2011a; EEA, 2010b; VÁTI, 2011).

Figure 2.4 Percentage of the EU and EEA-32 urban population potentially exposed to ozone concentrations over the target value threshold set for protection of human health, 1997–2009



Source: EEA, 2011c (CSI 004).

2.1.3 *How can cities adapt to heat stress?*

The use of grey infrastructure — cooling for buildings and urban areas

Due to the expected increase in the number of hot days and heatwaves, it is anticipated that demand for air conditioning will increase. However, an increase in the use of air conditioners produces additional heat outside buildings and generates more greenhouse gases. Therefore, passive measures to provide cool spaces should be considered first — building designs that keep rooms cool via insulation (thick and well-designed walls, small windows, double glazing and the correct choice of materials) or blinds and public space providing shade and natural ventilation.

It is common that insulation measures are already considered as ways to reduce energy consumption and mitigate climate change. Integrating the adaptation concerns would provide even greater benefit to these measures. In the event that active cooling of buildings continues to be necessary, the most energy efficient air conditioning systems should be used and promoted through the Eco Labelling Directive (EC, 2000a) and awareness raising campaigns. District cooling is also an energy-efficient way to prioritise absorption cooling (which allows the use of excess heat from other processes) over compression cooling (which mainly uses electric energy). In Vienna, as well as in Dresden, district and local cooling are combined together.

The use of green infrastructure

Conservation and improvement in existing green and blue areas in cities and the creation of new spaces to ameliorate the urban heat island effect is hugely important and can have a number of additional benefits such as creating areas for recreation, biodiversity, filtering air and draining and storing water. Vegetation provides cooling through shading and enhanced evapotranspiration. Parks and open water areas are essential. Green and blue roofs lower temperature in buildings during the summer through insulation and enhancing evapotranspiration. Vegetation areas have a significant effect on the local climate as they incite the production of fresh and cold air, particularly at night, and have a thermally balancing effect during the day due to a high percentage of trees (SustainableCities.dk). Box 2.7 provides an example from Manchester with the issue being further elaborated in Chapter 3. The European Commission encourages green solutions as well, considering green infrastructure as an essential tool for climate change mitigation and adaptation. Investing in and building up green infrastructure needs smart and integrated approaches to spatial planning to ensure that Europe's limited land is turned into areas capable of providing multiple functions for nature and society (EC, 2012a).

Green infrastructure needs to be established in a careful way. The selection of plants needs to consider local water availability and potential scarcity.

Table 2.3 Overview on grey, green and soft adaptation measures to heatwaves following the structure of Box 2.2

Grey measures	Green measures	Soft measures
• Building insulation to keep the inside cool • Blinds to provide shade • Passive cooling of buildings • Urban designs providing shade • Ventilation of urban space by intelligent urban design • Emission reduction of air pollutants	• Boosting green infrastructure, such as green urban areas, trees, green walls and roofs where possible, but ensuring sustainable watering • Ensuring that fresh air from green areas outside the city can flow in	• General awareness raising and ensuring broad participation • Mapping of urban heat island as well as cool places • Identification of vulnerable groups and their distribution as basis for targeted action • Warning systems • Heat action plans including appropriate institutional structures • Preparedness of health and social care system • Information on adapting behaviour during heatwaves in particular to the vulnerable • Adapting building codes to include insulation and shadowing to cope with heatwaves • Consider reducing heatwave impacts through urban renewal projects and urban planning • Transport management to reduce air pollutants

Box 2.7 Manchester, United Kingdom — increasing green infrastructure helps to cool down

The modelling of surface temperatures in the conurbation of Greater Manchester has shown that they closely followed the pattern of areas covered by vegetation in the urban area. In town centres and areas of retail or industry (20 % vegetative area) the surface temperatures reached 31.2 °C on a hot summer day. By contrast, in woodlands (98 % vegetative area) the surface temperature was only 18.4 °C. While climate change will lead to an increase of temperatures in every part of the city, green space will significantly buffer some of the predicted warming. By 2080, under a high CO_2 emissions climate change scenario, surface temperatures would rise to 35.5 °C in the town centres (+ 4.3 °C), but just 21.6 °C in woodlands (+ 3.2 °C). If the amount of green space decreased by 10 % in town centres and other densely built-up areas, the surface temperature under the high emissions scenario could rise by as much as 8.2 °C by 2080 from the present 31.2 °C. On the other hand, an increase of green areas by 10 % would keep the maximum surface temperatures at nearly the same level as the 1961–1990 baseline conditions (Gill et al., 2007).

Photo: © Bogna Kazmierczak

Thus, the quantity of green spaces in the city is important for managing temperatures and other climate change impacts. The on-going project by Manchester City Council, 'City Centre Green Infrastructure Plan', recognises this factor and identifies where urban greening is the most needed. It also identifies actions needed for implementation. On a broader scale the Greater Manchester green infrastructure framework is currently being implemented addressing the areas of green space need and deficiency across the conurbation, with climate change adaptation as one of the guiding principles.

Source: http://www.greeninfrastructurenw.co.uk/resources/1547.058_Final_Report_September_2008.pdf.

The introduction of invasive alien species or the replacement of natural areas by artificial green areas can have negative impacts on biodiversity.

Soft measures

Awareness and behaviour changes
Awareness of the local population regarding effects of excessive heat on human health coupled with information on simple measures to prevent excessive heat stress enhances a city's preparedness. Such measures can reduce sensitivity to heat exposure at the individual and community level. Simple heat warning advices from 'avoid drinking alcohol' to 'wear a hat' can be very effective (see Box 2.8 for a Swedish example).

Health warning systems and heat action plans
Awareness raising is usually one of the components of so-called heat action or heat warning plans (Ebi et al., 2004; S. Hajat et al., 2010). The World Health Organisation Europe (WHO Europe) has published guidance on how to develop such plans (Barredo, 2009; Matthies et al., 2008)). The development of a Heat Health Watch Warning System (HHWWS) can be considered as a long term option to address heatwaves and other high temperature events. This usually comprises of a menu of individual options to respond to and prepare for extreme temperature events. Successful systems comprise of

- An agreement of a leading body to coordinate a multipurpose, collaborative mechanism between bodies and institutions and to direct the channelling of information flows in the event of an emergency;

Box 2.8 Botkyrka, Sweden: Tips on what to do in the event of a heatwave

Photo: © Sekkha

- Avoid unnecessary efforts. Assist with food shopping. Stop immediately what you are doing if you become dizzy or tired. Seek help if you feel unwell.
- Avoid stressful and unnecessary travel plans. Remember that it is often cooler in the morning and hottest early in the afternoon.
- Do not stay in the sun. Choose cool and shaded places when you are outdoors.
- Stay, where possible, in air conditioned or cool rooms. Select the coolest room in the house and ventilate during the night.
- Note that fans may cool down unless it is extremely hot in the room then they can cause dehydration.
- Libraries, restaurants and shopping centres may be air conditioned.
- Take a shower every day to stay cool.
- Choose light clothes which 'breathe'.
- Drink adequate amounts, preferably before you get thirsty. Water is fine, but avoid alcohol and very sweet drinks. Overly cold drinks can cause cramps. Request medical advice on fluid intake or if you use diuretics, ask your doctor about the appropriate action.
- Avoid hot drinks or eating overly hot food as this raises the body temperature.
- Replace salt and minerals in your body if you sweat heavily. Mineral water and sport drinks work well.
- Keep in regular contact with relatives, friends or neighbours. If you are old or sick, ask someone to stay in touch with you.
- Follow weather reports and bear in mind that health problems increase with an average daily temperature for more than two consecutive days over 22–23 °C.

Source: Botkyrka kommun, 2011; http://www.botkyrka.se/Nyheter/Sidor/Värmebölja-.aspx.

- Accurate and timely alert systems (systems trigger warnings, determine the threshold for action and communicate the risks);
- Heat-related health information plan (what is communicated, to whom and when);
- Reduction of indoor heat exposure (medium- and short-term strategies; advice to the public on how to keep indoor temperatures low during heatwaves);
- Particular care for vulnerable population groups;
- Health and social care system preparedness (staff training and planning, appropriate health care and the physical environment);
- Real-time surveillance and evaluation of measures (Matthies et al., 2008).

After the heatwave of 2003 several countries such as France, Hungary, Portugal, and the United Kingdom established national HHWWS. In Spain a HHWWS was established at the regional level in the province of Catalonia. Such systems already exist in several German federal states and the Netherlands. A number of municipalities across Europe have established similar systems adopting those elements from those national plans relevant and feasible for them (e.g. Madrid, Barcelona, Paris, Lyon, Marseille, Rome, Milan, Verona, London and Budapest. The 'Heat Alert' system in Budapest is coupled with a smog alert system and an UV alert system. It showed success in 2007 when mortality rates due to the extreme event had been lower in comparison to a similar period in 2003 (Paldy and Bobvos, 2010).

Stakeholder involvement

All relevant municipal stakeholders (e.g. municipal departments, public health services, meteorological services, hospitals and other medical institutions, schools, kindergartens, transport companies, mass media, local environmental protection organisations and companies) have their own 'protocol of activities' and the mandate to carry out these actions in the event of a heatwave. In Paris the city council's climate plan encourages elderly and disabled citizens to be listed on a special extreme heat register (CHALEX) (Mairie de Paris, 2011). Through an emergency number these vulnerable groups can acquire information on heat stress prevention measures and request a home visit when necessary. Volunteers and charities can play a major role in risk situations. An example is the Big Response project in the United Kingdom. The National Council for Voluntary Organisations in the United Kingdom, together with the Green Alliance and Global Action Plan, have completed a pilot project with four major UK charities to assess how the changing climate could directly affect their constituents and to provide input on what is needed now to protect services and people in the future (NCVO, 2012).

Mainstreaming into existing programmes, plans and policies

Additional soft options include the integration of adaptation concerns into local, national and European building codes, namely the demand for insulation and the provision of shade. The early integration of climate change adaptation into urban planning, such as a network of green areas, offers a more cost effective and long term solution than retrofitting the city with less optimal measures (note the Stuttgart example mentioned previously). In Copenhagen planning law demands that all new buildings with flat roofs have to be greened (Københavns Kommune, 2012).

Further reading

- Shaw, R., Colley, M. and Connell, R., 2007, *Climate change adaptation by design: a guide for sustainable communities*, TCPA, London (www.preventionweb.net/files/7780_20070523CCAlowres1.pdf).
- Matthies, F., Bickler, G., Cardenosa Marin, N. and Hales, S., 2008, *Heat-health action plans — Guidance*, WHO Regional Office for Europe, Copenhagen, Denmark (http://www.euro.who.int/__data/assets/pdf_file/0006/95919/E91347.pdf).
- CoR, 2011a, *Adaptation to Climate Change: Policy instruments for adaptation to climate change in big European cities and metropolitan areas,* European Union, Committee of the Regions, Brussels (http://80.92.67.120/en/documentation/studies/Documents/Adaptation%20to%20Climate%20Change/EN.pdf).
- Kazmierczak, A. and Carter, J., 2010, *Adaptation to climate change using green and blue infrastructure. A database of case studies*, University of Manchester, United Kingdom (http://www.grabs-eu.org/membersArea/files/Database_Final_no_hyperlinks.pdf).

2.2 Flooding

Key messages

- In Europe the natural hazards which have caused the greatest economic losses are flooding and storms. 2002 proved to be a record year with major flood events in six EU Member States and material damages rising to more than USD 21 billion Many European cities have to deal with flood risk management issues on a regular basis.
- In a warmer climate projections show a further increase in:
  - the risk of river floods in many western European and central eastern European areas;
  - of urban drainage flooding in in particular western and northern Europe;
  - the risk of coastal floods in particular for cities along north-western European, northern Italian and Romanian coasts due to sea level rise in combination with storm surges.
- Local city characteristics tend to be highly important along with regional characteristics in terms of impacts from projected increases in floods and intensive precipitation events.
- Cities can carry out a number of actions to enhance their protection against flood damage. These are not limited to 'grey' flood protection and appropriate urban designs but also green solutions (space for rivers) and various 'soft' solutions.
- Flood risks in a city can be strongly influenced by factors outside the city boundaries such as upstream river management. It requires a regional approach for solving the urban flood problems.

2.2.1 *What are the challenges for cities regarding flooding?*

Cities and flooding

Between 1950 and 2006, there have been 12 flood events in Europe (flash floods and river floods) with the number of fatalities exceeding 100 in each case (Barredo, 2006). The severe floods in Europe in the first part of this century were mostly caused by heavy rain events. The year 2002 proved to be a record year with major flood events in six EU Member States (Austria, Czech Republic, France Germany, Hungary and Romania). The total number of deaths was 78 with material damage rising to more than USD 21 billion (Genovese, 2006; Barredo, 2006 and 2009). Rivers have historically been and continue to be important transport routes. Therefore, most of Europe's large cities and conurbations are located along major rivers. For the same reasons of accessibility coastal areas have a concentration of major cities.

Many European cities have to deal with flood risk management issues on a regular basis (Barredo, 2006; Lugeri et al., 2010). The high economic losses caused by floods include damage to infrastructure, public and private property due to the flooding itself, erosion or landslides, indirect losses in or beyond the flooded areas such as interrupted power generation and deteriorated groundwater quality caused by pollution or salinization in coastal areas. Socio-economic challenges in the form of lower productivity, failure of services, loss of jobs and income sources pose additional problems.

In addition, floods cause loss of life and disease. The latter is due to the exposure to contaminated surface water (e.g. contaminated with sewage water or toxic heavy metals). People can also suffer from post-traumatic stress disorder (PTSD). Children, the elderly and people in poor health are also at risk. Table 2.4 shows four categories of flood impacts in urban areas.

Table 2.4 List of potential flood impacts in urban areas

Material impacts	Economic impacts	Health impacts	Emergency assistance impacts
Damage to: • residential, commercial and public buildings, space and assets; • transport infrastructure; • public utility objects and networks (electricity, communication, gas, water); • other vulnerable objects, e.g. petrol stations.	• Disruption of electricity network; • disruption of communication network; • disruption of traffic: Motor vehicles, public transport, bicycles, emergency services; • loss of business.	• Death; • health impacts due to contact with contaminated flood water; • health impacts due to damp and associated fungi; • citizens' experience of all relevant impacts in a flood event — post traumatic stress disorder due to dislocation and loss.	• Fire department services; • policy department services; • sewer management services; water board services.

Source: Adapted from van Riel, 2011.

In Europe, different types of floods appear (Box 2.9). Floods in urban areas can be attributed to one or several of these types. In addition, extreme precipitation events can deplete the urban drainage systems causing flooding in lower lying urban areas combined with sewer overflow (urban drainage flooding).

Box 2.9 Types of flooding affecting urban areas

Photo: © Katman1972

River floods are triggered by heavy rainfall, melting snow in upstream areas or tidal related influences. Ground conditions such as soil, vegetation cover and land use have a direct bearing on the amount of run-off generated. River floods occur when the river run-off volume exceeds local flow capacities due to intensive rainfalls. The river's level rises slowly and the subsequent period of rise and fall is particularly long, lasting several weeks or even months, particularly in areas with flat slopes and in deltaic areas. Those drainage or flood control works upstream failing or being poorly operated can also sometimes lead to riverine flooding.

Flash floods occur as a result of the rapid accumulation and release of run-off waters from upstream mountainous areas, which can be caused by extreme rainfall, cloud bursts, landslides, the sudden break-up of a dike or failure of a flood control works. Over natural watersheds they typically occur in the instance of more than 200 mm of rain during less than six hours, while in built-up areas even rainfall of 50 mm within one hour can produce a local flash flood. They are characterised by a sharp rise followed by a relatively rapid decline causing high flow velocities. Discharges quickly reach a maximum level and diminish almost as rapidly.

Coastal floods occur during storm surges when there are temporary increases in sea levels above the normal tidal range (EEA et al., 2008). An increase in storm surge height can cause severe urban coastal estuary, delta and embayment flooding and erosion. Coastal flooding may be exacerbated by river flooding when a river is unable to discharge into the sea due to sea level rise. Although the increase in sea level during a storm surge may be temporary, urban flooding episodes can last much longer depending on the ability of the urban area to drain the excess flood water. Accelerated coastal erosion, loss of property and land and the loss of human life are all indirect effects of storm surges. Where major urban areas are located on the coast disruption to transport and communications can affect the whole country for weeks afterwards.

Urban drainage flooding during extreme precipitation events is caused by an insufficient capacity of the piped system or less effective drainage into an outfall because river levels are raised. The excess water travels down roads and other paths of least resistance and floods low lying areas. Urban flooding is exacerbated by saturated or impervious soils. As such, built environments with roads, infrastructure and substantial surface sealing prevent rainfall from infiltrating into the ground, thereby causing a higher surface run-off that may be in excess of local drainage capacity.

Groundwater flooding, caused by extensive periods of precipitation (weeks or months), may lead to a slow move of groundwater to low-laying areas where the groundwater table breaks the groundwater. Depending on the local hydro-geological situation, groundwater rising or subsurface flows can be other causes in the generation of urban floods.

Table 2.5 Factors contributing to flooding

Meteorological factors	Hydrological factors	Human factors aggravating natural flood hazards
• Rainfall • Storm surges • Temperature • Snowfall and snowmelt	• Soil moisture level • Groundwater level • Presence of impervious cover • Channel cross-sectional shape and roughness • Topography, slope, basin geometry • Presence or absence of over bank flow, channel network • Synchronisation of run-offs from various parts of watershed • High tide and heavy swell impeding drainage • Presence of strong ice cover on rivers	• Land-use changes (e.g. surface sealing due to urbanisation, deforestation) • Inefficiency or non-maintenance of sewage system; river margins clearing • Building in flood-prone areas • Reducing/cutting off retention areas

In the main text of this section, we focus on the kinds of floods and flood impacts that are most relevant for urban areas. We do not elaborate in detail as to the effects of high winds (for additional information see Box 2.13) neither do we address the secondary effects of climate impacts, such as flooding, outside the city area.

Flood determinants and their effects

Floods result from a combination of meteorological and hydrological extremes. In most cases floods are additionally influenced by human factors. For example, human settlement into flood prone areas and lack of flood response plans increase the damage potential. Although human influences are very diverse, they generally tend to aggravate flood hazards by accentuating flood peaks. Thus, flood hazards in built-up environments have to be viewed as the consequence of natural as well as man-made factors. Table 2.5 lists meteorological, hydrological and human factors contributing to flooding. In order to manage urban floods, it is essential to understand the causes and impacts of each one of them.

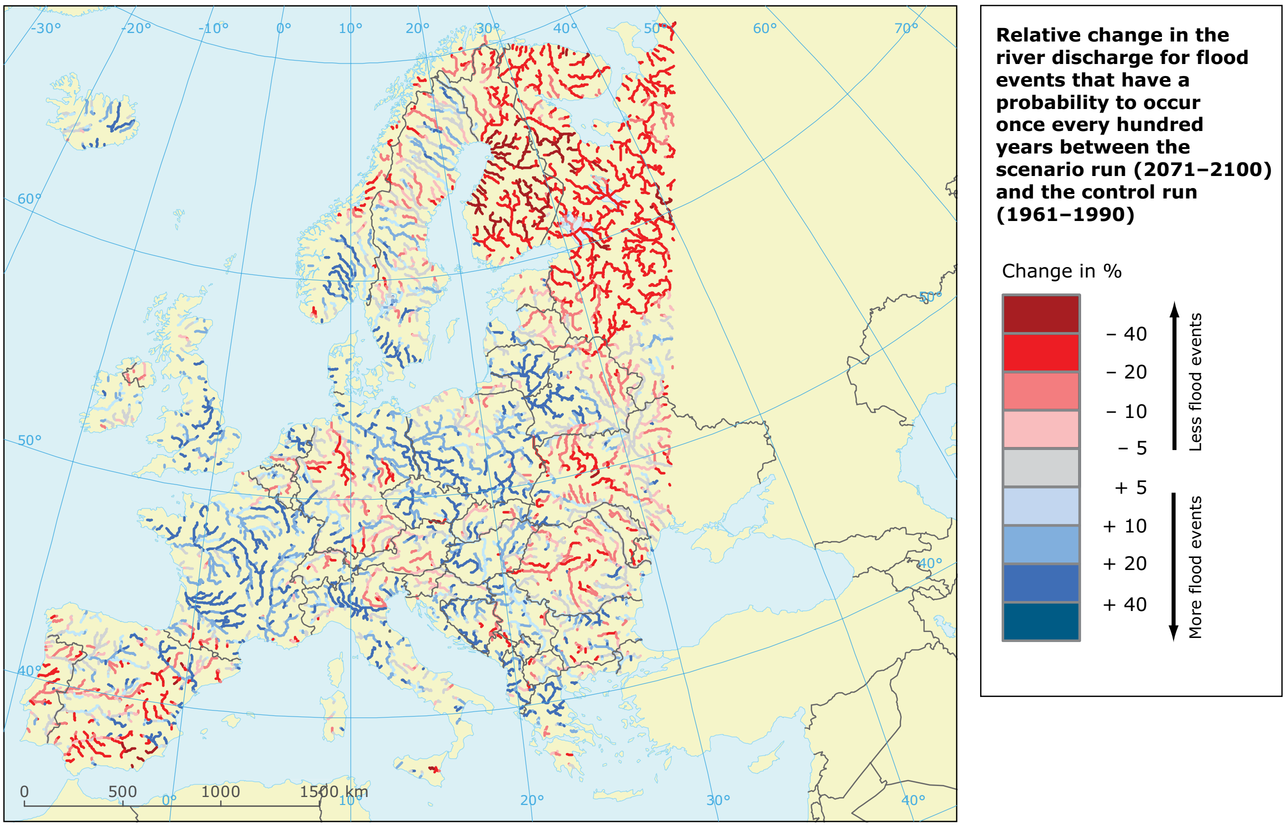
2.2.2 *What are the potential flooding impacts on Europe's cities?*

River floods

Future projections made by multi-model simulations with global and regional climate models show a precipitation increase in northern Europe during all seasons, whereas a decrease for Southern Europe is found. In central Europe, precipitation is projected to rise in winter and decline in summer (Christensen and Christensen, 2007; Van der Linden and Mitchell, 2009; Harris et al., 2010). Besides extreme precipitation snowmelt can also cause floods in snow-affected river catchments. Due to increased temperatures, the snow pack decreases and leads to lower snow melt induced flood peaks. Snowmelt starts earlier within the year and leads to a temporal shift of the snowmelt peak.

Projections of river flood hazard in Europe show that climate change leads to an increase in the likelihood and intensity of extreme high river flows for large parts of Europe (Lehner et al., 2006; Hirabayashi et al., 2008; Dankers and Feyen, 2008). In other regions the frequency and intensity of floods could decrease, yet even in regions that will become dryer on average, floods could occur on a more frequent basis. Map 2.8 shows the projected change in the river discharge for a flood which indicates an extreme flood event that statistically returns only once every 100 years. Other flood projections have recently been performed in the ClimWatAdapt project. It projects an increase of water level for 100 year flood events in northern United Kingdom and along the North Sea coast in the Netherlands and Belgium, the United Kingdom, Ireland, and Norway by 2025. In 2050 such a once every 100 years event could cause severe floods in more than 80 % of the area of the United Kingdom, Western France, Belgium, Netherlands, western Germany, Finland, as well as large areas in Portugal and Spain according to the upper end of projected ranges (Flörke et al., 2011).

Map 2.8 Relative change in the river discharge for flood events that have a probability to occur once every hundred years between the scenario run (2071–2100) and the control run (1961–1990)

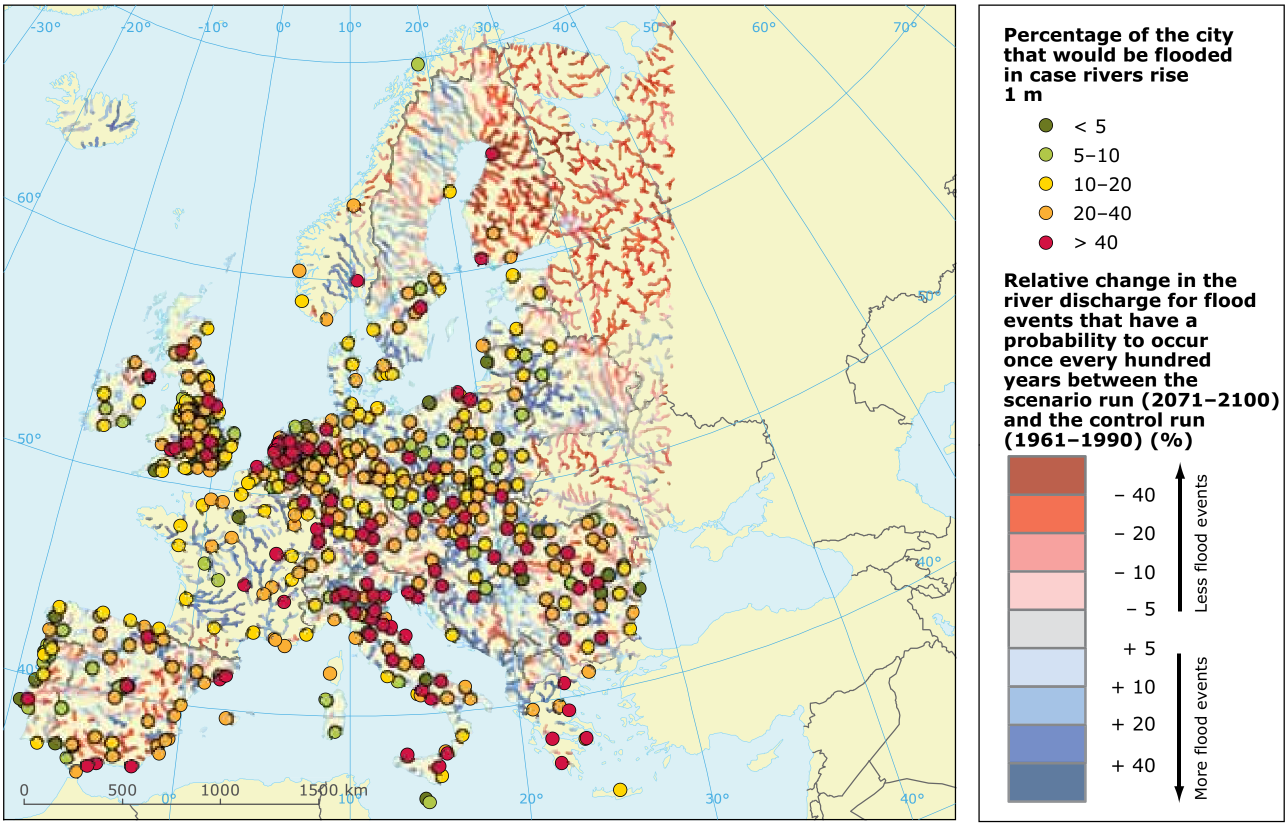


Note: Simulations with LISFLOOD model driven by HIRHAM — HadAM3H/HadCM3 and IPCC SRES scenario A2. Only rivers with a catchment area of 1 000 km² or more are shown. Map elaboration by EC JRC/IES.

The sensitivity of cities depends on several factors. Urban areas situated on low-lying areas in the middle or lower reaches of river basins are particularly sensitive to extensive riverine floods. Increased urbanisation via land take and soil sealing combined with deforestation and the reduction of wetlands in the wider region diminish the natural water storage capacity. As a result run-off increases. In the event of intensive precipitation this leads to a growth in the flow amplitude and a shorter time before peaking. Parts of the city below the flood line and protected by artificial levees face devastating flooding through the breaching of the levees.

Map 2.9 depicts the percentage of the urban area of a city that would be flooded in the event the water rises by one metre. The map indicates if a city has a large share of low-lying parts but one should expect that the potential damage increases with a larger flooded area. The map indicates the risk of considerable damage throughout Europe in particular deltas in the Netherlands (Rhine-Meuse) and North Italy (Po). However, the map should be interpreted with caution, since neither coastal floods nor flood protection measures are considered in the calculations.

Map 2.9 Percentage of the city that would be flooded in case rivers rise one metre



Note: The background (= Map 2.8) shows the relative change in 100-year return level of river discharge (red = decreased discharge, blue = increased discharge).

Neither coastal floods nor flood protection measures are considered in the calculations.

The potential flooded area is based on a 'volume model'. This model is based on water level and subsequent difference between modelled water level and the digital elevation model. The city is defined by its morphological form (Urban Morphological Zone) inside the core city boundaries derived Urban Audit (Eurostat, 2012).

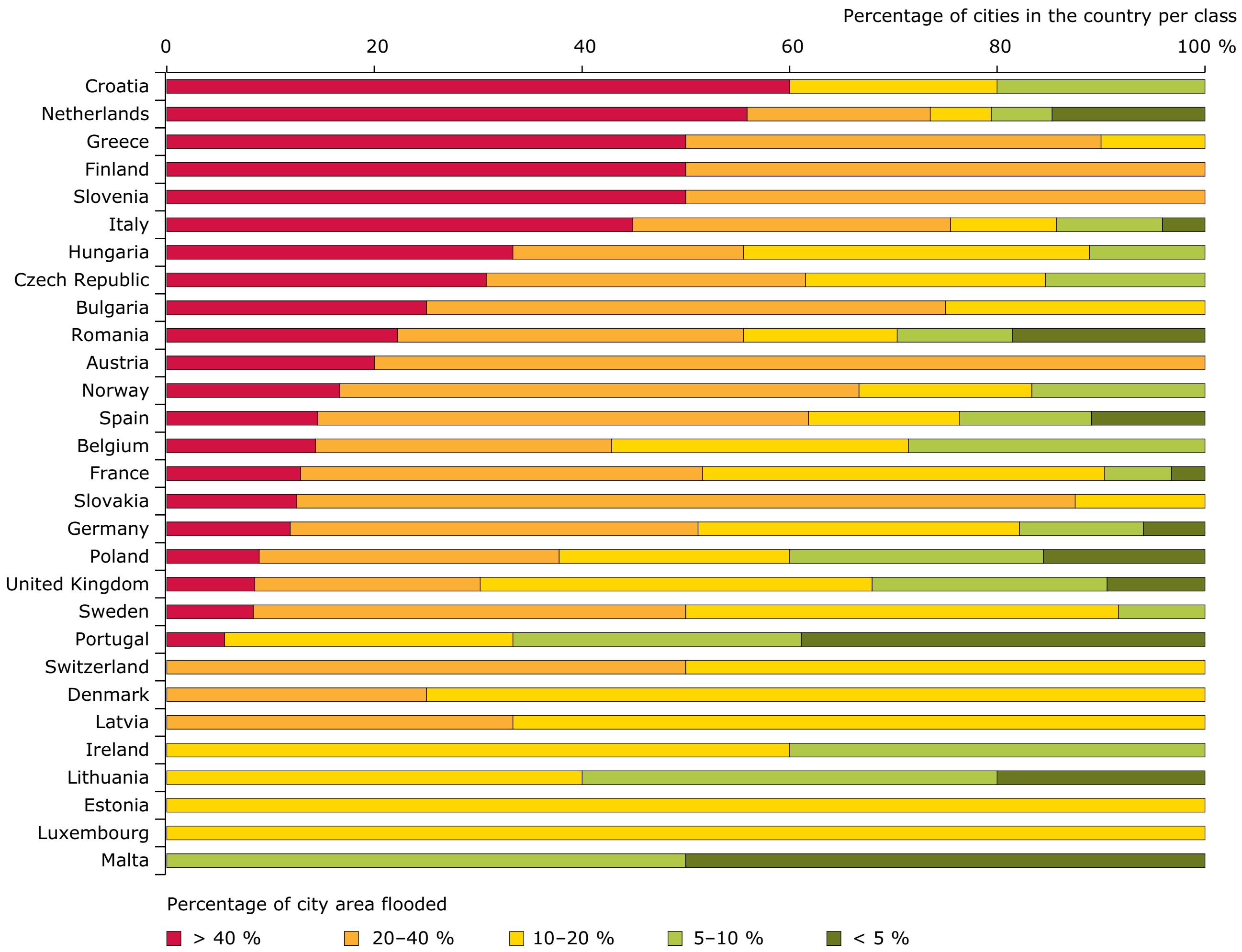
Source: EC JRC/IES; EEA.

On a country level, Figure 2.5 reveals that roughly one fifth of European cities with over 100 000 inhabitants can be placed into the vulnerable category (> 40 % flooded). The share of these cities is in particular high in the Netherlands, Croatia, Slovenia, Greece and Finland. In some countries, such as Ireland, the risk is more uniformly distributed, with cities only in the lower categories. In other countries, such as the Netherlands and the United Kingdom, the differences amongst the cities are large.

These results suggest that cities sensitive to river floods do not cluster in one region only. High sensitivities can be found in areas with a projected increase and decrease in flood events. Local city characteristics tend to be more important than similar regional characteristics.

Different scenarios indicate that between 250 000 and 400 000 additional people per year in Europe by the 2080s will be affected by river flooding — most of them in cities (Ciscar et al., 2011). Socio-economic

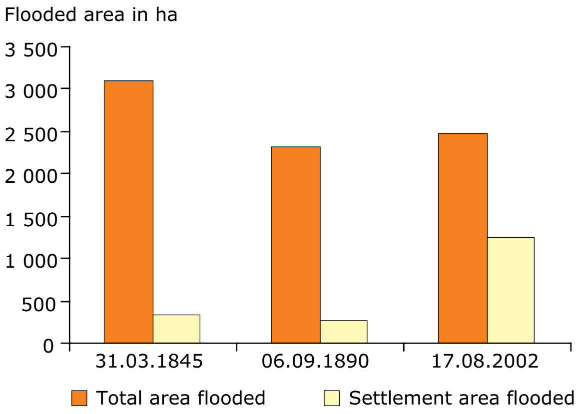
Figure 2.5 Percentage of the urban area that would be flooded as displayed in Map 2.9 — share of cities per class per country



Note: Generally, only cities with more than 100 000 inhabitants are considered.

trends such as urbanisation can exacerbate the risk. The highest numbers of people affected by severe floods will be in areas with large population densities. Urbanisation and associated increases of impermeable land surface coupled with housing and business development of river floodplains exacerbate flood risk in urban areas. Building on floodplains and flood retention areas increases the risk as shown in the Dresden example. The comparison of three major flood events from the river Elbe in 1845, 1890 and 2002 shows that the built-up area increased dramatically over time. Although the total flooded area in 2002 was only slightly bigger than in 1890 and smaller than in 1845, the settlement area in flood plains had grown considerably over the past century (Schumacher, 2005; EEA, 2010b) (see Figure 2.6).

Figure 2.6 Flood events and flooded built-up areas in Dresden, Germany



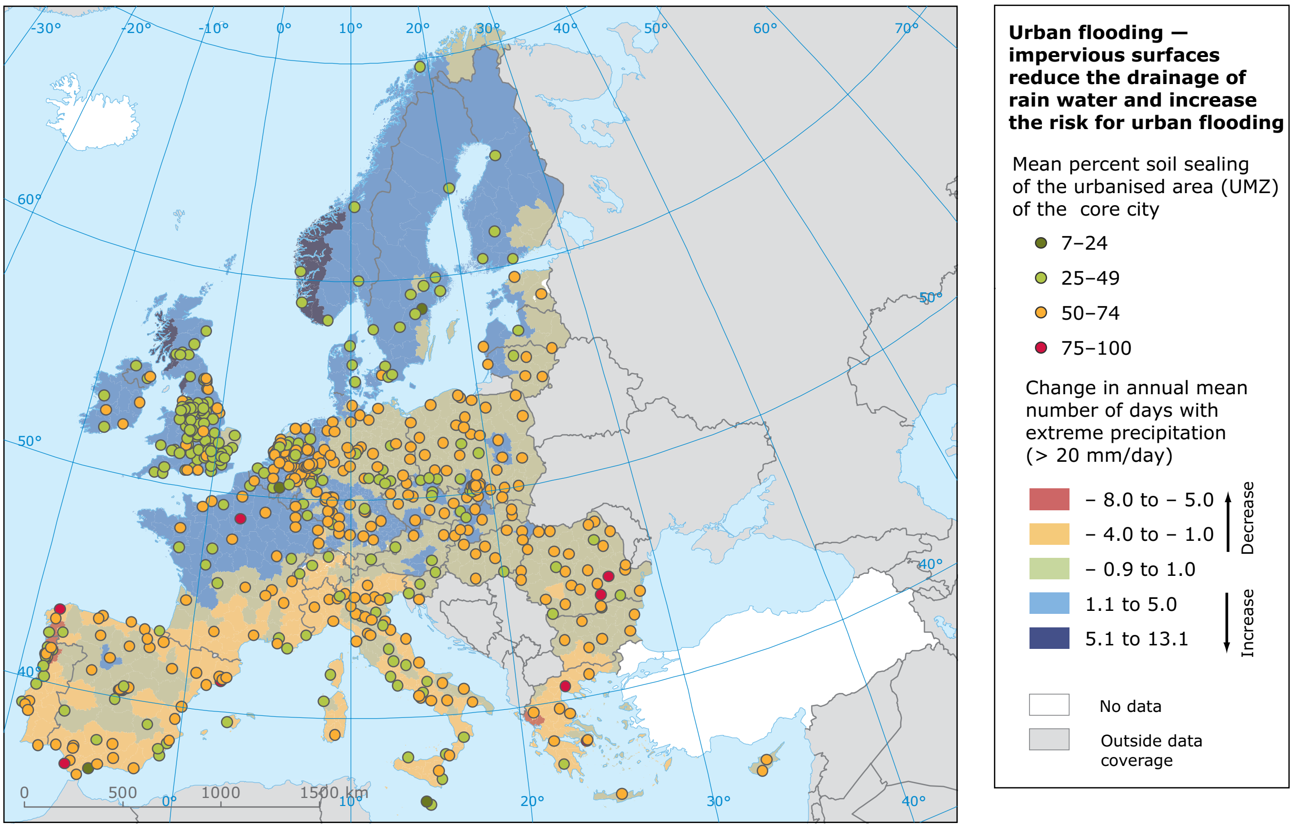
Source: Schumacher, 2005; EEA, 2010b.

Urban drainage floods

In regions with an increase in average precipitation, the occurrence of intense precipitation events (frequency or proportion of total precipitation) is very likely to increase (IPCC, 2012). The reverse is true for regions with declining average precipitation. Map 2.10 shows the projected change in the annual number of days with heavy rainfall in 2071–2100 against the reference period (1961–1990). It shows an approximate north-south division with the imaginary division line being the Alps. Projections for regions south of the line show, in general, a decline in the number of days with extreme precipitation of up to five days and more. Most regions north of the line expect an increase, mostly of one to three days. Yet the coastline of Norway as well as Ireland and western United Kingdom and some parts off the Atlantic coast of France can expect an increase of between four and 13 days (Greiving et al., 2011).

In addition, Map 2.10 shows the degree of mean soil sealing per urbanised areas of cities. This indicates reduced natural drainage as the water is passed on to the sewage system. Cities with high soil sealing and an increasing number of intensive rainfall events — in particular in north-western and northern Europe — face a higher risk of urban drainage flooding. Nevertheless cities in areas with a decreasing number of such events but high soil sealing still face a flooding risk, just less often. Cities of high and low soil sealing can be found in all regions and do not cluster in a particular region with the exception of low sealing levels in cities in Finland, Norway, Slovenia and Sweden. Cyprus, Estonia, Greece and Luxembourg are countries with a high share of cities with elevated levels of soil sealing (Figure 2.7).

Map 2.10 Urban flooding — impervious surfaces reduce the drainage of rain water and increase the risk for urban flooding

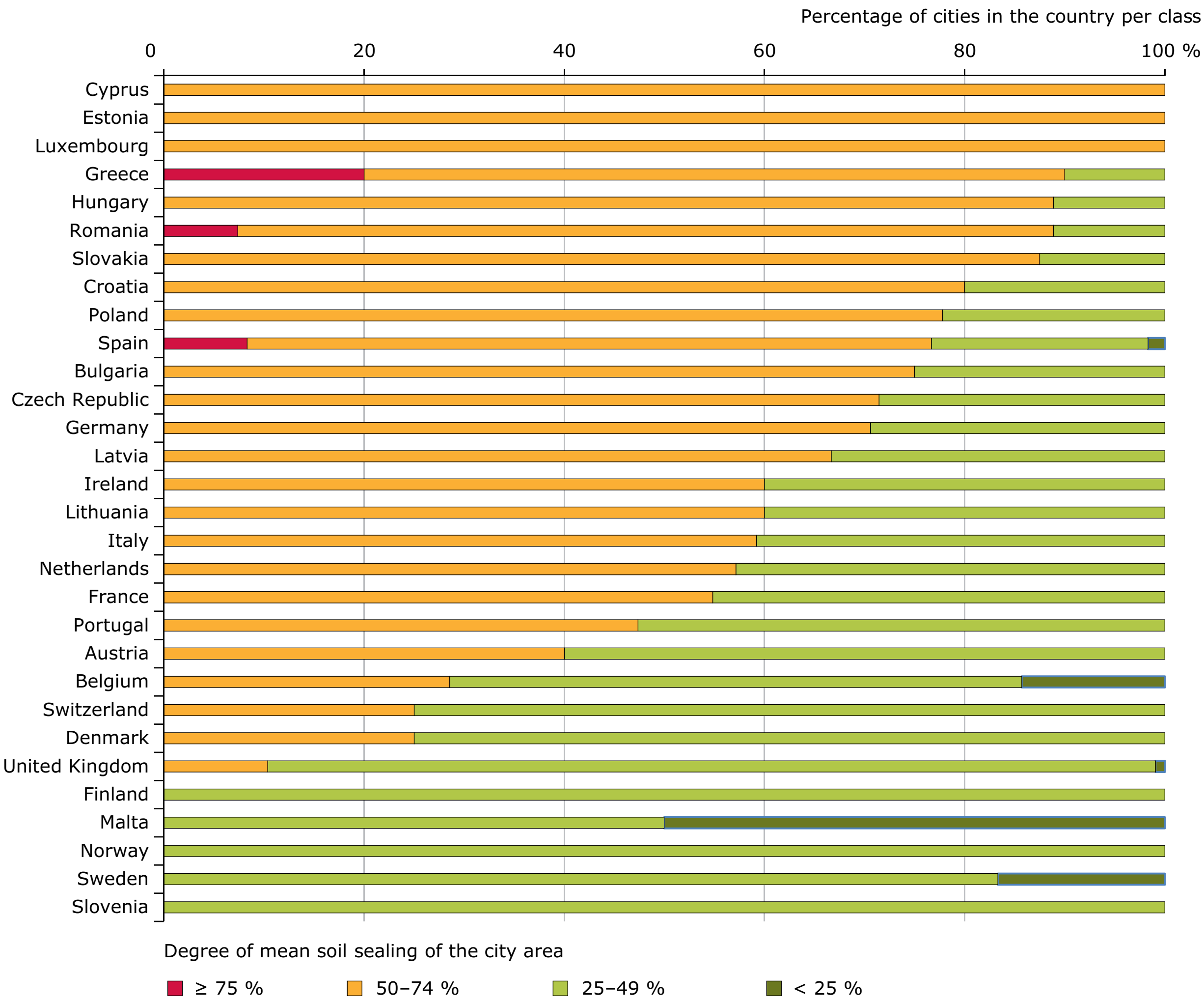


Note: Mean per cent soil sealing per city and change in annual mean number of days with extreme precipitation (> 20 mm/day) between the CCLM scenarios run (2071–2100) and the reference run (1961–1990) for IPCC scenario A1B.

The city is defined by its morphological form (Urban Morphological Zone) inside the core city boundaries derived from Urban Audi (Eurostat, 2012).

Source: EEA (soil sealing); Lautenschläger et al., 2009 (precipitation).

Figure 2.7 Degree of mean soil sealing per city — share of cities per class per country (based on Map 2.10)



Note: Generally, only cities with more than 100 000 inhabitants are considered.

A city's weakness does not depend solely on soil sealing but also on rain water management. For decades urban drainage systems have been optimised to drain a shower with a particular return period. Considering future climate and on-going urbanisation, this 'carrying capacity' has already turned out to be inadequate in a number of cities (see the Copenhagen example in Box 2.10). There are several factors that tend to increase the risk.

- Old drainage infrastructure often does not keep pace with on-going urbanisation. The increase in the share of impervious surfaces overloads the capacity of the sewage system in the face of extreme events.
- The conventional way of dealing with rainfall and waste water in urban areas has been to carry it away as quickly as possible via underground pipes and sewers. Older areas normally have a combined sewer system, where rainfall drains into sewers carrying sewage and both are transferred to sewage treatment works. These systems are more vulnerable to excessive rainfall than a separate treatment.
- The existence of inadequate maintenance of the drainage channels to monitor debris and solid waste within such systems.
- Inadequate discharge of excess water to the regional water system. This is particularly apparent in delta areas in the Netherlands where surface level differences and hydraulic gradients are small and urban flooding occurs easily.

Box 2.10 Flooding in Copenhagen, Denmark on 2 July 2011

After a substantially hot period Copenhagen was hit by a huge thunderstorm on 2 July 2011. During the afternoon clouds and thunder had been building up over the southern part of Sweden. During a two hour period over 150 mm of rain fell in the city centre. This constituted the biggest single rainfall in Copenhagen since measurements began in the mid-1800s.

The city's sewers were unable to handle all of the water and as a result many streets were flooded and sewers overflowed into houses, basements and onto streets thereby flooding the city. The consequences were quite drastic as emergency services had to close roads and attend to people trapped in their cars. The emergency services were within minutes of having to evacuate the city's two biggest hospitals because of flooding and power cuts.

Insurance damages alone were estimated at EUR 650–700 million. Damage to municipal infrastructure not covered by insurance, such as roads, amounted to EUR 65 million.

That the city's sewers could not handle the huge amounts of rain water was no surprise — they are designed to handle much smaller amounts of precipitation. The city's sewage system combines rainwater and sewage together thereby making the city vulnerable if the amount and intensity of rainfall increases.

The fact that Copenhagen over the last year has experienced a number of torrential rain falls has caused the city to really take notice. The city has prepared and approved a climate adaptation plan with the principle aim being to separate as much rain water from sewage water as possible. The city has estimated that it is currently not an option to expand the sewage system to handle the predicted larger amounts of rain water.

Photo: © Risager

The city is currently preparing a so-called 'cloudburst plan'. The plan has four steps:

- Rescue services — the city is preparing a new rescue service plan to handle extreme rainfall. This includes warning systems and pumps to ensure quick relief.
- Vulnerability — communication with citizens, businesses and public institutions to provide advice on taking appropriate measures to protect properties and vital systems (such as technical systems which are typically in basements).
- Optimising the city's existing sewage system. The water utility company has prepared a number of initiatives to allow the sewage system to handle more rain water by having a 'cloudburst' control which can be activated in case of heavy rain and will enable the system to handle more water.
- A long term plan has been suggested to process the majority of the surface rain water via a system of small canals that can divert the water either to streams, the harbour or areas where it can be stored until being processed into the sewage system. This plan will be implemented in cooperation with neighbouring municipalities that also process their sewage water through Copenhagen.

Sources: Lykke Leonardsen, city of Copenhagen, personal communication, 2011.
Copenhagen climate plan (short version): http://kk.sites.itera.dk/apps/kk_publikationer/pdf/794_kZEjcvbgJt.pdf;
long version (Danish): http://www.kk.dk/sitecore/content/Subsites/Klima/SubsiteFrontpage/~/media/1366A5817180444D88FD0DAE316229A0.ashx.

Flash floods

In Europe, 40 % of the flood-related casualties in the period 1950–2006 were due to flash floods (Marchi et al., 2010; Barredo, 2006). Most flash floods occurred in a geographical belt crossing Europe from western Mediterranean (Catalonia and south-western France) to the Black Sea, covering northern Italy, Slovenia, Austria, Slovakia and Romania. In the Mediterranean and Alpine-Mediterranean regions, flash floods occur predominantly in the autumn, whereas in the inland continental region their occurrence is often during summertime, suggesting the impact of different climatic factors. In addition, flash floods in Mediterranean areas are generally more intense, and the spatial extent and duration of the events larger than in continental areas.

Box 2.11 Flash flood in Dresden, Germany in August 2003

Photo: © Archiv BF Dresden

On the 12 and 13 of August 2002, the city of Dresden in Germany and surrounding settlements were hit by a flash flood from the river Weißeritz, a small tributary of the Elbe (Hutter et al., 2007). The low pressure system 'Ilse' caused continuous, intensive rainfall for 1.5 days over the eastern parts of the Federal State of Saxony. The situation around Dresden was exacerbated by its topography leading to heavy rainfall in the Ore Mountains. The area faced the highest precipitation in a two day period since records began. The total rainfall amounted to 180 mm in Dresden, 250 to 300 mm in the lower and middle ranges of the Ore Mountains, and more than 300 mm in the upper ranges (locally up to 400 mm). The water masses caused heavy flash floods in river catchments of four Elbe tributaries (Goldberg et al., 2003). The flash flood of the Weißeritz hit Dresden and was later classified as a flood event likely to take place only once every 500 years. The discharge at Freital, a town located at the edge of Dresden's city boundary, was 300 times higher than normal (Goldberg et al., 2003). In Dresden the river used its old riverbed as a second discharge channel. The riverbed had been replaced in the 19th century. The flood caused several casualties and large damage to buildings, bridges, railway tracks, streets and other infrastructure (Goldberg et al., 2003; Hutter et al., 2007). The material damage in the Weißeritz catchment amounted to EUR several hundred million (Goldberg et al., 2003), while for Dresden alone damage was estimated to be EUR 250 million (Hutter et al., 2007).

Several days after the flash floods, a flood wave from the river Elbe arrived, caused by heavy rainfall in eastern Germany and the Czech Republic. The peak of this flood, with an unprecedented height of 9.40 metres, reached the city on 16 August (Landeshauptstadt Dresden, 2011). Several areas of the city were flooded for a second time.

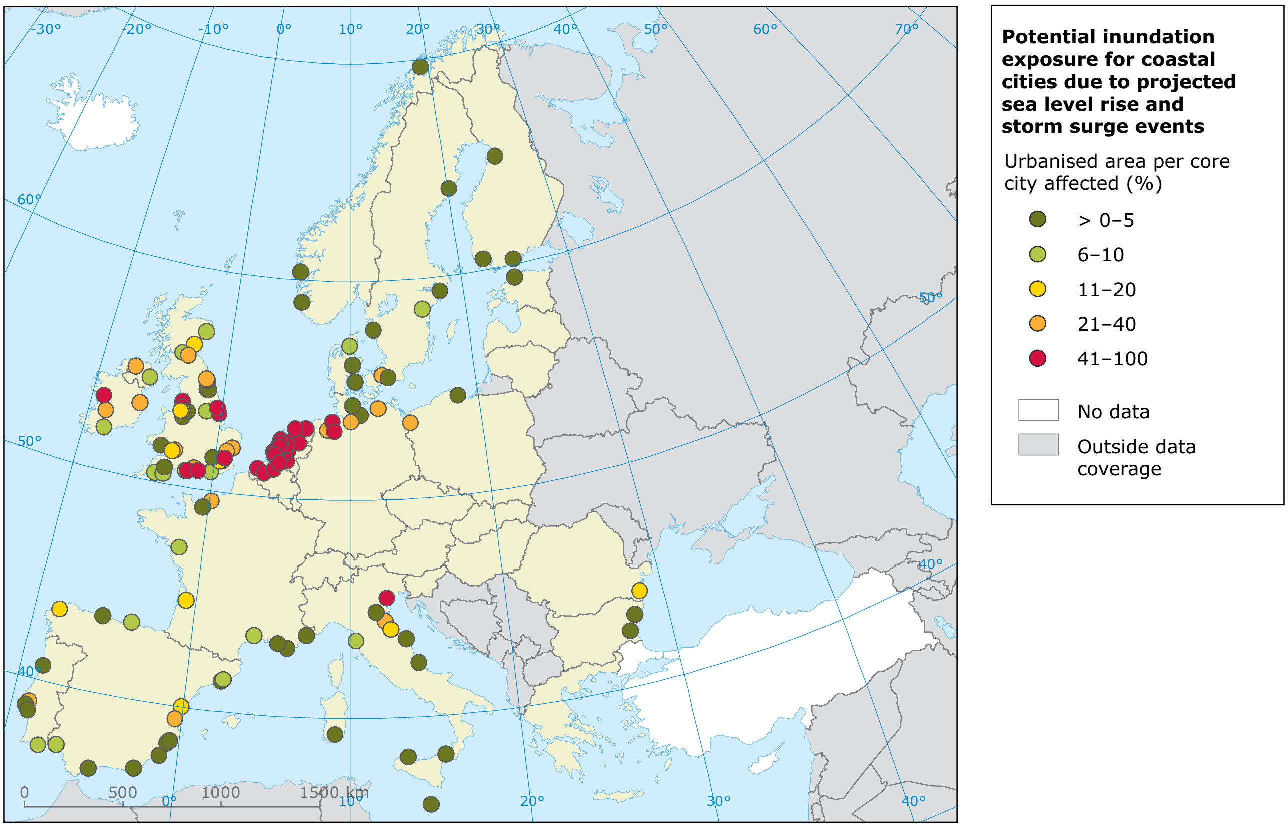
Flash floods depend on a complex array of factors including rainfall intensity, rainfall duration, surface conditions and the topography and slope of the receiving basin. Therefore, it is difficult to predict future risk assessments, in particular at the European level. The projected increase in frequency of extreme precipitation events will increase the risk of flash floods. Also, the potential impact (casualties, economic damage) could well increase in a number of regions in flash-flood prone areas in Europe due to the increasing pressure on land use (Marchi et al., 2010).

In densely populated areas flash floods are more destructive than other types of flooding because of their unpredictable nature and unusually strong currents carrying large concentrations of sediment and debris. Little time would be available for communities living in the flood's path to adequately prepare for its arrival leading to major destruction to infrastructure and humans.

Coastal flooding

Sea level rise projections for Europe indicate the greatest increases for the Baltic and Arctic coasts and northern Mediterranean coasts (Johansson et al., 2004; Meier, 2006; Nicholls, 2004). Wave height is likely to increase from North Sea storm surges predominantly affecting those coastal urban areas in north-west Europe where major cities and economic centres are located (EEA et al., 2008). The latest projections on sea level rise on the basis of a balanced scenario indicate values for the year 2100 that are between 0.97 and 1.56 meters above the 1990 annual mean sea level. This follows the SRES A1B scenario (Vermeer and Rahmstorf, 2009). These results should be viewed with caution due to the fact that the physical basis of the models for these estimates is lacking (Stocker et al., 2010).

Map 2.11 Potential inundation exposure for coastal cities due to projected sea level rise and storm surge events



Note: This calculation includes the change of inundation height due to coastal storm surge events generated by the DIVA project. A potential sea level rise of one metre has been calculated.

Source: Greiving et al., IRPUD 2011, © ESPON 2013 (inundation); EEA (Urban Atlas, UMZ).

Future projections indicate a slight decrease in the number of storms, but an increase in the strength of the heaviest storms. Projections to the end of the 21st century show a significant increase in storm surge elevation for the continental North Sea and south-east England (EEA et al., 2008). Map 2.11 shows how major cities are potentially affected by the change of inundation height given a 100 year coastal storm surge event that includes sea level rise. Primarily cities at the Dutch, German, Belgium and northern Italian coastlines would expect severe changes. Due to data constraints, coastal defence systems such as dikes could not be considered in these calculations so that the map only shows the potential effect on urban areas. The hotspots which emerge from this analysis appear, however, to be plausible and can serve as a basis for checking local and regional preparedness to climate change accelerated coastal storm surges.

The city is defined by its morphological form (Urban Morphological Zone) inside the core city boundaries derived from Urban Audit database (Eurostat, 2012).

Although the increase in sea level during a storm surge may be temporary, the flooding of urban areas can last much longer depending on the ability of the urban area to drain the excess flood-water. Accelerated coastal erosion, loss of property and land and the loss of human life are all indirect effects of storm surges. When major urban areas are located on the coast, disruption to transport and communications can affect the whole country for weeks afterwards. See Box 2.12 for an example in Belgium.

Many coastal areas were preferred to establish large cities and urban agglomerations due to the importance of international maritime transport. They have seen rapid population increases and urbanisation (McGranahan et al., 2007; Nicholls

Box 2.12 Coastal erosion and urban areas at the Flemish coast, Belgium

Coastal erosion occurs naturally with or without climate change. It mostly affects natural and rural areas. However, where it happens in proximity to urban areas, local implications can be significant in terms of loss of buildings, infrastructure, and flood defence systems. An increasing urbanisation of coastal areas has interrupted or changed natural processes of erosion and accretion and exacerbated the problem. Further exacerbation from climate change could well follow.

Along large parts of the Flemish coastline erosion forms an acute threat despite numerous protection measures taken. The existing almost linear coastline is man-made. The seawall is the main barrier to protect the coast, its inhabitants and the lower lying hinterland from storm tides and floods. Both the coast and the polders behind are densely populated and of high economic, social, recreational and ecological value.

In the city of Oostende, for example, the old town centre with its seawards position compared to the rest of the coastline (see photo) and low-lying city centre at the mean high-water level, is protected against flooding by a seawall which was built some 140 years ago. The seawall has, over years, accelerated the erosion process of the beach in front. The remaining narrow beach and the seawall offered only limited protection against damages from storm surges and by consequence the city centre was until recently only protected against flooding for storm events statistically occurring once every 25 years.

Photo: © Sillevl

During regular yearly storms water was frequently washed over the sea wall. In 1953 a storm caused serious city centre flooding in which eight people died and extensive material damage took place. In 2004, emergency beach replenishment ('nourishment'), in anticipation of a more sustainable project, created a beach that increased the protective level against a storm the size of which would only occur once every one 100 hundred years. This is a temporary measure which requires continuous maintenance work. The measure was not sufficient to protect against a storm the size of which would occur once every 1 000 years, something which is required by the Flemish government's coastal protection plan released in 2011.

The coastal protection plan for Oostende now foresees a new beach which will protect the city from flooding by a storm of that size. The most important stabilising element for this beach is a dam construction perpendicular to the coastline at the north-eastern side of the new beach. This dam reduces the movement of sand along the shore and stabilises the new beach. It will reduce the need for beach replenishment to once every ten years. The coastal protection plan for Oostende was combined with the harbour improvement plan and several additional projects such as the renovation of the promenade and the construction of an underground parking area forming part of the dike.

These measures are part of the Flemish government's coastal protection plan of 2011. It requires a minimal protection level for a storm the size of which would only occur once every 1 000 years including the projected levels of sea level rise up to 2050 and a protection against higher storm surges in cases of significant residual risk of damage or casualties. Where possible, it opts for more natural options such as replenishing the beach and supplementing this with fixed constructions including sea dikes.

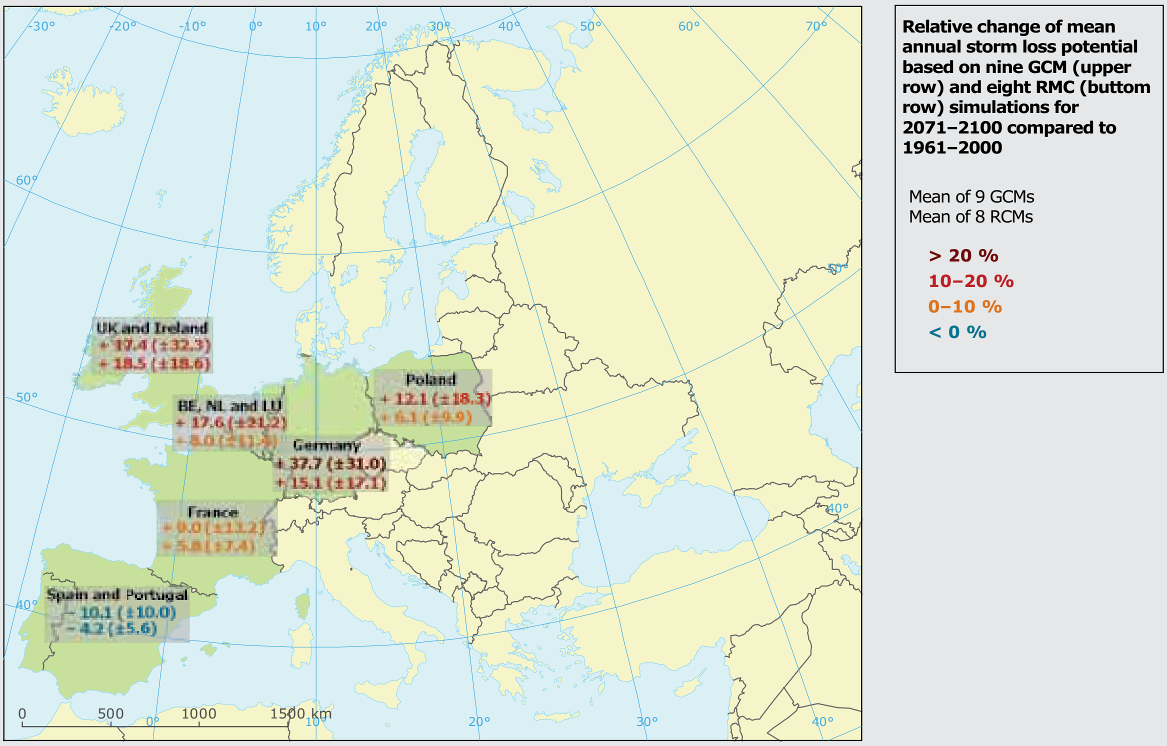
Source: Coastal Atlas: http://www.coastalatlas.be/en/themes/coastal-defence-management.
Coastal protection plan: http://zeeweringenkustbeheer.afdelingkust.be/level2.asp?TAAL_ID=1&ITEM_L1_ID=12&ITEM_L2_ID=24.

et al., 2007). Projections made by Ciscar et al., 2011 show that without adaptation the number of people affected annually in the 2080s would increase significantly in all scenarios. This could potentially affect between and 775 000 and 5.5 million people. The British Isles, central Europe, northern and southern Europe are the areas potentially most affected by coastal floods (Ciscar et al., 2011). However, when adaptation (dikes and beach replenishment) is taken into account, the number of people potentially exposed to floods is reduced significantly.

Box 2.13 Risks of storms and high winds for cities — not only on the coast

Storms are, together with other extreme events, the main threat of climate change for built-up areas. Casualties can occur, but their number is relatively low compared with other extreme events such as heatwaves or floods (Schauser et al., 2010). Wind-related insured losses in Europe are projected to increase by 5 % until 2080, considering only climate change factors (Hunt and Watkiss, 2010). Built-up areas (especially roofs and facades) and green areas are particularly vulnerable. Furthermore, transport and supply systems may be jeopardised, particularly by fallen trees and lampposts. Failures in these systems affect almost every field of contemporary life (Schauser et al., 2010; VÁTI, 2011). For Europe, the total number of storms is projected to decrease, while the strength of heavy storms might increase (EEA et al., 2008). However, in the entire Atlantic region of Europe (Benelux, north-western parts of France and Germany, Ireland and the United Kingdom) storms are projected to be more intensive and frequent. In southern Europe storm wind speeds of are projected to decrease (Schauser et al., 2010). Projections of intensity and frequency of storm events are very uncertain (Hunt and Watkiss, 2010; EEA et al., 2008). Storms appear often in combination with other extreme events such as storm surges, hail, thunder or heavy precipitation.

Map 2.12 Relative change of mean annual storm loss potential on nine GCM (upper row) and eight RCM (bottom row) simulations for 2071–2100 compared to 1961–2000 (SRES A1B scenario)



Source: Donat et al., 2011.

Cities facing increasing risks of storm damage can respond in several ways. Grey infrastructure approaches can include the design of buildings in a more wind-resistant way and the reconstruction of vulnerable buildings, decentralisation of energy systems and placement of electricity and other cables underground. Soft measures can include the adjustment of building regulations, financial support for retro-fitting of buildings, insurances to finance repairs and replacements after storm events, preparation or adjustment of emergency response plans. This would include for public transport in the case of blocked roads, electricity supply back-up systems for health care and other emergency services and the strengthening of local disaster management (e.g. improve or expand equipment, develop tactics). Forecasting and early warning systems are fundamental for emergency responses. Cooperation with meteorological services can help to improve these arrangements (Schauser et al., 2010; VÁTI, 2011; ONERC, 2010; OECD, 2010; CoR, 2011a).

In the Hungarian city of Tatabánya, the CLAVIER research project evaluated the vulnerability of buildings to storms. It categorised the buildings depending on their exposure (basic wind load), sensibility (height and roof construction of the building, building density of neighbourhood) and ability to adapt (age, design). The results were incorporated in a map, which can be used for urban planning and focused response policies (VÁTI, 2011).

Social sensitivity

Factors determining sensitivity of people to floods are in principle similar to those influencing heat. Usually the elderly, young children and people with health problems are more vulnerable. It appears that in a large number of cities in Belgium, Germany and Italy the proportion of elderly people as a percentage of the population is relatively high (see Map 2.7 in Section 2.1.2). Furthermore, a number of other factors have to be taken into account including income, social status, housing type, type of households, number of social hot spots such as schools, hospitals, kindergartens and pensioners' homes (Schauser et al., 2010).

Current and future flood impacts are the result of several intertwined trends — climatic and non-climatic — which make population and economy more sensitive to flooding. Besides climate change, economic and demographic developments are very important drivers. Where development and economic growth continues the scale of potential losses will also rise. Economic growth tends to take place in cities which may lead to an increase in related climate change risks rather than in suburban and rural areas.

2.2.3 *How can cities adapt to flooding?*

Strategic planning for flood risk management

The cross-border nature of flooding requires a regional approach in which local measures are embedded. Flood risk management plans involve a region much larger than the city itself. Multi-level action is required involving decision makers at regional, national and sometimes even international levels.

To support the transition from traditional flood defence strategies to a flood risk management approach at the scale of entire river basins in Europe, the European Union has adopted a floods Directive (EC, 2007a). This Directive requires Member States to develop and implement flood risk maps and management plans (de Moel et al., 2009; EEA, 2010e). These plans shall take into account the likely impact of climate change on the occurrence of floods. This will have consequences for land use practices taking place in a river basin and for floodplains and riverine cities. Member States are currently uploading their preliminary flood risk assessment to the European Commission and the EEA and will include these in the Water Information System for Europe (WISE). The European flood action programme emphasises the importance of damage prevention by appropriate spatial planning. Important aspects include:

- avoiding construction of houses and industrial buildings in current and future flood-prone areas;
- adapting future developments to the risk of flooding;
- appropriate land use, agricultural and forestry practices (EC, 2004).

At the regional or river basin level some trans national prevention programmes exist. Examples include the Rhine across, France, Germany, the Netherlands and Switzerland and the Meuse across Belgium, France and the Netherlands. Wider trans national cooperation is stimulated by macro-regional strategies of EU regional policy, for example, for the Baltic and the Danube (EC, 2009c; EC, 2010a; EC, 2010c).

Table 2.6 Adaptation measures to flooding in cities and regions following the structure of Box 2.2

Grey measures	Green measures	Soft measures
• Make new buildings and infrastructure flood proof by appropriate design and material use. • Maintenance/upgrade of drainage system. • Temporary water storage in basins or fascines. • Separate treatment of rain water, disconnected from sewage, improved ground drainage. • Innovative design of buildings and areas such as elevated entrances, building on poles, floating houses, temporary water storage, green roofs. • Dams, flood defences.	• Avoid/remove impervious surfaces wherever possible. • Maintain and further increase green infrastructure in cities, parks and gardens, wetlands, water bodies but also green roofs. • Maintain and manage green areas outside and inside the cities for flood retention including the use of appropriate agricultural and forest practices. • 'Re-naturalisation' of rivers and wetlands.	• Mapping of flood risks taking into account climate change scenarios and information distribution. • Forecasting and early warning systems. • Awareness raising, knowledge and capacity building for all groups to cope with floods and flood risks. • Strategic planning in river basins — ban building in flood prone areas, protect flood retention and other green areas. • Flood risk management plans. • Rain water management. • Guidance for behaviour changes such as not storing valuables in basements. • Adapting building and planning codes to include flood resistance. • Taxes or incentives, such as concerning the amount of sealed area per property, amount of waste water used (including rain water). • Insurance of damages.

Grey infrastructure approaches

Integrated water management at the river basin level

Infrastructure beyond the urban fringe, such as temporary overflow areas or by-passes, can prevent flood waters from reaching the cities. Such measures need to be established through regional or national collaboration. The Dutch government initiated the program 'room for the river' in 2006. By providing more space for water around Dutch rivers, flood risks in downstream areas, including cities, will be reduced. One example of this project will take place in the town of Nijmegen. The Dutch government has targeted the building of a replacement inland dike alongside the river Waal in Nijmegen as the best solution to reduce flood risk (see also Box 2.14). A by-pass of the river IJssel is projected to reduce flood risk in the Dutch city of Kampen.

Another example of the FloodResilienCity project is the Dijle River basin, the source of which is situated half in the Walloon and half in the Flemish regions of Belgium. Because of a high risk of flooding the authorities decided to designate and redevelop roughly 1 200 ha of natural area as an overflow and create an additional artificial temporary storage basin closer to the city to protect the medieval inner city of Leuven against rainfall levels that are only predicted to occur once every hundred years (FRC, 2012).

Urban storm water disposal

Options to prevent urban drainage floods focus on improvement of the local drainage and the sewerage system. Urban drainage floods, including adaptation options, are currently being studied in Copenhagen, London, Malmö and Rotterdam. The City of London Corporation, for example, has identified 'hot spots' vulnerable to flooding, where it plans to install new sustainable drainage systems and invest in maintenance to accommodate the expected rise in the volume of precipitation (PBL, 2011;

Box 2.14 Urban and building design options to prevent flood damage

Amsterdam and Almere in the Netherlands have built man-made islands with floating houses which 'naturally' adapt to water levels (http://www.deltasync.nl/deltasync; http://marquetteturner.com/2011/the-floating-houses-of-amsterdam).

Photo: © inhabitat.com

Malmö in Sweden manages rainwater flows with a new open storm-water-system. Here, green roofs and open water channels lead rainwater into collection points that form a temporary reservoir to collect surplus water (http://www.malmo.se/English/Sustainable-City-Development/Augustenborg-Eco-City/The-Green-City.html; http://www.malmo.se/English/Sustainable-City-Development/Bo01---Western-Harbour/Green-City.html).

In **Rotterdam**, the Netherlands, open water channels in new neighbourhoods have been built to funnel water flow and increase storage and drainage capacity. The city plans so-called 'water squares', low-lying public spaces which can be used for temporary water storage during heavy precipitation or flooding events (http://www.rotterdamclimateinitiative.nl/en/english_2011_design/100_climate_proof/projecten/water_plazas_playgrounds_doubling_as_water_storage?portfolio_id=59).

In **Vienna**, Austria, the sewage system itself provides storage. The loading of the sewer system is monitored continuously in real time and interventions are possible through centrally controlled sluices and pump stations to optimise the full storage capacity of the 2300 km long system and prevent outflows during high precipitation events (http://www.wien.gv.at/umweltschutz/umweltbericht/pdf/abwasser.pdf).

Nijmegen, the Netherlands, explores opportunities in which buildings are part of the flood defence. In the concept Adaptable Flood Defences (AFD), structures such as car parks, buildings, dwellings or roads are transformed and redesigned with protection of the hinterland against flooding in mind (Stalenberg and Vrijling, 2009).

A new metro line is being built in **Copenhagen**, Denmark. Entrances will be elevated to avoid storm water flooding the tracks (http://www.cowi.com/menu/specialfeatures/climate/COWIsclimatestrategy/Documents/0212-1900-001e-09b_COWIClimateChangeServices_low.pdf).

Kamal-Chaoui and Robert, 2009). The town of Cascais in Portugal has recognised the importance of drainage system maintenance and has put into practice by cleaning and restoring small streams to reduce flood risks (Oliveira et al., 2010).

Source control techniques are particularly attractive for storm water treatment. They reduce the amount of storm water which needs to be taken up by the sewage system and thus reduce the necessity to extend and upgrade the existing sewage system. It includes a variety of techniques that aim to reduce the quantity and improve the quality of storm water at or near its source by using infrastructure or natural physical resources. Source control includes further soft measures to change behaviour or force the implementation of measures. The city of Stockholm, as well as several municipalities in Denmark, currently plan to implement source control techniques to all new sewage projects (Chouli et al., 2007).

Temporary water storage in the city

Integrating water storage in the design of new city areas or redesigning existing areas is another adaptation option which is often cheaper than extending the sewage system. It can also increase the attractiveness of public spaces.

Innovative design of buildings and infrastructure

Adaptation options are also available for individual buildings. This can range from minimal changes such as elevated entrances to highly innovative constructions. Short-term measures usually can be taken in existing buildings and infrastructure (green roofs, maintenance drainage system and specific usage of lower floors in flood-prone buildings), while medium to long term measures can focus on the climate-proof design of residential and commercial buildings and new urban developments. The fact that cities are continuously changing suggests that such measures would have minimal costs (PBL, 2011).

Green infrastructure approaches

The capacity of soils and vegetation to retain water is an important flood prevention feature as it reduces peak discharges across river basins. The way agricultural and forestry land is used is therefore relevant to flood risk management on a regional scale. The European Union's Common Agricultural Policy (CAP) reform of 2003 and on-going policy development may contribute to flood prevention by promoting soil protection and the maintenance of permanent pastures and thereby improving the capacity of soils for water retention in areas upstream of flood-prone cities.

Box 2.15 River restoration as urban flood protection in Łódź, Poland

Łódź, meaning 'boat' in Polish, is a city whose history has been shaped by water. Many severe environmental problems have resulted from the industrial history of the city: loss of forests and green spaces, soil contamination, degradation of rivers and streams and poor water quality. During the periods of industrialisation and urbanisation most of the city's urban streams were converted to a mixed storm water drainage and sewage system.

Łódź has been subject to frequent flooding due to the reduced water absorption capacity of its land area. As a solution to many of these problems, Łódź is focusing on ecohydrology and integrated water management including the restoration of the city's rivers, notably the river Sokolowka. Restoration has included the building of reservoirs, the invention of a storm water bio-filtration system and the development of a wider development plan for the river valley.

Photo: © Jorge Ueyonahara

This broader approach reflecting on the linkages between the water cycle and other aspects of urban development and beyond has proven a success. Stakeholder involvement through the city's Learning Alliance (which was established during the SWITCH project) has succeeded in changing mind-sets, so that up-scaling to the rest of the city's rivers is planned.

Source: Loftus, 2011; http://www.switchtraining.eu/fileadmin/template/projects/switch_training/files/Case_studies/Case_study_Lodz_preview.pdf.

Sustainable land use practice in the context of river-basin management preferably encompasses flood prevention measures in combination with agri environmental practices, territorial planning policies and nature development strategies, including river restoration. Green roofs, parks, natural depressions and wide river beds can all store storm water. River restoration can act as a catalyst for sustainable urban development that takes into account green infrastructure in combination with other solutions (Box 2.15).

Soft measures

Forecasting and early warning systems
Mapping of flood risks, forecasting and early warning systems enhances flood preparedness. Warning the authorities and the public by forecasting severe weather events several days or hours ahead of approaching storm events is crucial for emergency actions. These can include evacuating vulnerable areas and buildings and the transportation of the population to storm shelters.

Awareness raising, knowledge, capacity building and training
Awareness raising, knowledge, capacity building and training are important tools to enable cities and citizens to cope with flooding. The city of Orléans, the Val de Loire conurbation, and the Loiret departmental council in France are working together on the project 'FloodResilienCity' (FRC). The aim of the project is to raise awareness of the potential impact of flooding by the River Loire to the public, among stakeholders and with government and decision-makers. The goal is to reduce the risk of wealth destruction and human health impact by increasing the resilience of buildings and infrastructures and by preparing evacuation and recovery plans preventively. The United Kingdom's Climate Impacts Programme (UKCIP) ([7]) provides climate scenarios, as well as an adaptation wizard to help users to work their way through potential vulnerabilities and methodologies to appraise options and make decisions. Flood-risk maps, such as those provided by the Environment Agency of England and Wales, are a valuable tool in developing strategic spatial plans.

Box 2.16 Examples of forecasting and early warning systems

The website www.meteoalarm.eu provides European weather warnings from EUMETNET countries and facilitates the exchange of warning information at the European scale. National meteorological services can submit and retrieve severe weather reports via the European Severe Weather Database (ESWD, http://essl.org/ESWD). The European Centre for Medium-Range Weather Forecasts (ECMWF) provides 3- to 15-day weather forecasts to its Member States and cooperating states.

National meteorological services tend to share information on their web pages whereas in some countries this is the responsibility of the emergency authorities. Denmark (photo), Germany, Hungary and the Netherlands provide text message alerts to mobile phones. Finnish media are obliged to immediately announce extreme weather events. In Portugal, the National Meteorological Institute provides meteorological warnings, while the National Authority for Civil Protection sets alert levels for risks linked to meteorological and other emergency situations on their official site.

The Finnish Meteorological Institute (FMI) receives weather-related emergency reports directly from the emergency response centres which manage emergency calls.

Hungary and Germany utilise spotter groups to support the meteorologist services with weather reports. A storm spotter actively maintains the development and progression of specific weather events while relaying important information to the local weather agency in a timely manner.

More than one million people subscribe to the flood warning system of the Environment Agency of England and Wales.

Source: Rauhala and Schultz, 2009.

([7]) http://www.ukcip.org.uk.

Integrate climate change into building codes and spatial planning
Inclusion of storm and flood resistance into all building codes can decrease the losses from wind storms and floods. However, climate change has not yet been included in the EUROCODES for the design of buildings and other civil engineering works and construction products ([8]). Spatial planning plays an important role in flood prevention by restricting building in flood plains, conserving flood retention areas and minimising impermeable surfaces. Malmö, Sweden uses a green scoring factor for new urban developments. The system ensures that a certain proportion of the development will consist of green space. Different solutions receive different scores depending on their efficiency (e.g. sealed surface = 0; green roof = 0.7; vegetation on the ground = 1), which allows the developer some flexibility but also ensures that the requirements for green space provision are met (Kruuse, 2010). For the development of the Western Harbour area, for example, developers had to ensure an allocation of 50 % share to green space.

Regulations and fiscal incentives
Different policy instruments such as taxes, specific regulations and controls and information campaigns can all be applied. In Germany the North Rhine-Westphalia region obliges all new development projects to allow for storm water channelling and offers funding to municipalities. The water company in Dresden collects taxes based on the imperviousness level of properties (Mechler et al., 2011; Chouli et al., 2007). A policy in the Netherlands aimed to reduce by 50 % the combined sewer overflow by 2005. Municipalities and industries pay fees to the water authorities, depending on the level of pollution apparent in waste water. This policy has forced many municipalities to construct new waste water treatment plants with the capacity to treat both wastewater and storm water. A new national policy in the Netherlands aims to disconnect rain water drainage from the sewer network in 20 % of all urban areas in order to separate rain and waste water (Chouli et al., 2007).

Municipalities organise public information campaigns, offer technical guidance and financial help to those who wish to disconnect. House owners in Nijmegen in the Netherlands receive EUR 5 per m^2 disconnected area, meanwhile in the city of Dresden in Germany collects taxes based on the impervious surface of the property (Chouli et al., 2007).

Insurance
Insurance serves to finance the repair or replacement of structures that suffer irregular and unforeseeable losses. Several European insurance companies have already included climate change driven wind storms and flood events into their insurance portfolio such as Munich Re in Germany. Well-designed insurance contracts can provide incentives for risk reduction. However, insurance can also provide disincentives for people to prevent losses if, for example, those insured become less diligent in reducing losses due to their 'safety net'. Insurance providers can liaise with governments and communities to promote land use planning, emergency response and other types of risk-reducing behaviour (Mechler et al., 2011).

Mainstreaming activities across Europe are not yet feasible because of different administrative and political conditions.

Further reading

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([8]) http://eurocodes.jrc.ec.europa.eu/home.php.

2.3 Water scarcity and droughts

Key messages

- Socio-economic factors such as population growth, increased consumption, and land use have a huge impact on water scarcity with climate change exacerbating the problem.
- Water resources are expected to decrease in Europe as a result of increasing imbalance between water demand and water availability.
- Many cities in southern and eastern Europe, as well as some in western Europe are already experiencing water stress during the summer. Future projections see an aggravation and also northwards extension of the problem.
- Cities can overcome regional water scarcity through imported water yet they become more dependent on other regions and the price would then rise.

2.3.1 *Why are water scarcity and drought challenges for cities?*

Water availability and cities

Water scarcity and droughts pose serious problems with drastic measures often being required to solve them. The 2008 example of Cyprus can illustrate this point. The country had suffered its fourth consecutive year of low rainfall and drought and was obliged to ship in water from Greece by tanker and concurrently cut the domestic water supply by 30 %.

Europe's larger cities generally rely on the surrounding region for their water resources. The availability of adequate clean and fresh water is crucial and is a basic requirement for sustainable development. Fresh water is used for drinking, by industry (production processes and cooling), energy production, recreation, transport and nature. Sufficient water of good quality is therefore indispensable to ensure human health and to fuel the economy.

However, water scarcity and droughts are not exclusive to the drier areas in Europe but have become an issue in many other regions. During the drought of 2003, the affected area extended from Portugal and Spain to the Czech Republic, Romania and Bulgaria (EEA, 2010e). Water resources are expected to decrease in Europe as a result of the increasing imbalance between water demand and water availability. Cities compete with agriculture, energy generation and other sectors. Climate change will most likely exacerbate the adverse impacts, with the occurrence of more frequent and severe droughts in many parts of Europe.

Determinants of water scarcity and droughts

Water scarcity and droughts are two separate issues. Water scarcity refers to long-term water imbalances between water demand and available natural resources. This is when water demand exceeds the supply capacity of the natural resources. Such situations usually emerge in areas with low water availability or rainfall. However, they can also occur in regions with high water consumption due to high population density, or as result of intensive agriculture or industrial activities. Moreover, water imbalances can lead to problems with the water quality. This may exacerbate the water scarcity problem because, for example, the water available is unsuitable for consumption.

Drought refers to a temporary decrease in water availability. A distinction can be made between meteorological drought (low rainfall), hydrological drought (low river flow and abnormal low groundwater levels), and agricultural drought (low soil moisture content). The primary cause of the emergence of drought is usually rainfall deficiency in a region. High air temperatures and evapotranspiration rates can exacerbate the acuteness and duration of droughts. Droughts can occur anywhere in Europe.

In conclusion, droughts are mainly caused by climate conditions and soil properties, whereas water scarcity is to a large extent human driven depending on the balance between water availability (climate driven) and demand.

Box 2.17 Water scarcity a problem in the south — Ankara, Turkey...

Photo: © Manyag

From 2006 until 2008, Ankara suffered from severe droughts. In August 2007 the water supply had to be cut off because the capacity of eight major water reservoirs dropped to 5 % of normal levels. The situation was aggravated by the bursting of two main pipelines. From April 2007 to March 2008 an emergency plan came into action and the municipality constructed a system of pipelines from the Kizilirmak dam.

Drought is not unusual in Turkey caused by the large variation in rainfall over the years. During the previous 80 years the situation in Ankara regarding water demand has changed dramatically. The population increased from 75 000 in 1927 to 3.2 million in 2000 and is expected to grow further to 7.7 million in 2025. This will put an enormous strain on the city's water supply that is already insufficient to meet current demands. Moreover, due to an increase in prosperity, water consumption per person has increased and is expected to increase further from 169 litres per day in 1995 to 203 litres in 2025.

While Ankara's population is expected to increase further, precipitation and river flows are expected to decrease due to climate change. Hence, the frequency and intensity of drought periods will likely increase in the coming decades.

Source: Ceylan, 2009; GWI, 2007; Tigrek and Kibaroglu, 2011; EEA, 2009; EEA, 2010e.

... but also in the north, London, the United Kingdom

The amount of water available per citizen in London is by far the lowest in the United Kingdom due to the relatively low annual average precipitation of 690 mm in the Thames catchment area and the large population. Even in comparison with much hotter and drier countries it is strikingly low and comparable to countries such as Israel. London has already experienced water shortages in 2003 and 2006. The probability of a drought event is currently low. However, changes in precipitation patterns will increase the likelihood of such an event to occur. The principle water sources for London — the rivers Thames and Lee and a chalk aquifer underneath the city — are rain fed. Climate change projections for the south-east of England show that rainfall will become more seasonal with wetter winters (10 to 20 % more precipitation by 2050, up to 30 % by 2080) and drier summers (20 to 40 % less precipitation by 2050, up to 50 % by 2080). Despite higher winter precipitation, groundwater recharge might be reduced due to increasing evaporation and public water demand. Hence, prolonged periods with water scarcity become more likely.

Since the 1970s, water consumption has increased from 110 litres to 161 litres per person per day, which is above the UK average of 150 litres. At present, there are no incentives to reduce water spillage. Four-fifths of households pay a flat rate, based on the historic taxable value of the property. Only one-fifth of all households have a water meter. Furthermore, one quarter of the water distributed does not reach its destination due to network leakages. London's water network is in in many areas older than 100 or 150 years and often in poor working condition.

To improve the situation of London's water supply a water management strategy has been proposed with the following priority:

1. Reduction of losses through better leakage management;
2. Improving water efficiency;
3. Grey water recycling and rain water harvesting for non-potable uses;
4. Develop the water resources with the least environmental impact.

Source: Greater London Authority, 2010; London Climate Change Partnership, 2002.

Table 2.7 Factors contributing to water scarcity and droughts

Meteorological factors	Hydrological factors	Human factors aggravating water scarcity and droughts
Precipitation deficit High temperatures (large evaporation)	Low soil moisture level and low soil water retention capacity Low groundwater level and limited quantity Low surface water availability Land cover (less vegetation and wetlands; impervious soil) Salt water intrusion into rivers and groundwater due to sea-level rise	Increase of population and economic activities Increasing water withdrawal for use in cities (citizens, business, industries) and in the surrounding area, e.g. by agriculture Land-use changes (e.g. surface sealing due to urbanisation, deforestation) altering run-off and groundwater level; occupation of areas important for groundwater generation; e.g. wetlands Melioration Water pollution Inefficient water supply infrastructure Lifestyle with high water consumption patterns Inefficient water management policies

Table 2.7 presents a list with factors contributing to water scarcity and droughts. Even though freshwater resources are widely available in Europe, their spatial and temporal distribution leads to water scarce areas and periodic drought situations. However, additional non-climatic drivers need to be highlighted as they contribute significantly to increasing climate related impacts. Changing lifestyles, reduced water availability due to climate change and drinking water standards that prohibit using water in and around large cities (due to pollution) are all factors making cities vulnerable to water scarcity and droughts. The impacts of economic and social development on water resources may be of the same magnitude as that of climate change on water availability.

Additional factors include:

- Water pricing policies generally do not reflect the level of sensitivity of water resources at local level. The 'user pays' principle is rarely implemented and leads to mismanagement of water resources.
- Spatial planning can be one of the main drivers of water use. Inadequate choice of city location results in imbalances between water needs and existing water resources.
- Cities compete with other sectors for water — energy generation is the major user with 45 %, followed by agriculture with 22 % and public water supply with 21 % (EEA, 2010e). In addition, tourism puts strong seasonal pressure on water use in certain regions, particularly in southern Europe and in coastal areas.
- European countries waste between 10 and 25 % of their water due to inefficiency, e.g. through losses in public water supply and irrigation networks, inadequate water appliances in households and inefficient water practices in industry and agriculture (EEA, 2010e).

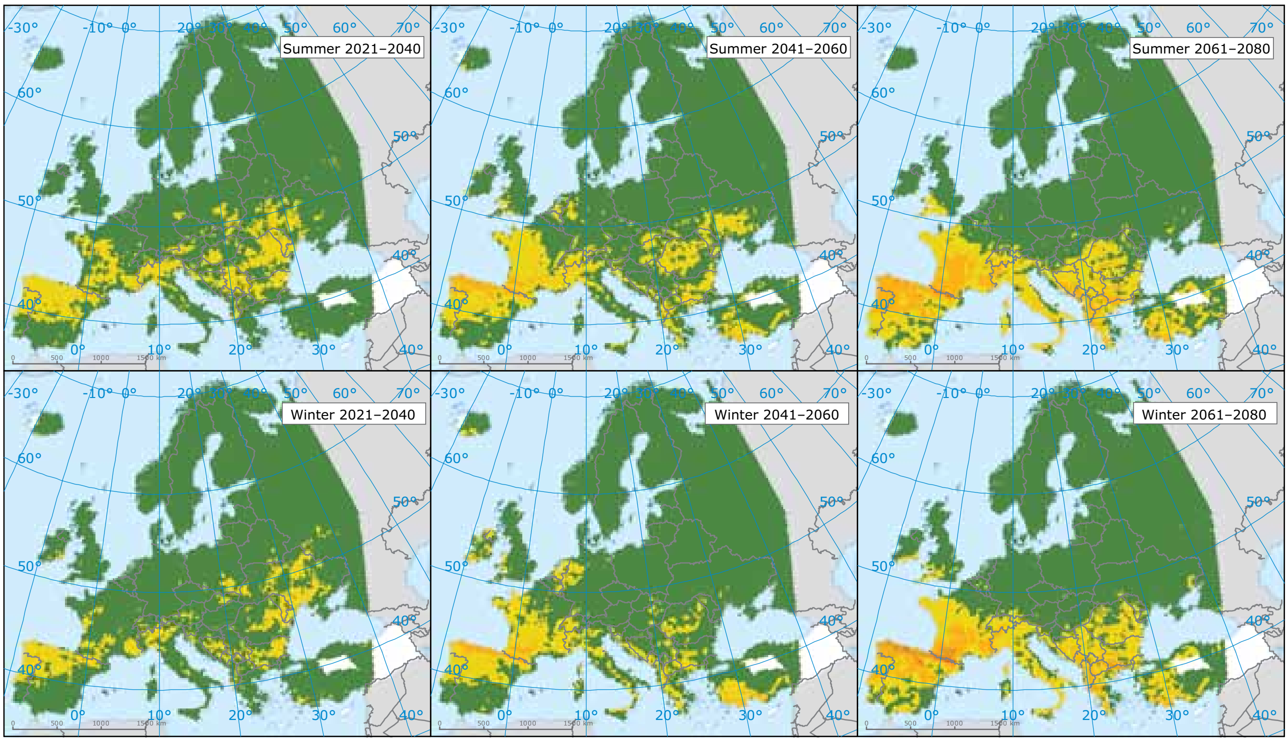
2.3.2 *What are the potential impacts of water scarcity and droughts on Europe's cities?*

European cities — present and future exposure to water scarcity and drought

During the 20th century there has been a clear trend towards drier conditions, with decreases in rainfall and moisture availability in all Mediterranean regions with the exceptions of north-western Iberia and most of Turkey that reveal an increase of moisture availability (Sousa et al., 2011). As a result, severe drought episodes (in a meteorological and hydrological context) have become more frequent and persistent, namely in the Balkans and Iberia.

The total area affected by water scarcity and droughts doubled — from 6 to 13 % — during the last 30 years. Peaks appeared in 1976, 1989–1991, 2003 and 2005 (EC, 2007b). The duration of each event, as well as the area affected, varies considerably. In Mediterranean countries droughts can last one or several years, while in central and northern countries droughts last several months. Droughts affect a large part of some countries, whereas in others they often only affect specific regions but with higher frequency. Map 2.13 shows how the precipitation deficit is projected to change in the future in summer and winter.

Map 2.13 Precipitation deficit in summer (JJA) and winter (DJF) for the periods 2021–2040, 2041–2060 and 2061–2080



Precipitation deficit in summer (JJA) and winter (DJF) for the periods 2021–2040, 2041–2060 and 2061–2080. Deficits are presented as probability for extreme dry situation using SPI-12 (according to the definition of SPI extreme dry is SPI below – 1.5 means having 1.5 standard deviation less precipitation as in the baseline period)

No data | Outside data coverage | Probability for dry events: Low – High: 0.0, 0.1, 0.2, 0.3, 0.4, 0.5

Note: Data are obtained from 8 RCMs (ENSEMBLES) and are bias corrected using distribution fitting method. The spatial resolution is 25 km.

Source: EEA.

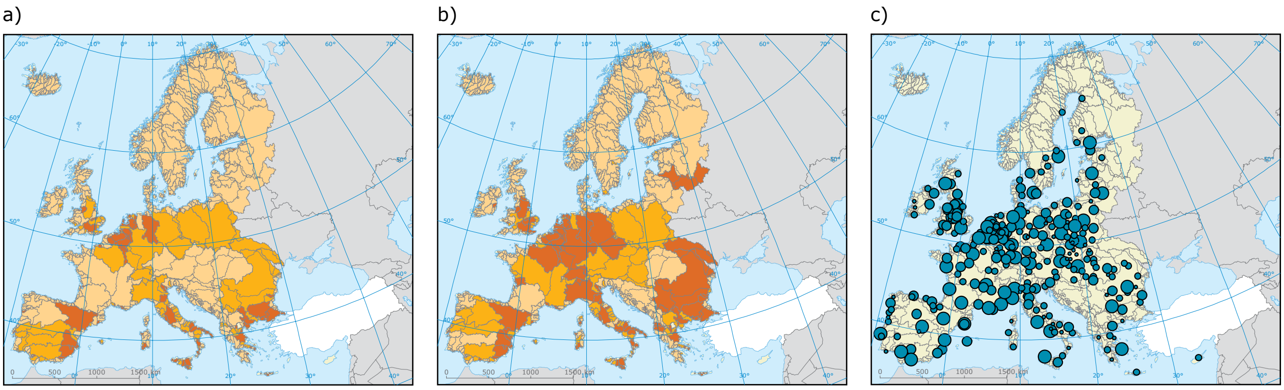
Climate and socio-economic drivers are both drivers for water scarcity and need to be considered together. The water stress indicator (WEI) describes the ratio between total water withdrawals against water availability. It illustrates to which extent the total water demand puts pressure on the available water resources in a given territory and points out the territories that have high water demand compared to their resources.

Map 2.14 shows the water stress related to the major river basins based on modelled estimates of water demand. The modelled results show that parts of southern and north-western Europe are already under severe water stress. Under an 'economy comes first' scenario the situation worsens and most parts of Europe will be under severe or medium water stress with the exception of northern Europe. The map refers to annual average conditions, while during drought periods it is likely that demand will be higher with availability lower.

The impact on cities

An increase in water related stress is expected in areas of high urbanisation and population density, in western Europe and coastal areas.

Map 2.14 Water stress indicator WEI for annual average on river basin level for the a) baseline, b) 2050 under the 'economy comes first' scenario, and c) compared with urban population numbers



Water stress indicator WEI for annual average on river basin level for the a) baseline, b) 2050 under 'economy comes first' scenario, and c) compared with urban population numbers

Withdrawals-to-availability ratio
- 0–0.2 (low water stress)
- 0.2–0.4 (mid water stress)
- > 0.4 (high water stress)
- No data
- Outside data coverage

Total population in cities, 2004
- < 100 000
- 100 000–250 000
- 250 000–500 000
- 500 000–1 000 000
- > 1 000 000

Source: Flörke et al., 2011.

Cities have adapted to current water scarcity in their own way. Cities such as Athens, Istanbul and Paris have managed to obtain sufficient water from other regions via various transportation networks. This will increase dependency on far-off resources and increase the cost.

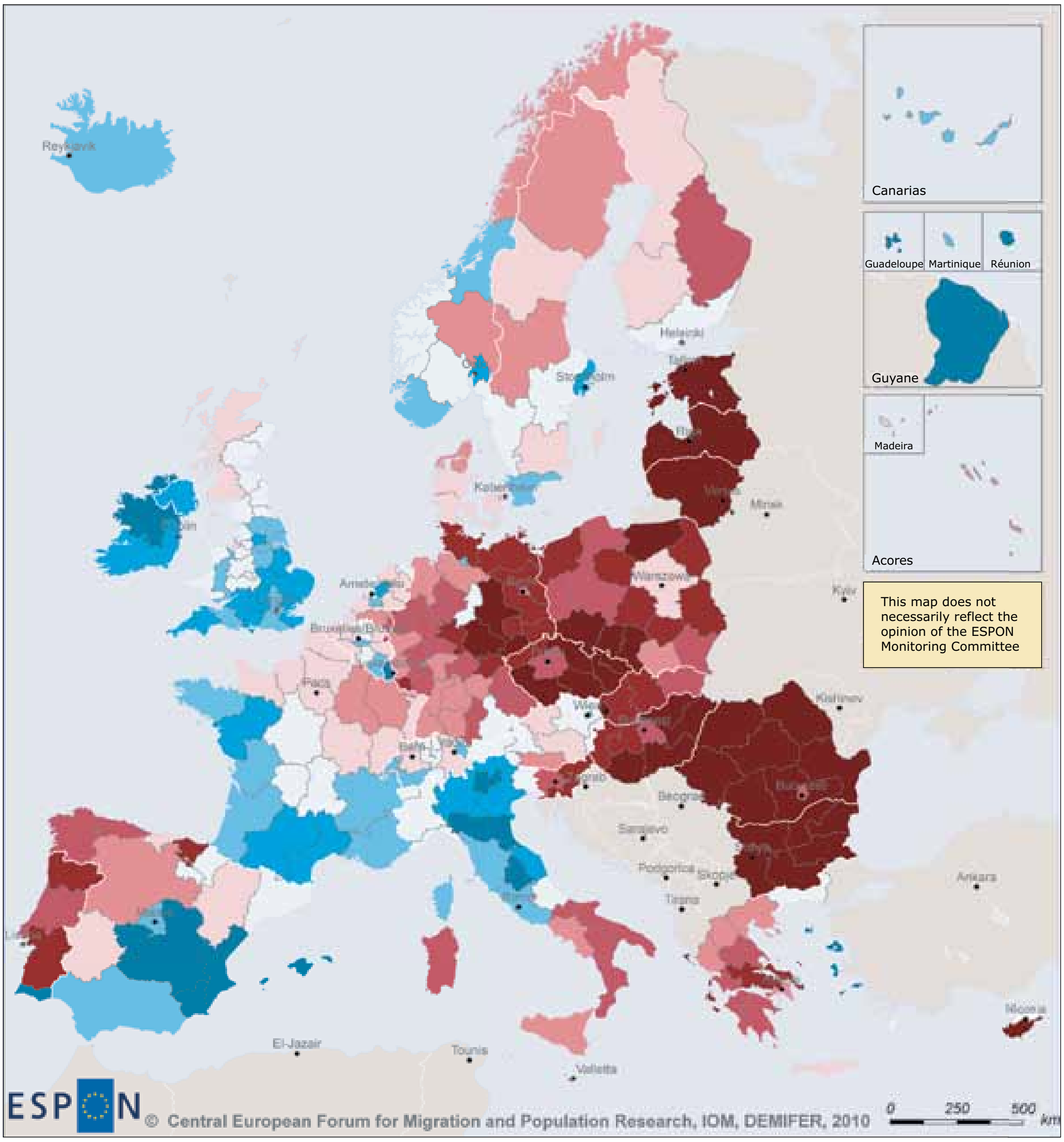
Factors determining the sensitivity of people to water scarcity and droughts are in principle similar to those influencing sensitivity to heat and floods and affect similar groups — the elderly (see Map 2.7 in Section 2.1.2), young children and people with health problems. Regarding water scarcity, socio-economic factors are, however, related to the ability to pay higher prices. Map 3.6 in Section 3.1 provides an overview regarding the general economic situation in north-western European cities with a much higher gross domestic product (GDP) than those in eastern European cities. Large income discrepancies will challenge social equity.

Potential impacts

Water scarcity situations encountered at river basin level have already had noticeable impacts on the economy, society and environment with subsequent effects on costs. Main sectors include:

- public water supply and side-effects on tourism;
- energy production: water shortage can have a huge impact on the energy sector because a lack of cooling water limits the production by thermal power plants, can cause incidents in nuclear power plants, and/or because low water levels in reservoirs limit hydropower production;
- income losses;
- social impacts can be created by the possible increase of water prices due to the implementation of compensating measures (e.g. desalination units);
- impacts on groundwater (with possible aquifer depletion due to over-pumping and seawater intrusion), surface waters (with minimum water flows not always being ensured and increased water temperature and concentrations of pollutants due to less dilution) and wetlands, as well as impacts on soils through erosion and desertification;
- health: water-borne infectious diseases associated with water scarcity and higher water temperatures, however no fatality could be attributed in past droughts in Europe;

Map 2.15 Change in population between 2005 and 2050 under a status quo scenario



Change in regional populations in 2005–2050, in %, 'Status Quo' (STQ) scenario

- – 73.0 to – 40.0 (34)
- – 40.0 to – 30.0 (28)
- – 30.0 to – 20.0 (35)
- – 20.0 to – 10.0 (31)
- – 10.0 to 0.0 (40)
- 0.0 to 10.0 (45)
- 10.0 to 20.0 (32)
- 20.0 to 30.0 (24)
- 30.0 to 170.0 (14)
- No data

Source: ESPON DEMIFER, 2010; © ESPON, 2013.

- clay shrinking and swelling threatens the supporting structures in buildings and other infrastructures.

The overall economic impacts of water scarcity and drought events in the past 30 years are estimated at EUR 100 billion at EU level (EC, 2007b). From 1976–1990 to the following 1991–2006 period the average annual impact doubled, rising to EUR 6.2 billion per year in the most recent years. The exceptional drought in 2003 was estimated to have cost EUR 8.7 billion (EEA, 2010e).

Droughts in combination with heatwaves can acerbate the threat of serious forest fires. Forests in proximity to cities increase such risks (Box 2.18).

2.3.3 How can cities adapt to water scarcity and droughts?

Generally cities have two options regarding reacting to water scarcity: decreasing water use or increasing supply. Water resource management can take place on three levels: the catchment area, the urban or neighbourhood scale and the buildings. The European Commission carries out an extensive programme on responding to water scarcity and droughts, covering four major areas:

- increasing water efficiency in buildings;

- efficiency of water-using products in households, commercial business, industry and agriculture;

Box 2.18 Droughts and high temperatures increase the risk of forest fires and also threaten cities

Higher temperatures during longer periods, reduced precipitation, and changing wind patterns increase the risk of forest fires in many European regions. These climatic changes can not only lead to a higher number of forest fires but also to fires of increased intensity and longer fire seasons. The threat is especially growing in the Mediterranean region and Central and Eastern Europe particularly in regions with warmer and drier climates and more conducive weather (EEA et al., 2008). Nevertheless, the risk of forest fire is growing in other regions such as the Alps (Schauser et al., 2010; EEA, 2010a; EEA et al., 2008).

Forest fires inside and outside city boundaries can affect cities directly and indirectly such as with the demolition of houses, loss of life, pollution as well as the disruption to energy, water and food supplies.

Photo: © titdark

A forest fire on the outskirts of Marseille in July 2009 led to hundreds of homes being evacuated (MailOnline, 2009).

Many city authorities seem unaware about the increasing threat (Caballero, 2008). Following analysis of European cities, only one city acknowledged forest fires as a challenge caused by the impact of climate change (CoR, 2011a).

Fighting forest fires calls for a coordinated and cooperative approach between cities and the surrounding municipalities regarding adaptation measures. Cities have several adaptation options concerning the increase in risk of forest fires. Better urban and building design alongside forest management can contribute to the reduction of fire risks (Schauser et al., 2010; Caballero, 2008). The city of Tatabánya in Hungary has enhanced the capability of fire brigades to fight forest fires by providing specialist training and equipment which has led to a reduction in damage from forest fires and casualties among fire fighters (CoR, 2011a; VÁTI, 2011). Improving the road network in forest areas enhances accessibility to the fire for the emergency services. Watchtowers or camera systems as well as well-managed emergency response systems help to recognise forest fires at an early stage. The use of fire weather indices helps the fire brigade to prepare for and respond to such events (CoR, 2011a; Schauser et al., 2010).
A strengthening of local and regional disaster management does not only help to deal with forest fires but with other natural hazards which are projected to occur more frequently because of climate change e.g. storm events, floods (VÁTI, 2011).

Table 2.8 Examples of adaptation measures related to water scarcity and droughts in urban areas and their regions following the structure of Box 2.2

Grey measures	Green measures	Soft measures
• Water saving devices • Grey water recycling systems • Ground water recharge systems • Rain water harvesting systems • Supply from more remote areas (pipelines) • Desalination plants	• Rain water storage in wetlands and water bodies for later use • Maintain and manage green areas outside and inside the cities to ensure water storage instead of high run offs • Use of plants which have adapted to drought conditions	• Mapping of drought risks and water availability via climate change scenarios • Forecasting and early warning systems • Awareness raising knowledge and capacity building to save water • Spatial planning • Water pricing as incentive to use water more efficiently • Restriction of water use • Drought and water management plans • Organisation of emergency water supply

- reducing leakages in water networks;
- halting desertification through technologies and good practices (EC, 2012b).

Grey infrastructure approaches

Desalination and re-allocation of water resources from water-rich regions to water-stressed regions are options to increase the water supply. These solutions are, however, often expensive and need to be addressed at a national level rather than at a municipality level. Spain and Turkey are planning such infrastructure solutions. However, cities such as Ankara, Barcelona or Istanbul cannot afford such investment on their own. Such solutions run the risk of being poor adaptation measures due to increased energy demand and the fact that the projects themselves may be vulnerable to climate and other stresses.

Local solutions include rainwater harvesting, ground water recharge and grey water recycling, e.g. for toilet flushing and irrigation. Such solutions can be simpler with additional benefits including increasing soil moisture levels for vegetation, sustaining evaporative cooling and reducing the risk of urban flooding (Shaw et al., 2007). Water saving technology and devices in households and industry as well as a proper maintenance of the supply system avoiding water loss will reduce overall demand.

Green infrastructure approaches

Vegetated areas slow down water run-off, store storm water and allow water infiltration in the soil keeping it available for vegetation or other uses. Natural depressions, rivers and wide shallow water-ways can also store storm water. Green roofs can contribute rainwater harvesting.

Green infrastructure approaches can offer occasional problems via the solutions offered. Although the shade provided by trees lowers the temperature and reduces evaporation and thus water loss, the trees themselves need water. A careful selection of plants for gardens and public areas, which are drought resistant but still attractive as a part of an urban green space, is necessary combined with watering them with grey water or harvested rainwater.

Soft solutions

While grey and green solutions generally focus on prevention, those soft solutions addressing water scarcity and droughts aim to enhance preparedness. Specifically coping with droughts requires the availability of timely and reliable climate information which aids decision-makers at all levels in making critical decisions. Central and local government and water authorities are the most important for managing water systems and enhancing the level of preparedness for drought situations. Through public awareness campaigns water conservation can be promoted to encourage individual action. Drought management plans reduce risk and economic, social and environmental impacts. They emphasise efficient use of existing water supplies and contain guidelines and drought contingency plans for public water suppliers, but also restrictions on water use, rationing schemes, special water tariffs or the reduction of low-value uses. Alternatively, or additionally, the price of water can be temporarily raised to suppress demand.

Box 2.19 Zaragoza, Spain combines awareness raising and regulatory measures to enhance water efficiency

Following water shortages in the mid-1990s, the municipality of Zaragoza increased water supply and managed demand by developing a 'water saving culture' targeting businesses, industries and the local population.

The Zaragoza Water Saving City programme was initiated in 1996 by the NGO Fundación Ecologica y Desarollo (FED) with support from the municipality. It included awareness raising campaigns, the implementation of 50 examples of good practice and voluntary public commitments by citizens and businesses. The water tariffs were revised to ensure a full cost recovery through revenues as well as ensuring affordable access for low income households. They now provide a disincentive for water consumption and waste water and an incentive for savings in the form of a water bill for households that reduced their consumption by at least 10 %. Measures to control leakages led to further savings.

Photo: © D. Talukdar

After 15 years the city achieved a reduction of water consumption by almost 30 %, despite a 12 % population increase. The bulk of achievements were due to changes in water use behaviour. The results allowed one to conclude that combining changes in water use behaviour, water efficiency technology and reduced leakage can generate sufficient savings to make new and costly water supply infrastructure redundant.

Factors behind this success included the active promotion of a 'water saving culture', the multi-stakeholder approach and the broad participation of the citizens themselves. The establishment of a central coordination unit, working directly with stakeholders and leading by example and political commitment were key factors of success.

Sources: Philip, 2011; CoR, 2011a; http://www.switchtraining.eu/fileadmin/template/projects/switch_training/files/Case_studies/Zaragoza_Case_study_preview.pdf.

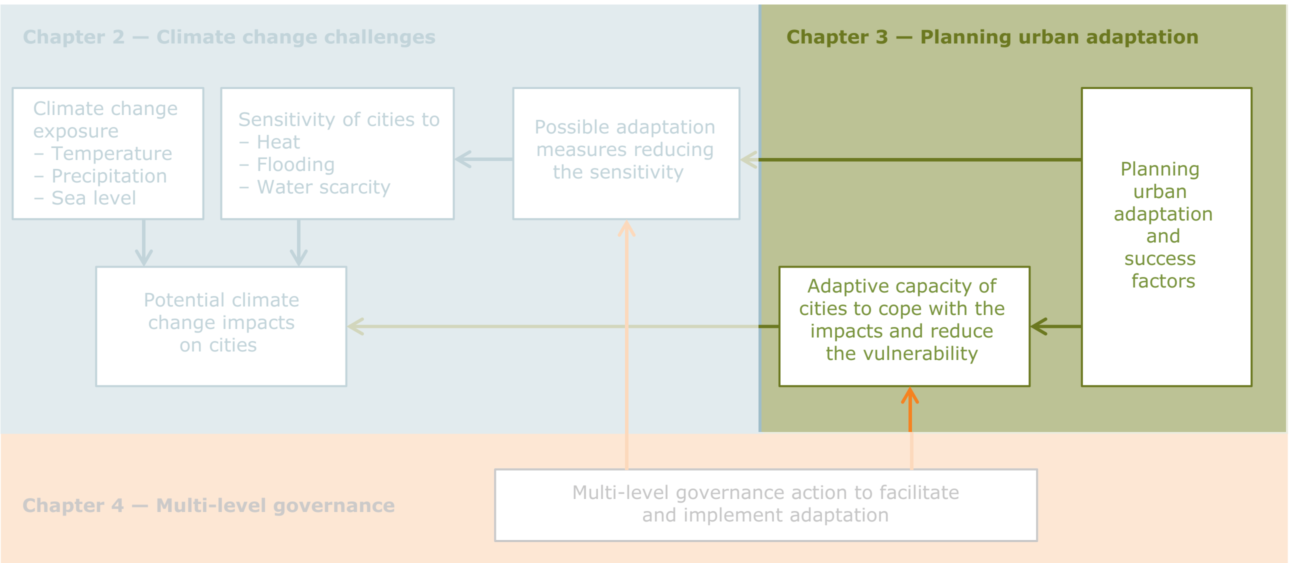
Further reading

- Shaw, R., Colley, M. and Connell, R., 2007, *Climate change adaptation by design: a guide for sustainable communities*, TCPA, London (www.preventionweb.net/files/7780_20070523CCAlowres1.pdf).
- *SWITCH Managing Water for the City of the Future — Trainings Desk* (http://www.switchtraining.eu/home).
- CoR, 2011a, *Adaptation to Climate Change: Policy instruments for adaptation to climate change in big European cities and metropolitan areas,* European Union, Committee of the Regions, Brussels (http://80.92.67.120/en/documentation/studies/Documents/Adaptation%20to%20Climate%20Change/EN.pdf)
- Kazmierczak, A. and Carter, J., 2010, *Adaptation to climate change using green and blue infrastructure. A database of case studies,* University of Manchester, United Kingdom (http://www.grabs-eu.org/membersArea/files/Database_Final_no_hyperlinks.pdf).

3 Planning urban adaptation

In Chapter 2, specific adaptation options were discussed for different climate risks including heat stress, floods and water scarcity. Successful delivery of these relevant solutions needs to be supported by the improvement of the overall adaptive capacity of an urban area (Section 3.1) following a systematic adaptation planning process (Section 3.2) and taking into account a number of planning principles (Section 3.3).

Figure 3.1 Placing Chapter 3 within the framework of the report



3.1 Capacity to adapt in Europe's cities

Key messages

- Enhancing adaptive capacity can decrease vulnerability of cities to climate-related risks. Adaptive capacity includes several components such as knowledge and equity, access to technology and infrastructure, economic resources and effective institutions.
- Adaptive capacities vary between European cities and both within and between countries.
- Some indicators point to cities in north-western Europe being characterised by higher levels of equity, access to knowledge and technology and government effectiveness. The cities in the Benelux and Scandinavian countries score particularly high on indicators relating to education and social trust. Cities in eastern and southern Europe have a lower age dependency index meaning that currently they may cope better with the financial pressures of adaptation of climate change compared to north-western Europe which is burdened with the cost of the ageing population.

IPCC (2007) defines adaptive capacity as 'the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences'. Adaptive capacity should thus be seen as a set of enabling conditions, conducive to adaptive action. Thus, two areas of similar geographic and socio-economic characteristics, when exposed to the same climate threats, may demonstrate differing impacts depending on their respective adaptive capacities (Næss et al., 2005; Keskitalo, 2010e). Consequently, policy measures should be directed not only at short-term promotion of adaptive measures in response to risk (as discussed in Chapter 2), but also at long-term development and maintenance of structural conditions for adaptation (Keskitalo, 2010e).

Adaptive capacity can be assessed at different spatial scales, from national (Yohe and Tol, 2002; Greiving et al., 2011; Haddad, 2005; Westerhoff et al., 2011) to local. However, as adaptation decisions are context-specific, and the adaptation decisions are often made at the local level, the local and regional scales are particularly relevant for assessment of adaptive capacity (Storbjörk, 2007; Engle and Lemos, 2010; Greiving et al., 2011).

Elements that appear to support climate change policymaking at the local scale have been identified as, inter alia:

- good governance;
- presence of national programmes facilitating local action;
- democratic and participatory nature of institutions;
- cities' competences and authority to regulate climate-relevant issues;
- the commitment of cities to take climate action, including the presence of a local champion;
- availability of economic resources, knowledge and information, for example via the involvement of cities in national and transnational networks facilitating the exchange of experience (Martins and Ferreira, 2011; Kern and Alber, 2008).

These elements are clearly interlinked. The determinants of adaptive capacity in this report are grouped under three dimensions (Schröter et al., 2004; Greiving et al., 2011; Smit and Pilifosova, 2001):

- 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.
- The ability dimension reflects the potential of a society to design and implement adaptation measures, and is associated with access to technology and infrastructure
- The action dimension, which relates to the potential of implementing the adaptation solutions, is associated with the economic resources available and the effectiveness of institutions.

3.1.1 Awareness: knowledge and equity

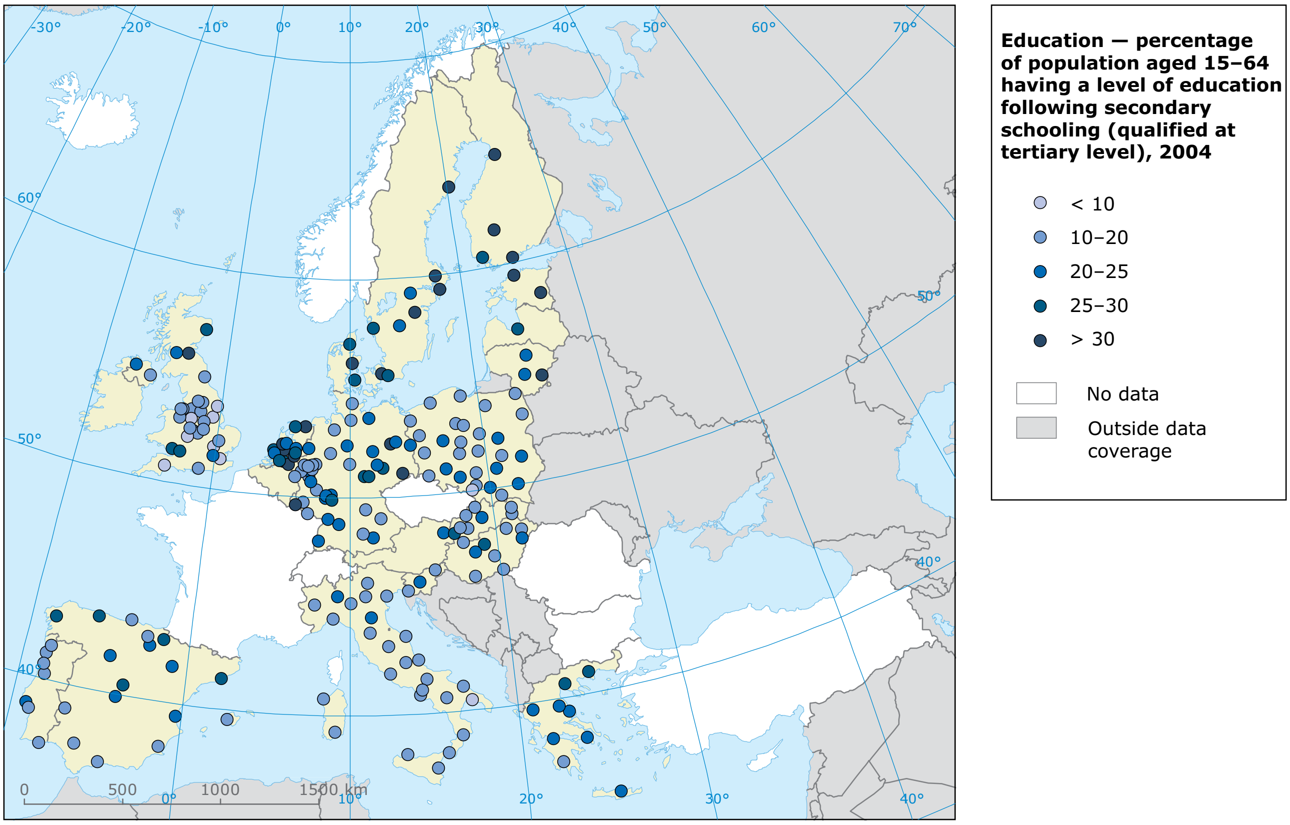
The awareness of the need to adapt, the ability to develop available options and the aptitude to assess and implement them are crucial for adaptive capacity (IPCC, 2001). Firstly, there is a fundamental and persistent need to create understanding of the problem of climate change and to gain public support for climate change adaptation policy. Without this it is very difficult to promote adaptation activities. Creating understanding comes through awareness raising and communication to a wide audience (Rob Swart et al., 2009) including policymakers, planners, and the public. Support for climate change awareness can be promoted through national communication initiatives. Development of multi-level, virtual information hubs on adaptation is particularly helpful. Examples include the UK Climate Impacts Programme and the following websites: klimatilpasning.dk (Denmark), klimatilpasning.no (Norway), climate-guide.fi (Finland) and KomPass (Germany). These initiatives can increase the support for certain measures that are taken by the government at different administrative levels, including cities.

It is important to note, however, that implementation of adaptive measures does not follow directly from providing more information on climate impacts. The availability of up-to-date information does not easily translate into adaptive action due to a number of constraints, including the lack of trust in the practical relevance of the information in local decision-making (Demeritt and Langdon, 2004). Thus, there is a clear requirement for the information relating to adaptation to be tailored to the local level. This also includes the access to downscaled climate change scenarios and their impacts.

Skilled, informed and trained personnel enhance adaptive capacity of governmental organisations. One way to provide effective and efficient adaptation is to learn from knowledge on climate and climate change impacts elsewhere in the world. For example, the participants in the INTERREG IVc GRaBS project took part in an intensive programme of project meetings and mentoring visits, where the partners would perform the role of either the mentor or the mentee, which facilitated the exchange of knowledge and experience between the individuals working for different local and regional authorities across Europe.

The distribution of adaptive capacity is the result of social and economic processes that affect not only the society as a whole, but also individuals based on, inter alia, their age, gender, health and social status (IPCC, 2012). Thus, equity in terms of even access to resources or decision-making processes is an important consideration in relation to resources and power in governing resources for adaptation

Map 3.1 Education — percentage of population aged 15–64 having a level of education following secondary schooling (qualified at tertiary level), 2004



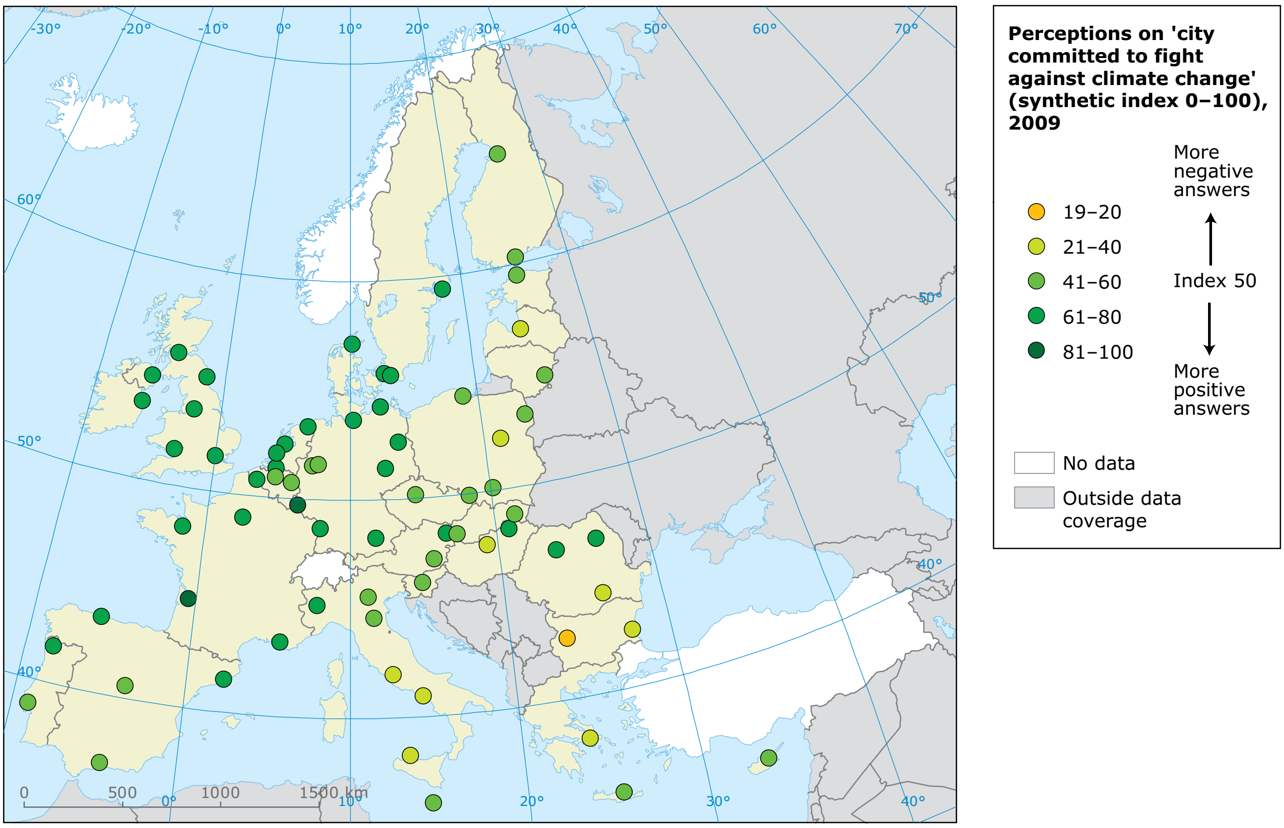
Note: Data for Finland, Italy, Poland, Portugal, Slovenia, Slovakia and Spain are from 2001.

Source: Eurostat Urban Audit database, 2004.

(IPCC, 2001). Equity concerns also relate to the distribution of material and economic resources which are also often distributed unequally, resulting in a lower adaptive capacity in certain areas or with certain groups or individuals (Keskitalo, 2010e).

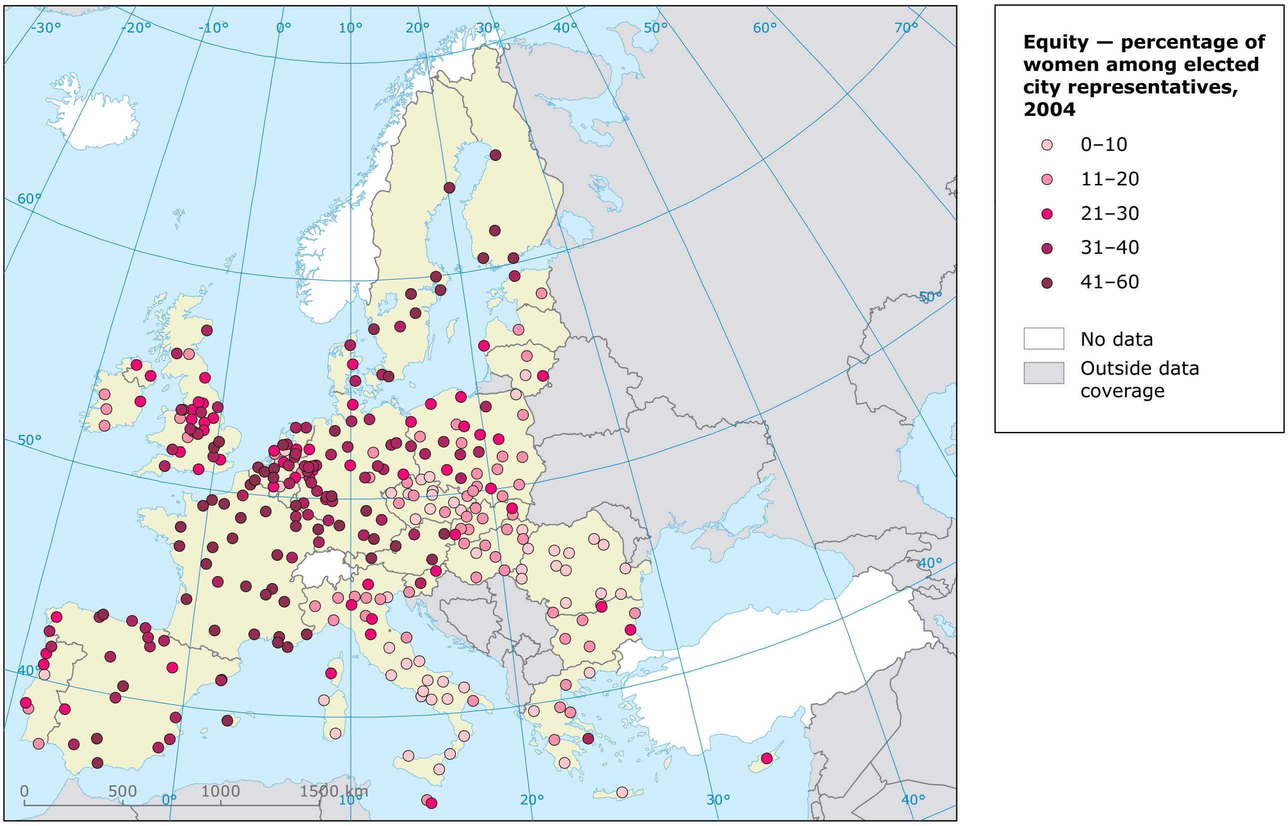
All aspects of adaptive capacity, including the dimension of awareness, are difficult to assess. Maps 3.1–3.3 offer examples of indicators that give some indication of the current levels of local awareness, education and equity. These indicators can be considered as proxies for the awareness dimension of the adaptive capacity of Europe's cities. Cities with the highest percentage of people having a level of education following secondary schooling are present in Scandinavia, the Baltic States and the Benelux countries. Cities, where most citizens feel that their administration is committed to fighting climate change, are predominantly located in western and northern Europe. The percentage of women among elected members in the city, which can be seen as indicative of equity, is lower in eastern, south-eastern and southern Europe (with the exception of Spain) compared to the higher percentage in north-western Europe (slightly lower in Ireland and the United Kingdom). These indicators suggest that European cities are divided in terms of adaptive capacity based on awareness. This division could potentially be bridged by further development of knowledge exchange programmes and strengthening equity and participatory processes.

Map 3.2 Perceptions on 'city committed to fight against climate change' (synthetic index 0–100), 2009



Source: DG REGIO/Eurostat: Urban Perception survey 2010; data 2009.

Map 3.3 Equity — percentage of women among elected city representatives, 2004



Note: Data for Czech Republic, Greece, Hungary, Lithuania, the Netherlands, Slovenia and partially Belgium are from 2001.

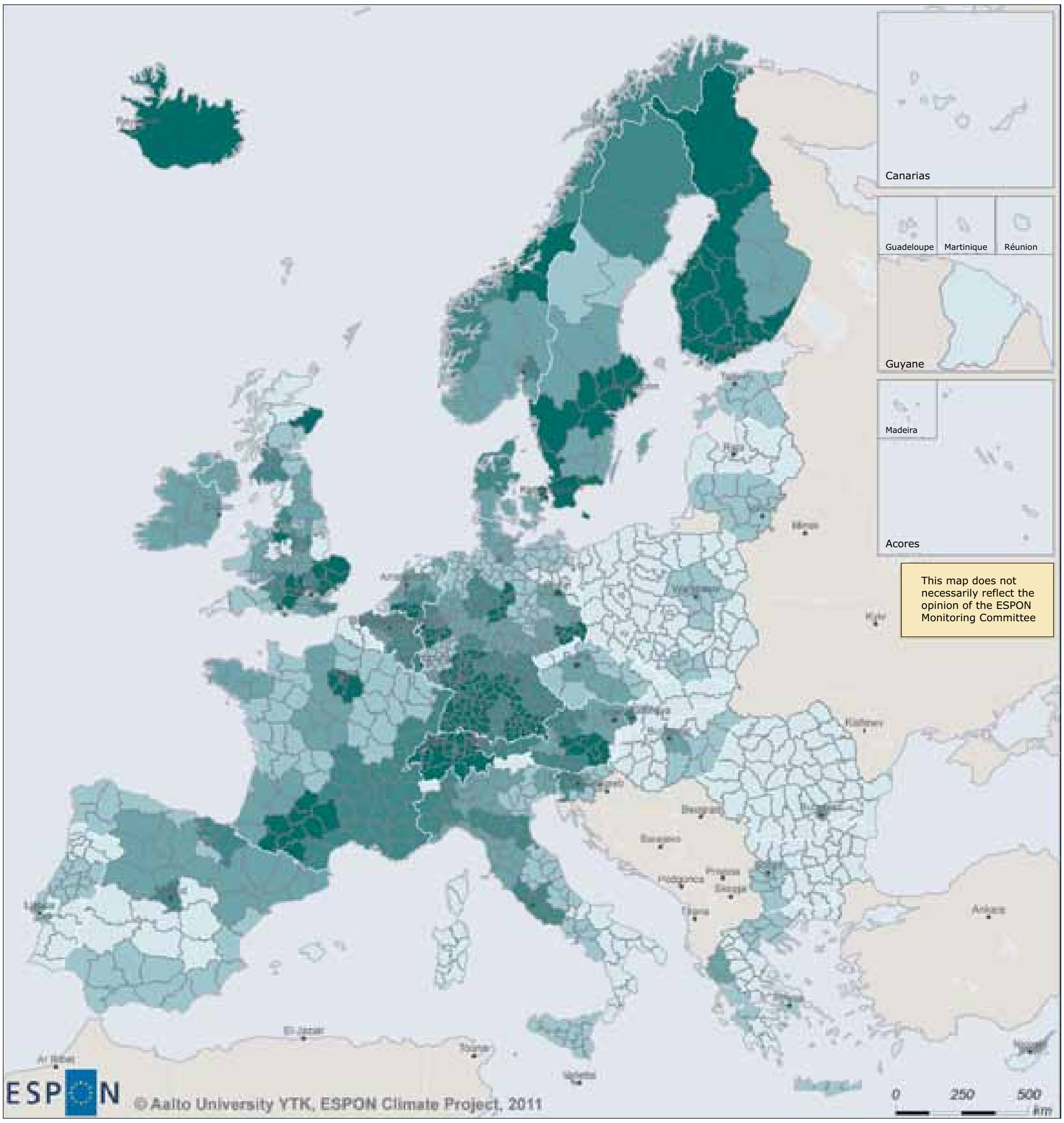
Source: Eurostat, Urban Audit database, 2004.

3.1.2 *Ability: access to technology and infrastructure*

Technological resources can contribute to the design and utilisation of adaptation measures. Societies that lack access to technology and perform poorly in developing new technologies have lower adaptive capacity. This is because many of the strategies that can be identified in response to climate change involve technology (IPCC, 2001). Development of technologies can be undertaken by both the public and the private sector and innovation is considered an important factor in this. Thus, technological development may determine ways in which adaptation options can be developed, for instance, whether high-tech or low-tech solutions are possible. It is important to highlight the distinction between general technological capacity versus a particular technological response that can be developed for a specific climate change impact (IPCC, 2012). Chapter 2 provides information on a variety of technological or 'grey' adaptation options for specific climate risks.

Map 3.4 presents a synthetic index prepared in the 'ESPON CLIMATE' project (Greiving et al., 2011) on technology as one determinant of adaptive capacity. The index is compiled of three distinct indicators: Research and development (R&D) expenditure relative to GDP, personnel working in R&D functions and the number of patent applications. The map highlights regions in central and northern Europe that are currently equipped with high technological capacities, and also active in innovation. These regions are more likely to develop technological responses to pressing climate change problems.

Map 3.4 Technology as one determinant of adaptive capacity, based on the NUTS 3 level



Adaptive capacity: Technology

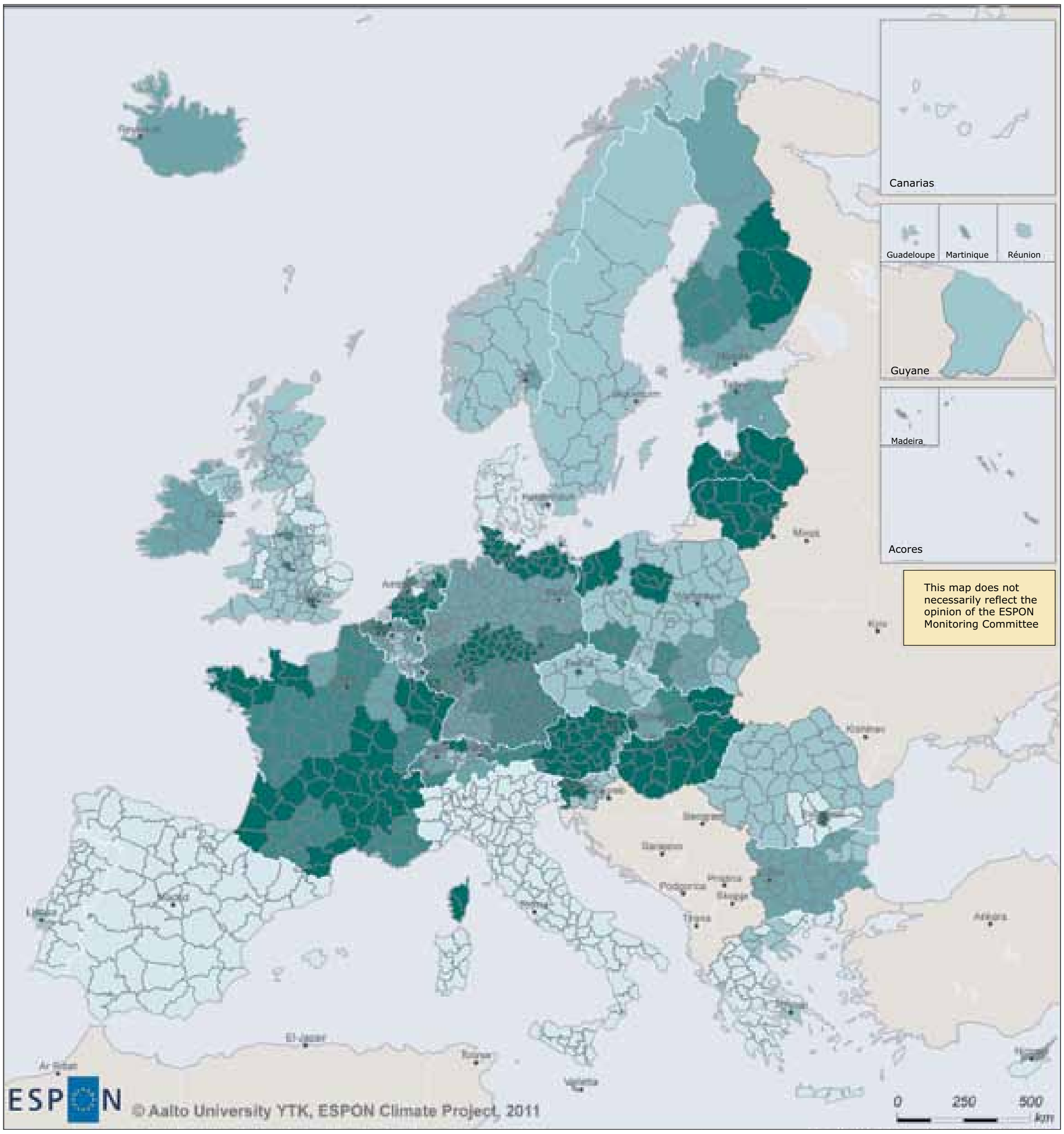
- Highest capacity
- High capacity
- Medium capacity
- Low capacity
- Lowest capacity
- No data

Technological capacity to adapt to climate change classified by quintiles.

The technology dimension of adaptive capacity towards climate change combines indicators on research and development expenditure, research and development personnel and patent applications.

Source: Greiving et al., 2011; © ESPON, 2013.

Map 3.5 Infrastructure as one determinant of adaptive capacity



Adaptive capacity: Infrastructure

- Highest capacity
- High capacity
- Medium capacity
- Low capacity
- Lowest capacity
- No data

Infrastructural capacity to adapt to climate change classified by quintiles.

The infrastructural dimension of adaptive capacity towards climate change combines indicators on the road network density, hospital beds and sustainable water use.

Source: Greiving et al., 2011; © ESPON, 2013.

Infrastructure often forms the basis for the development of adaptation options and measures, as it underlies the basic functions of societies. Different types of infrastructure are also vulnerable to particular impacts of climate change, and a greater variety can help to buffer the impacts of climate change in both the short and long term. Infrastructure is also important in the capacity of a system to cope with sudden impacts of climate change such as extreme weather events. Cities depend on their infrastructures for their safety and well-being.

In terms of indicator development, especially at regional and city level, infrastructure poses a number of challenges. Constructing uniform indicators on urban infrastructure is constrained by data availability and quality issues. Urban audit data does not properly cover this thematic area. An attempt has been made in the 'ESPON CLIMATE' project (Greiving et al., 2011) to assess the level of adaptive capacity related to infrastructure. An index at regional level is used for three underlying indicators: the density of the road network, the number of hospital beds, and the water exploitation index. Map 3.5 shows this index, which seems to highlight certain countries and regions, with no evident patterns. It should be noted that data constraints and quality concerns persist here as well.

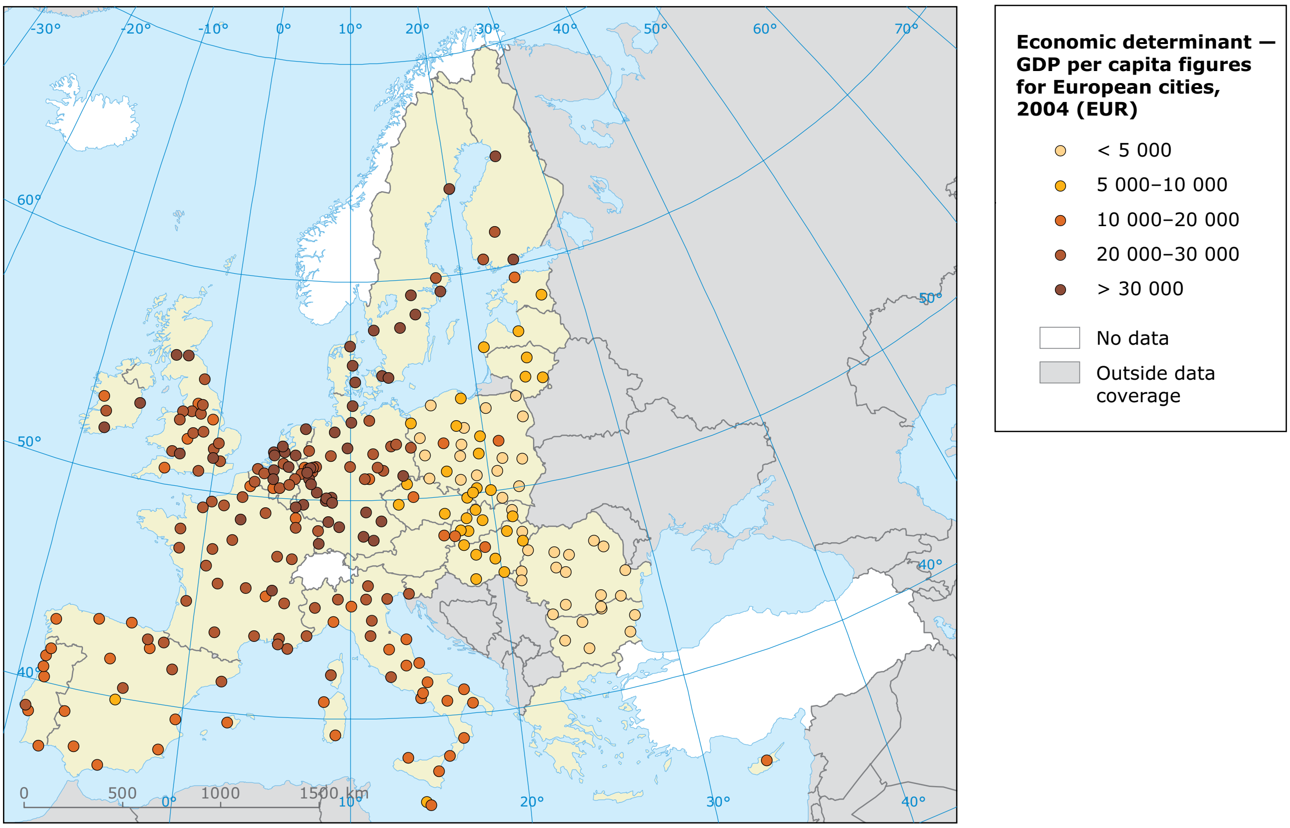
3.1.3 Action: economy, resources and institutions

Economic resources, capital assets and financial means are important parts of adaptive capacity (Smit and Pilifosova, 2001). Wealthy societies are better placed to adapt as they are able to bear the costs of adaptation and plan and pay for measures to increase their capacity. However, high income per capita alone is neither a necessary nor a sufficient indicator of the capacity to adapt (IPCC, 2001). While it seems evident that rich cities are better positioned than poor cities to adapt, very little information on costs of adaptation is available, other than for a small number of options such as flood defences. 'Green' and 'soft' solutions (see Chapter 2) can often provide low-cost solutions and there is usually enough knowledge for their implementation. High-tech and new solutions usually require more resources, knowledge, experience and training.

Map 3.6 shows the current GDP per capita figures for urban audit cities. It shows a marked divide in wealth between cities in eastern and western Europe, and a less marked one between northern and southern European cities. In some countries (notably Germany and the United Kingdom) the disparities between cities are greater than in others, which points to the importance of subnational, city-level measures, often masked by national averages.

Insurance can be seen as a consequence of the economic aspect of adaptive capacity since it is predominantly an instrument used by wealthier nations and individuals. Insurance can be very important in terms of coping capacity for example in the aftermath of extreme weather events. Depending on the use of insurance instruments, it can also guide long term development in adaptive capacity (i.e. the total withdrawing of insurance coverage from the riskiest locations). Figure 3.2 on insurance penetration shows the overall share of GDP used for insurance per country. The figures cover different types of insurance, including health and property, not only insurance instruments directly related to climate change impacts. The national figures demonstrate a rather clear east-west divide in Europe. The differences are further accentuated by the respective differences in GDP per country.

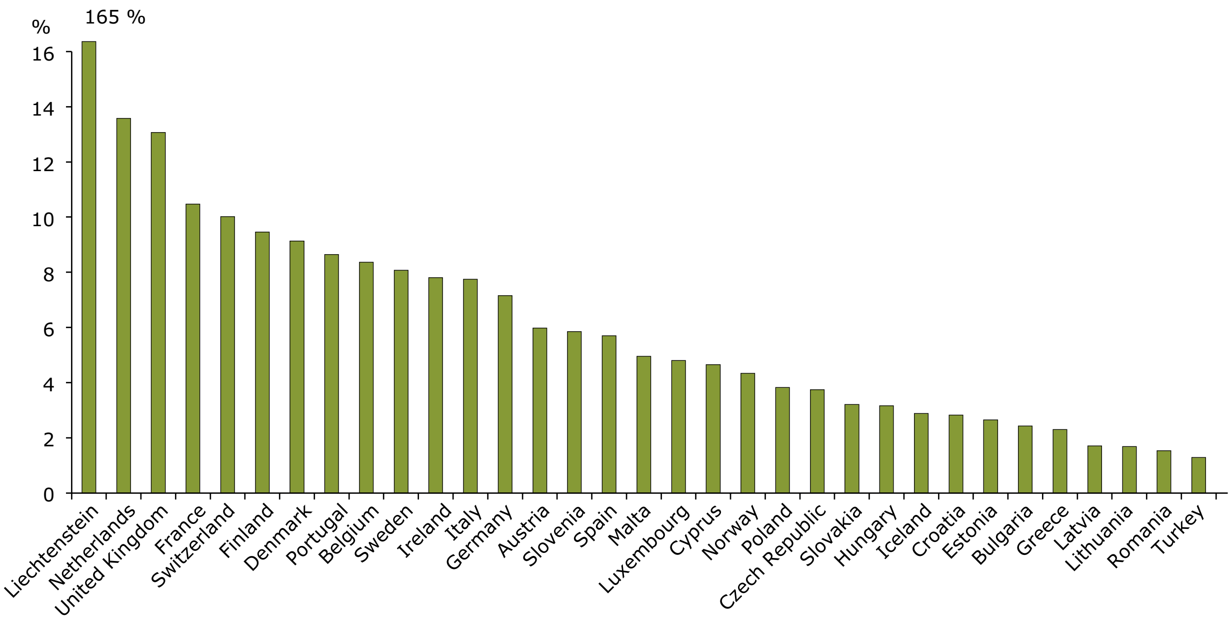
Map 3.6 Economic determinant — GDP per capita figures for European cities, 2004 (EUR)



Note: Data for Spain are from 2001 due to data-quality issues.

Source: Eurostat, Urban Audit database, 2004.

Figure 3.2 Insurance penetration as proportion of GDP

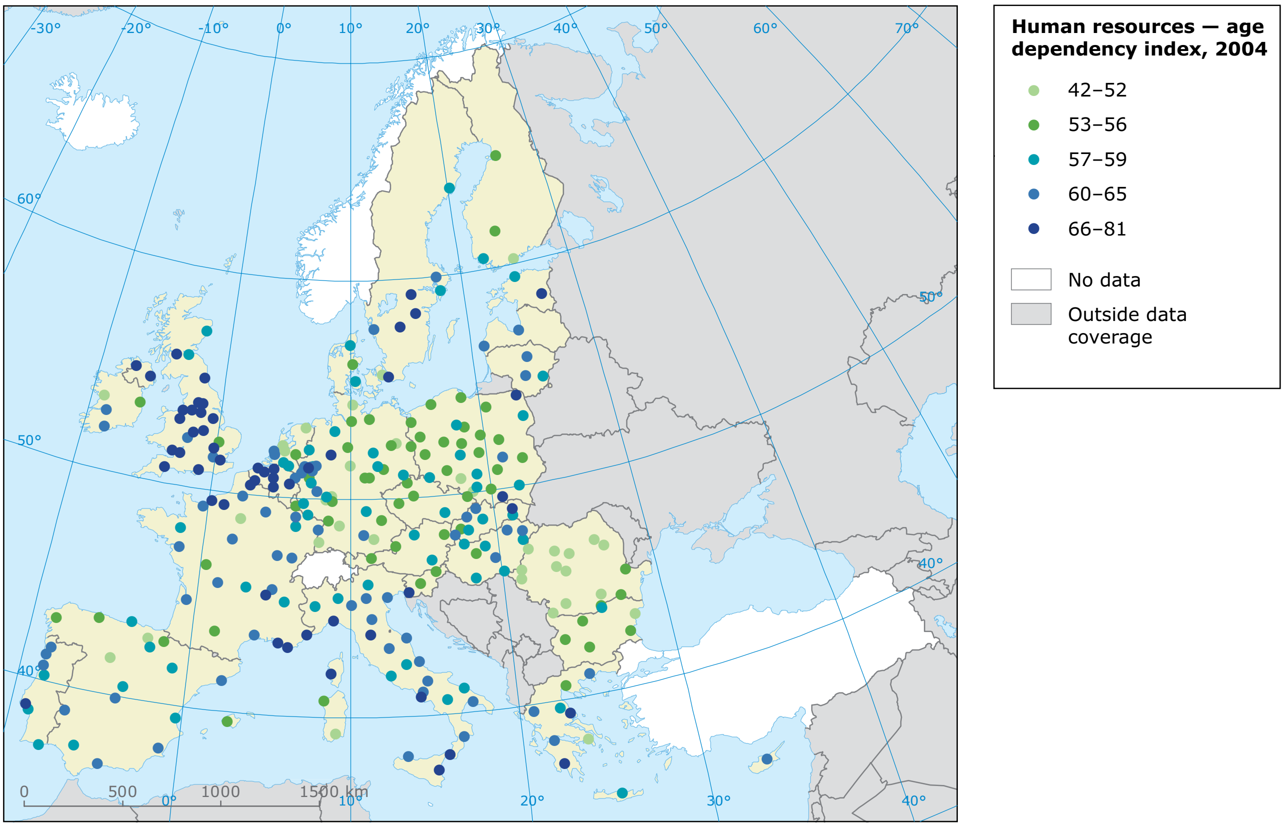


Source: CEA Statistics No 42, European Insurance in Figures. November 2010.

An indication of resources that include human actions and not uniquely economic activity is also relevant when considering adaptive capacity. Map 3.7 concentrates on the issue of human resources, as reflected by age dependency, i.e. the dependency level of young and old people on the economically more active part of the population. The age dependence indicator reflects demographic changes (ageing, fertility) and is relevant for the burden of support in economic and other terms between the active, working age population and everyone else. Contrary to the GDP indicator, cities in central, eastern and south-eastern Europe currently demonstrate higher adaptive capacity. This is due to a lower proportion of the young and the elderly in relation to the proportion of those more economically active. In the future this could well change due to projected demographic changes in Europe. There are, however, no projections at city level available.

Having well-functioning and efficient institutions (defined as the formal and informal structures and practices that hold society together) can enable adaptation to take place and reduce the impacts of climate-related risks (IPCC, 2001). Countries that have well developed and functioning institutions are considered to have higher adaptive capacity in relation to developing or transition countries. Such institutions and governance structures not only have the capacity to deal with present day challenges but also enable planning for the future. In Chapter 4, the roles and responsibilities of institutions at different administrative levels are discussed in a multi-level governance perspective, taking into account that different European countries have different governance systems ranging from federal to centralised. Social capital has been seen as an elusive but important aspect of institutional adaptive capacity. It refers to norms and networks that enable people to act collectively. One aspect of

Map 3.7 Human resources — age dependency index, 2004



Note: The number of people under 20 years old and over 65 years old is divided by the number of people 20–65 years old and multiplied by 100.

Data for Bulgaria, Cyprus, Czech Republic, Finland, France, Ireland and Latvia are for 2001.

Source: Eurostat Urban Audit database, 2004.

social capital is to trust both in other people and in institutions. Thus, it can be seen as an underlying factor of institutional adaptive capacity, relevant for predicting whether communities will act together facing future climate change adaptation challenges (Adger, 2001; Adger et al., 2008; Yohe and Tol, 2002).

Maps 3.8 and 3.9 present indicators that can be used as proxies for the current strength of governance at the city level. They measure the effectiveness of the central government and levels of social capital (measured by trust in other people). They suggest that the adaptive capacity in north west Europe is likely to be higher than of those in south-east Europe.

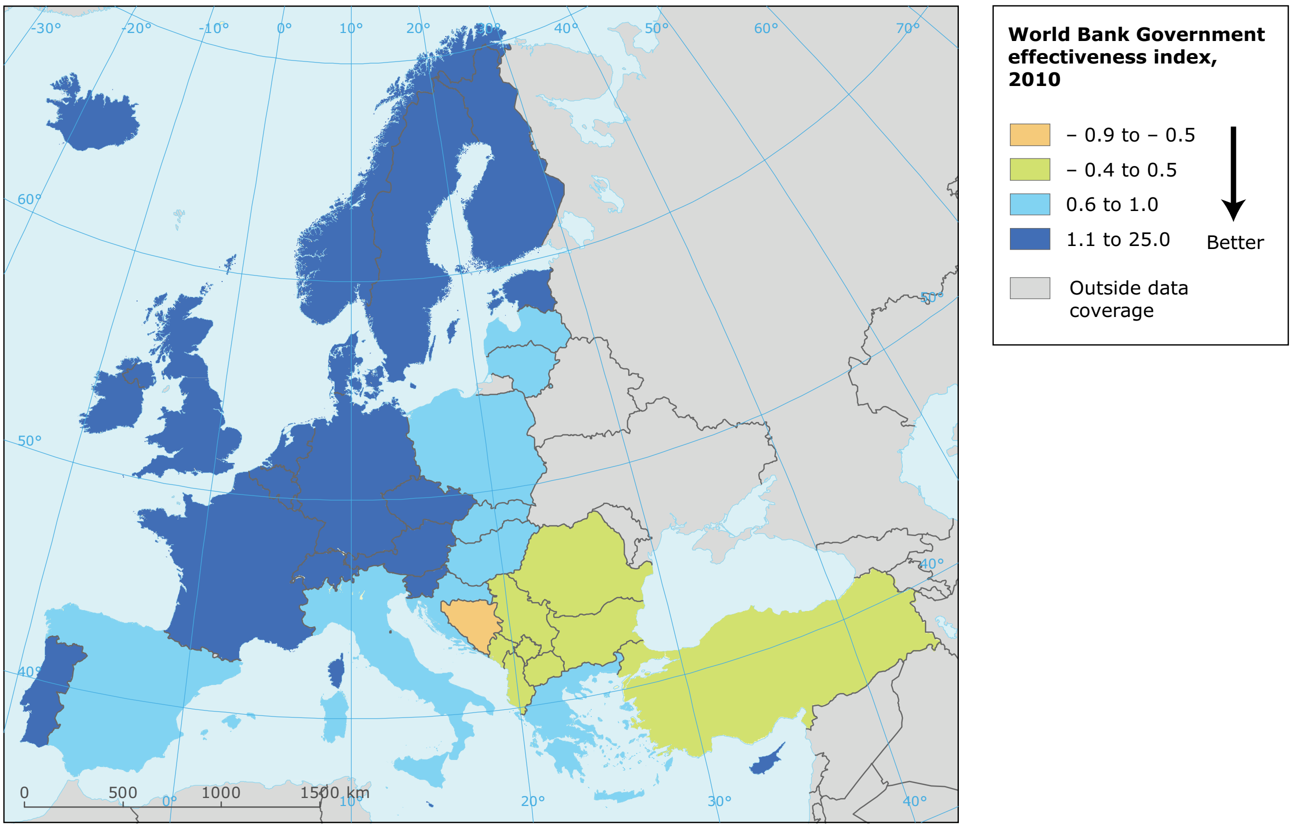
3.1.4 Summarising the adaptive capacity of cities

Current adaptive capacity varies among European cities. As with the impact indicators described in Chapter 2, the adaptive capacity seems not uniquely dependent on the country and region but also relates to the cities themselves. This emphasises the importance of subnational and city-level approaches and indicators. Whilst it is difficult to distinguish clusters of cities of similar adaptive capacity, several geographical trends can be observed.

In general, cities in north-western Europe are characterised by higher levels of equity, access to knowledge and technology and government effectiveness. Cities in the Benelux and Scandinavian countries score particularly high on indicators relating to the qualifications of the population and social trust. However, cities in eastern and southern Europe have a lower age dependency index. This means that currently they may cope better with the financial pressures of adaptation of climate change compared to north-west Europe which is burdened with the cost of providing for an ageing population.

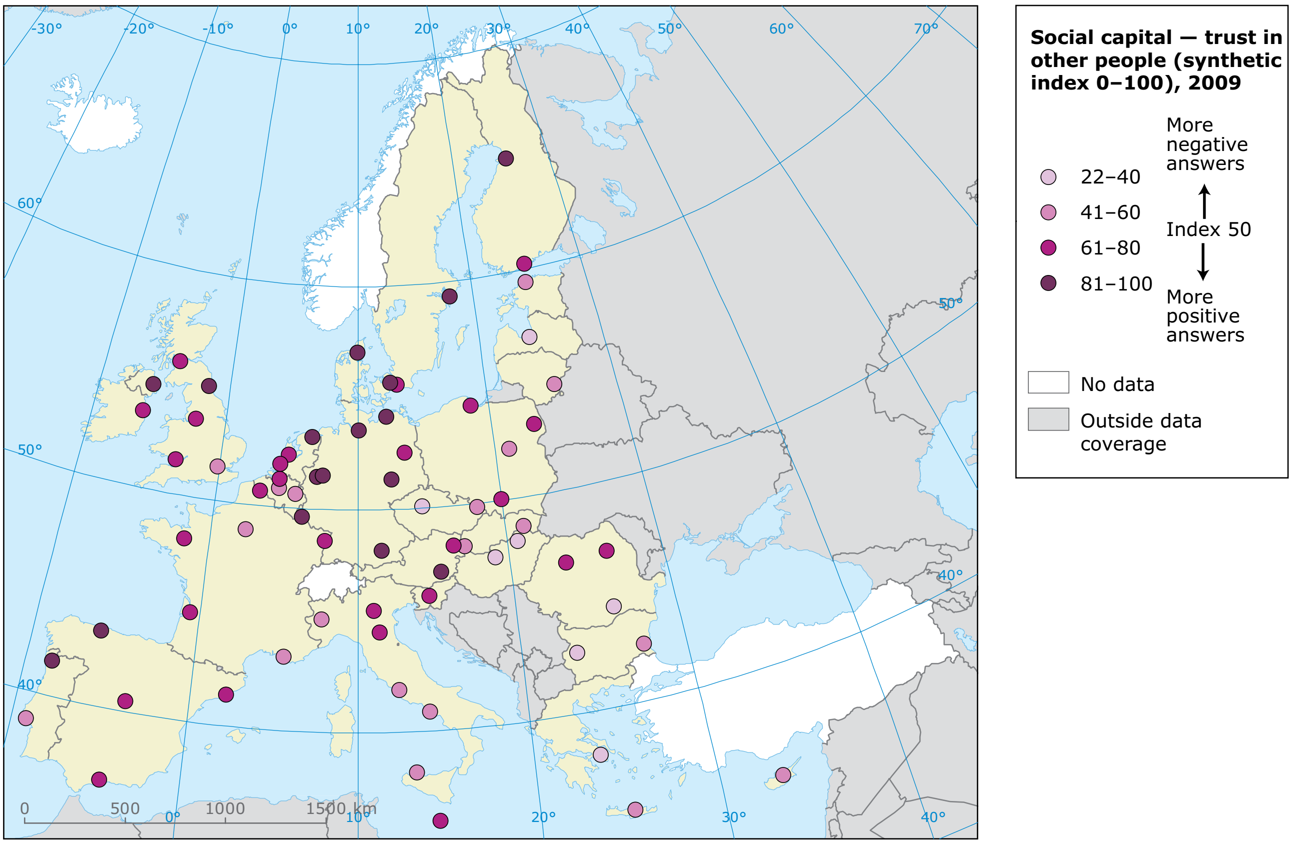
This spatial distribution suggests, firstly, that regional programmes relating to climate change adaptation can be tailored to different locations. For example, whilst south-eastern Europe would

Map 3.8 World Bank Government effectiveness index, 2010



Source: World Bank, 2012.

Map 3.9 Social capital — trust in other people (synthetic index 0–100), 2009



Source: DG REGIO/Eurostat: Urban Perception survey 2010; data 2009.

benefit from awareness raising and the increased commitment of local governments to climate change adaptation, in north-western Europe the economic, social and demographic conditions would be appropriate for promotion of bottom-up, community-based approaches. Moreover, the differences between European cities present an excellent opportunity for exchange of experiences and learning. Cities in the north-west can relate their own experiences in developing adaptation strategies and using technological solutions. Valuable lessons can be learned from experiences of countries in the south as regards dealing with heat and water scarcity, for example in traditional urban design, and by evaluating current strategies and techniques.

One must use the presented indicators with caution. Data on cities are not comprehensive across Europe, and the selection of indicators is constrained by data availability and quality. The presented results can, therefore, only serve as a starting point for discussion and require further in-depth analysis. Additional research is needed to show which determinants are more predictive than others as to how they support actual adaptive measures. Moving from generic to more predictive indicators of adaptive capacity would require improved data on adaptive capacity indicators with broader coverage, better data on actual adaptive measures taken in cities and finally further research on the correlation of certain determinants and actual adaptive measures (to serve as basis for weighting the different determinants). Thus, there is a clear need for improved city-level indicators for coherent comparisons of adaptive capacity. It would be especially important in this respect to develop a coherent system of monitoring actual adaptive policies and measures).

3.2 Planning steps to urban adaptation

Key message

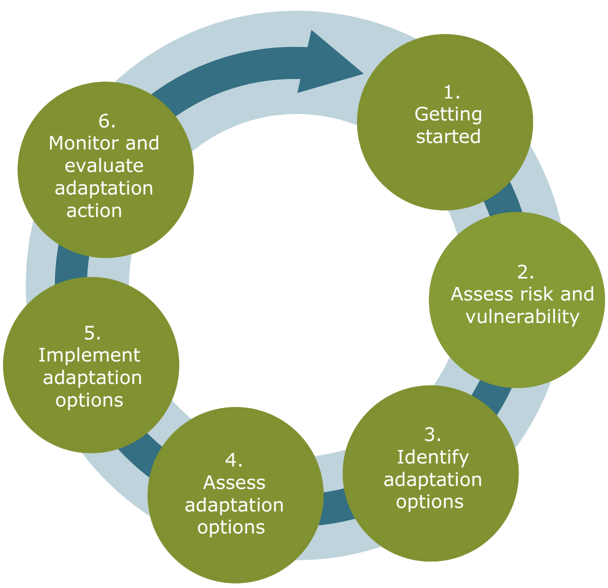
Planning urban adaptation should be a systematic and cyclical process. This report proposes six basic steps:

- Getting started;
- Assessing risks and vulnerabilities to climate change;
- Identification of adaptation options;
- Assessment of adaptation options;
- Implementation;
- Monitoring and evaluation of adaptation actions.

To be successful and effective, adaptation planning for urban areas should be systematic and follow a logical process. A number of approaches to adaptation planning have been developed (Smit et al., 2000; Ribeiro et al., 2009; CBT, 2009). This report follows the 'one step at a time' approach to adaptation planning which is derived from the United Kingdom Climate Impacts Programme's (UKCIP) adaptation wizard and used in the European climate adaptation platform CLIMATE-ADAPT (EEA and EC, 2012). The steps are based on a policy cycle, highlighting that climate change adaptation is an iterative process (Figure 3.3).

These six steps are summarised below. The European Climate Adaptation Platform CLIMATE-ADAPT provides extensive information in relation to each of the steps, including data, documents, websites, tools and guidance materials.

Figure 3.3 Adaptation planning steps



3.2.1 *Get started: initiate adaptation, ensure commitment and management*

Decision makers may ask why they should include adaptation to climate change on their agenda, given the other challenges facing Europe. In science it is well established that a certain amount of warming is unavoidable, due to greenhouse gases that are already present in the atmosphere. The effects of global warming have already been observed, and will continue to do so for decades to come. Adaptation is crucial to soften the impacts of the unavoidable changes in climate and to take advantage of the opportunities.

However, not all decision makers may be convinced by scientific evidence alone. In some countries national adaptation plans and strategies provide a stimulus for the development of adaptation plans at the city level. However, where there is little or no policy pressure adaptation planning at the local level tends to be triggered by various influences. This can include recent extreme weather events, a presence of a motivated individual within the institution, a concerned NGO, an engaged private-sector body or a research institution with an interest in climate impacts and adaptation, publication of a study concerning climate change impacts in the area or providing good practice examples from other cities. These triggers may be used to generate interest. If the interest is present, gaining political backing and managerial commitment is essential to progressing the adaptation agenda (M. Ribeiro et al., 2009) (see Box 3.1) followed by establishment of a clear mandate for the management of the adaptation process. This responsibility often rests with the local

Box 3.1 Gaining support and securing leadership from the local government in Southampton, United Kingdom

The cities, provinces and regions participating in the 'GRaBS' project (Green and Blue Space Adaptation for Urban Areas and Eco Towns) went through a specific process when preparing their adaptation action plans. One important step was the development of a high level policy statement noting the aims and objectives of the adaptation plan, which could be then accepted and signed off by the elected members.

The city of Southampton's low carbon strategy, is one example, which combines mitigation and adaptation goals. The foreword was provided by the cabinet member for Environment and Transport at the council, followed by eight key priorities for a city that can thrive in a low carbon economy and be competitive and prosperous despite the changing climate.

Involving local politicians in adaptation planning ensures their support. In Southampton's case, the commitment of the politicians helped to move adaptation from a peripheral position on the city's agenda to the forefront, thus ensuring that adaptation planning was not affected by budget cuts.

Source: Southampton City Council, 2011.

Photo: © Ian Britton

municipal authority or particular NGO. The power and responsibilities of the managing unit should be well defined over a sufficiently long time-scale to cover the development, implementation and evaluation of the adaptation plan.

3.2.2 *Assess potential climate change risks and vulnerabilities*

In this particular step, those responsible should assess any urban vulnerability (see Chapter 2) and elements such as the built environment, transport networks and critical infrastructure, including electricity and water supply. This should be done in relation to analysing all other climate impacts which can affect the functioning of the urban area and the well-being of its residents. Costs of climate change impacts can also be taken into consideration (see Box 3.2). A map with relevant locations to be viewed as priority areas for adaptation could be one suggested way of analysing data.

The uncertainty of the scale of climate change impacts should be taken into consideration, alongside the uncertainty of future socio-economic scenarios. Developing contrasting scenarios for the city and exploring the need for adaptation under different climatic and socio-economic conditions could assist with this task. A number of pan-European and national projects have created different socio-economic and climate scenarios across a variety of sectors (see the European Climate Adaptation Platform CLIMATE-ADAPT).

As part of preparing for adaptation planning the city's adaptive capacity should also be evaluated. This step is crucial for cities to set priorities for public and private spending, as the optimal allocation of resources is part of good governance. It should be noted that the assessment of impacts and vulnerability should not be limited to an economic analysis but also include the impacts on goods not on the market, such as ecosystem services.

3.2.3 *Identify a wide range of adaptation options*

After the priority areas, sectors and elements of the urban system have been decided, adaptation options able to reduce particular climate risks should be identified. Adaptation options aim to manage climate risk to an acceptable level and enable advantage to be taken of any positive opportunities that may arise. Chapter 2 describes a number of 'grey', or structural, 'green' and 'soft' adaptation options which can be considered. Alongside concrete actions, adaptation options include solutions that help to build general adaptive capacity. The latter is seen as an important response to cope with the inherent uncertainty in climate projections. Building adaptive capacity involves developing the ability

Box 3.2 Costs and benefits of adaptation

Photo: © City of Malmö

Due to the relatively recent focus on adaptation, little is known about the cost of potential climate damage, the cost of inclusion of adaptation in urban policies and projects and the cost of actual adaptation measures. Preliminary estimates suggest that benefits often exceed costs. Taking advantage of opportunities related to urban renewal as well as designing multi-purpose solutions can result in adaptation benefits exceeding the costs.

Two recent European projects (ClimateCost FP7 and PESETA) have looked at the costs in damage terms related to climate change for coastal systems, human health, agriculture tourism, and floods (Watkiss, 2011; Ciscar et al., 2009). In relation to health, the mortality rate related to heat exposure in Europe is likely to increase in all European regions, in particular southern Europe (Watkiss, 2011). The cost of heat-related deaths varies according to the method used. If the 'value of a statistical life' method is used estimated welfare costs will be EUR 30 billion average per year during the period 2011–2040, EUR 102 billion for 2041–2070 and EUR 146 billion for 2071–2100. However, if the 'value of a life year lost' method is used, these values decrease more than tenfold (Watkiss, 2011). This means that a careful consideration of costs is needed to guide the eventual choice of adaptation solution.

Adaptation planning does not necessarily have to be a costly and time-consuming process when it is integrated as one of the drivers into the development of urban policies. The 'Climate as Opportunity' project assessed 100 large infrastructural investment projects in the Netherlands, mostly related to spatial planning and water management with several of them in cities. The findings demonstrated that integrating climate change in planned urban renewal and upgrading projects improved project sustainability thus reducing the future costs. This was achieved via the following:

- lengthening the time scale;
- widening the scope of projects;
- exploring options for multi-functional land use;
- placing the projects in a much wider spatial context;
- involving a larger group of stakeholders;
- offering opportunities for private sector initiatives;
- improving the quality of projects generally without additional costs (Watkiss, 2011; Sedee and Pijnappels, 2010).

Adaptation costing studies to date have predominantly focused on a limited set of easily monetised measures such as flood defences or other infrastructure. Costing of measures such as urban greening is more complex. A recent study (Altvater et al. 2011; 2011a; 2011b) estimated the costs of green space maintenance and the installation of green roofs in those European cities included in the Urban Audit database by extrapolating the findings of individual case studies to the European level. These amount to over EUR 5 billion for green spaces and EUR 100 billion for green roofs annually, following an initial investment of about EUR 7 billion. The estimates for green spaces are based on the loss of profits from potential development on the allocated land. The calculations are based around the adaptation needs related to current rather than projected climate issues and they do not consider the intangible benefits, such as human well-being. Similarly, the estimates for green roofs reflect private and public expenditure, and ignore the savings made, for example, by insulation. It is therefore important to take into account all costs as well as all benefits of the adaptation options available to estimate their real economic feasibility.

The ClimateCost findings also show that adaptation is generally very effective at reducing the impacts of climate change at low cost. However, uncertainty in the climate models affects adaptation costs and benefits as well as costs resulting from inaction. This highlights the need for adaptation strategies which are effective within a framework of decision-making made with some levels of uncertainty (Watkiss, 2011) (see also Section 3.3.5). Co-benefits are, furthermore, decisive for getting adaptation action prioritised in the political process and subsequently implemented.

Source: Altvater et al. 2011; 2011a; 2011b; Ciscar et al., 2009; Sedee and Pijnappels, 2010; P. Watkiss, 2011.

of people and ecosystems to respond effectively to climate change and is discussed in detail in Section 3.1.

3.2.4 Assess and prioritise adaptation options

The appraisal and prioritisation of adaptation options follows the initial exploratory exercise as described in the previous step. Once potential adaptation options have been identified, an assessment should be carried out in order to determine which of them suit the city's specific context. Possible adaptation options should be assessed based on their potential to meet the adaptation objectives and their feasibility. In addition they should be effective and efficient in order to be considered for implementation. Effective options are options that reduce certain vulnerabilities to a desired level. Efficient options are those options whose benefits (economic, social and environmental) exceed their costs and are more cost-effective than the alternatives (see Box 3.2 for costs and benefits of adaptation). Other typical key issues affecting the choice of adaptation options for cities are: national legislation, financial feasibility, spatial requirements, time scales, ecological concerns, cultural heritage protection and public acceptability.

Thorough assessment of feasible options can help avoiding decisions that lead to maladaptation. Different sets of criteria or success factors have been used to assess adaptation options. The most important ones are discussed in Section 3.3. The selected adaptation options should preferably have elements of 'low-regret', which means that they are either reversible or can deliver a number of related co-benefits (see Section 3.3.3). Solutions that offer the opportunities to work with the forces of nature rather than against them are preferred (see Section 3.3.5), hence the focus on green infrastructure solutions in this report. An important criterion for the selection of adaptation measures should be that the measure is consistent, or even complementary to adaptation or mitigation efforts in other sectors (Smit and Pilifosova, 2001).

Tools and guidance documents are provided in the European Climate Adaptation Platform CLIMATE-ADAPT to assist in selecting assessment procedures and feasible options. Many different approaches exist to evaluate, or prioritise adaptation policy options. This includes cost-benefit analysis, focusing narrowly on quantifiable economic costs and benefits, and multi-criteria analysis that uses more than one criterion to assess and rank various options. Examples of tools and guidance for inventorying and screening adaptation options include the Adaptation Wizard (UKCIP), the Adaptation Decision Explorer (weADAPT) and the Digital Adaptation Compendium (EU ADAM project). In addition see EEA (2007) for more details on the economy of adaptation in relation to the aggregate costs of adaptation and inaction.

3.2.5 Implement adaptation actions

This next step relates to the development of an implementation plan which converts adaptation options into action by listing the objectives, assigning the responsibilities and setting the deadlines for completion. Implementation of the chosen adaptation options will be strongly influenced by existing policies and procedures.

At present, the experience of implementing adaptation actions is limited. Many of the examples provided in this report actually relate to cases in which climate change adaptation was just one of many factors that determined how particular projects were implemented. Notwithstanding this paucity of practical experiences, the success factors discussed in Section 3.3 offers some guarantee that adaptation policies that take them into account can indeed be implemented effectively.

The implementation of adaptation plans in European cities can be potentially threatened by their incompatibility with local, national or European policies. The adherence of the adaptation plan to the national and European policies in place should be ensured to avoid potential conflicts. EU regulations are also subject to change, which offers the potential for greater incorporation of climate change adaptation in a number of directives (Box 3.3). However, at the local level, amendment of the local policies (for example spatial development plans) could be considered in order to comply with adaptation principles. The adaptation plan can be developed as a separate document, but adaptation can also be streamlined by incorporation of its principles into the relevant policy documents. During policy analysis it is useful to link adaptation options to established policy programmes and funding programmes (e.g. structural and infrastructural development funds). Funding from additional sources will broaden the portfolio of available adaptation options for the cities and in many cases it makes many inaccessible options subsequently available. Chapter 4 elaborates the roles of the various actors at the relevant administrative levels.

Box 3.3 Environmental impact assessments — a tool for integrating climate change adaptation into other policies

A recent OECD report emphasises the importance of mainstreaming adaptation measures with pre-existing tools and mechanisms that are already being used in planning and implementing various development projects and programmes (Agrawala et al., 2010). Environmental impact assessments (EIAs) are seen as particularly relevant for the purpose of procedural integration at an international scale, due to the broad thematic and institutional reach of EIAs.

The White Paper on Adaptation (EC, 2009b) sees the revision of the EU Directives on EIA and SEI (EC, 2011a; EC, 2001) as a way of ensuring that plans and projects which are the subject of environmental assessments also require climate proofing as a pre-condition (Mickwitz, 2009; Agrawala et al., 2010; Birkmann and Fleischhauer, 2009). The obstacles for implementation include the limited availability of detailed information on the historical climate; the uncertainties associated with the future climate projections for specific locations and thus the risk of counterproductive investments in altering project design (Agrawala et al., 2010). Therefore, there is a need for a degree of flexibility when reflecting on new information on climatic changes in the EIA process.

3.2.6 *Monitor and evaluate adaptation action*

Our knowledge of climate change, its impacts and the effectiveness of adaptation solutions is developing rapidly and the adaptation planning process should be sufficiently flexible to allow for changes. A crucial step in the process is the establishment of a long-term monitoring system of the implemented actions, in order to ensure that the actions are focused on the priority areas and to evaluate the effectiveness and efficiency of adaptation. Monitoring enables the adjustment and refining of the adaptation options where necessary thus eliminating maladaptation. For example, this could mean testing the 'grey' adaptation options, such as flood defence systems, or 'soft' responses such as flood or heat warning systems.

Furthermore, learning derived from monitoring and reviewing processes can enhance the adaptation process itself. It not only helps to assess the suitability of adaptation measures in a given location, but also offers a practical example for other cities, thus supporting the knowledge exchange. Good practice states that evaluation and monitoring is carried out by an organisation independent from stakeholders involved in adaptation implementation. Although experiences with monitoring and evaluation are as yet limited, some countries in Europe (Finland, Germany and the United Kingdom) are experimenting with the development of evaluation methods at a national level. The European Climate Adaptation Platform CLIMATE-ADAPT provides access to up-to-date information regarding these efforts.

Further reading

- UKCIP Adaptation Wizard (http://www.ukcip.org.uk/wizard).
- Snover, A. K., Whitely Binder, L., Lopez, J., Willmott, E., Kay, J., Howell, D. and Simmonds, J., 2007, *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*, ICLEI — Local Governments for Sustainability, Oakland, CA, USA (http://www.icleiusa.org/action-center/planning/adaptation-guidebook).
- VÁTI, 2011, *Climate-Friendly Cities: A Handbook on the Tracks and Possibilities of European Cities in Relation to Climate Change*, Ministry of Interior Hungary — VÁTI, Budapest (http://www.eukn.org/dsresource?objectid=224489).
- CoR, 2011a, *Adaptation to Climate Change: Policy instruments for adaptation to climate change in big European cities and metropolitan areas,* European Union, Committee of the Regions, Brussels (http://80.92.67.120/en/documentation/studies/Documents/Adaptation%20to%20Climate%20Change/EN.pdf).

3.3 Success factors

Key messages

The success of adaptation planning and implementation depends on several factors:

- Awareness-raising actions should be targeted at stakeholders ranging from citizens to national and European governments and cover various aspects of climate change adaptation.
- Successful adaptation cuts across sectors and scales. Planning and implementation needs to involve horizontal collaboration between different sectors or policy departments, as well as vertical coordination between different administrative levels.
- Adaptation solutions that deliver additional benefits, such as green urban areas, increase the willingness to accept and implement them.
- Working with nature, instead of working against natural processes, and using green infrastructure are sustainable solutions with multiple benefits.
- Many climate change adaptation measures can be implemented at low-cost or contribute positively in other areas. However, a sufficient resource base in terms of financial, human and institutional resources needs to be developed and secured.

The steps outlined in the previous Section offer a generic guidance on how to proceed in adaptation planning and implementation. As the adaptation agenda is relatively new (Kazmierczak and Carter, 2010; Ford et al., 2011), combined with the complex nature of both climate change and the urban areas, the planning process may be fairly complex. This Section aims to provide an overview where the processes have seen success as identified in previous research (Kazmierczak and Carter, 2010; CAP, 2007; CAG, 2009; PB, 2009; Bulkeley et al., 2009; Tanner et al., 2009).

When considering the successful development and implementation of appropriate adaptation measures a number of factors can be considered. The EEA's European Topic Centre on Air and Climate Change, for example, introduces ten guiding principles for climate change adaptation in Europe (Prutsch et al., 2010). This report focuses on five interlinked success factors which combine principles such as raising awareness, working across sectors and scales, capturing co-benefits, dealing with uncertainties and long timeframes and working with nature, along with experiences in various cities in Europe.

3.3.1 Raising awareness of climate change and the need to adapt

Climate change will affect all sectors of human activity. Thus, it is paramount that adequate awareness of climate change exists. Awareness raising is particularly important among the following groups (Füssel, 2007):

Senior management within decision-making bodies. This could include: heads of government agencies at national and regional levels; city mayors and elected members and directors of municipal departments. They all need to be aware of the necessity of climate change adaptation. The presence of a strong leader or champion can, firstly, help to prioritise the adaptation within the organisation; secondly, they decide about implementation of any changes to policies; thirdly, they can ensure the availability of human and financial resources for development of adaptation strategies. Also, leaders (ministers and mayors) can raise the profile of adaptation planning in their area and secure support from key stakeholders (M. Ribeiro et al., 2009).

The staff of organisations planning the adaptation strategy. The understanding of the problems associated with climate change and the solutions is needed for the officers working at local, regional and national levels in order to be able to formulate the policies and develop the delivery plans. Adaptation to climate change requires attention and action by people who have not explicitly considered climate in previous decisions. Managers of climate-sensitive resources (for example water managers, forest managers, urban and spatial planners, architects, tourism managers and health care providers) have usually assumed regional climate is essentially stationary. This assumption is no longer valid under global climate change, in particular when long-term decisions are concerned (Füssel, 2007).

Practitioners and consultants. Natural resource managers who would actually implement the recommended changes can provide key information about how processes are undertaken and why. This information is a crucial starting point for planning any changes.

Non-governmental organisations can also participate actively in climate change-related actions. If they understand the risks associated with climate change, they can play an important role in the countries where there is little regulatory push for local authorities to develop adaptation action plans (see Box 3.4 for an example in Slovakia).

Other external stakeholders, in particular those responsible for critical infrastructures or emergency services whose understanding of the need for adaptation is crucial to ensure that a given area can function under the changing climate and cope with extreme weather events.

The general public. Informing and involving the local communities in climate change adaptation actions can ensure smoother implementation of the necessary measures.

The development of knowledge-sharing should be targeted. Four important aspects can be identified:

- Awareness of risks associated with climate change. For more details see Chapter 2.
- Understanding what adaptation is. One of the main constraints in the development of adaptation strategies is the lack of understanding among policymakers as to what adaptation actually is. It is often not understood that adaptation is as important as mitigation, regardless of the level of mitigation, since a certain level of climate change cannot be avoided.

Awareness of adaptation costs and benefits. If stakeholders are aware of the risks and knowledgeable about effective response measures, the awareness-raising process should focus more on the expected costs and benefits of the specific options available (Füssel, 2007).

3.3.2 *Cutting across different sectors and levels*

As the issue of climate change is cross-sectorial and multi-levelled, responses to climate vulnerabilities may be the remit of different sectors of the administration. Thus, climate risks need to be considered in all sectors, including urban planning, transport and health, in an integrated fashion. For example, in order to ensure an efficient response to heatwaves affecting human health, adaptive actions related directly to health protection (e.g. heat wave plans for health and social care practitioners) should be accompanied by, inter alia, adaptive building and urban design measures. In the Dutch 'Room for the River' project, there is a need to plan for higher river flows through improved drainage. Yet, sea level rise interferes with water drainage. Improved flood protection and water management, therefore, require considering both river flows and sea level.

Box 3.4 Community network in Bratislava, Slovakia

While in some countries the main driving forces for the creation of an adaptation action plan are local authorities or local parliamentarians, in the Slovak case the network was instigated by the non-governmental sector. The Regional Environmental Centre in Slovakia became a facilitator of discussion between the local authorities and the non-governmental sector, and a moderator of a network of community and government representatives. Although there was no formal agreement with the city of Bratislava, the network became a full member of the task groups preparing the Bratislava Strategic Development Plan.

The active participation of environmental organisations within the network has led to improvements to the Strategic Development Plan. Climate change challenges and mitigation and adaptation issues were fully incorporated as priorities under the objectives of improving the quality of the environment and urban spaces.

Source: Hudeková and Tvrdoň, 2011.

Photo: © HatM

One issue cannot be addressed independently of the other. Challenges can arise when responsibilities for issues are divided (Scarlett, 2011) thus emphasising the need for intra- and inter-organisational collaborations (see Section 3.3.3). In particular, different types of infrastructures, critical for the functioning of cities, are often mutually dependent, requiring coordination between the services responsible for them (see Box 3.5).

Bridging the divide between different sectors can help to eliminate instances of maladaptation, i.e. where the adaptive actions in one sector have negative secondary effects on other sectors (see Box 3.6). Similarly, adaptation which can be successful at a specific temporal or spatial scale can become maladaptation at another level. In Chapter 4 the roles and responsibilities at different administrative levels are discussed in more detail, from local to European. Here, we focus on the linkages between different sectors and levels within a city (from building to neighbourhood to urban scale), capturing the various components of the governance systems relevant for climate change adaptation.

One sector particularly important for cross-sectorial adaptation is land-use planning. Present and future land-use planning greatly affects the impacts of climate change on cities and all infrastructure systems. This is because population distribution affects the location of infrastructure and hence the potential impacts. The way land is developed affects flood magnitudes and losses, water quality, water availability, and local heat island effects. Prohibition of new developments in flood zones is an example of land use regulation that can both decrease potential damages to property and improve hydrological conditions, thereby decreasing the severity of flooding. Transportation analysis further suggests that it can also be important to avoid commercial or residential development in areas that can often become inaccessible during extreme weather events. In general, good land-use planning will not increase vulnerability but will rather decrease it (Kirshen et al., 2007). If climate change adaptation is integrated with the regular plans for city renewal and expansion, costs of investments in infrastructure could be minimised. This also reinforces the importance of involving spatial planning departments in the development of adaptation strategies. Multi-scale land-use approaches to managing high temperatures and the risk of flooding are promoted by the United Kingdom's Town and Country Planning Association, focusing on three spatial scales in cities: the conurbation, the neighbourhood and the building (Figure 3.4) (Adger et al., 2005; Shaw et al., 2007).

Box 3.5 Interdependencies between infrastructure types

The report 'Infrastructure, engineering and climate change adaptation — ensuring services in an uncertain future' by the Royal Academy of Engineering (2011), examines vulnerabilities in different sectors of the United Kingdom to the effects of climate change and the modifications that would be needed to increase resilience. It also considers vulnerabilities that affect the infrastructure system as a whole and which arise as a result of interdependencies between different sectors. The functioning of cities depends on such viable systems.

Extreme events in particular highlight the interdependencies in infrastructure as they are liable to lead to 'cascade failure' where the failure of one aspect of infrastructure, such as flood defences, can lead to other failures. One example of this could be flooded power stations leading to power cuts which thereby affect telecommunications networks, the pumping of drinking water and control systems. The interdependencies in infrastructure therefore need to be managed well. For example, a smart grid will mean energy systems rely more on information and communication technology, and the electrification of transport systems will mean transport is more reliant on the national grid.

Photo: © Genkaku

Source: Royal Academy of Engineering, 2011.

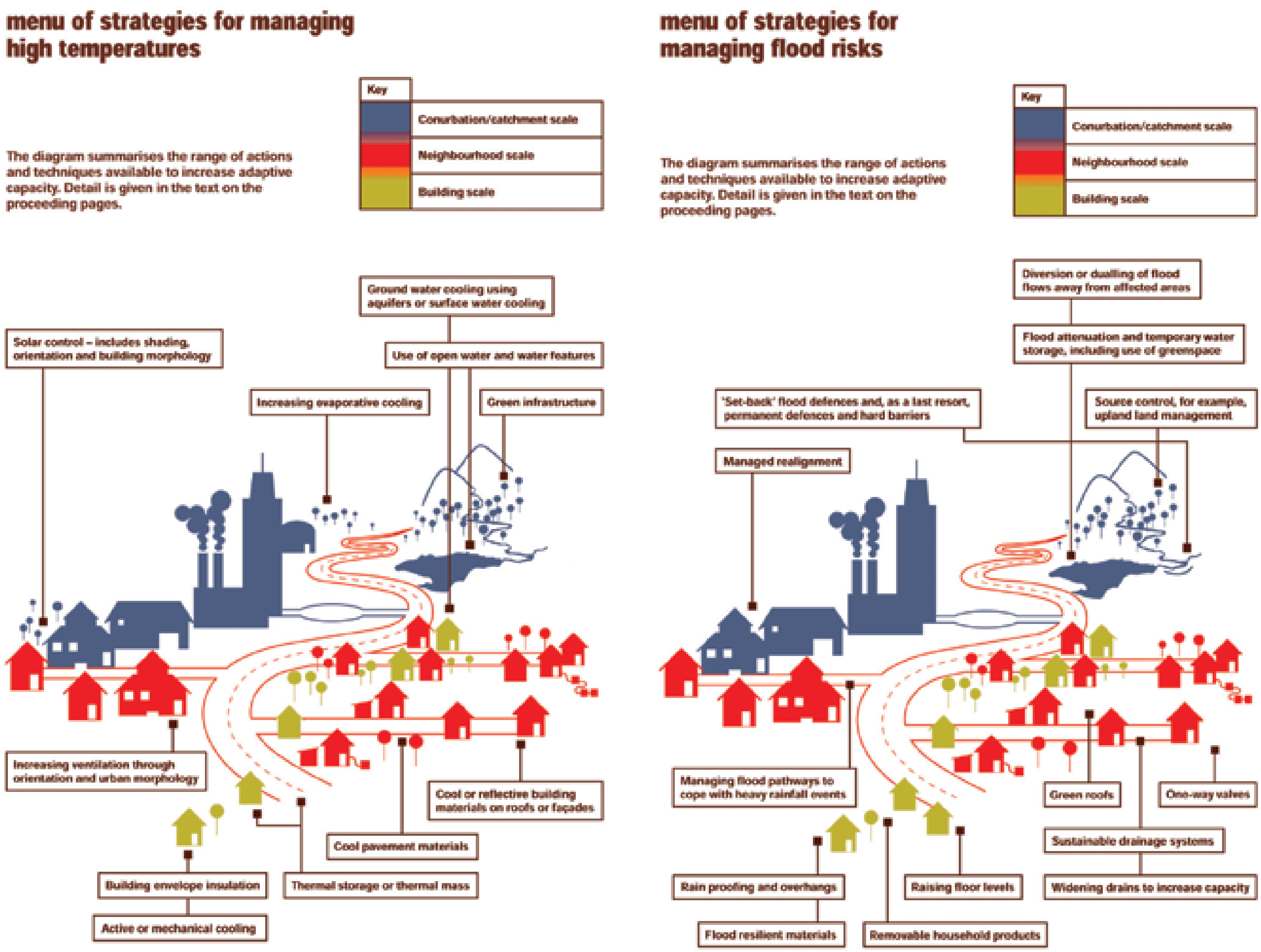
Box 3.6 Avoiding maladaptation

Adaptation measures which can be successful at a specific temporal or spatial scale can also become maladaptation (Adger et al., 2005). For example, hotter summers will result in increased need for cooling buildings. However, provision of air-conditioning and fans would result in increased use of electricity, thus increased carbon emissions. Moreover, the hot air from the air conditioning units would increase street temperature, thus exacerbating the problem. Thus, provision of air conditioning can be seen as maladaptation and other solutions should be considered. For example, better insulation in houses can keep them cool in the summer and warm in winter. Meanwhile planting trees for shade not only provides cooling benefits in the summer but also allows for contact with nature for urban dwellers.

In conclusion, adaptation measures need careful planning to avoid negative side effects and thus maladaptation.

Photo: © A. Svensson

Figure 3.4 Multi-scale approaches to managing high temperatures and flooding



Note: From 'Climate Change Adaptation by Design'. Courtesy of the TCPA. Graphic by thomas.matthews (www.thomasmatthews.com).

Source: Shaw et al., 2007.

In order to ensure cross-sectorial planning and delivery of adaptive actions it is essential to coordinate actions between departments within the same level of government. Starting an adaptation planning process must involve setting up internal organisational structures and procedures across all relevant departments in order to institutionalise the adaptation 'motto' in various key sectors. Adaptation to climate change is very often led by an environment or sustainability department.

However, engagement from other departments may help to mainstream adaptive actions. In particular, engagement from the departments responsible for spatial planning and development control is important, especially when the adaptive actions are targeting land-use change or promoting restrictive development. Coordination mechanisms can be either formal or informal, depending on the political and legal tradition (M. Ribeiro et al., 2009). Box 3.7 provides two examples of cross-departmental collaboration in southern Europe.

Box 3.7 Cross-departmental collaboration and external stakeholder involvement in Kalamaria, Greece

The Municipality of Kalamaria (Thessaloniki, Greece) has developed an adaptation action plan focusing on the use of green spaces as adaptation. Before starting the process, strategic co-operation between different directorates and departments in the municipality was lacking. The city started with an internal SWOT analysis (strengths, weaknesses, opportunities and threats). It involved interviews with personnel of the Department of the Land Registry Office and Municipal Property, the Department of Technical Works, Maintenance and Environment, the Planning Department; the Department of Greenery and the Office of Protection of the Environment. A cross-departmental climate change monitoring task force, involving representatives from the Department of Technical Works, Maintenance and Environment, Planning Department, Programming Department and Civil Protection, led to the development of an action plan with clear roles for all stakeholders. The task force will monitor and evaluate the implementation and then report to the mayor.

Photo: © Ioannis Tsionas

The adaptation action plan was also developed in collaboration with a number of external stakeholders — the region of Central Macedonia, the Union of the Municipalities of Thessaloniki, Kalamaria and others, 'Anatoliki' a local government development company, the Aristotle University of Thessaloniki, various technical, transportation and planning bodies within Thessaloniki, the water company and the fire service. The meetings resulted in concrete proposals and their prioritisation. They were synthesised and included in the adaptation action plan.

This cross-departmental and multi-stakeholder process brought different perspectives and types of experience to the adaptation action plan. They improved the understanding of climate change impacts across stakeholders and, as a co-benefit, helped to established long-term collaboration which otherwise would not have taken place. The participants felt committed to sustaining the network following completion of the adaptation action plan.

... and Genoa, Italy

The adaptation action plan was developed by the local planning department in the province of Genoa, Liguria. The adaptation action plan concerns in particular two practical projects aiming to balance development in the province with environmental vulnerabilities that may be exacerbated by climate change. To ensure successful delivery of the projects, the province of Genoa set up a multidisciplinary working team. It included representatives from the Department of Land and Basin Planning (three geologists, four land planners and a hydraulic engineer); the Department of Natural and Protected Areas (an ecologist) and finally the Department of Energy and Environment (a physicist). Support was provided by two external experts in landscape planning and landscape design. This approach was intended to allow for differing viewpoints and to deliver projects addressing both environmental vulnerability and climate change adaptation in a sustainable manner.

Source: Municipality of Kalamaria, 2011; Provincia di Genova, 2011; http://www.grabs-eu.org.

The development and implementation of successful urban adaptation plans requires cooperation between a number of stakeholders. Stakeholders can be defined as those with an interest in climate change impacts on urban areas. Good management structures and a comprehensive goal where adaptation is concerned should motivate stakeholders to actively participate. Transparent decision-making processes and fair treatment of stakeholder interests should enhance cooperation and avoid potential conflicts. The example of the Municipality of Kalamaria, in Thessaloniki, Greece (Box 3.7), illustrates how different stakeholders can be involved in the process of development of an adaptation action plan.

3.3.3 Utilising the co-benefits of adaptive actions

While the previous Section stressed the need for sectors to collaborate, it is also evident that this becomes easier when benefits can be identified for more than one sector. Wherever relevant, adaptation measures have to be examined in relation to other policy areas, such as those of nature conservation, agriculture, urban development, transport, climate change mitigation or energy supply and demand. Presenting the benefits of a given adaptation option in an economic manner can be particularly important in order to persuade decision-makers that adaptation measures are feasible and desirable.

As highlighted in Box 3.8, green infrastructure solutions (see Section 3.3.5 for more detail) have the potential to deliver a number of benefits. Possibly the most important driver for climate change adaptation is the improvement in quality of life in cities. This could lead to increased investment leading to greater prosperity. The Augustenborg neighbourhood in Malmö, Sweden illustrates how solutions aimed at reducing the risk of flooding have also contributed to social regeneration (Box 3.9).

The synergies between adaptation to climate change and mitigation action are of particular interest (see also Box 3.6). In some instances the two

Box 3.8 Natural Economy North West, United Kingdom: estimating the economic benefits of green infrastructure

Natural Economy Northwest was a partnership led by Natural England, the Northwest Regional Development Agency and SITA Trust between 2006 and 2009. The partnership worked with a wide range of partners and stakeholders to help in placing ecosystem services and natural environment at the heart of thinking about sustainable economic development, quality of life and quality of place. It recognised that ecosystem services underpin the social, cultural and economic prosperity of the region. The environmental economy (public and private sector activities related to ecosystem services) in the north west of England already generates GBP 2.6 billion within the regional economy every year and employs 109 000 people. The recognised eleven major economic benefits are:

- Economic growth and investment: business attract and retain more motivated staff in greener settings;
- Land and property values: views of natural landscapes can add up to 18 % to property values;
- Labour productivity: green spaces near workplaces reduce sickness absence, increasing productivity;
- Tourism: rural tourism supports 37 500 jobs in the north west;
- Health and wellbeing: green infrastructure reduces pollution which leads to asthma and heart disease;
- Recreation and leisure: footpaths, cycle paths and bridleways enable healthy, low-cost recreation;
- Quality of place: community-owned green spaces can create jobs and local pride;
- Land and biodiversity: green infrastructure provides vital habitats and jobs managing the land;
- Flood alleviation and management; urban green spaces reduce pressure on drainage and flood defences;
- Climate change adaptation and mitigation: green infrastructure can counter soaring summer temperatures in cities.

The approach helped to reaffirm that green infrastructure is necessary for a region's prosperity. It emphasised that green infrastructure is crucial for the functioning of the region. Strong leadership by the regional public bodies was the principal reason for success.

Source: Natural Economy North West, 2012; Natural Economy North West, 2012; ECOTEC, 2008; http://www.naturaleconomynorthwest.co.uk/about.php.

Box 3.9 Sustainable urban drainage systems as a driver for urban social regeneration in the Augustenborg area of Malmö, Sweden

The neighbourhood of Augustenborg has experienced periods of socio-economic decline in recent decades, and at the same time frequently suffered from floods caused by overflowing drainage systems. Augustenborg underwent significant regeneration between 1998 and 2002. The main drivers for this initiative were the difficult social and economic situation in the neighbourhood, flood risk management, waste management and biodiversity improvement. Significant physical changes in infrastructure took place as a result, focusing on the creation of sustainable urban drainage systems, including ditches, retention ponds, green roofs and green spaces. The project was carried out collaboratively by the city council and a social housing company with extensive residents' participation. The project was deemed successful as the rainwater runoff rates have decreased by half and the increase in green space has improved the area's image.

Source: Kazmierczak and Carter, 2010; http://www.grabs-eu.org/membersArea/files/malmo.pdf.

Photo: © Town and Country Planning Association (TCPA)

can be in direct opposition as it may be difficult, for example, to combine green roofs and solar panels on one building. However, in many cases adaptation and mitigation are compatible. Building insulation allows energy-saving for heating but also maintains lower temperatures in hot periods. Green infrastructure solutions in particular can address both the root cause and the impacts of climate change. Vegetation provides a carbon sink whilst at the same time lowering temperatures in the city. The INTERREG IIIc project AMICA specifically focused on integration adaptation and mitigation in the areas of energy, construction, and spatial planning, i.e. those sectors where 'common ground' between adaptation and mitigation policies is expected. AMICA developed a tool for city planners (AMICA, 2012).

In some cases adaptation is the principle driver for action. In others it can be but one consideration amongst many. Examples include:

- The floating houses development situated on the new island neighbourhood of IJburg in Amsterdam, the Netherlands respond to the existing demand for houses built near to water. Such developments also cope well with sea level rise or high storm surges. This example demonstrates the potential of climate change adaptation to act as a stimulus for innovation (see Box 2.14).
- The 'Warm Front' ([9]) scheme in England provides heating and insulation improvements to households on certain income-related benefits living in properties that are poorly insulated and/or do not have a working central heating system. Qualifying households can qualify for improvements worth up to GBP 3 500. Grants are available for improvements such as loft insulation, draught proofing or cavity wall insulation. These improvements have also been efficient in reducing the risk of overheating to properties, thus reducing related risks to the vulnerable.
- Smart homes, known as 'telecare technology', refers to equipping residences with a set of advanced electronics and automated devices. These are designed to enhance health care delivery (and remote physiological monitoring of residents) to enable early identification of possible problems and emergency situations and to maximize residents' safety and overall well-being. Smart homes aim to assist the elderly in remaining independent at home by

([9]) http://www.direct.gov.uk/en/Environmentandgreenerliving/Energyandwatersaving/Energygrants/DG_10018661.

proactively addressing their needs. Inclusion of temperature and flood sensors in smart home technology can be important aspects of adaptation reducing mortality rates among the infirm and the elderly and improving their quality of life.

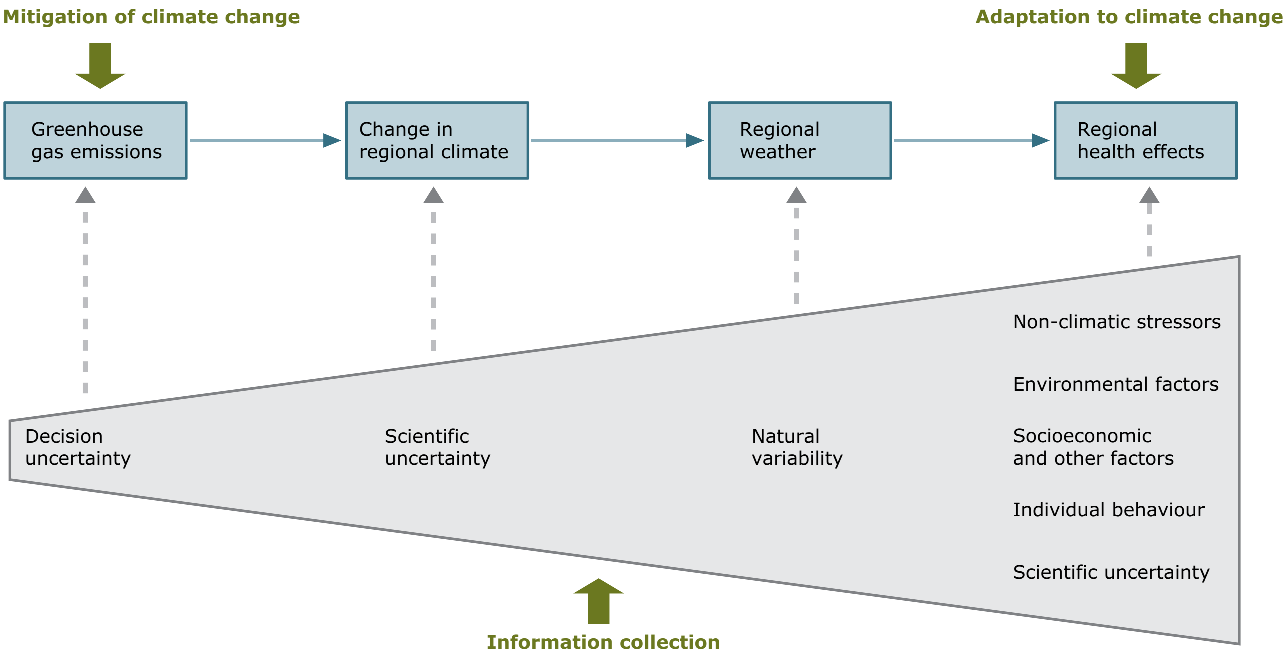
In general, climate adaptation can be considered as not just a reactive or defensive response but as a proactive implementation of a long-term economic and sustainable development strategy.

3.3.4 *Dealing with uncertainty and long time frames*

Uncertainty is one of the key constraints when developing adaptation strategies (Ribeiro et al., 2009). It gives decision-makers latitude to ignore the problems associated with climate change or delay development of adaptation strategies. Decision-makers should aim to assess how they can improve the decision-making process leading to development and implementation of adaptation strategies regardless of uncertainties. This is certainly no easy task as uncertainties abound. The IPCC Special Report on Emissions Scenarios (SRES) (IPCC, 2000) defined six different future emissions pathways based on potential storylines for the future, and thus six scenarios for the associated increase in global average surface temperatures. Fortunately, the climate projections for the different emissions scenarios only start to diverge after 2050. Therefore, considering the full range of climate projections is important only for adaptation investments with a very long life time such as flood protection measures.

At the same time, in the medium term the main uncertainty is related to differences between the outputs of different climate models. In the scientific community, there is a trend towards development of increasingly complex climate models and downscaling the projections to more and more local levels. However, creating more complex models may not necessarily provide greater accuracy of predictions. There may also be a conflict between providing spatially precise projections, and making these projections accurate (Dessai et al., 2009). The predictive power of the climate models is uncertain and different strategies are adopted to address this limitation. Focusing on either the upper or the lower bounds of scenarios can lead to, respectively, scaremongering or neglecting the issue. Good practice when handling uncertainties in climate impact scenarios is to provide a plausible description of any future impacts.

Figure 3.5 Simplified cause/effect pathway regarding climate impacts on human health (in blue), along with sources of uncertainty (in grey) and target points for societal response options (in green)



Source: Füssel et al., 2006.

In addition, it is important to recognise that when considering adaptation, climate is only one of many processes that influence outcomes. Many of the other processes (for example, socio-economic and political issues that determine vulnerability such as globalisation, economic priorities, regulation and cultural preferences) cannot be adequately predicted either. The on-going economic crisis; the uncertainty faced by the Euro zone or the 2011 political developments in north African and middle-eastern countries are examples of the unpredictable turn of events. Figure 3.5 presents how the uncertainties add up in relation to the risks of climate change to human health.

Information about climate change for specific locations can be difficult to obtain. In this context, basing future adaptation strategy on past extreme weather events can be effective, in particular when current climate related risks can be considered large and needing action (Füssel, 2007). However, it may be difficult for local government to predict local climate risks owing to the low probability of extreme events occurring. Translating global and national information into information relevant at the more local level may be challenging. Thereby gathering local information is crucial for the formulation of adaptation strategies at local or regional levels (Ribeiro et al., 2009). In Stuttgart, Germany long-term meteorological observations provided a thorough understanding of the weather-related problems in the city (see Box 3.10).

For the majority of cities and regions the possibilities of developing in-house expertise are limited, which emphasises the importance of collaboration with research institutes and other stakeholders. Box 3.11 provides an example of a simple framework, used in the United Kingdom, for considering current weather patterns and their impacts. Historical records describing the impact and costs of locally relevant extreme events are rare and often inadequately record key information for modelling future adaptation plans (Scott and Weston, 2011). Caution is recommended when future adaptation responses are based on past events. Predicting climate events based on previous incidents is not usually reliable and such risks should be acknowledged by city governments.

Box 3.10 Developing in-house knowledge of the local climate in Stuttgart, Germany

Stuttgart is located in a valley basin. Due to its industrial activity the city has been susceptible to poor air quality since the 1970s. Development on the valley slopes has made the situation worse by preventing air from moving through the city which in turn has contributed to the urban heat island effect (see Box 2.5).

The importance of climatic conditions for human comfort in health has been recognised in Stuttgart since 1938 when the city council employed a meteorologist whose job was to analyse the climatic conditions in Stuttgart to understand the connection between climate and urban development. Since then meteorological conditions have been recorded continuously. Based on this information a 'climate atlas' was developed illustrating how landforms and structures affect the movement of air through the city. It identifies the surrounding slopes, forests and agricultural areas as major sources of fresh air for the city. These findings had a significant impact on city planning. The city established an environmental office with the task of assessing proposed developments and their effect on the local climate. The climate atlas was updated in 2008. The aim was to preserve those areas key to improving local climate through development control measures and to improve the presence of vegetation across the city.

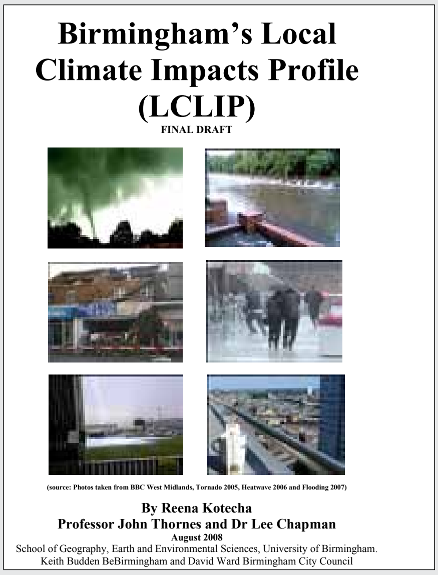
The city has accumulated a significant amount of location-specific weather and climate knowledge which is easy to access. This has enabled a comprehensive understanding of the weather-related problems in the city. As a result, green areas cover more than 60 % of the city and over 39 % of Stuttgart's surface area receives protection through conservation laws — a record for the whole of Germany. Other cities, such as Berlin in Germany and Kobe in Japan have adapted this successful approach.

Source: Kazmierczak and Carter, 2010.
Climate atlas region Stuttgart: http://www.stadtklima-stuttgart.de/index.php?klima_klimaatlas_region.

Box 3.11 Local Climate Impacts Profile (LCLIP) — A simple framework for considering current weather patterns and their impacts in order to cope with future uncertainties

Understanding current vulnerability is an appropriate starting point for the preparation of an adaptation strategy. In 2006, The UK Climate Impacts Programme (UKCIP) developed a Local Climate Impacts Profile (LCLIP) as a simple framework for considering current weather patterns and their impacts. The purpose of preparing a LCLIP at municipality level is to raise awareness of current vulnerability to weather events in a particular area. A LCLIP should aim to provide a straightforward list of the main consequences of weather events to which a locality is exposed and some understanding of local preparedness. The logical source from which to gather at least some of this information is the local authority — particularly from emergency services' records. Such records are not always available therefore local media can be a good source for gathering information.

Between 2006 and 2009, over one hundred LCLIPs were carried out by local authorities in the United Kingdom and significantly raised awareness of climate change impacts and vulnerability. One example is Manchester, where the LCLIP raised the profile of adaptation within the city council and brought to light areas of current and future vulnerability. For instance, the council's green spaces team became aware that increases in the frequency and intensity of future extreme weather events could substantially impact their budget.


Birmingham's Local Climate Impacts Profile (LCLIP)
FINAL DRAFT
(source: Photos taken from BBC West Midlands, Tornado 2005, Heatwave 2006 and Flooding 2007)
By Reena Kotecha
Professor John Thornes and Dr Lee Chapman
August 2008
School of Geography, Earth and Environmental Sciences, University of Birmingham.
Keith Budden BeBirmingham and David Ward Birmingham City Council

Source: UKCIP, 2009; http://www.ukcip.org.uk/lclip/; http://www.ukcip.org.uk/case-studies.

Science has provided enormous benefits to decision-makers. Collaboration can involve minimal engagement via reporting roles to more active engagement such as the interpretation of scientific information. Scientists can also report, interpret and then integrate their scientific information and analysis into policy or management options. Indeed, some scientists may actually advocate particular policy or management options. At the far end of the spectrum are circumstances in which scientists participate in making policy choices (Scarlett, 2011). An advanced model of collaboration between a city government and a research institute is the Institute for Sustainable Urban Development in Malmö, Sweden (Box 3.12).

Box 3.12 Translating scientific results into policy relevant information in Malmö, Sweden

The Institute for Sustainable Urban Development (ISU) is a joint venture between the city of Malmö and Malmö University. ISU was established in recognition of the fact that to fully develop post-industrial Malmö, innovative solutions based on an increase in economic, ecological and social sustainability factors were needed. ISU was founded to develop new ways to cooperate in order to facilitate the development of practically oriented research and to collect, provide and exchange knowledge and experience. ISU evolved from an earlier cooperation between the University of Malmö and the city of Malmö and is run by a board with two members from each. The base funding for ISU comes from the city of Malmö and the University of Malmö. The Institute deals with sustainability in its broad sense, which includes ecological, economic, social and cultural issues. ISU aims to initiate, empower and study processes of change aimed to create sustainable urban development. The work comprises taking part in urban redevelopment projects in Malmö, and includes the transfer of knowledge and experiences between researchers and practitioners.

Photo: © Sundstrom

Source: http://www.isumalmo.se/isumedia/ISU_ENG_WEB.pdf.

The uncertainty of future climate and socio-economic characteristics requires careful consideration of adaptation options. Even in the absence of accurate knowledge about future changes approaches can be chosen to take action with low risks of maladaptation or overinvestment. These can be categorised as 'no regrets' or 'low regrets' with safety margins built in, and 'flexible' measures. Hallegatte, 2009 and Wardekker, 2011 explain further:

- **Low-regret.** Low regret options are options that yield benefits even in the absence of climate change, such as implementing early warning systems for floods and heat waves or extending the green and blue spaces in the cities to improve living conditions. This is discussed in more detail in Section 3.3.3 on co-utilising benefits of the adaptation solutions. Low-regret options can also be seen as those whose costs are small or even negative under all plausible climate scenarios. Assessment and selection of these options does not necessarily depend on reliable climate impact projections (Füssel, 2007). One example of a 'low-regret' adaptation option is restrictive land use, i.e. banning development in certain areas which may be lifted if the area is no longer at risk.

- **Safety margins.** Urban projects can be designed with additional a capacity to cope with climate variability via a built-in safety margin (see Box 3.13). Other examples of safety margin would include low-elevation spaces with non-essential functions that can store excess water in case of flooding. These would include squares, parks and parking garages all offering buffer capacity. Examples of redundancy measures include the creation of multiple transport routes for access and evacuation or designing power and water supply networks in such a way which secures system connectivity even if parts are affected by climate events.

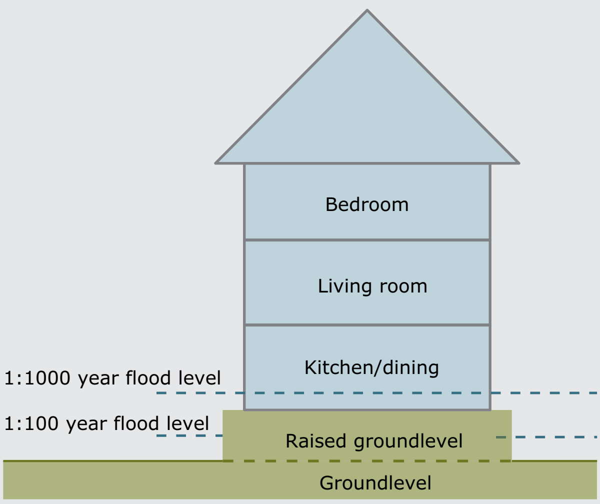
- **Flexibility.** Climate projections generally span 50 to 100 years, while most urban planning strategies choose a time frame somewhere between 20 and 40 years (Füssel, 2007). Infrastructure in and around cities needs to be built to last. Buildings, roads and open spaces all need to be adequately designed for present as well as for future conditions including climatic conditions. Taking explicit account of a changing climate to ensure the sustainability of investments over their entire lifetime is often referred to as 'climate proofing'. In this process adaptation efforts have to incorporate sufficient

Box 3.13 Safety margins provide more security in uncertain situations — Salford, United Kingdom

Large areas of the city of Salford in the United Kingdom risk being flooded. Concurrently the municipality is under pressure to provide new residential and non-residential developments. In order to resolve the conflict between development and flood risk a document entitled 'Planning Guidance on Flood Risk and Development' was adopted in July 2008. The guidance specifies that new residential development proposed in high flood risk zone should be designed and built in a way that floor levels for habitable rooms and kitchens would be no more than 600 mm below the flood level predicted for a one in one thousand year extreme flood event, and not below the flood level predicted for a one in one hundred year event. Thus, the design ensures that no structural damage is done to the property even as a result of an extremely unlikely event and that the damage is minimised for more probable flood events.

Source: Salford City Council, 2008.

Figure 3.6 Building with safety margins



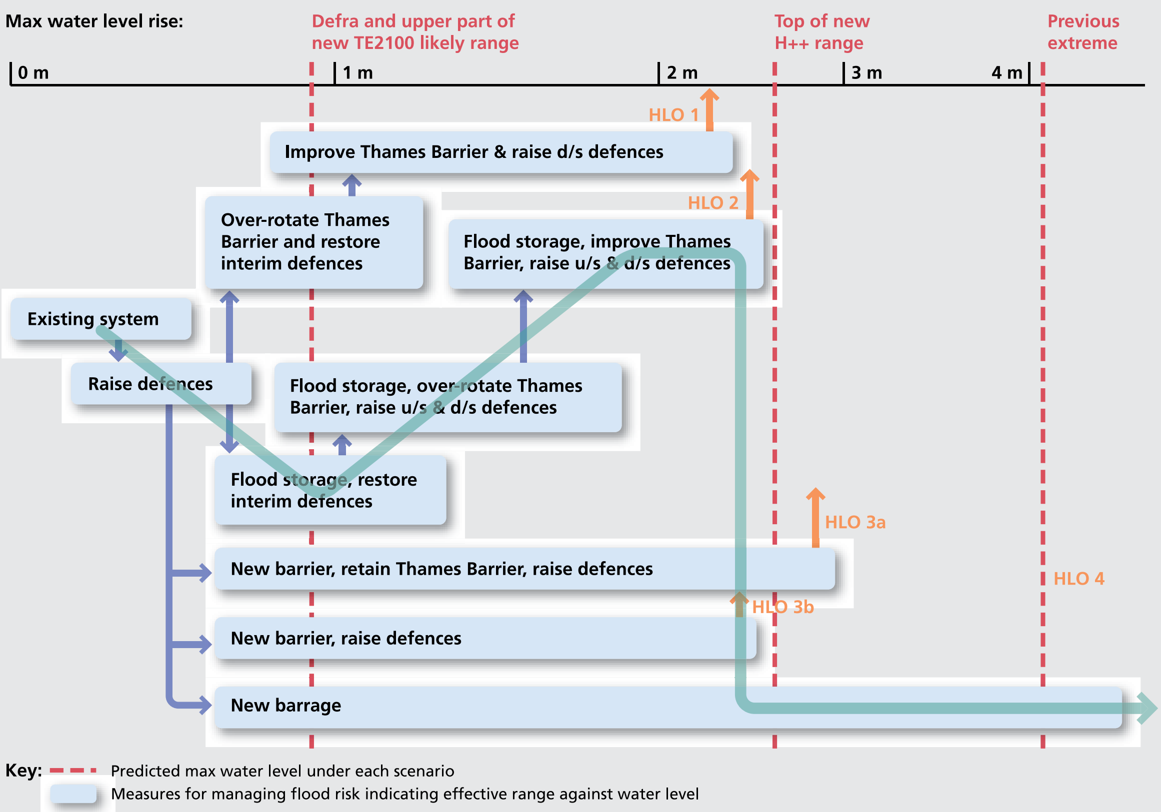
flexibility to deal with changing climate risks and uncertainties. In addition, the adaptation process itself needs to be flexible and allow room for on-going reviews, monitoring of results and potential adjustment (Box 3.14). Flexibility can also be incorporated in urban and transport design and other infrastructure. Expectant urban design can, through combining the best practice in sustainable architecture (e.g. storm water treatment guidelines) with creative, open, multi-purpose solutions, provide convenience for multiple users under different climate change and urban development scenarios.

Box 3.14 Flexibility in the Thames Estuary 2100 project, United Kingdom

The 'real options' approach adopted in the Thames Estuary 2100 (TE2100) project is a well-known example of long-term adaptation planning. The project identified a set of decision pathways for flood defences during the next 100 years and mapped out available options. For each option thresholds for responses were calculated together with the required lead times necessary for implementation. These thresholds are related to different sea levels rather than to different time horizons, making them scenario-neutral and thus allowing flexible planning despite large uncertainty in the current climate projections.

Photo: © Ian Britton

Figure 3.7 The Thames Estuary 2100 project



Source: Decision pathways for the Thames Estuary 2100 project, © UK Climate Projections 2009.

- **Appropriate timing and windows of opportunity.** Climate change is a relatively slow process, but because of the long-term effects of urban restructuring, spatial choices and the relative irreversibility of initiated developments, the current policy agenda requires choices to be made now in the light of future climate resilience. Different time-scales can be considered for various adaptation options for example, improvement to the drainage system can be seen as a short term solution, whilst additional provision of trees in city centres is a mid- to long-term solution. Furthermore, there are multiple windows of opportunity, in the short term, for combining climate change adaptation with other objectives. In urban areas in particular there are significant on-going projects focusing on urban densification, renewal and development. This provides opportunities for incorporating climate change adaptation solutions with other measures considered for these developments, such as those aiming at improved quality in the living environment or reduced energy consumption.

3.3.5 Working with nature — not against

Traditionally risks from natural processes have been managed with engineered or technical measures. These have been proven to work to a certain extent but when they fail the effects can be disastrous. For example, whilst dikes can protect against coastal flooding, they still require additional 'soft' protection measures such as emergency plans or insurance schemes in the event the dikes do not hold. Thus, they may not be the most effective or the most financially viable solutions. Consequently, a broader set of options should be considered. One approach is to provide adequate space allowing the natural processes in urban areas to take place (Box 3.15).

Box 3.15 Working with nature, not against it: the Netherlands live with water

For centuries, spatial planning in the low-lying Netherlands has been a matter of separating and maintaining the division between land and water. However, in 1999 the Ministry of Transport, Public Works and Water Management and the Association of Water Boards formed an independent committee to assess whether current water management policies were adequate to deal with the effects of climate change and to maintain a safe, liveable and attractive environment. The committee in its 'Water Management Policy in the 21st Century' report stated that a change in water management policy was required, involving relinquishing space to water rather than winning space from it. This was to be achieved by lowering and widening the flood plains and constructing water retention and storage areas.

Photo: © Martin van Lokven

In the case of Nijmegen, this involves moving the Lent dike further back from the river Waal and constructing an ancillary channel in the flood plains. This will create an island in the middle of the Waal river resulting in a unique urban park in the heart of Nijmegen with room for living, recreation, culture, water and nature.

The measure at Lent shown in phases

The present situation with the existing dike. The dike is to be moved 350 metres inland. An ancillary channel is to be dug in order to give the river more room. This will create an elongated island.

Sources: Kazmierczak and Carter, 2010; http://www.ruimtevoorderivier.nl/meta-navigatie/english.

Working with nature can provide benefits from the natural systems themselves (Scarlett, 2011; Bolund and Hunhammar, 1999). Natural ecosystem services have often been replaced by artificial equivalents in cities and urban areas such as drainage, shading or slope stabilisation measures. A move towards greater use of natural ecosystem services and away from technical and engineered approaches has been observed. This is particularly relevant in relation to flooding. For example, in the United Kingdom there is declining support for flood defence systems to reduce the impact of flooding in favour of land use planning (Ford et al., 2011). In the case of coastal protection, traditional flood and storm surge protection has relied on 'grey' infrastructure such as dikes and levees. This infrastructure may perform well under certain conditions. Yet increasing the performance of this grey infrastructure to withstand more frequent and more intense storms may be exorbitantly expensive in many cases relative to solutions that supplement existing grey infrastructure with natural solutions like beach nourishment, wetlands restoration and sea marsh protections. The latter mix of options may provide greater functionality and more resilience across a broader range of conditions than traditional infrastructure (Scarlett, 2011). The concept of green infrastructure (a network of green and blues spaces in and around urban areas) emphasises that green space planning, delivery and maintenance should be equally important to that of other types of infrastructure (transport, communications, water supply etc.), and is thus considered as an integrative part of the city indispensable to its functioning (Pauleit et al., 2011). Green infrastructure consists of natural or semi-natural areas in cities, including forest areas, parks, playing fields and other open spaces; vegetated road-sides and tree-lined roads; private gardens; rivers, canals, lakes, wetlands, wades and seashores; green roofs and green walls.

Perhaps the most important role of green infrastructure in climate change adaptation in cities is reducing temperatures in urban areas. In particular, tree shading reduces the surface temperatures thus significantly improving human comfort (Ennos, 2011). Whilst replacing sealed surfaces such as concrete with grass also brings some cooling benefits, tree planting is the preferred adaptation option for cooling with green walls and roofs being used for building insulation.

Green spaces also contribute to flood prevention. A study in the Greater Manchester area, United Kingdom, indicated that green infrastructure led to a significant reduction in surface run-off following rainfall. For example, on sandy soils, for an 18 mm precipitation event in the Greater Manchester conurbation, low-density residential areas (66 % vegetated area) were characterised by 32 % runoff, compared with 74 % runoff in town centres (20 % vegetated area) (Gill et al., 2007). Green and blue infrastructure (a combination of vegetated areas and water bodies) is being used in management of surface water runoff for example in Malmö, Sweden (Box 3.16) and Łódź, Poland (Box 2.15).

Box 3.16 Sustainable urban drainage in Western Harbour, Malmö, Sweden

Västra Hamnen in Malmö functioned as a shipyard until it closed several few decades ago leaving 6 000 people unemployed. This problematic area was turned into a sustainable district. The mixed-use development covers 24 ha, includes, to date, 1 300 apartments and approximately 2 000 inhabitants. One of its distinct features is the large open storm water system, managing storm water within the area and consisting of narrow concrete canals and ponds. The system can function due to the fact that every courtyard in the development lies above the storm water system. Each courtyard has its own storm water pond. The courtyard and roof run-off flows into the narrow canals integrated into streets, alleys and squares. There is a ridge along the centre. The storm water to one side of the ridge is led through vegetated ponds to the larger salt water canal. The water to the other side of the ridge goes to the sea.

Photo: © Birgit Georgi

The system is not regarded as crucial for managing the storm water at the site — pipes taking the water directly to the sea and salt water canal would have been sufficient. However, the main purpose of including the open storm water system was its high aesthetic value, as well as to pilot a system of this character within a dense housing district. As a result, similar approaches are now being used in other new developments in the city.

Source: Dalman; Kruuse, 2010; http://www.grabs-eu.org/downloads/Climate_Adaptation_Strategy_Malm__webb.pdf.

Green spaces in cities can both promote and hinder climate change adaptation (Kazmierczak and Carter, 2010). While the current emphasis on sustainability and contribution of green spaces to the attractiveness of cities could be used as additional leverage for adaptation responses, the need for the financial gains from urban development and regeneration, often associated with the administrative and socio-economic situation of the area, can be a conflicting issue. In addition, short term investments in grey infrastructure provide greater returns and long term benefits of green infrastructure are often considered in terms of indirect or non-monetary value. Thus, in the case of green infrastructure trade-offs are necessary. However, as highlighted in Box 3.8, green infrastructure provides a number of additional benefits.

It is also important to acknowledge that green infrastructure in many cases can perform its functions only when well-maintained and adapted to current and future climate conditions. It is essential to incorporate green infrastructure in the early stages in the development of new urban areas (see Box 3.16) to ensure it is not considered as an afterthought. For example, parks lacking in lush vegetation have a limited potential to provide cooling. As the European summers are likely to become drier and hotter it is important to consider green infrastructure in conjunction with other adaptation solutions, such as using drought resistant plants, stored flood water, harvested rain water or recycled grey water for watering the vegetation.

3.3.6 *Securing resources for adaptation*

Many climate change adaptation measures can be implemented at low-cost. Some measures, such as infrastructural measures that would not have to be taken without climate change, could require major investments. For both low-cost and high-cost measures, a sufficient resource base in terms of financial, human and institutional resources needs to be developed and secured.

The 'Financing the Resilient City' report (ICLEI, 2011) offers a bottom-up strategy for building capacity to finance and implement resilient urban development. The idea of this strategy is not merely to raise funds for adaptation projects, but more comprehensively to build local capacities to plan, finance and implement resilience upgrades. The report thus calls for a shift in both adaptation and disaster risk reduction, from a singular and specific focus on affected locations towards a more integrated focus on overall risks, development conditions and local area performance.

The integrated strategy foresees that local capacity needs to be built in order to prepare, structure and manage large scale redevelopment and to leverage the right finance for this purpose. Capacity is also needed at the local level to organise effective demand for resilience as one of the key conditions for comprehensive upgrading of vulnerable urban areas. This would allow locally driven, large and complex projects to advance as quickly as conventional top-down projects.

The key challenge is to match local demand for resilience with the right supply of enabling finance. This requires preconditions to be met at the local level. Stages include:

- bottom-up planning processes need to be in place for identifying vulnerabilities and risks, and linking the related risk mitigation solutions with priority performance enhancements in relevant areas or systems;
- technical and institutional capacity needs to be enhanced for designing comprehensive resilience upgrading projects, for managing and staging complex project execution, and for preparing the related investment propositions;
- support for bottom-up procurement of investment through managed, competitive sourcing mechanisms and processes.

When it comes to mobilising financial resources a number of approaches are generally available such as using local budgets, tapping into private sources and obtaining supportive funding from national governments and at the European level. These include climate-based taxes and charges, subsidies and budget allocations, removal of subsidies or taxes with harmful impacts, rules stipulating the ways public funds can be used and monitored (Mickwitz et al., 2009). Examples of such local revenues are given in Section 2.2.3.

As with other climate proofing efforts, funding options should be developed jointly between local and higher levels of governance. Additional funding from the national and European level, such as the EU Structural Funds, can make a decisive contribution. Funds aimed at disaster risk reduction, such as INTERREG and LIFE+, would also be valid. For the period 2014–2020, the European Commission has proposed allocating at least 20 % of the overall Multiannual Financial Framework for both climate change mitigation and adaptation measures. This 20 % will be sourced from the budgets of a wide variety of policy sectors (EC, 2011b). This is further discussed in Section 4.3.4.

Private investments of different kinds, including the insurance sector, are another funding source. Although governance in adaptation cannot rely on market actors as heavily as in the field of mitigation, and, consequently, the overall weight for some measures, such as flood defences, has to be carried by public actors. There are exceptions, such as green roofing for which the burden falls on private actors, unless local governments decide to subsidise such practices. Challenges of using market-based instruments and private funding in the context of adaptation are that market failure may also hinder effective adaptation, as incentives for change are not diffused effectively through market mechanisms. Climate change is dealt with in a narrow way through a subset of policies targeting a limited range of actors or investments. Compared to mitigation-related market signals, adaptation-related market mechanisms remain clearly underdeveloped. This may slow change and limit the cost-effectiveness of climate policy initiatives across levels of government. This also implies that the promotion of win-win measures addressing climate change mitigation and adaptation concurrently could be a method for obtaining private funding in this area.

Further reading

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- VÁTI, 2011, *Climate-Friendly Cities: A Handbook on the Tracks and Possibilities of European Cities in Relation to Climate Change*, Ministry of Interior Hungary — VÁTI, Budapest (http://www.eukn.org/dsresource?objectid=224489).
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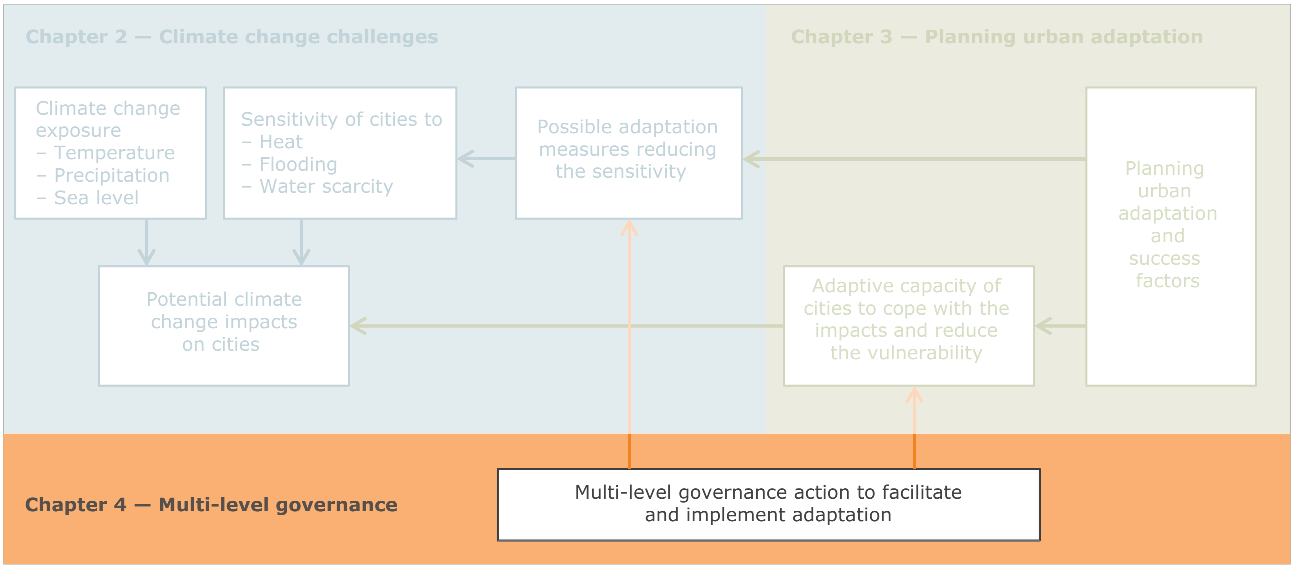
- Ribeiro, M., Losenno, C., Dworak, T., Massey, E., Swart, R., Benzie, M. and Laaser, C., 2009, *Design of guidelines for the elaboration of Regional Climate Change Adaptations Strategies*. Study for European Commission.

4 Multi-level governance — enabling urban adaptation

Figure 4.1 Placing Chapter 4 within in the framework of the report



4.1 Governing adaptation at different spatial levels

Key message

- Urban adaptation to climate change in Europe is a task that concerns all governmental levels — from local to European. While municipalities and regions focus on the implementation of place-based adaptation measures, national and European governments should have a supporting role.

Taking a place-based approach to adaptation policies is a way to further policy integration and coherence. The key question here is how different policy sectors and levels of government interact to support the implementation of local adaptation measures. Looking at adaptation through an urban lens, different ways can be identified for varying levels of government to contribute to successful adaptation.

Berkhout (2005) has identified five key challenges facing climate adaptation and uses these as a basis for proposing rationales for policy action on climate adaptation. These relate to:

- information provision and research;
- early warning and disaster relief;
- facilitating adaptation options in a bottom up way, for example, by farmers, harbours or municipalities;
- regulating the distributional impacts of adaptation, for example, the allocation of water resources;

- developing, funding and regulating the maintenance of infrastructures such as dikes.

Table 4.1 summarises the roles of local, regional, national and European action in the field of climate change adaptation on the local level. Action at the local level contributes to the implementation of adaptation programmes and strategies at higher policy levels.

4.1.1 *The local level*

Role and options

As adaptation is place-based local level decision-making is important. Local conditions determine vulnerability and adaptive capacity. The local level can best implement adaptation activities. Local stakeholders know the specific conditions well and can devise flexible solutions using their knowledge (Corfee-Morlot et al., 2009). Some cities are already very ambitious in working on climate policies and many adaptive actions have emerged without guidance or support from higher levels of government (Mickwitz, 2009; Kern and Bulkeley, 2009; Keskitalo, 2010e).

In new urban developments and restructuring projects, cities can implement structural measures such as the construction of parks, canals, ponds, thermal energy storage and modified sewerage systems. The key players at neighbourhood or city scales are municipal councils and real estate developers. In existing urban areas the most appropriate measures involve adaptation at the scale of individual buildings or streets such as insulation, green roofs and modifying street paving for water retention. The key actors at this scale are housing corporations, companies and private property owners.

Urban areas are constantly changing and if municipal authorities, developers, housing corporations and private owners consistently incorporate climate resilience into their investments in the urban environment they can minimise the additional costs of climate adaptation (PBL, 2011). There are many opportunities for combining these tasks with other objectives, such as improving the quality of life, reducing energy consumption and cutting emissions of greenhouse gases. Municipal authorities are the best suited to play a leading role in coordinating and managing these adaptation efforts.

Local governments can use different methods of governance to foster adaptation as described in Table 4.2.(Kern and Alber, 2008).

Table 4.1 Actions at different governmental levels towards urban adaptation

Local action	Regional action	National action	European action
← **Implementing action**			
• Planning and implementation of local adaptation strategies • Mainstreaming of adaptation concerns into other policy areas • Spatial integration of adaptation needs through urban planning • Local emergency plans • Allocation of municipal resources and raising of other funds • Upgrading local infrastructure to make it resilient to climate change • Engaging civil society and private actors	• Providing incentives, funding and authorisation to enable local action • Addressing inter-municipal and urban-rural relations of climate change impacts and vulnerabilities • Developing and implementing with cities regional approaches, e.g. in river basins • Ensuring regional coherence of local /municipal plans and measures	• Providing a supportive national legal framework, e.g. appropriate building standards • Mainstreaming of urban adaptation into the different national policy areas and the national adaptation strategy • Funding of local adaptation measures • Providing national information related to climate change and regionally downscaled information • Funding of research and knowledge development for urban adaptation • Supporting boundary organisations who link science and policy to local adaptation needs • Adjusting the degree of decentralisation of competences and authorities	• Providing a supportive European legal framework • Mainstreaming of urban adaptation needs into the different European policy areas, e.g. cohesion policy • Funding of local adaptation measures as well as knowledge development for urban adaptation; • Providing European and global information related to climate change • Enabling and coordinating exchange of knowledge and experience across national borders • Addressing and coordinating cross-border adaptation issues
			Supporting action →

Table 4.2 Modes of local governance and available instruments

Mode of local governance	Explanation	Instruments	Adaptation action	Examples
Self-governing	The capacity of local governments to govern their own activities.	Internal reorganisation, institutional innovation, strategic investment.	Adapting local assets such as public buildings and infrastructure to climate change. With adaptation measures such as flood protection and cooling, the municipality sets an example for other local actors.	Storm water systems in Malmö, Sweden (see Box 3.16). Water squares in Rotterdam, the Netherlands (see Box 2.15).
Enabling	Coordinating and facilitating partnerships with private actors and promoting community engagement.	Persuasion, positive incentives, participatory mechanisms.	Raising awareness; engaging interest groups and encouraging private actors in participatory planning; identify vulnerable groups and motivate. Extreme weather events can be used as 'focusing events' for communication efforts, as they boost stakeholders' motivation and provide media attention for adaptation.	Comprehensive approach with the participation of many stakeholders to cope with urban flooding in Copenhagen, Denmark. The devastative flood in 2011 has given the activities a higher profile (see Box 2.10).
Provision	Delivery of particular forms of services and resources.	Infrastructure, financial policy.	Service provision such as the creation of local warning systems and emergency planning. Municipalities provide various services (e.g. health care and social services), which can be used to promote adaptation.	Botkyrka, Sweden has mapped out where inhabitants vulnerable to high temperatures live, which enables the municipal services to formulate plans to assist them (see Box 2.2).
Regulation	Use of traditional forms of authority.	Legislation, control and sanction mechanisms.	Urban planning regulations, local building codes, regulations for watering of gardens etc.	Town planning regulation provides extra building capacity available to developers in return for green space in Faenza, Italy (see Box 4.1).

Source: Adapted from Kern and Alber, 2008.

Box 4.1 Local regulation in Faenza, Italy, encourages developers to create green space

The Municipality of Faenza implemented a bio-neighbourhood incentive programme for developers. This was included in their town planning regulations. The incentive programme aims to achieve energy savings, promote aesthetic qualities of neighbourhoods, and also to create better microclimate conditions to prepare for future rising temperatures associated with climate change. The incentive programme allows developers to extend the size of buildings in bio-neighbourhoods in excess of approved standards if the buildings meet certain criteria of environmental sustainability. These include green roofs, green walls and water retention systems as well as the creation of continuous public green spaces by developers.

These regulations do not include a set of standards. Agreements are negotiated on a case-by-case basis. The negotiations between town authorities and developers or housing associations means that the wait for building permits to be obtained is shortened, thereby providing an incentive to developers to engage in the scheme.

Sources: 'Faenza: Extra cubature for developers in return for green space'. In: Kazmierczak and Carter, 2010; GRaBS project: http://www.grabs-eu.org/membersArea/files/faenza.pdf.

Photo: © Julie70-Flickr

Limitations of local governance

Local authorities face different obstacles in their efforts to design and implement adaptation policies. Factors affecting local policy design can be of a variety of natures including jurisdictional and institutional and economic and budgetary. They can stem from local sources such as local legislation and policy but also from other levels including national and European legislative frameworks. A summary of typical constraints and possible multi-level governance responses are further listed and discussed in Section 4.2.2 and Table 4.5.

Important limitations relate to the scale of intervention. Although boosting green urban infrastructure can contribute effectively to the reduction of heat island effects, municipalities cannot solve the problems of river flooding on their own. This requires up-stream interventions and often a regional or even national approach and proper inter-municipal coordination. The municipalities' efforts need to encompass both horizontal co-operation with other municipalities and vertical cooperation with regional and state authorities. Moreover, depending on the Member State, municipalities do not have the same regulatory competences and financial capacities which can lead to problems in the design and implementation of cross-border adaptation action.

4.1.2 The regional level

Role and options

As mentioned under the limitations for local action in the example of flood management (Section 4.1.1), regional governments play an important role when adaptation issues exceed municipal boundaries. Municipalities often need to cooperate with their neighbours to address the problem of institutional fit, i.e. the match between the spatial dimensions of the adaptation challenge and municipal jurisdiction (Young, 2002). Hence a key area of collaboration is spatial planning across municipal borders.

Such regional approaches can not only ensure success but provide further benefits in the form of higher efficiency. Some measures supported beyond city borders can come at a lower cost and are more sustainable than building flood barriers within the city. In addition, shared costs for regional vulnerability and impact assessments can reduce the burden for each stakeholder.

The specific role that regional governments can take depends on the dynamics of national structures. While an elected regional government can play a significant role in developing regional adaptation policies, administrative regional bodies may only play a role in implementing state policy. In a federal state a large part of decision-making rights will be based in the regions, resulting in relatively large differences between regions in how they act on adaptation (Keskitalo, 2010a).

Limitations of regional governance

The regional scale is an emerging level of adaptation strategy development with significant potential and room for improvement. Regional strategies focus more on letters of intent than concrete action plans.

In countries where the regional level is weak and has no constitutional backing, the regional level may suffer from limited influence, lack of resources and institutional instability such as in the case of the United Kingdom (Box 4.2).

As with other levels of government, the key determinants are institutional fit, scale and interplay between the actors (Young, 2002). Regional governance can be limited when an administrative region does not match the scale of the adaptation problem. This can be seen in the example of river systems which stretch across borders or when dealing with large scale water scarcity which require a national or cross-border approach.

4.1.3 The national level

Roles and options

Despite the recent emphasis on governance through non-hierarchical networks, where cities and city networks can bypass administrative levels and collaborate directly with the European Commission, national governments provide the crucial link between EU priorities and local adaptation action. National institutional structures may even be the most important element determining how to integrate adaptation as a policy aim (Keskitalo, 2010e).

Firstly, national governments can provide a strategic framework. National adaptation strategies have become a key instrument. These strategies can embed local action into the national context and

Box 4.2 Consequences of the abolishment of the regional planning level for adaptation in the United Kingdom

Until May 2010 the governance structure in England consisted of national, regional and local tiers. At the national level detailed planning policy guidance was issued, including documents directly pertaining to adaptation to climate change and associated problems, such as flooding. The government's regional body, alongside the Regional Development Agencies (RDA), was producing spatial, housing and economic strategies which in many cases also related to climate change adaptation. In addition, there are examples of climate change action plans being developed by partnerships at the regional level, for example in the north west of England, where the RDA developed a robust region-wide green infrastructure framework for adaptation (Kazmierczak and Carter, 2010).

The current government brought a substantial change. It includes the simplification of the detailed national policy guidance to overall principles of sustainable development; removal of the National Performance Framework; and abolition of the regional tier. Instead, duties for local authorities to coordinate their actions have been introduced, and a bottom-up system of spatial planning has been proposed. The Localism Bill proposes the introduction of a new neighbourhood scale system of spatial planning, where the communities set out specific policies and land use designations for the local area. These neighbourhood plans will be adopted as part of the official local development plan (subject to compliance with its overall vision) which would give them significant weight in the determination of planning applications (Adaptation Sub-Committee, 2011).

Whilst these changes are expected to give more freedom to local authorities and engage the local communities, there are concerns about the consistency of such bottom-up planning between different areas due to different priorities of those involved in the development of the plans. In addition, certain adaptation measures such as flood management require regional approaches rather than those uniquely local. This, combined with the absence of direction from higher tiers, may jeopardise the possibility to deliver strategic objectives and implement large-scale solutions. Moreover, adaptation planning requires considerable expertise which may not exist within the local communities. The local authorities face significant budget cuts and without national indicators adaptation is unlikely to be viewed as a priority (Scott, 2011).

link cities and regions. They can set the framework by developing national legislation and creating a variety of standards and incentives (Swart et al., 2009).

Secondly, national governments can climate-proof national legislation and policy and mainstream adaptation into different areas whilst ensuring that national policies are also coherent and supportive for local adaptation (Corfee-Morlot et al., 2009). A further task is to remove barriers to urban governance as in the example in Box 4.3. National governments also can play a key role in greening urban finance by re-designing sub-national taxes and grants at local government level (OECD, 2010).

In terms of regional development, national governments need to pay attention to equity issues and create climate change policies that address differences in vulnerability across different sectors and spatial divisions. National governments can also support the legal and institutional conditions for inter-municipal cooperation.

Thirdly, national governments play a crucial role as supporters and enablers of local and regional strategies and action. They provide the necessary background information and regional climate data, scenarios and assessments. This is addition to providing tools, guidance and funding for local government action. Box 4.4 provides one example.

Supporting local adaptation measures provides national governments the opportunity for policy learning. Neighbourhoods can be seen as testing grounds for policy providing valuable lessons on the performance of policy measures in different local contexts. National governments can observe and carefully study local implementation of national adaptation strategies, flood risk management procedures and other measures since they reveal the strengths and weaknesses of national approaches and measures. It also allows for the identification of related interests, incentives and trade-offs which can help or obstruct implementation and serve to provide input into the national framework. Local adaptation measures also allow for observation of direct costs and benefits. Such observations can prove to be useful especially within a national

Box 4.3 Better incentives for local risk management in France — getting the national framework right

In France property, which is insured against damage such as fire, burglary and storms, is automatically insured against damages by natural disasters. In this case, the insurers and reinsurers use money from an additional 12 % premium to provide compensation. This additional premium is a legal requirement. If the main reinsurer, the Caisse Centrale de Reassurance (CCR), goes bankrupt the state grants additional money to insure 100 % coverage. This system has been in place since 1982.

The advantage of this system is its security. Everybody who has a basic insurance is insured against damage in the case of a natural disaster. In addition those settling in risk areas who do not have the resources to move to another place to settle are supported. The system can, however, work against risk management at a local level. As the state will pay in the case of a natural disaster, people may still choose to settle in potentially risk prone areas. This can make it difficult to restrict development in such areas.

Photo: © Piotr

Since 1995 the state has taken action to minimise any disadvantages arising from the CCR and to provide local governments with a better legislative framework. The state has agreed to develop and implement Natural Risk Prevention Plans in the various municipalities. The plans aim to limit urban growth in risk areas and minimise damage.

Source: Grislain-Letremy and Peinturier, 2010; Letremy and Grislain, 2009.

Box 4.4 Stadtklimalotse — a guidance tool provided to local governments

The German Federal Ministry of Transport, Building and Urban Development supported the development of the 'Stadtklimalotse' (urban climate pilot). Local governments can use this guidance tool when developing urban adaptation plans and measures. The database provides around 140 adaptation measures, relevant policy documents and international examples. The core element — the 'pilot' — guides the planners through:

- Identification of the specific adaptation context;
- Selection of the relevant thematic areas;
- Vulnerability assessment;
- Selection of appropriate measures;
- Own list of action for climate change adaptation.

The Stadtklimalotse enables not only adaptation pioneers but also other cities to make use of shared adaptation knowledge and experiences and to develop their own adaptation plans.

Source: http://www.stadtklimalotse.net/stadtklimalotse.

context where direct results are put in an overall national context (Corfee-Morlot et al., 2009).

Limitations of national governance

Observations point to a gap between local, bottom-up adaptation and national adaptation strategies. The Finnish example shows that local and regional adaptation strategies and measures may develop independently with very little linkages to national adaptation strategies (NAS). In the case of the Finnish NAS, the national focus undermined regional and local perspectives, making the strategy less interesting for local actors (Juhola, 2010). Sweden and several other countries face similar limitations. Although this deficiency has been recognised, it provides a stark reminder that even well prepared national adaptation strategies do not automatically lead to local action.

Another limitation for implementation at the national level relates to the barriers between policy sectors. Without flexible and cross-sectoral coordinated measures, adaptation efforts may be hampered by sectoral thinking.

Financial constraints are present also at the national level, especially in austere times. In such instances local government funding lines are unlikely to stretch to climate action which becomes less of a political priority.

4.1.4 The European level

Role and options

As at national level, the EU can support local and regional adaptation and assist with speeding up implementation. In particular, EU cohesion policy shall ensure that the most disadvantaged regions are supported. The European Commission's White Paper on Adaptation (EC, 2009b) complements national adaptation initiatives. It aims to coordinate adaptation at the European level and facilitate important trans-national connections thereby providing a common strategic approach and a supportive policy framework. The goals of the White Paper up until 2012 are to:

- build a solid knowledge base on the impact and consequences of climate change for the EU;
- integrate adaptation into EU key policy areas;
- employ a combination of policy instruments (market-based instruments, guidelines, public-private partnerships) to ensure effective delivery of adaptation;
- step up international cooperation on adaptation.

These activities will lay the ground for preparing a comprehensive EU adaptation strategy to be implemented as from 2013. All these actions support directly and indirectly urban adaptation.

The newly launched European Climate Adaptation Platform CLIMATE-ADAPT provides a comprehensive knowledge platform including information on urban related issues. The platform will be updated continuously and has also the potential to support exchange between cities and other stakeholders. Furthermore, the Seventh Framework Programme (FP7), INTERREG, LIFE, ESPON and other EU programmes generate knowledge relevant for urban adaptation. DG CLIMA recently launched a project to support adaptation strategies for European cities (see Box 4.12).

Mainstreaming of adaptation into relevant EU policies is an important opportunity to create the necessary supportive framework for effective climate change adaptation at local level. The European Commission has started concrete initiatives to integrate adaptation into EU sectoral policies, in particular with water and flood risk management, agriculture and rural development, health, and nature protection and biodiversity. The proposal for the Multiannual Financial Framework (MFF) for the period 2014–2020 draws explicitly on the concept that financing for climate change receives contribution from different policy areas such as cohesion, environment, agriculture, research and external cooperation (EC, 2011b) (Table 4.3).

The current direct spending on climate change mitigation and adaptation under the EU budget does not reflect the importance of climate change for Europe's future. In 2007–2013 a total of only EUR 9 billion, or 3 % of the total budget, has been directly allocated to mitigation goals in energy efficiency and renewable energy. An additional 10 % of the budget (EUR 32 billion) links to indirect spending on transport including clean public

Table 4.3 EU policy sectors, adaptation, and impacts at the urban level

Policy sector	Integration of climate change adaptation	Importance for urban adaptation
Regional and cohesion policy	High potential of structural funds and related cooperation taking place in the framework of INTERREG, URBACT for regional and local adaptation projects. Currently little or no input by Member States, but important changes towards better inclusion of climate change in the 2014-2020 are proposed. The budget share for adaptation in relation to mitigation still needs clarification.	Relevant for integrated urban renewal projects, brownfield redevelopment, building insulation, green infrastructure projects etc. Exchange and generation of knowledge and awareness in INTERREG and URBACT. Support for local adaptation projects varies depending on Member States' priorities and operational programmes. At present regional policy may also be a source of maladaptation when large sums of money are spent on non-climate proof measures.
Environment	Water framework and Floods Directives (EC, 2000b; EC, 2007a) provide a good basis for integration of adaptation to floods. Droughts and Water Scarcity strategy (EC, 2007c) relates also to future climate changes. Nature directives do not address climate change yet. Natura 2000 network can be a solution for migrating species; the new green infrastructure strategy can also serve climate change adaptation. 20 % of the future LIFE programme 2014–2020 shall be dedicated to climate change. The directives on Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) (EC, 2011a; EC, 2001) do not sufficiently consider climate change impacts. The review of the EIA directive offers the opportunity for change.	Flood directive (EC, 2007c) relevant for urban adaptation: urban areas are often water bottlenecks that require upstream adaptation of rivers. Combating water scarcity and drought also a priority for many cities. Green infrastructure in and around cities delivers important services for urban adaptation such as cooling under heat waves and water management. The national implementation of EIA makes it also relevant for local projects
Agriculture and rural development	CAP allows for spending on adaptation-related measures. Better cross-compliance with climate change through the CAP reform (pillar 2).	Relevant for urban areas in regional approaches, e.g. upstream flood prevention measures or water management in water scarce regions.
Transport and energy	Mitigation-oriented sectors with limited progress in adaptation measures. EU Energy Performance of Buildings Directive (EC, 2010b) focuses only on mitigation, but insulation could also be a contribution to adapt to heat waves. Eurocodes for construction works and structural construction products, C(2003) 4639), (2003/887/EC) can be a suitable tool for designing construction works, checking the mechanical resistance of components, or checking the stability of structures to climate change impacts.	High relevance for urban adaptation; critical infrastructures to be build climate-proof involving long time scales and far-reaching repercussions. Synergies between mitigation and adaptation measures.
Industrial/ enterprise	No integration of adaptation, but the business community is clearly interested in climate impacts.	Positive responses can be expected from local businesses and their interest in coping with climate change impacts.
Employment/ social	No integration of adaptation; emphasis on green growth and jobs.	Importance of addressing social equity issues and distributional impacts of climate change.
Health and consumer protection	Ample research under way; policy focus shifting to include climate impacts. EU Health Strategy 2008–2013 acknowledges the need for action to tackle climate impacts on health.	Highly relevant for urban adaptation as the majority of European population lives in cities and many health impacts related to climate change concentrate here.
Research	Considerable research efforts; new information and monitoring systems (e.g. early warning systems).	Clearly beneficial for local adaptation, but the uptake of many research outcomes remains limited.
International development (UNFCCC)	Focus on climate change mitigation and adaptation. The 'Copenhagen Accord' (2009) included a pledge by developed countries to raise USD 100 billion per year by 2020 to help poor countries fight climate change and adapt to its inevitable consequences. Establishment of a Green Climate Fund. Durban conference (2011) agreed on a roadmap for drawing up a legal framework by 2015 for climate action by all countries. Durban Adaptation Charter for Local Governments.	So far potential for adaptive action in urban areas in developing countries, but little impact on European cities yet.

Source: Adapted from Ellison, 2010.

transport and investment in rail infrastructure. On the adaptation side the figures are clearly lower. Climate change adaptation financing can be linked to the provision of approximately EUR 6 billion stemming from risk prevention expenditures and other categories of expenditure where adaptation is integrated (Medarova-Bergstrom et al., 2011).

The EU budget proposal for 2014–2020 promises a substantial increase — at least 20 % — around EUR 200 billion — shall be used for climate change and come from different policy fields (EC, 2011b). For example, the LIFE+ programme supports integrated projects focusing, among others, on themes relevant for climate change adaptation such as river basin management plans, cross-border flood prevention strategies and climate adaptation plans in the EU Member States. The total budget of LIFE+ over 2014–2020 is EUR 3.2 billion, out of which EUR 0.8 billion are destined for climate change (EC, 2011c). However, the proposed 20 % shall support both climate change mitigation and adaptation. Following the current discussion and under the perspective of the Europe 2020 strategy, the focus seems to be on mitigation rather than adaptation. For example, in Cohesion policy the proposal of ring-fencing of funding currently concerns only energy efficiency and renewable energies while the use of funding for climate change adaptation is not mandatory (EC, 2011d).

The EU seeks to guarantee the effectiveness of climate related spending through mechanisms such as:

- (ex ante) impact assessments to determine climatic and environmental impacts of proposed measures;
- streamlining proposed measures under specific objectives and checking deliveries against result indicators;
- tracking expenditure across different funding instruments to secure synergies.

In addition, the cohesion policy foresees mechanisms for climate and environmental investment proofing (EC, 2011d; Medarova-Bergstrom et al., 2011) and promotes a broader approach to sustainable urban development.

Perhaps the most relevant for urban areas is the EU's cohesion policy with its related structural funds which comprise a substantial part of the EU budget. This is in addition to the INTERREG and URBACT programmes. The funds hold the potential to support specific adaptation projects in cities and regions. For example, urban renewal projects can actively consider climate change by providing sufficient green infrastructure. Furthermore, the funds and the INTERREG programme (Box 4.5) support knowledge development, testing and validation of knowledge development, developing and implementing regional adaptation strategies and projects and generation of awareness amongst relevant stakeholders and the general public (Ribeiro et al., 2009). However, cohesion policy can potentially also hinder adaptation when, for example, large infrastructure projects are not climate proofed. Systematically integrating adaptation requirements in projects, programmes and policy evaluation would help to avoid such maladaptation.

Furthermore, EU cohesion policy, targeting economic growth, education, technological

Box 4.5 INTERREG projects highly supportive for local and regional adaptation

A series of INTERREG projects in the Baltic sea region has addressed climate change adaptation since 2002. Three consecutive projects: SEAREG (Sea Level Change Affecting the Spatial Development in the Baltic Sea Region, 2002–2005), ASTRA (Developing Policies & Adaptation Strategies to Climate Change in the Baltic Sea Region, 2005–2007) and BaltCICA (Climate Change: Impacts, Costs and Adaptation in the Baltic Sea Region, 2009–2012) have been important platforms for several local, regional and state agencies. This is with respect to raising awareness about regional and local climate impacts and the relevance of adaptation in their respective jurisdictions as well as devising adaptation options for particular local and regional challenges in fields such as tourism, urban planning, and water management.

A number of INTERREG projects directly targeting urban or regional climate change adaptation in different regions of the EU have since been initiated.

Source: Schmidt-Thomé and Peltonen, 2006; Hilpert et al., 2007.
Project websites: SEAREG: http://www.gsf.fi/projects/seareg; ASTRA: http://www.gsf.fi/projects/astra; BaltCICA: http://www.baltcica.org.

development and infrastructure provision, can increase the adaptive capacity of cities by promoting learning and broad participatory action. A systematic mainstreaming of adaptation into policies and programmes would increase the chance that adaptive capacity is raised.

Important pieces of legislation for mainstreaming adaptation in the EU include the Water Framework Directive, the Floods Directive and the Water Scarcity and Droughts strategy (EC, 2000b, 2007a, 2007c). The Environmental Impact Assessment Directive (EC, 2011a) can be an important tool for procedural integration of adaptation (see discussion later in Section 4.3.1). Currently it does not consider climate change adaptation sufficiently. The on-going review offers the opportunity to correct this. The European Commission is developing a strategy for an EU-wide green infrastructure as part of its post-2010 biodiversity policy. This would include not only areas falling under the remit of Natura 2000 (EC, 1992) but also urban green areas, green roofs and walls supporting biodiversity as well as climate change adaptation.

Box 4.6 Mainstreaming Adaptation — the Water Framework and the Floods Directive

The Water Framework Directive (EC, 2000b) establishes a legal framework to protect and restore clean water across Europe by 2015 and ensure the longterm sustainable use of water. It required that river basin management plans for the period 2009–2015 were developed by December 2009 in all river basin districts across the EU. These were due to take climate change impacts into account. In addition, climate change must also be properly integrated in the implementation of the Floods Directive (EC, 2007a). Water directors of EU Member States issued a Common Implementation Strategy (CIS) guidance document (EC, 2009d) that addressed the integration of climate change impacts and adaptation in the implementation of the Water Framework Directive, the Floods Directive and the Strategy on Water Scarcity and Droughts (EC, 2007c). This was particularly in view of Member States' second (2015) and third (2021) river basin management plans. Under the 2012 Water Blueprint, the European Commission will also review the Water Framework and Floods Directives, and the Strategy on Water Scarcity and Droughts.

Photo: © Zoli

The Flood Directive provides the background to updating national water laws and can accelerate activities as regards reducing the impact from flooding. In countries such as Poland, where little awareness exists on the impacts of climate change and adaptation needs, EU legislation such as the Floods Directive can trigger and support some local and regional adaptation work. Its implementation led to the assessment of flood risks in Poland. On this basis many cities in Poland were able to prepare adaptation plans for flood risks including:

- the identification of vulnerable regions and cities;
- flood impact assessment;
- flood risk management;
- monitoring and information system;
- guidelines and procedures;
- information on rescue services, resources, and regulations.

See also: http://www.kzgw.gov.pl/pl/Wstepna-ocena-ryzyka-powodziowego.html.

Limitations of European governance

The level of involvement of the European Union in local and regional adaptation, vis-a-vis the subsidiarity principle, still remains an open issue. The subsidiarity principle delegates regulations to the lowest relevant level of government. Interpreting this literally can lead to problems with providing effective climate change adaptation due to the fact that this involves cooperative actions at various levels. The extent of control that the EU will have over various levels of planning within the Union still remains to be debated (Swart et al., 2009). For example, Member States decide with their Operational Programmes which projects it will include and where exactly EU funds will support. It is in their power to ensure adaptation is sufficiently considered in EU spending. A governing in partnership model was discussed in respect to the Europe 2020 strategy and future cohesion policy. Yet a partnership gap still hinders the strategy as local and regional authorities have only been consulted, but not involved, in the conception and implementation of national reform programmes (CoR, 2011b). The process of developing the European Adaptation Strategy 2013 can be a cornerstone for a better partnership approach.

Policies for economic and social cohesion have traditionally targeted the economy and living conditions across Europe. Climate change adaptation requires place specific approaches. The identification of adaptation hotspots and a cohesion policy which targets climate change adaptation needs with territorial selectivity would break new ground whilst acknowledging that challenges remain. (see discussion in Section 4.3.2).

Achievements in the integration of adaptation in sectoral policies remain a challenge for the EU. Next to the water and nature directives, adaptation policy must also be embedded in sectoral policies such as agriculture, transport and energy (see examples in Table 4.3). Even if the EU's principle spending programmes (CAP, structural funds, INTERREG, LIFE) already allow for spending on adaptation-related measures there is ample room for improvement (Ellison, 2010). For example the URBACT programme targeting the exchange of experiences between cities regarding urban development has not one single project for climate change adaptation.

Further reading

- VÁTI, 2011, *Climate-Friendly Cities: A Handbook on the Tracks and Possibilities of European Cities in Relation to Climate Change*, Ministry of Interior Hungary — VÁTI, Budapest (http://www.eukn.org/dsresource?objectid=224489).
- CoR, 2011a, *Adaptation to Climate Change: Policy instruments for adaptation to climate change in big European cities and metropolitan areas*, European Union. Committee of the Regions, Brussels (http://80.92.67.120/en/documentation/studies/Documents/Adaptation%20to%20Climate%20Change/EN.pdf).
- Ribeiro, M., Losenno, C., Dworak, T., Massey, E., Swart, R., Benzie, M. and Laaser, C., 2009, *Design of guidelines for the elaboration of Regional Climate Change Adaptations Strategies*. Study for European Commission.

4.2 Bridging the levels — multi-level governance

Key messages

- Ambitious municipalities can certainly carry out truly innovative projects in urban adaptation. Doing this effectively and efficiently is, however, only possible if support comes from regional, national and European levels.
- Mainstreaming of adaptation in other policy areas and legislation such as the Water Framework, and the Floods directives, and EU cohesion policy is key. It must be stated, however, that a number of regulations and funding mechanisms do not mention adaptation. The proposal for the EU's next Multi-annual Financial Framework will require that 20 % funding for climate change mitigation and adaptation is sourced from different policy sectors.
- A holistic multi-level governance approach can bridge the gaps between the different levels of governance and provide a coherent and effective framework for urban adaptation.
- Since 'adaptation' is a relative newcomer in policy development, multi-level governance in the form of dialogue between government levels, private actors and citizens is of particular importance.

4.2.1 *The needs and benefits of multi-level governance*

Cities within one nation can differ significantly, for instance, with regard to the degree of inclusion of non-governmental partners in local development. Cities are in a unique position to develop tailored responses to the impacts of climate change. They have first-hand knowledge of local conditions and can develop proactive strategies in response to climate change, experimenting with local solutions and committing to ambitious targets. Local authorities can work together with voluntary efforts such as city networks, the private sector and community organisations to develop new institutional models for local adaptation (Piorr et al., 2011).

Cities do not act in a vacuum. They are embedded in a legal and institutional context set by national governments, the EU and global developments — conditions which can be supportive or constraining. Ambitious local governments can complement national and European priorities through linkages with similar-minded municipalities. This can be viewed via initiatives such as the Durban Adaptation Charter for Local Governments (2011) and efforts from various pioneering cities. Another example was the 'Nottingham Declaration' in the United Kingdom which supported the national government in developing adaptation requirements for the local level (Keskitalo, 2010b).

In this context, a multi-level governance approach can build bridges between disconnected levels of government, issue-specific jurisdictions and stakeholders to support concerted action. The benefits of multi-level governance are:

- coordination can lead to implementation that is more than the sum of individual measures;
- joint work between stakeholders at all levels avoids processes becoming locked in conflict;
- it allows for measures which cannot be developed or implemented by one actor due to limits of jurisdiction or responsibility;
- multi-level governance promises effectiveness and efficiency gains.

The concept of multi-level governance

Modern governance is not based on a centralised 'command and control' system but is dispersed across multiple centres of authority (Hooghe and Marks, 2003). There are many self-organising, inter-organisational networks which complement existing hierarchies in terms of allocating resources and exercising control and coordination (Rhodes, 1996). Two dimensions of governance exist: vertical and horizontal. As Section 3.3 has already dealt with the horizontal dimension, subsequent sections will focus on the vertical dimension i.e. multi-level governance.

Different types of multi-level governance exist. Type 1 refers to a clear division of jurisdiction

Table 4.4 Two types of multi-level governance

	Type 1	Type 2
Tasks	General-purpose jurisdictions: multiple functions, and in many cases, a court system and representative institutions	Task-specific jurisdictions, for example, solving a particular common resource problem
Members	Non-intersecting memberships	Intersecting memberships
Levels	Jurisdictions organised at a limited number of levels	No limit to the number of jurisdictional levels
Design	System-wide architecture	Flexible design, no great rigidity

Source: Based on Hooghe and Marks, 2003.

between hierarchical levels of government. It relates to the division of tasks in federal states and is about power sharing among a limited number of governments operating at just a few levels. Type 2 refers to flexible networking activities related to a specific task. Functional jurisdictions are continuously shifting and have no clear borders (Table 4.4) (Hooghe and Marks, 2003).

Urban adaptation policy is at an embryonic phase and a lack of fluidity should be accepted by policymakers. In this instance type 2 multi-level governance is of particular relevance for urban adaptation, although in practice a combination of both types is needed. This report uses the following definition for multi-level governance: non-hierarchical forms of policymaking, involving public authorities as well as private actors, who operate at different territorial levels, and who realise their interdependence (based on Kohler-Koch and Rittberger, 2006).

The overall governance context

Developing multi-level governance approaches for urban adaptation in Europe needs to consider the diversity of formal governmental systems within Europe. Government structures vary in Europe as well as the extent to which a centralised or decentralised approach is used. These systems can determine the ways in which local, regional and national authorities can act (Keskitalo, 2010a).

In a more decentralised state, or a state with strong regional and local authorities, the local level usually has stronger decision-making rights and more responsibilities and options for managing adaptation rather than being dependent on funding from the state level. In federal states — such as Germany — regional governments usually have strong decision-making rights. Unitary states, where the central government determines the powers and competences, can also have strong local and regional governments. Sweden, for instance, although an unitary state, has strong municipal governments holding so called 'local planning monopolies' (Keskitalo, 2010a; PLUREL, 2011).

If cities have the capacity to make more decisions then this will place them in the position to decide, relatively independently, on issues related to adaptation. However, if a city has not prioritised adaptation itself little pressure will be forthcoming. Large differences between the cities can develop as it is the case in Sweden. Adaptation as a priority does not always develop in vulnerable cities even if the administrative power to do so exists. Other factors, such as political leadership and the economic situation, can also be driving forces (Keskitalo, 2010a; 2010b).

In a more centralised state or administration, the local level is in general guided by the central or regional administrations. If adaptation is high on the national or regional agenda, legislation can ensure a minimum level of relevant action at the local level. In the United Kingdom the previous government developed relatively strong central steering on adaptation. This included an indicator on adaptation within the system for local government evaluation (Box 4.7) (Keskitalo, 2010b). However, a centralised state or administration that is not focused on adaptation may restrict possibilities for local governments.

Understanding of the different governmental contexts in Europe is decisive when developing appropriate multi-level governance approaches.

As well as interacting at the state level, local governments can also operate within a European level. This allows for cooperation between territories of the European Union, like the European macro-regional strategies of the Baltic Sea or the Danube (Piorr et al., 2011). Such programmes can encourage cooperation between local governments with EU funding assisting to finance

Box 4.7 UKCIP — an example of support for coordinating adaptation across governmental levels

The United Kingdom Climate Impacts Programme (UKCIP) has often been hailed as a success story in providing support for coordination of climate change action across levels. A comprehensive approach, facilitating local and regional, public and private actors to devise and implement adaptation measures contributed to its success. The UKCIP provides a uniform platform for local authorities and for coordination on adaptation in the English regions. It supports bringing local authorities to certain minimum levels of adaptation. It also provides a uniform knowledge base of climate scenarios and an important channel of communication between different levels of government and the scientific community.

Sources: Keskitalo, 2010b and 2010d; McKenzie Hedger et al., 2006.

adaptation-related development (Keskitalo, 2010d; Juhola, 2010; Westerhoff, 2010). The EU also holds a large number of policies that impact local and regional land use, including the Habitats and Water Framework Directives (Ellison, 2010).

The complex collective-action problems related to climate change mitigation and adaptation lead to a situation where no actor can resolve these problems single-handedly (Kooiman, 1993; Stone, 1986). In Europe, each level of government has a role to play in supporting climate change adaptation in cities and towns.

4.2.2 Challenges

Multi-level governance also faces barriers that cause ruptures in the policy cycle of adaptation. Preliminary results of a survey among the EU Member States presented in the European Climate Adaptation Platform CLIMATE-ADAPT lead to the conclusion that multi-level governance on climate change is not yet fully established. In a range of countries, urban adaptation still happens in an ad hoc fashion and in isolation. Different barriers lead to problems in policy formulation, knowledge integration for decision support, decision-making, implementation and, finally, in monitoring and evaluation.

Barriers can have structural, institutional or more operational characters:

- Structural challenges to governing climate change adaptation include:
  - Unclear authority and responsibilities, linked with financial constraints to urban adaptation. The current structures and budgets for strategy development and decision-making at local, regional, national and European level are often not appropriate for multi-level governance.
  - A narrow interpretation of the subsidiarity principle restricts interaction with other governmental levels. Once the responsibility of certain adaptation-related duties is relegated to one authority, others are less inclined to facilitate and coordinate.
  - Adaptation is a long-term process while political structures and persons at all levels are changing over shorter periods. Long-term decisions prove difficult to achieve (ICLEI, 2010).
- Operational challenges include:
  - A lack of communication and transparency between different spatial scales and sectors. A lack of understanding of each other's language and culture can lead to unnecessary conflict; it takes time to build trust and understanding.

- Inadequate organisation of the science-policy interface leads to a lack of capacity to raise awareness on adaptation challenges and responses, to sustain attention on adaptation, and to provide a sound knowledge base for adaptive action.

- Financial constraints are evident barriers to operational multi-level governance, because multi-level governance requires additional resources. This includes costs which are typically subsumed as working hours.

- The complexity of the adaptation challenge may well prove a problem for politicians who wish to demonstrate the direct impact of their work (ICLEI 2010).

Table 4.5 lists typical structural and operational barriers governing urban adaptation at local/regional and national/European level and adds possible responses from a multi-level approach.

Table 4.5 Key barriers to local adaptation and possible multi-level governance responses

Barrier type	Barriers at local and regional level →	Possible support from a multi-level governance approach	← Barriers at national and European level
Jurisdictional and institutional	Lack of mandate at the subnational level to address adaptation issues and problems of regional coordination between municipalities.	Clear mandates for local authorities, clarity of responsibilities between local, regional, national and European actors; Acceptance of the territorial cohesion approach and the Territorial Agenda.	Narrow interpretations of subsidiarity leaves little room for flexibility.
	Maladapted institutional designs which hinder coordination across relevant issues (vertical/horizontal).	Ensuring policy coherence, establishing mechanisms and incentives for horizontal and vertical coordination, addressing issues of scale and the problems of institutional fit and interplay; Development of the EU adaptation strategy as an opportunity.	Novelty and instability of the adaptation agenda, the EU's role still being developed.
	National or regional laws, rules and regulations lead to maladaptation and increase vulnerability.	Climate proofing/mainstreaming of local adaptation needs into national and European legislation and budgeting; Policy coherence through procedural integration of adaptation, e.g. in SIA, SEA and policy evaluation.	Sectoral policies with vested interests.
Political	Local authorities influenced by particular special interests.	Enforce the applications of the principles of good and democratic governance; Ensure broad public participation.	Authorities influenced by particular special interests.
	Pressure to maintain 'business as usual' development pathways.	Clear signals, including incentives, from national and European to local policy levels, that change is necessary; Articulate, to national and European level, local demand for change based on local adaptation experiences; Using the momentum of extreme weather events and other crises to forward the adaptation agenda.	Pressure groups and political interests emphasise 'business as usual' development pathways.
	Pressures of short-term electoral cycles on effective risk management and long time-lag to reap full adaptation benefits.	Raising awareness for the challenge and urgent need for adaptation — use local pressure where climate change impacts are felt first; At the local level, use integration into long-term national and European processes; Sustained attention on procedural integration of adaptation in monitoring and evaluation efforts.	Adaptation not a priority at national or European level, rather on mitigation, eco-efficiency, innovation and green growth.
	Lack of willingness to accept costs and behavioural change.	Build clear evidence on costs and benefits of adaptation; Communication about early-adapters and best practice; Exchange European-wide knowledge; good practice and dialogue with stakeholders across all levels; Use local pressure to act.	Lack of willingness to accept costs.

Table 4.5 Key barriers to local adaptation and possible multi-level governance responses (cont.)

Barrier type	Barriers at local and regional level →	Possible support from a multi-level governance approach	← Barriers at national and European level
Economic and budgetary	Lack of resources or funding to address problems identified.	Climate proofing the budgets at different levels; Provide guidance and support for applicants to EU and national funds; Support the creation of market demand for adaptation; Establish support for local adaptation policies and measures, e.g. through public-private partnerships.	Lack of resources, including immediate challenges of financial austerity.
	Differences between perceived and real costs and benefits.	Improve, exchange and coordinate knowledge across Europe; Grasp the chance for structural improvements in the context of the financial crisis; Search for solutions across levels.	Uncertainty about the costs of climate change; Problems in determining sufficient level of intervention.
	Difficulties mainstreaming adaptation into different budget lines.	Awareness raising and education of stakeholders in other sectors than adaptation; Exchange knowledge and experience with other regions and other level governments; Establish clear guidelines for systematic mainstreaming.	Difficulties mainstreaming adaptation in different budget lines.
	Inter-sectoral competition over budgeting in view of no increase expected.	Need to make an economic case on adaptation — show economic benefits of multi-purpose adaptation measures; Use good practice from elsewhere.	Inter-sectoral competition over the national/European budgeting — no increase expected.
Technical and scientific	Lack of local scale relevant scientific or technical information.	Collect and summarise knowledge and information via central platforms such as the European platform CLIMATE-ADAPT; National and European research aimed at local vulnerability and adaptation, also with high emphasis on practice-oriented results and tools; Exchanges with regional and local knowledge holders; Establish science-policy organisations (boundary organisations) and networks such as regional climate partnerships; Support European climate research through EU instruments (Framework programmes) and national instruments, including joint programming between Member States; Establish and develop monitoring tools for following progress in adaptation strategies and measures (e.g. national reporting comparable to climate policy in mitigation).	Lack of coherent, comparable, up-to date knowledge on national regional and local vulnerabilities and adaptation.
	Inadequate understanding or ignorance of climate risks.	Develop climate change communications programmes and training tools; Make use of communication efforts at other levels; Use of information and training tools provided at internet portals at national and European level like the European platform CLIMATE_ADAPT.	Challenges in communicating climate change effectively.
	Scientific uncertainty; Lack of technical capacity or access to expertise.	Establish across levels common guidelines for vulnerability assessments; Provide support tools and training from national and European levels; Support practice-relevant and academic research and support by boundary organisations.	

Source: Adapted and expanded from Corfee-Morlot et al., 2009; Corfee-Morlot et al., 2010.

4.2.3 *Success factors*

Making multi-level governance for climate change adaptation a success depends on certain factors including:

- broad acceptance of the complexity of adaptation challenges and necessary action together with a strong commitment from concerned stakeholders to cope with the challenges by integrated and multi-level governance while respecting Europe's principle of subsidiarity and responsibilities;
- adequate distribution of authority and responsibility, correct processes and good relationships and coordination between spatial scales and actors;
- multi-level institutional and decision-making structures that reflect the complexity of adaptation challenges and the interlinkages between the different governmental levels;
- stable structures over longer periods despite political changes to ensure continuous work as increasing the adaptive capacity requires time;
- a comprehensive knowledge base about climate change impacts, vulnerabilities and adaptation options needs to be established and continuously updated such as the European Climate Adaptation Platform CLIMATE-ADAPT;
- regional projections on impacts and vulnerabilities, alongside global and European information;
- tools of active information exchange and continuous learning supplementing CLIMATE-ADAPT and making it work via joint projects, development of transferability tools for good practice, training, staff exchange and coaching (Rob Swart et al., 2009; Georgi et al., 2012).

Research and experience on environmental policy integration shows that a variety of communicative, organisational and procedural instruments can also support integration. Mickwitz, 2009 points to measures such as making impact assessments climate change inclusive, coordinating territorially through spatial planning, using national and other public budgets for mainstreaming and introducing cross-compliance requirements (such as on environmental regulations) for target groups receiving benefits in other policy fields.

Further reading

- Keskitalo, E. C. H., 2010, *Developing adaptation policy and practice in Europe: multi-level governance of climate change*, Springer, Dordrecht; New York.
- Corfee-Morlot, J., Kamal-Chaoui, L., Donovan, M., Cochran, I., Robert, A. and Teasdale, P., 2009, *Cities, Climate Change and Multi-level Governance OECD Environmental Working Papers N° 14*, OECD Publishing.
- VÁTI, 2011, *Climate-Friendly Cities: A Handbook on the Tracks and Possibilities of European Cities in Relation to Climate Change*, Ministry of Interior Hungary — VÁTI, Budapest (http://www.eukn.org/dsresource?objectid=224489).

4.3 Pillars for multi-level governance

Key messages

- Policy coherence, territorial governance, cross-level institutional capacities, access to funding and an adaptation knowledge base linking all levels are important building blocks towards a holistic multi-level governance approach.
- The outlook on successful climate adaptation governance is rather optimistic, provided that European actors at different levels learn to work together and that climate change adaptation can be sustained as part of the EU political agenda.

Based on these ideas and the factors mentioned in Section 4.2 the report elaborates the following pillars for multi-level governance:

- policy coherence through multi-level climate proofing;
- territorial governance and spatial planning as means for policy integration;
- building institutional capacities across levels;
- securing access to funding for adaptation measures;
- developing the multi-level knowledge base.

Table 4.6 provides a first overview.

4.3.1 Policy coherence through multi-level climate proofing

The principle goal of climate proofing is to adapt the legal and policy framework, removing inconsistencies and barriers, until it supports urban adaptation to climate change. There are several ways to achieve this.

Firstly, policymakers can screen existing frameworks for climate relevance and add, where necessary, the requirement to consider climate change. Systematic climate policy evaluation work can support evidence-based policymaking and learning in the longer term (Haug et al., 2009). Obvious examples at EU level are the Water Framework Directive and the Floods Directive (EC, 2000b; EC, 2007a). Introducing cross-compliance requirements (e.g. on environmental regulations) can also play a role in future revision processes. The climate proofing project from DG CLIMA (Altvater et al., 2011) has made efforts in this regard by assessing the European legal framework in four areas, one of which being urban areas.

Secondly, climate proofing should play an important role when new regional and local policies are developed such as the EU budget for 2014–2020 (Box 4.8). Based on an analysis of sectoral policies and related adaptation measures, Urwin and Jordan (2008) suggest that climate proofing works best when integrated into the development of new policies at local and regional levels.

Table 4.6 Summary table of possible actions of the different stakeholders to develop the multi-level governance framework and tools for urban adaptation in Europe

	Contributions to put a multi-level governance approach into practice by:				
	Local (urban) governments	**Regional governments**	**National governments**	**EU institutions**	**Other stakeholders**
Policy coherence	Linking up with national and EU adaptation strategies; Integration between city-sectoral programmes; Climate-proof budgeting and planning.	Integrate local needs with national and EU regional policy goals.	Use the national budget as a driver for policy coherence; Eliminate national incentives for maladaptation; Climate-proofing and territorial governance.	Use the EU budget as a driver for policy coherence; Mainstream adaptation into different policy areas providing a framework for national and subnational governments.	Businesses can engage in climate-proofing and support their local governments to follow suite.
Institutional capacity	Establish structures to access national and EU decision-making, e.g. intermediary associations and transnational networks such as CEMR, EUROCITIES, ICLEI.	Establish intermediary organisations to facilitate regional climate co-operation and organise capacity building.	Adjust responsibilities and tasks of the state; Establish clear roles and coordinating procedures between national and subnational governments.	Facilitate access for local authorities in EU policymaking.	NGOs and transnational municipal networks play an important facilitative role in climate policy and voicing local concerns at higher levels of policymaking.
Spatial planning and territorial governance	Integrate adaptation in urban planning and demand implementation into regional, national planning.	Address adaptation in a regional planning approach in functional terms (i.e. regardless of city limits, bio-geographical regions, river basins etc.); Engage in EU territorial cooperation.	Adopt and make use of the Territorial Agenda principles at national level; Include the spatial aspect of climate change impacts in national adaptation strategies.	Promote the EU Territorial Agenda and encourage Member States to do so as well; Integrated adaptation into the territorial cohesion concept.	Regional intermediaries (e.g. chambers of commerce, civil societies) can be supportive for territorial approaches.
Funding	Secure access to multiple sources of funding; Use value capture mechanisms to raise funds for local adaptation.	Build regional networks and partnerships for adaptation funding.	Facilitate local access to national and EU funding through national programming, guidelines and supporting tools.	Climate-proofing the EU budget; Integrating financing adaptation into cohesion and other policies; Securing accessibility of EU funds to cities; ensure that adaptation is not overshadowed by mitigation.	Private actors, e.g. insurance companies can facilitate innovation by raising funds.
Knowledge	Build capacities to knowledge absorption and adaptation; Cooperate with research institutions and individual knowledge providers; Provide local knowledge to other levels.	Share adaptation knowledge on a regional forum; Provide regional knowledge to national and European level; Coordinate climate relevant research and development projects regionally to save costs; Encourage the exchange of knowledge and practice.	Establish national climate change communication programmes and information portals and link with the other levels; Adaptation research; Guidance and training programmes; Establish boundary organisations to bridge science and policy.	Channel research and innovation funds towards adaptation and ensure a broader usability in practice; Provide the European data context and improve data on urban adaptation; develop a coherent monitoring mechanisms for adaptation action; Make full use of CLIMATE-ADAPT	Provide knowledge, e.g. universities, experts, citizens; Engage with practitioners at different levels, place value on practical applications of adaptation research.

Box 4.8 Climate proofing the EU budget 2014–2020

The Institute for European Environmental Policy (IEEP) analysed the opportunities for climate proofing the EU budget and developed a guide for policymakers. It aims to aid policymakers in the forthcoming preparations and negotiations for the post-2013 MFF.

The guide aims to clarify what climate proofing the EU budget actually means and how it can be put into practice when addressing the forthcoming EU budget. Experience gained through the implementation of the current Cohesion Policy can also be used. It also addresses some of the key questions on the future EU budget, including whether or not the main priorities and policy goals of the EU budget are coherent with the EU's climate change objectives. If not, what could and should be done about this? And how can the EU budget be turned into a tool to support efforts to tackle climate change?

Among the priority measures, the following are identified:

- securing more funds for climate change, including a dedicated climate fund;
- setting cross-cutting priorities on climate change in the EU budget;
- applying conditionality and incentives;
- reforming and phasing out harmful spending;
- development of climate change-related indicators and reporting (Medarova-Bergstrom et al., 2011).

In the case of the Cohesion Policy for the period 2014–2020, the proposal for the regulation of the Structural Funds already foresees climate change adaptation and risk prevention as conditionality. National and regional risk assessments have to be in place to obtain funding (EC, 2011e). It would ensure that infrastructure in particular, which lasts for decades and is very expensive, can cope with future climate changes.

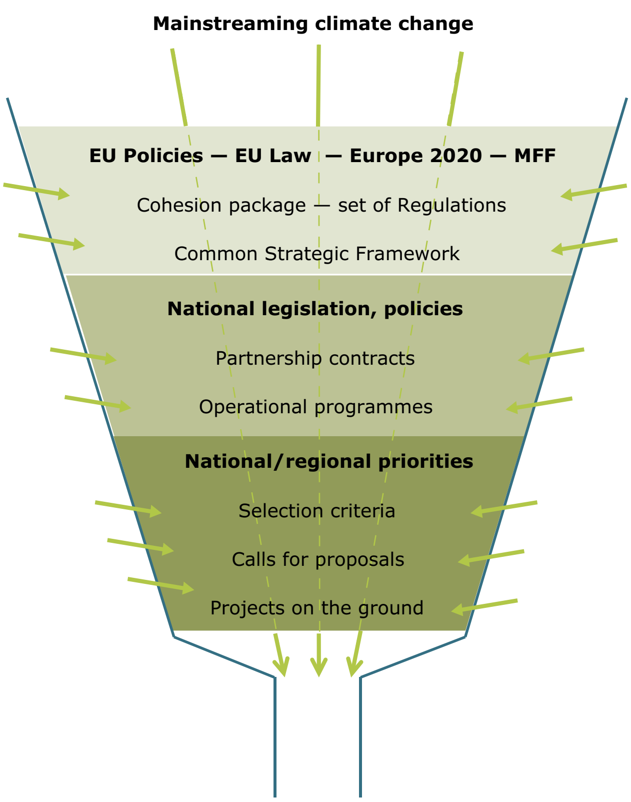
Thirdly, designing laws and policies in a way that provides people with sufficient adaptive capacity can also increase support to the legal and policy framework. Policies and laws in particular in the areas of economy, social, cohesion, education and research can enable society (individuals, organisations and networks) to cope better with climate change (Gupta et al., 2010). A higher level of education is assumed to increase citizens' adaptive capacity due to better knowledge absorption skills and higher incomes. The current proposal for the European Social Fund regulation (ESF) shall support a shift towards climate resilience through the reform of education and training systems, developing skills and qualifications (EC, 2011b). European programmes to support a smarter and more inclusive European development can thus increase the adaptive capacity of individuals, cities and societies.

Overall, both new and existing policies and regulations need not only to be climate proof but also urban proof. This means that regional, national and European governments check the likely impacts of their policy on the options open for cities to act in order to be supportive rather than hindering local action. If, for example, rail tracks or motorways, planned at national level and eventually funded by the EU budget, cut off areas for flood retention, local and regional governments are left with fewer options for flood management.

One facet relevant for building policy coherence is the so called 'procedural integration'. Procedural integration requires considering climate change adaptation in the whole process at all levels without dictating the outcome. See Figure 4.2 for an example of integration into the framework for cohesion policy.

Environmental Impact Assessments (EIAs) are another example particularly relevant for the purpose of procedural integration (Agrawala et al., 2010). This is due to the wide thematic and institutional reach of EIAs. Incorporating adaptation concerns in EIAs would affect existing modalities for development project design, approval and implementation and would be done through multiple entry points. Several national and sub-national (local, regional) authorities, as well as international organisations using EIAs have made some progress in examining the possibilities of incorporating climate change impacts and adaptation measures within the EIA context. Highly relevant for this mainstreaming effort is the on-going revision of the EIA directive as a way to ensure that

Figure 4.2 Mainstreaming climate change into the process of cohesion policy at different levels



Source: Adapted from Claus Kondrup, 2011.

plans and projects falling under this scope require climate proofing as a pre-condition with implication for the local and regional development (Mickwitz, 2009; Birkmann and Fleischhauer, 2009).

The inclusion of climate change adaptation into EIA and SEA involves a number of challenges. The limited availability of detailed information on historical climate patterns, as well as specific scenarios of future climate for the project location poses a major challenge. In many jurisdictions such information is currently not available (Agrawala et al., 2010). In addition, if the process does not adequately consider the uncertainties associated with climate change projections, it risks counterproductive investments in altering project design. Thus, the procedures need a degree of flexibility to accommodate new information on climate change. In this sense, the climate-proof EIAs need to demonstrate features of adaptive management, where new information on both climatic and socio-economic changes can be factored into the EIA process (Pahl-Wostl, 2009).

4.3.2 Territorial governance

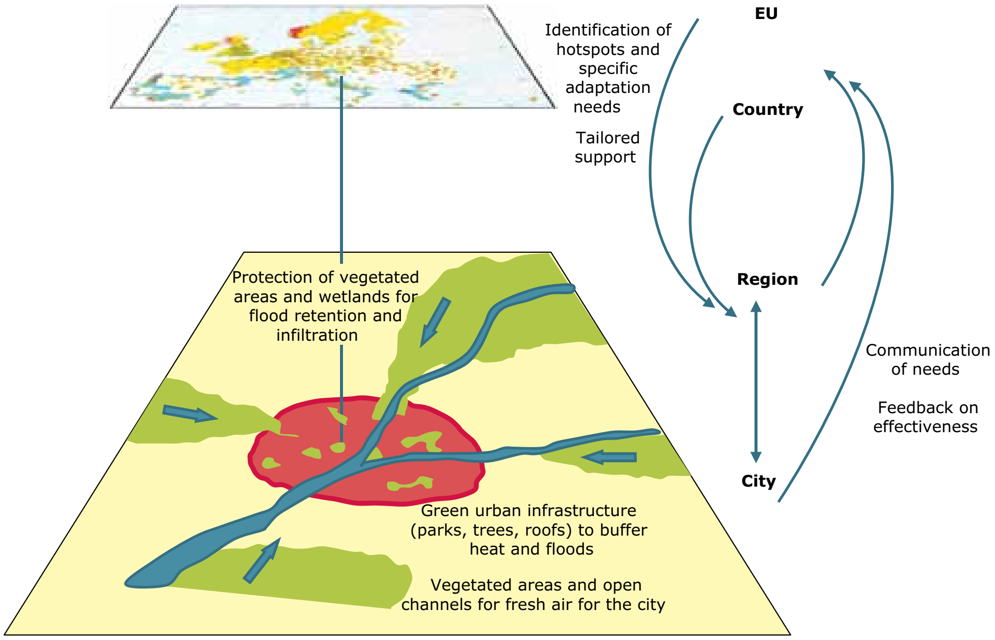
From a European perspective, the European Union institutions along with the national governments need to identify regions and cities with similar problems as well as hotspots for adaptation. The results of Chapter 2 and Section 3.1 show that the impacts of climate change and the adaptive capacity of cities differ between cities as well as regions. This enables them to channel their support to urban adaptation where it is most needed because of high climate impacts or a low capacity for adaptation. The tailored support is more effective than a one-size-fit-all-approach.

Spatial or territorial planning provides an important tool for bridging existing governmental levels and sectoral agendas and provides a procedure for solving multiple problems simultaneously. The integration of climate change considerations into spatial plans at different levels can increase urban resilience in efficient and non-disruptive ways. For example, a heightened flood risk and an urban heat island effect can both be addressed by increasing green and blue (water) spaces in local plans and, at the same time, serve recreation and nature. The effect will however be more efficient if regional planning protects vegetated areas outside the city for flood retention and as creators of fresh air. If national governments and the European Union have identified a particular region as an adaptation hotspot and support it, this will accelerate local adaptation and contribute to a more resilient Europe with a balanced and harmonious development (Figure 4.3).

It seems that stakeholders at different levels broadly understand the importance of spatial planning but in practice they have yet to develop comprehensive and consistent territorial multi-level governance for adaptation. A review of European national adaptation strategies confirms this observation (Mickwitz, 2009). If the territorial approach is not incorporated at national and subnational levels, friction is likely to emerge between local planning and national policymaking. In Finland, for instance, this issue has been addressed by establishing so called national land use objectives above regional and local planning in the planning hierarchy. Among European countries, the Netherlands seems to place the use of spatial planning as the highest priority in its national adaptation strategy (NAS).

EU Member States have generally rejected overtures from the EU on spatial planning in the past. In practise however, EU policies and legislation have influenced regional and local planning in a broad

Figure 4.3 Generic example of a multi-level territorial approach to adapting to flood risks and heatwaves in a city



and diffuse way. EU directives focusing on air quality, noise and water have become a point of reference for regional actions. European resources, in particular available through structural and cohesion funds, have shaped territorial policies, while their financial requirements and evaluation procedures have influenced regional governments (Faludi, 2009). EU territorial approaches imply soft methods of coordination, including the evaluation of policy and feedback from national and sub-national levels as tools of coordinating adaptive actions in the EU.

The EU's Territorial Agenda, a process which began with the European Spatial Development Perspective (ESDP) at the end of the 1990s, marked a turning point in the EU's role as regards spatial planning. The Territorial Agenda has moved from an implicit to explicit stage, even if it still lacks the status of official EU policy (Faludi, 2009). Importantly, climate change has had a growing, even constitutive, role on the Territorial Agenda, building pressure within the EU to develop territorially oriented, coordinated responses to the multiple and varying challenges of climate change. In 2007, under the German presidency of the EU, the agenda stipulated that joint trans-regional and integrated strategies should be further developed in order to face natural hazards, reduce and mitigate greenhouse gas emissions and adapt to climate change. It also established the link between territorial cohesion policy and territorially differentiated adaptation strategies (German EU presidency, 2007).

The present EU Territorial Agenda 2020 (Hungarian EU presidency, 2011) notes that the impacts of climate change vary considerably across Europe with varying impacts and different degrees of vulnerability. It addresses the geographically diverse impacts by referring to regions' varying risk profiles and opportunities in relation to both adaptation and mitigation challenges. The agenda further notes that these challenges draw attention to the territorial coordination of policies especially climate, energy, water management, agriculture, housing, tourism and transport.

In parallel, EU cohesion policy developed the concept of territorial cohesion in addition to social and economic cohesion. The concept, introduced with the EU Green paper on territorial cohesion (EC, 2008), aims to promote a balanced and harmonious development in particular by reducing social and economic disparities between regions. Addressing regional imbalances will be more relevant than ever in the future and of particular relevance for climate change adaptation. The implementation of the post-2013 MFF will show

Box 4.9 Towards a Baltic Sea regional adaptation strategy — an EU territorial approach

Photo: © Romtomtom-Flickr

The EU Strategy for the Baltic Sea Region (EUSBSR) is a pilot case of new location-based policymaking in the European Union and acknowledges that the Baltic countries have major environmental problems to address together. This transnational regional initiative embodies the idea of territorial governance, focusing on the horizontal integration of policy goals in a given territorial context.

As part of a common Baltic action plan, the EUSBSR calls for the development of a 'regional adaptation strategy at the level of the Baltic Sea Region' which would provide a useful framework for strengthening co-operation and sharing information across the region on this issue. The strategy would also ensure complementarities with the White paper on adaptation (EC, 2009b) and other EU initiatives, focusing on cross-border issues, developing more robust evidence on the impacts of climate change and raising awareness on the issue in the region (EC, 2009c). Building on a longer term process of regional research cooperation in the region, the on-going BaltAdapt project seeks to answer the call for the macro-regional adaptation strategy. The project seeks to identify commonalities in the adaptation strategies at different levels in the Baltic Sea Region, and to develop a common policy platform for the development of a Baltic Sea Region Climate Change Adaptation Strategy.

The macro-regional strategy attempts to link regional and local activities with European and global measures. The strategy has led to concrete action, with a more streamlined use of resources. New working methods and networks have been established and a number of initiatives developed. The strategy is a pioneer case also aiming to better streamline all funding instruments (EC, 2011f).

Source: http://www.interact-eu.net/baltic_sea_strategy/eusbsr/284/3949.

how the concept of territorial cohesion including a territorial approach to climate change adaptation is put in practice.

Despite the growing acceptance of EU territorial governance, the process is still informal and depends on political priorities. Multi-level implementation is still at an early stage. Only a few Member States have adopted the territorial agenda and territorial governance approaches in their national level practices (Faludi, 2009). Regarding territorial cohesion and the consideration of the urban dimension as well as climate change adaptation, the process of designing the next programming period 2014–2020 will show how far the principles of territorial governance are accepted and climate change is considered as a central thematic area.

4.3.3 *Developing institutional capacities across levels*

Climate change is a multi-level challenge which cannot be tackled at one administrative level only. Besides intergovernmental institutional linkages, there is a clear need for functioning communication channels between government authorities and private and public actors which is crucial for coordination of climate adaptation. The organisation of effective participation and communication is therefore an important prerequisite for climate adaptation. This communication between individuals, public and private actors gives rise to 'network power', which emerges as diverse participants in a network focus on a common task and develop shared meanings and common heuristics that guide their action (Booher and Innes, 2002).

Comprehensive participation and communication can sometimes pose a challenge as it can conflict with the existing capacities of governmental organisations. Departments with a highly technical character, such as water management, can lack the capacity to organise dialogue. They may even express an aversion ('all talking and no action'). This may necessitate awareness raising, training, hiring communication specialists and establishing a new culture towards a more open attitude.

The channels through which local authorities gain access to the EU policy process are an important aspect of institutional capacity building in Europe. So far, local authorities have no direct access, but the process of 'Europeanization' implies that cities can play a new role in shaping EU policy. Access to the European level becomes possible and traditional structures of domestic policymaking can be partially bypassed. Important initiatives in the past included the Sustainable Cities and Towns Campaign and the Covenant of Mayors where the European Commission interacted directly with local authorities. Experience gained there can serve to shape the multi-level approach around the EU adaptation strategy.

Networks and associations such as the Council of European Municipalities and Regions (CEMR), and EUROCITIES make use of the opportunities to engage with the European Union. Cities gain access to the EU policy cycle through these intermediary bodies that have a status as accredited participants in the so called 'structured dialogue' with the Commission. The declaration 'Governing in Partnership' (2011) from the presidents of CEMR, AER, CPMR and EUROCITIES aims to prepare a code of conduct that the European Commission would adopt to ensure the involvement of the partners in the preparation, implementation, monitoring and evaluation of key policy documents.

The European Parliament is also an important access point. Cities and their representative organisations can join political coalitions strengthening the Parliament's bargaining power and independence towards national actors. Organisations such as CEMR and EUROCITIES seek to establish a more formal role with the European Parliament and its MEPs (Heinelt and Niederhafner, 2008).

In addition to CEMR and EUROCITIES, many environmentally minded municipalities participate in transnational municipal environmental networks such as ICLEI or the Climate Alliance. These non-governmental networks are efficient in building knowledge and capacities in cities through peer-to-peer networking. These networks are clearly networks of pioneering cities, which means they can also process unique, innovative knowledge capacities as 'forerunners' (Kern and Bulkeley, 2009). Furthermore, these networks enable the European Commission and national governments to interact efficiently with a wide range of local authorities. The EU can play a role to foster multi-level governance by emphasising the importance of effective partnership in regional, national and European documents and settings.

From the Commission perspective, cities are not only the places where adaptation takes place. They can provide feedback on the effectiveness of the Commission's proposals. After all, cities are unique observers of how different policies feed in to the local level. Cities may adopt a role of monitoring and carrying out compliance checks with a view to delivering feedback.

Alongside these positive developments such informal ways of governance also bear risks. In the absence of formal procedures, participation depends on political will, lobbying and the local capacity. The ability of cities to benefit from EU structural funds depends, for example, on existing national procedures in place to develop and implement the various operational programmes. Participation possibilities for cities differ between countries.

Developing clearer institutional frameworks which describe the specific roles of the different stakeholders and the interlinking forms can be crucial for successful multi-level approaches. Dividing responsibilities between levels of government in systematic and explicit ways provides benefits for both national and local authorities. For instance, the Dutch national adaptation strategy in 2007 included an explicit statement about the division of responsibilities between central government and other levels of government (see Box 4.10). Such delineations need adjustments over time as climate change adaptation is a relatively novel field and part of an on-going learning process.

Cooperating with a diverse range of partners and finding joint solutions also has implications for senior management structures. Not every stakeholder feels confident with this situation as personal attitudes and different political cultures can create barriers to the policy process. Sufficient investment of time and resources with strong leadership can lead to these barriers being overcome.

Lack of information is a potential barrier for multi-level approaches to climate change adaptation. Multiple studies demonstrate that it is not the information as such that makes a difference rather, it is the context within which it is placed that can make it relevant for specific stakeholders (see more in Section 4.3.5).

Box 4.10 Distribution of responsibilities between national and local governments in the Netherlands

A PBL study (2011) in the Netherlands shows that for (cost) effective adaptation a division is needed of responsibilities between national government and other parties within a comprehensive multi-level approach. The national government has the responsibility of providing a legal framework, a customised decision-making mechanism as well as financing mechanisms. In addition, the central government has the overall responsibility for tasks such as spatial planning, freshwater supplies and flood protection. In decentralising these responsibilities, the central government must create preconditions for adaptation to climate change for municipal authorities, water boards and city developers. This means that central government must indicate where the limits of its responsibility of care lie and what investments it expects. Regional and local authorities must steer adaptation strategies through multi-stakeholder alliances. If this multi-level coordination system works, the study expects that urban regions can be climate-proof within 60–80 years. In addition, the principle of negotiating responsibilities between levels of government has been adopted as part of the Dutch national adaptation strategy. Table 4.7 shows the delineations between the governments which need to fit together.

Table 4.7 The distribution of responsibilities between central and decentralised governments in the Dutch national adaptation strategy, 2007

National government	Local and regional governments
Assess the vulnerability of the national spatial development plan;	Integrate climate change in provincial spatial strategies;
Assess the impacts of climate change in the context of water;	Integrate climate change in new and existing research programmes at a provincial level;
Finance knowledge development;	Revise regional adaptation funds to finance adaptation measures;
Develop risk assessment, early warning systems, and methods to increase social awareness;	Conduct small to medium sized case study projects.
Actively monitor the adaptation process;	
If needed, adjust policy-instruments (law, regulations) and strategic frameworks.	

Sources: PBL, 2011; Swart et al., 2009.

4.3.4 *Securing access to funding for adaptation measures*

National and European funding can support and accelerate urban adaptation. As with other climate proofing efforts, funding options should be developed jointly between the local and higher levels of governance. Thus, funding climate change adaptation can rely on local or regional funds, national government and EU funding instruments. The multiple facets of budgeting and public finance allow for a variety of instruments to be used. These may include climate-focused taxes and charges, subsidies and budget allocations, removal of subsidies or taxes with harmful impacts and rules stipulating the ways public funds can be used and monitored (Mickwitz, 2009) (see also Section 3.3.7). These instruments should be used innovatively to promote climate change adaptation while securing policy coherence — i.e. funding adaptation measures needs to go hand in hand with the removal of incentives leading to maladaptation (see also the French example in Box 4.3).

Although there have been regular concerns raised related to the level of funding for adaptation (e.g. Mechler et al., 2010 on refinancing losses from extreme events, and the European Solidarity Fund), many types of funding have already been available for adaptation. Whether it is urban renewal or making infrastructure climate proof by using EU structural funds, supporting regional adaptation strategies and measures by INTERREG projects, or national risk and disaster funds, a broad range of funds are available which can also provide support for local and regional climate change adaptation. The proposed increase towards 20 % of the EU budget earmarked for climate change in the financial period of 2014–2020 will further improve the situation (EC, 2011b).

Since funding instruments in the EU do not exclude the possibility of using them for funding adaptation measures, the accessibility and mobilisation of those funds, rather than their actual size, is a crucial factor for promoting adaptation. Even if convincingly designed, funding for climate change adaptation can fail if corresponding implementing structures are not in place or the respective political conditions and the opportunities presented are not taken into account. Indeed, the problem faced by cities and regions is that they may never gain access to EU funding instruments due to 'bottlenecks' at the national level, such as problems with operating procedures within the structural funds, information gaps and technical competence, lack of guidance and good practice examples (Baltzar et al., 2009) (Box 4.11).

Baltzar et al. (2009) point to important gaps in the funding chain from EU to local level. Although the gaps relate mainly to climate change mitigation targets, they can also be highly relevant for adaptation goals (Table 4.8). He argues that the two principal ways in which operational programmes can improve the integration of climate change considerations into project development and preparation are through project application documents and assistance and guidance to project applicants (Box 4.11).

The 'Financing the Resilient City' report (ICLEI, 2011) suggests local strategies for capacity building to enable the financing and implementation of resilient urban development projects. The key challenge is to match local demand for resilience with the right financial options (see also Section 3.3.7). The ICLEI report highlights the fact that there are challenges to the supply of finance. Such a financial market for resilience needs to respond to varying circumstances across localities and institutional settings. When financial instruments are flexible, funded projects can be locally responsive. This is in marked contrast to a setting where markets require standardised investment propositions along with predictability about the preparation and subsequent performance of the propositions.

To foster such innovative financial products enabling resilience measures, the ICLEI report proposes that international adaptation funds, or similar national level funds or programmes, need to focus on three areas:

- funding for local, national, and international initiatives to mainstream new resilience standards into conventional urban development projects;

Box 4.11 Access limitations to European funds — a Romanian local authority perspective

Many Romanian local authorities fail to absorb EU funding because they are inappropriately informed, have poorly trained staff, are run on small budgets or are unable to partner with other institutions or associations.

The Soros Foundation Romania (SFR) commissioned a study on local authorities' access to European funding in 2008. Four of Romania's eight development regions were surveyed (north-east, south-east, west and south-west) which accounted for 1 579 town halls. This was complemented by 16 in-depth case studies. The purpose was to reveal the factors which preclude certain towns or areas from tapping into development funding (particularly into the EU's post-accession funding). The specific problems that local actors report they face in implementing EU-funded projects were also investigated.

The conclusions contrast the positive official reporting by the authorities currently coordinating the distribution of EU funding. According to the study, and for the period between 2005 and 2008, out of the total number of administrative units surveyed, one quarter did not submit even one project requesting governmental or European Union financing. Meanwhile an additional quarter submitted only one single project. For those who did apply, the average rate was 2.5 projects per town hall submitted with a 50 % success rate.

The authorities best equipped were most successful in raising EU project funding potentially leading to widening gaps in capacity, skills and well-being.

Source: Soros Foundation Romania: Local Authorities Access to European Funds. http://www.soros.ro/en/program_articol.php?articol=150.

Table 4.8 General gaps in programming and funding cycles with related responses

Budget cycle phase	Gaps identified	Possible responses in a multi-level framework
Call for proposals (announcement)	Insufficient knowledge among project applicants about the opportunities offered by projects related to climate change. Limited experience of the possible types of activities and outputs.	Organising thematic calls for proposals and by providing technical assistance to project applicants by EU and national governments. Climate related questions in the application documents. Improved guidance documents to raise quality and climate awareness for the applications. Technical assistance (designated personnel) to provide support for applicants. Consultation with environmental authorities or broader dialogue within environmental networks.
Project appraisal process	Climate change related impacts not clearly identified. Lack of expertise of project evaluators in environmental assessments.	Use of innovative mechanisms such as environmental (EIA) panels to bring expertise and knowledge into the assessment. Use checklists and guides for the impact assessments.
Project monitoring and evaluation	Difficulties in monitoring projects and programmes, relevant for all Member States and the EC. Lack of monitoring systems and impacts inventories.	Strengthen evaluation systems in EU funding programmes that focus on climate trends, impacts, challenges and opportunities. Evaluate prior, during and after EU funded programmes are carried out. Perform a rigorous evaluation of the 2007–2013 period to identify investment needs for mitigation and adaptation from EU funds in European regions. Use evaluations as a basis for post 2013 programming.

Source: Based on Baltzar et al., 2009.

- special funding for local projects in highly vulnerable urban areas and systems;
- financial product innovation (e.g. 'value capture mechanisms' from development) for the purpose of creating private investment flows into the upgrading of infrastructure resilience (ICLEI, 2011).

In addition, adaptation measures can be led by private actors. Funding options need to include private investments of various kinds. The role of the private insurance industry will continue to remain critically focused. Their ability to assess and to communicate risk, to spread the economic impact through a variety of insurance products, to encourage behaviour change through price-based devices and their ability to survive high cost years by accessing global financial markets will be important support mechanisms for adaptation (McEvoy, 2009). However, adaptation-related market mechanisms remain clearly underdeveloped (Corfee-Morlot et al., 2009). This implies that governance arrangements in adaptation cannot rely on market actors as heavily as in the field of mitigation and, consequently, public actors have a decisive role to play in the field.

The economics of climate change adaptation are of key importance for any given case — whether operating with public or private funds or a top-down/bottom-up approach. The fact that the economy — and especially an economy in crisis — and employment nearly always take priority over climate change on the political agenda highlights the need to focus on the economics of adaptation. It also underlines the importance of adaptation measures with multiple benefits and potential funding sources. Making this case is relevant for all levels of governance from the local to the European including international climate negotiations. With respect to EU cohesion policy funding, there is a need to explicitly include climate change measures in the national programming documents (the NSRFs) and to demonstrate the potential of those measures for economic growth and job creation. Displaying such synergies helps to integrate climate change into cohesion policy (Baltzar et al., 2009). Similarly, the synergies between climate change adaptation and cohesion policy could be improved if adaptation were more visibly included in the European green economy discourse which predominantly emphasises mitigation through resource and energy efficiency. Within this context it is important to highlight examples such the Dutch 'delta programme' which aimed to build long-term safety against flooding. Nations such as Vietnam and Bangladesh have shown an interest in the procedure with assistance from Dutch consultancy firms (Knowledge for Climate, 2012a).

4.3.5 Multi-level knowledge base

The preceding chapter highlighted the fact that knowledge is crucial in developing adaptation strategies and measures. This is also applicable regarding local climate change impacts, adaptive capacities as well as the governance of adaptation at and between the different levels and stakeholders.

Demeritt and Langdon (2004) found in their study that over three quarters of responding local authority officers in the United Kingdom felt that they did not have access to the best information about the impacts of climate change on their regions. It seems that despite the free availability of governmental information sources these were not used regularly. Also, during the Resilient Cities conference in Bonn in 2011, participants confirmed that while knowledge regarding climate change and adaptation was available, problems to do with access and understanding were prevalent (Georgi et al., 2012).

In essence, locally specific information on climate change impacts is acutely needed in many localities, but this availability is no guarantee that it will be adopted and used in practical adaptation efforts (Demeritt and Langdon, 2004). Only an active dialogue with authorities at different levels as well as scientific institutions can help to overcome this barrier. Georgi et al. (2012) suggests various proposals.

- A strong collaboration between key stakeholders — policymakers, knowledge providers, business owners, citizens and communities. In particular, active collaboration between decision-makers and knowledge providers ensures that the scientific community can respond to the information needs of cities.

- Developing a shared language on climate change adaptation thus overcoming the specialised vocabularies and the interpretation of terms used by the different stakeholder groups through on-going conversations and debates with stakeholders from various backgrounds.

- Continuous social and institutional learning in collaborative adaptation processes. Centralised information portals can substantially support this process of knowledge sharing and learning.

Through direct contact with scientists, municipalities can access climate and adaptation science. Stuttgart in Germany is one such example where the municipality has established a special Section called 'Urban Climatology' within the Office for Environmental Protection (Box 3.10). Local and regional governments can engage with their educational institutes and universities and establish regional climate change partnerships (see also Box 3.12).

National and European governments and knowledge institutions have an important role to play in supporting local knowledge use. They can provide funding for basic adaptation research, including climate modelling (e.g. NOAA, UK Hadley Centre), but also support regionally tailored research, such as INTERREG projects. The Dutch 'Knowledge for Climate' program (Knowledge for Climate, 2012b), for example, supports eight regional consortia ('hotspots') to develop regional and local adaptation strategies. The EU will continue to support climate change related research under its framework programmes (Box 4.12).

Chapter 2 demonstrated that there is a strong link between climate change vulnerabilities and vulnerabilities arising from socio-economic trends. There is a clear need for research linking climate change with societal and spatial patterns and future scenarios, besides the on-going work to reduce uncertainties via downscaling climate scenarios. There is also a need to understand adaptation as well as governance processes themselves, including the need to establish procedures for eliciting data on adaptive measures in Europe's cities and regions.

Science and policy interface organisations, also called boundary organisations, can make information on climate and adaptation available. Boundary organisations are institutions that specialise in facilitating the transfer of useful knowledge between science and policy (Guston et al., 2000). Examples are environmental agencies and consultancies which translate scientific results into policy relevant guidance and which communicate policy needs and shape research agendas (Box 4.13; see also Box 3.12).

An important action at EU level is the European Climate Adaptation Platform CLIMATE-ADAPT.

Box 4.12 Adaptation Strategies for European cities — building local capacities across countries

The European Commission's Directorate General for Climate Action (DG CLIMA) recently launched a project to support the development of urban adaptation strategies and to enable cities to actively participate in developing and implementing a European adaptation strategy for 2013. A core task of the project is to develop capacity for, and with, local authorities. The project shall evaluate best practice across Europe, provide guidance and tools for adaptation strategies and design and organise training. The latter shall use web based tools, workshops and coaching.

Source: http://eucities-adapt.eu.

Building on various national and sub-national initiatives its main functions are:

- enhancing information structuring and sharing and acting as a facilitator for collecting and disseminating scientific information, data and case studies about climate change impacts and vulnerability, to build a consistent and updated knowledge base;
- assisting an effective uptake of this knowledge by international, EU, national, regional, local or sectoral decision makers, by offering guidance, tools, best practices for assessments of vulnerability to climate change at different geographical levels and of adaptation plans and measures;
- contributing to a greater level of coordination among the relevant sectoral policies, and among different institutional levels.

The development of national, regional, local adaptation strategies and now finally one focused on the EU will demonstrate the usefulness of this tool.

Box 4.13 The UKCIP as key boundary organisation in adaptive governance

UKCIP operates as a public-private partnership, and mediates between climate scientists, technology experts, policymakers and stakeholders. The UKCIP has been operating since 1997 to support decision-makers' assessments of their vulnerability to climate change so that they can plan how to adapt. The programme was developed incrementally, taking advantage of collaborative funding and facilitating long-standing partnerships.

Whilst the core framework of scenarios and tools has been developed centrally, most studies have been stakeholder-funded and led. Stakeholders usually are positioned in a consultative role in research. In contrast, the UKCIP aims to bridge the gap between research and policy in a way that decision-makers can take control. The programme's results suggest that if decision-makers are supported, capacity is built for assessments, and research outputs are directly applicable to their on-going work and strategic planning. This capacity-building has worked across scales and sectors and is an effective route to mainstreaming climate change adaptation.

The implication, therefore, is that more support should be given by funding agencies to develop institutional capacity to support adaptation to climate change in both the private and public sectors (McKenzie Hedger et al., 2006). Internationally, the UKCIP constituted an important inspiration for other countries (Keskitalo, 2010c) in the way it has provided concrete information on scenarios, impacts and risk assessment for both local and regional level.

Source: http://www.ukcip.org.uk.

Figure 4.5 Homepage of the European Climate Adaptation Platform CLIMATE-ADAPT

Source: http://climate-adapt.eea.europa.eu.

CLIMATE-ADAPT and other similar intermediaries between knowledge and action are needed since science can only play a limited role in social learning. Intermediaries, formal networks and other 'translators' have a crucial role in learning processes where not only individuals but the institutional system itself must learn to adapt. Learning proceeds through expanding 'loops' — from evaluating a fixed norm and taking corrective actions (single loop) to evaluating and changing the norms (double loop) or completely reframing them (triple loop) (Georges et al. 1999). It becomes evident that multi-level governance can help in a European effort to shift from the all-too-typical norm-following corrections (see Pahl-Wostl, 2009) towards higher orders of learning and innovative ways of changing and re-framing relevant norms.

Further reading

- Keskitalo, E. C. H., 2010, *Developing adaptation policy and practice in Europe: multi-level governance of climate change*, Springer, Dordrecht; New York.
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- ICLEI, 2011, *Financing the Resilient City: A demand driven approach to development, disaster risk reduction and climate adaptation — An ICLEI White Paper*, ICLEI Global Report, ICLEI, Bonn (http://iclei.org/fileadmin/user_upload/documents/Global/Publications/Report-Financing_Resilient_City-Final.pdf).

Glossary

Adaptation to climate change —Adjustment in natural or human systems (e.g. urban areas) in response to actual or expected climatic stimuli or their effects. It moderates harm or exploits beneficial opportunities of climate change. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation.

Adaptive capacity (in relation to climate change impacts) — The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Apparent temperature — is a measure of relative discomfort due to combined heat and high humidity. It is used as an index to describe thermal comfort.

Climate — 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. These 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. The classical period of time is 30 years, as defined by the World Meteorological Organization (WMO).

Climate change — Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), which 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'.

Climate (change) scenario — A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships and assumptions of radiative forcing, typically constructed for explicit use as input to climate change impact models. A 'climate change scenario' is the difference between a climate scenario and the current climate.

Climate variability — Climate variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability).

Erosion — The process of removal and transport of soil and rock by weathering, mass wasting and the action of streams, glaciers, waves, winds and underground water.

Extreme weather event — 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 be as rare as or rarer than the 10th or 90th percentile of the observed probability density function. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. Single extreme events cannot be simply and directly attributed to anthropogenic climate change, as there is always a finite chance the event in question might have occurred naturally. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g. drought or heavy rainfall over a season).

Forecast — Projected outcome from established physical, technological, economic, social, behavioural, etc. patterns.

Global warming — Global warming refers to the gradual increase, observed or projected, in global surface temperature, as one of the consequences of radiative forcing caused by anthropogenic emissions.

Governance — Modern governance is not based on centralised 'command and control' but is dispersed across multiple centres of authority (Hooghe and Marks, 2003). There are many self-organising, inter-organisational networks which complement markets and government hierarchies as governing structures for allocating resources and exercising control and coordination (Rhodes, 1996). Two dimensions of governance exist — vertical and horizontal coordination — which work in combination.

Green and blue areas refer in this report to the Urban Atlas classes. These are green urban areas, sports and leisure facilities, agricultural areas, semi-natural areas and wetlands, forests, discontinuous low density urban fabric as a proxy for private gardens and water bodies.

Green infrastructure –is seen in this report as an interconnected network of natural and green man-made features, such as forests, extensive grasslands, wetlands, but in urban areas also parks, gardens, cemeteries, trees at streets, green walls and roofs. Such green infrastructure enables ecosystem services, like flood protection, regulating temperature, filtering of air, recreation areas among others.

Grey infrastructure — construction measures such as buildings, technical and transport infrastructure, dikes and other technical protection constructions using engineering services.

Mal-adaptation is an adaptation action or process that actually increases vulnerability to climate.

Mitigation (climate change) — An anthropogenic intervention to reduce the anthropogenic forcing of the climate system. It includes strategies to reduce greenhouse gas sources and emissions and enhancing greenhouse gas sinks.

Multi-level governance — In this report the term is understood as non-hierarchical forms of policymaking, involving public authorities as well as private actors, who operate at different territorial levels, and who acknowledge their interdependence.

Projection — The potential evolution of a quality or set of quantities, often computed with the aid of a model. Projections are distinguished from predictions in order to emphasise that projections involve assumptions, concerning, for example, future socio-economic and technological developments, that may or may not be realised, and are therefore subject to substantial uncertainty.

Resilience — The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation and the capacity to adapt to stress and change.

River discharge — Water flow within a river channel, for example expressed in m3/s.

Run-off — That part of precipitation, snow melt or irrigation water that appears in uncontrolled surface streams, rivers, drains or sewers.

Soft measures — non-physical measures such as policies, plans, programmes, procedures

Soil sealing — is the covering of the soil surface with materials such as concrete and stone as a result of new buildings, roads, parking places but also other public and private space. Depending on its degree, soil sealing reduces or most likely completely prevents natural soil functions and ecosystem services within the area concerned.

SRES scenarios — refers to the scenarios described in the IPCC Special Report on Emissions Scenarios (2000). The scenarios are grouped into four families (A1, A2, B1 and B2) that explore alternative development pathways.

A1: A world of very rapid economic growth, a global population that peaks in mid-century and rapid introduction of new and more efficient technologies.

A2: A very heterogeneous world with high population growth, slow economic development and slow technological change.

B1: A convergent world, with the same global population as A1, but with more rapid changes in economic structures toward a service and information economy.

B2: A world with intermediate population and economic growth, emphasising local solutions to economic, social, and environmental sustainability.

Uncertainty — An expression of the degree to which a value (e.g. the future state of the climate system) is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from quantifiable errors in the data to ambiguously defined concepts or terminology, or uncertain projections of human behaviour. Uncertainty can therefore be represented by quantitative measures, for example, a range of values calculated by various models, or by qualitative statements, for example, reflecting the judgement of a team of experts.

Urban — In this report, 'urban' is used as a collective term to fit with the different country specific definitions of cities and towns.

Urban Heat Island (UHI) effect — It describes the increased temperature of the urban air compared to its rural surroundings. The temperature difference can be up to 10 °C or more (Oke, 1982). The difference is particularly stark at night.

Urban Morphological Zone (UMZ) — is defined as built-up areas lying less than 200 m apart. They are primarily made up of four Corine Land Cover classes and include continuous urban fabric, discontinuous urban fabric, industrial or commercial units, green urban areas, port areas, airports and sport and leisure facilities.

Vulnerability — A variety of definitions exist according to the specific context. The United Nations International Strategy for Disaster Reduction (UNISDR, 2009), 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. The Intergovernmental Panel on Climate Change defines vulnerability to climate change as the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007). While being aware of the different definitions and concepts of vulnerability, we do not use a specific definition or concept stringently in this report but rather use the term in a more generic way.

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Annex I Key information

The European Climate Adaptation Platform CLIMATE-ADAPT (Figure A.1) provides a huge variety of information on climate change adaptation at European, national, regional level and for cities including case studies, tools, reports and documents. This collection will be continuously updated. In addition national information portals provide information for urban adaptation.

Figure A.1 Homepage of the European Climate Adaptation Platform CLIMATE-ADAPT

Source: http://climate-adapt.eea.europa.eu.

The following list highlights selected key sources.

a) Selection of key literature and studies

VÁTI, 2011, *Climate-Friendly Cities: A Handbook on the Tracks and Possibilities of European Cities in Relation to Climate Change*, Ministry of Interior Hungary — VÁTI, Budapest (http://www.eukn.org/dsresource?objectid=224489).

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Schauser et al., 2010, *Urban Regions: Vulnerabilities, Vulnerability Assessments by Indicators and Adaptation Options for Climate Change Impacts — Scoping Study*, European Topic Centre on Air and Climate Change, Bilthoven (http://acm.eionet.europa.eu/reports/docs/ETCACC_TP_2010_12_Urban_CC_Vuln_Adapt.pdf).

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EEA, JRC and WHO, 2008, *Impacts of Europe's changing climate: 2008 indicator-based assessment*, EEA Report No 4/2008, European Environment Agency (http://www.eea.europa.eu/publications/eea_report_2008_4).

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Kamal-Chaoui, L. and Robert, A. (eds), 2009, *Competitive Cities and Climate Change*, OECD publishing (http://www.oecd.org/dataoecd/30/36/44232251.pdf).

Kazmierczak, A. and Carter, J., 2010, *Adaptation to climate change using green and blue infrastructure. A database of case studies* (http://www.grabs-eu.org/membersArea/files/Database_Final_no_hyperlinks.pdf).

Keskitalo, E. C. H., 2010, *Developing adaptation policy and practice in Europe: multi-level governance of climate change*, Springer, Dordrecht; New York.

b) *Selection of tools and guidance for adaptation*

Shaw, R., Colley, M. and Connell, R., 2007, *Climate change adaptation by design: a guide for sustainable communities*, TCPA, London (www.preventionweb.net/files/7780_20070523CCAlowres1.pdf).

Matthies, F., Bickler, G., Cardenosa Marin, N. and Hales, S., 2008, *Heat-health action plans — Guidance*, WHO Regional Office for Europe, Copenhagen, Denmark (http://www.euro.who.int/__data/assets/pdf_file/0006/95919/E91347.pdf).

SWITCH Managing Water for the City of the Future — Trainings Desk (http://www.switchtraining.eu/home).

UKCIP Adaptation Wizard (http://www.ukcip.org.uk/wizard).

Snover, A. K., Whitely Binder, L., Lopez, J., Willmott, E., Kay, J., Howell, D. and Simmonds, J., 2007, *Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments*, ICLEI- Local Governments for Sustainability, Oakland, CA, USA (http://www.icleiusa.org/action-center/planning/adaptation-guidebook).

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Annex II City data

The selection of cities considered in the maps and diagrams of this report is based on the Urban Audit database(Eurostat, 2012). This database includes 321 European cities in the 27 countries of the European Union along with 36 additional cities in Norway, Switzerland and Turkey. The administrative unit of the city is here defined as the 'core city'.

Table A1 below lists the data types collected for the report. They were retrieved from the Urban Audit database as well as other public available data sources. It should be noted that not all data were available for each of the Urban Audit cities.

The following information can be downloaded at:

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

- Interactive maps and Excel data table with the collected and produced city data;
- Description of the methodology used to define the city area;
- Description of specifically developed indicators:
  - Share of green and blue urban areas;
  - Coastal flooding;
  - River flooding.

Table A.1 List of data types collected for the report

Available at: http://www.eea.europa.eu/publications/urban-adaptation-to-climate-change.

Data types	Primary data source	Link
Share of green and blue urban areas per city area	Urban Atlas	http://www.eea.europa.eu/data-and-maps/data/urban-atlas
Percentage of the city that would be flooded in case of water in rivers rises 1m	Urban Atlas; Projected change in 100-year return level of river discharge between 2071–2100 and the reference period 1961–1990	http://www.eea.europa.eu/data-and-maps/data/urban-atlas http://ec.europa.eu/dgs/jrc/index.cfm
Mean soil sealing degree	EEA FTSP on Land Monitoring — Degree of soil sealing 100 m	http://www.eea.europa.eu/data-and-maps/data/eea-fast-track-service-precursor-on-land-monitoring-degree-of-soil-sealing-100m-1
Change in the potential inundation exposure for urban areas due to sea level rise	Urban Atlas; ESPON CLIMATE	http://www.eea.europa.eu/data-and-maps/data/urban-atlas
Total population	Urban Audit	http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/introduction
Population density	Urban Audit	http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/introduction
Share of people > 65 years	Urban Audit	http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/introduction
Percentage of higher educated population aged 15–64 (qualified at tertiary level)	Urban Audit	http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/introduction
percentage of women among elected city representatives	Urban Audit	http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/introduction
GDP per capita	Urban Audit	http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/introduction
Age dependency index	Urban Audit	http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/introduction
Perceptions that the city is committed to fight against climate change	Urban perception survey	http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/introduction
Perceptions on 'most people can be trusted'	Urban perception survey	http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/introduction

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