Appendix 7: State of Play – Impacts vulnerabilities and adaptation in European cities

Adaptation Strategies for European Cities: Final Report

This is part of the Final Report of the project ”Adaptation Strategies for European Cities” which has been compiled by Ricardo-AEA for the European Commission Directorate General Climate Action

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Adaptation Strategies for European Cities: Final Report

Report for DG Climate Action

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Executive summary

Europe's adaptation is – to a major extent – urban. Cities are the places where adaptation measures will be planned, implemented and maintained. Local governments are the organisations to facilitate adaptation processes involving citizens and stakeholders and coordinate adaptation measures taken by various actors in all sectors represented in their territory to design, implement, monitor, evaluate and further a coherent, integrated and successful urban adaptation strategy.

The major threats to European cities are the impacts resulting from flooding, heatwaves, and water scarcity (or drought), coupled with coastal impacts for those cities in vulnerable locations. Impacts in cities are experienced directly and indirectly through multiple sectors. Interacting with current socio-economic pressures and vulnerabilities, climate change presents a very real threat to the quality of urban life, economic competitiveness, health and urban biodiversity. The number of Europeans living in urban areas is set to increase from the current figure of around 70% to around 80% in 2020, due mainly to rural to urban migration, but in the longer term from increasing immigration. Even without climate change, it is therefore increasingly important to enhance urban resilience to extreme weather events, but with projections for more frequent and more severe heatwaves, flash flooding and periods of water scarcity, and rising sea levels, the risks are also increasing.

Cities in Europe are starting to develop adaptation strategies or action plans, to a greater or lesser extent, often triggered by experiences of extreme weather disruption. Idealised adaptation planning processes (frameworks and guidance) are relatively widely available to support the development of such strategies. There are numerous examples of urban adaptation planning and actions. However, there is still a lack of *good practice* examples, and a lack of communication of these examples.

Cities are affected by a large number of policies both directly and indirectly. The principle of mainstreaming adaptation across a wide range of policy areas is key to ensure that adaptation strategies can be implemented at city level. At Member State level, not all countries have national climate change adaptation strategies, which may hinder the development of adaptation plans at lower spatial and/or administrative levels. In other countries, while there may be regulations at the national level for larger municipalities to develop adaptation plans, such regulations may not be strongly enforced. Adaptation remains a new policy area for many city administrations in Europe.

Given the economic, social and environmental importance of cities, they will also be critical to the European Commission's Adaptation Strategy. The EU can play a crucial role in facilitating knowledge transfer between cities in different Member States. There is an institutional argument for a role at EU level in urban adaptation: the EEA's recent report (EEA, 2012) has emphasised the concept of multi-level governance for adaptation, which brings with it challenges of co-operation and collaboration, both between levels of governance, and also across borders (where transnational impacts require co-ordinated cross-border adaptation responses).

The key objective for EU policy towards urban adaptation is *to enhance an integrated and multi-level governance approach to building climate resilience*. This would support, coordinate, encourage and synergise efforts, and enable enhanced replication of good practices at regional and local levels across Europe.

Given the large number of sectors requiring adaptation at city level, in different local contexts with differing vulnerability, a very wide range of technical measures for urban adaptation is available. The appropriate options are also dependent on the nature of local governance and its role / remit across affected sectors. Adaptation can also offer opportunities to promote innovation and create new jobs.

Urban adaptation will be facilitated by mainstreaming of adaptation into key EU policy areas, as well as the removal of potential policy conflicts at national and European levels. Areas identified as a high priority for mainstreaming include: climate proofing for the EU budget for 2014–2020; cross-compliance requirements; procedural integration and Environmental Impact Assessments; and spatial planning as the key tool for bridging existing governmental levels and sectoral agendas.

Across European cities, the private sector plays a key role as landowner, developer and user of the urban fabric at risk from adverse climate impacts, placing the private sector at the heart of effective adaptation responses. Existing city-level adaptation strategies highlight the potential role of the private sector in the delivery of urban adaptation and the importance of engaging the private sector in the development of adaptation strategies.

There is great potential for the European level to provide resources and coordinated action for research to fill existing knowledge gaps in urban impacts and adaptation, and making use of the Climate-ADAPT platform in dissemination, engagement and application of this knowledge base. Knowledge exchange can play an important role in raising awareness and building adaptive capacity among cities, and the EU can facilitate such exchange. The current DG Climate Action project on Adaptation Strategies for European Cities is providing a demonstration of the kind of activity that the EU can undertake to actively support peer-to-peer learning in adaptation.

A number of specific potential opportunities to enhance urban adaptation exist, including: exploiting both the increased urban emphasis and the new adaptation theme under cohesion proposals to support urban adaptation, increasing the take up of urban adaptation projects under, for example, the future LIFE+ programme, extending the urban section of Climate-ADAPT and linking with other urban (sustainability) platforms. Alongside the specific options, some broader policy issues are fundamental to setting the framework and priorities for urban adaptation, and these include continued emphasis on mainstreaming across EU policy, guarding climate funds under the new EU budget for adaptation, and enhancing data collection on urban areas across the EU.

The recently published report from the European Environment Agency provides a very detailed consideration of the impacts, vulnerabilities and adaptation needs of cities in Europe, and also provides clear and justified recommendations for the European level action required. This State of Play Report cannot achieve the same depth and breadth, but seeks to place the major findings from that report in the context of some other European literature and additional reviews of activities at city-level, a survey and results of European stakeholder dialogues being undertaken in the current Adaptation Strategies for European Cities project, and to structure this information appropriately for the development of the European Adaptation Strategy.

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1 Context, Problem Definition

Climate change is increasingly recognised as a major threat to the stability and prosperity of the European Union and it is at the city level that much of this challenge will need to be addressed. Extreme weather events resulting in hazards including heat waves, floods and droughts are expected to occur more frequently (EEA, 2012) posing major problems for European urban areas. Fundamentally, because the majority of the EU population lives in cities or urban areas, the impacts of climate change in the urban setting, and potential urban adaptation responses, are significant in the development of the European Adaptation Strategy. Cities are considered a cross-cutting issue in the development of the European Adaptation Strategy (rather than a discrete sector), and the urban dimension is potentially relevant to climate impacts and adaptation for multiple sectors, including:

- Construction and buildings (domestic and commercial)
- Transport, Mobility
- Energy (generation, infrastructure, demand)
- Water supply and wastewater
- Health and well-being
- Employment
- Ecosystems and biodiversity
- DRR

Box 1: Key terms used in this report

Adaptive capacity: The ability of a system or place (e.g. urban areas) to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, and/or to cope with the consequences.

Adaptation: Adjustment in natural or human systems (e.g. urban areas) in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. It moderates harm or exploits beneficial opportunities of climate change. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation (EEA, 2012).

City: For analytical purposes, a city definition based on a minimum density and number of inhabitants (over 50,000) has been developed jointly by the European Commission and the OECD (see table 1 below). However, in the political agenda concerning urban matters, "cities" broadly stands for "cities and towns" therefore including urban areas of less than 50,000 inhabitants. (DG REGIO, 2011)

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 (EEA, 2012).

Hazard (here: Climate Hazard): A physically defined climate event with the potential to cause harm, such as heavy rainfall, drought, flood, storm and long-term change in mean climatic variables such as temperature (UNDP, 2004).

Impacts: The climate- and non-climate-related factors which affect an urban system. Impacts can be positive or negative, and can increase the resilience or reduce the vulnerability of an urban system. Impacts, combined with the probability of an extreme weather-related event happening, create risks or opportunities.

Resilience (here: Urban Resilience): The ability of an urban system to cope with climate and other disaster risk and sustainability challenges, while maintaining the current form and function of that area. A resilient city is attractive to investors and inhabitants alike, and can turn challenges into opportunities through harnessing synergies, multiple benefits and fostering collaboration.

Risk: The combination of the probability of an event and its consequences (UNISDR, 2009). Risk can also be considered as the combination of an event, its likelihood, and its consequences, i.e., risk equals the probability of climate hazard multiplied by a given system's vulnerability (UNDP, 2004).

Strategy (here: Adaptation Strategy): A general plan of action for addressing the impacts of climate change, including climate variability and extremes. It may include a mix of policies and measures. Depending on the circumstances, the strategy can be comprehensive addressing adaptation across sectors, regions and vulnerable populations, or it can be more limited, focusing on a single city (adapted from UNDP, 2004 and CoR, 2011).

Town: an area where the urban centre has between 10,000 and 50,000 inhabitants (DG REGIO, 2011).

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.

Urban area: a collective term to describe cities, towns or parts of them (EEA, 2012).

Vulnerability: The degree to which a system is susceptible to, and unable to cope with, negative impacts of climate change. Vulnerability is influenced by social and economic pressures which have the potential to exacerbate the biophysical impacts of climate change, combined with a system's adaptive capacity. In this report, we largely consider vulnerability in terms of the contextual characteristics of a city (as opposed to the IPCC framing of vulnerability as the outcome from impacts moderated by adaptive capacity).

1.1 Describe the nature and scale of the problem

More than two-thirds of the European population lives in urban areas (DG REGIO, 2011). As hubs of economic activity, innovation and employment, cities play a pivotal role in the European economy and are where the majority of Europeans live and work. They are also vital centres of social and cultural exchange. Cities are exposed to a range of social and economic pressures which have the potential to exacerbate the biophysical impacts of climate change and increase the vulnerability of particular groups. Similarly, climate can magnify the pre-existing socio-economic challenges that cities face. As a consequence, vibrant and innovative urban centres should act as a crucible for adaptation solutions, minimising the adverse impacts of climate change while exploiting any opportunities these changes may present. Cities are critical to Europe's future prosperity and must be viewed as important foci for adaptation action.

In this section, we first establish the key non-climate themes and trends which set the urban context, and we then describe the nature and scale of climate impacts in that urban context.

1.1.1 Cities and the urban context and trends

What do we mean by cities?

DG REGIO (2011) recognises that there are many definitions of a city. 'City' can refer to an administrative unit or a certain population density. A distinction is sometimes made between towns and cities (the former being smaller). 'City' can also refer to the administrative city, and/or the morphological city, and these do not necessarily correspond.

The lack of a harmonised definition of a city and its functional area has hindered the analysis of cities in Europe. The way that any city is delimited, or defined, can result in some issues for consideration of climate change adaptation including (Carter et al 2012):

- Identifying and prioritising climate change hazards.
- Understanding the vulnerability of people and infrastructure.
- Developing and implementing adaptation responses.

To account for the different scales of governance and a need for flexible governance, DG REGIO followed a pragmatic path in the *Cities of Tomorrow* report and employed both terms to define cities 'as urban agglomerations in general as well as the administrative units governing them' (DG REGIO, 2011). In cooperation with the OECD, the European Commission has developed a relatively simple and harmonised definition (DG REGIO, 2011):

- A city consists of one or more municipalities (local administrative unit level 2 – LAU2);
- At least half of the city residents live in an urban centre; and
- An urban centre has at least 50 000 inhabitants.

Similarly, the EEA takes a pragmatic approach in its report on urban adaptation, Due to lack of European definitions and different country definitions, it uses terms such as "urban areas", "cities", "towns" as appropriate in particular contexts, although indicators developed are generally considering cities with more than 100,000 inhabitants (EEA, 2012).

Growing importance of cities in Europe

In many respects the European Union can be seen as a Union of cities, with a growing proportion of Europe's citizens living in urban areas. Some headline statistics are summarised in Table 1.

It is estimated that around 70 % of the EU population – approximately 350 million people – lives in urban agglomerations of more than 5,000 inhabitants. (DG REGIO, 2011). There are 23 cities of more than 1 million inhabitants and 345 cities of more than 100,000 inhabitants in the European Union, representing around 143 million people. Only 7 % of the EU population lives in cities of over 5 million inhabitants, while around 38 % of the total European population lives in small and medium-sized cities and towns of between 5,000 and 100,000 inhabitants (DG REGIO, 2011). About 1,600 settlements in Europe are considered to be functional urban areas, with over 50,000 inhabitants. 67 % of Europe's GDP is generated in metropolitan regions[1], while their population only represents 59 % of the total European population (DG REGIO, 2011).

Table 1: Defining cities by population *Source: "Cities of Tomorrow" (DG Regio, 2011)*

Population Class	Number of cities *		Population	
	absolute	in %	absolute	in %
rural population			154 125 040	32.1
towns and suburbs			156 398 720	32.6
50 000 – 100 000	387	52.9	26 690 068	5.6
100 000 – 250 000	224	30.6	35 708 402	7.4
250 000 – 500 000	62	8.5	21 213 956	4.4
500 000 – 1 000 000	36	4.9	27 041 874	5.6
> 1 000 000	23	3.1	59 292 080	12.3
Total	732	100.0	480 470 140	100.0

Note: Based on a population distribution by 1 km² raster cells.[10] Cities above 50 000 inhabitants are defined as clusters of grid cells of at least 1 500 inhabitants/km². Areas outside the urban agglomerations are defined as suburbs or towns if they are located in urban clusters of raster cells with a density above 300 inhabitants/km² and a total cluster population of at least 5 000 inhabitants.[11] Rural areas are the remaining areas.[12] All figures are estimates of the 2001 population of the EU-27. Sources: European Commission (JRC, EFGS, DG REGIO).

The Urban Audit shows considerable population growth across many European cities, with this trend expected to continue. The EEA in its *State of the Environment 2010* report suggested that around 80 % of Europe's population will live in urban areas by 2020 (EEA, 2010a). However, DG REGIO in its second *State of European Cities* report also recognises that some European cities are declining in population and/or facing industrial decline (DG

[1] Metropolitan regions are defined as 'larger urban zones' with more than 250 000 inhabitants (Source : DG REGIO).

REGIO, 2010). In fact, DG REGIO (2011) identified 3 kinds of European cities in terms of socio-economic and demographic change:

- *Economically dynamic cities which experience strong population increases through the inflow of both highly skilled and less qualified migrants attracted by the cities' sustained economic power and wealth*. These are mainly larger Western Europe cities closely connected to the world economy.
- *Cities with a strong economic background and stagnating or gradually shrinking populations.* Most of the small and medium-sized European cities will be in this category. In these cities, the gradual shrinkage of a city does not necessarily cause serious difficulties, and it may even be an advantage as the density of the urban environment decreases.
- *Cities within urban areas of complex shrinkage, where both demographic and economic decline can be experienced.* These urban areas are mostly located in the Central and Eastern part of the EU, although some peripheral areas of Western Europe are also affected.

Whether "growing" or "shrinking", cities will face greater challenges in the future, including demographic change such as ageing populations. Cities already face issues such as overcrowding, ageing infrastructure, increasing congestion and competition for services. These pressures can exacerbate or provoke social problems including the concentration of deprivation and unemployment in urban neighbourhoods, and environmental problems such as pollution from transport and industry.

Box 2: Key trends affecting European cities

There is significant variation in the socio-economic trends affecting European regions, however it is possible to categorise non-climate trends into four main groups: demographic change; diversity; urbanisation/urban sprawl; and economic crises/austerity.

Population and demographic change

The UN projects an increase in the urban population in Europe of just under 10% between 2009 and 2050; however the European population as a whole is predicted to decrease from around 2025 (UNDESA, 2010). The number of Europeans living in urban areas is set to increase from the current figure of around 75% to around 80% in 2020 (EEA, 2006a; UN, 2008). In the short term, most of the increase will be due to rural to urban migration, but increasingly urban areas will experience immigration triggered by the effects of climate change (EC, 2008a). Cities with the fastest population growth are those with the smallest elderly population.

By 2065 almost one third of the European population will be aged over 65, according to a forecast published by Eurostat (2008a). The combination of trends in fertility, life expectancy and migration will leave the total population size largely unchanged by 2050, but will transform Europe's population structure. The number of those aged 80 and over will sharply increase, doubling every 25 years. In the next 30 years, this age group will represent more than 10% of the population in many European cities.

In general, large cities have been expanding more quickly than smaller ones. Growth has been greatest in peripheral urban areas, while core cities within these urban agglomerations have experienced a decrease in population.

There is also a trend towards smaller and therefore more households. Household size is smallest in northern Europe (1.6 people per household in Stockholm), slightly larger in Central and Eastern Europe and highest in Southern Europe (up to 3.4 people per household). One-person households gravitate towards urban centres, while in most cities families with children are settling in the surrounding suburbs.

Diversity

In many European cities the number of inhabitants with foreign backgrounds now exceeds 20% of those under 25 years old[2]. Projections at city level indicate that the share of people with foreign backgrounds will further increase as a result of large waves of young immigrants.

Migration and immigration affects all cities across Europe (Map 2.2). In general, larger cities have higher immigration rates than smaller cities. Migration and mobility are likely to have an even greater role in urban population change in the coming decades.

Urban growth also affects the spatial organisation of cities. Typically, suburbanisation and urban sprawl have promoted segregation and polarisation along ethnic or socio-economic lines. For example, in the United Kingdom in 2004, 20% of those in the lowest income groups lived in poor quality environments compared to 11% of those in the highest income groups[3].

Urbanisation and urban sprawl

Urban land use has expanded nearly everywhere in Europe, even in areas with a declining population. Between 1990 and 2000, urban land in Europe expanded by three times the size of Luxembourg, an average 5.5% increase in built-up areas. Urbanisation is evident in many different forms, sometimes in concentrated compact centres but typically in low density developments associated with planned or spontaneous urban sprawl.

Urban sprawl and transport infrastructure have a reciprocal relationship. Transport volumes have increased substantially throughout Europe over the last decades driven particularly by urban sprawl. Good quality, accessible and safe walkable communities encourage citizens and commuters to walk and cycle in the urban area. Yet there are significant differences in the length of cycle paths in European cities, ranging from less than 1km/km^2 in cities such as Rome, Riga and Prague to 8.9km/km^2 in Helsinki. The quality of transport infrastructure has a major influence on walking and cycling in cities, but so do city structure, safety, geography, climate and cultural factors (EEA, 2009).

Consumption and urban lifestyle

Consumption in urban lifestyles is a socio-economic driver that significantly influences the possibilities for a more sustainable quality of life in cities, but inappropriate consumption can also undermine quality of life. European consumption is rising as measured in terms of the expenditure of households and public entities on goods and services. Across the EU-15, expenditure rose from approximately 13,000 USD in 1995 to just under 16,000 USD in 2005. The growth of the wealthy middle class throughout Europe contributes to changing values and the associated consumption patterns, which are increasingly used to make statements - 'I am dynamic', or 'I am smart'. These cultural trends are reinforced by business strategies, and often result in increasing material consumption.

Economic crisis / austerity

The negative effect of the recent financial and economic crisis, in particular the fiscal crisis with reduced public budgets and austerity policies combined with the rising need for social expenditure, have brought an additional number of cities (especially in Southern Europe) close to austerity. With the economies of many European cities relying on manufacturing, construction and retail sectors it may be that we have not yet seen the worst of the crisis. Over the past decades, globalisation has led to major changes in the EU economy. Production of capital and consumption goods continues to relocate to areas of cheaper labour, both within and outside Europe (Dicken, 2004; Eurostat, 2007). As a result many European urban economies have made a further shift towards service-oriented urban economies.

Source: EEA, 2009 (QoL: report No 5 / 2009)

[2] Analysis of Urban Audit 2001 and 2004 data collection; data from the CLIP network of cities. Presented in DG REGIO 2011.
[3] UK Office for National Statistics, 2007

1.1.2 The nature of climate impacts

Climate change is an additional challenge for European cities and may exacerbate existing risks and lead to new hazards and threats. For example, urbanisation of land can limit the land available for natural flood management and lead to higher peak run-off of rain and flood water (EEA, 2012) thus magnifying the impact of high intensity rainfall projected to occur as a result of climate change. Interacting with current socio-economic pressures and vulnerabilities, climate change threatens quality of urban life, economic competitiveness, health and urban biodiversity.

While regional climate projections do not necessarily reflect the specific challenges faced by the cities within each region, they are a useful starting point from which to explore the urban impacts of climate change.

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 which suggest (from EEA, 2012):

- 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;
- expected increase in the number, intensity and duration of heatwaves, extreme precipitation events and drought.

In the urban context, EEA (2012) explains that while urban areas will generally experience the same changes in climate as their surrounding region, the urban setting (physical form and socio-economic activity) can affect both exposure and sensitivity to weather events, and therefore the impacts felt at the local scale. In addition, built-up areas can create unique microclimates in terms of temperatures, wind and precipitation.

Following EEA (2012), this review focuses on those climate hazards of particular relevance for urban areas: heat, flooding and water scarcity (including droughts) to illustrate why and how the urban context comes into play for consideration of climate change impacts and adaptation.

1.1.2.1 The impacts of heat on cities

Research shows that heat waves have been the most prominent hazard causing human fatalities over the past decades (EEA, 2010a). Evidence suggests that it is very likely that the length, frequency and/or intensity of warm spells, or heat waves, will increase (IPCC SREX, 2011). The rate of projected increases in temperature over future years may be more significant than absolute values of minimum or maximum temperatures.

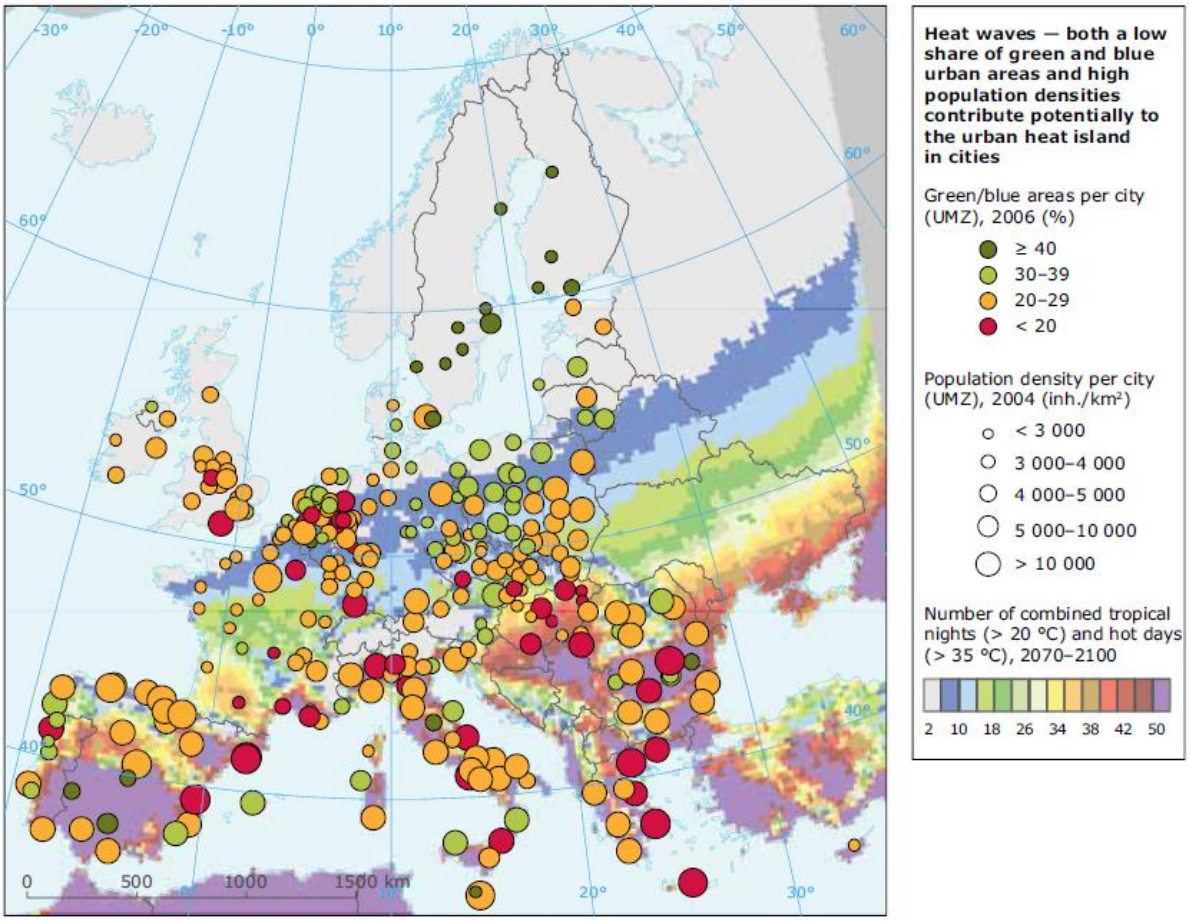
The impact of heatwaves is particularly strong in cities and towns because of the Urban Heat Island (UHI) effect, which describes the increased temperature of urban air, compared to rural surroundings. The UHI is particularly stark at night, which increases the potential for serious health effects during heat waves. Hot days without the recovery period provided by cool nights lead to exhaustion and cumulative adverse health impacts (Grize et al., 2005; Kovats and Hajat, 2008; Dousset et al., 2011). In addition to health impacts, such events can also adversely affect productivity as shown by a study in Germany which suggested that heat reduces work performance, resulting in an estimated output loss of between 0.1% and 0.5% of GDP (Hübler et al. 2008).

A range of secondary effects have also been experienced during heat waves which raise further challenges for urban centres, such as changes in energy supply and the timing of peak demand, diminishing air quality and sub-optimal performance of key infrastructure. High temperatures can combine with other adverse conditions, such as drought, to impact further on infrastructure. In 2009, over 180 water pipes were reported to have burst in Nicosia,

Cyprus, due to high temperatures and extreme differences in pressure during water cuts, thus exacerbating water shortages (Cyprus News Report, 2009[4]).

The characteristics of urban centres (e.g., little green space and large proportion of artificial surfaces, human activities and the release of additional heat from buildings, reduced advection of heat due to the form and structure of built-up area, etc) are responsible for the UHI. Possible future heat impacts on European cities are down in **Error! Reference source not found.** (from EEA, 2012), which shows a temperature scenario map overlain with population density and the proportion of green/blue areas in major European cities (both provide a proxy for the UHI effect).

Figure 1: Share of green and blue areas in cities, combined with population density
Source: EEA (2012)



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.

Cities in northern Europe are potentially as much exposed to the human health effects of heat waves as are cities in southern Europe, given the different heat thresholds and levels of acclimatisation of local populations.

[4] http://www.cyprusnewsreport.com/?q=node/65

European Heat Wave of 2003

A severe heatwave extending over large parts of Europe in 2003 resulted in a rise in summer temperatures by 3 to 5 °C in most of southern and central Europe (IPCC 2007[5]). Maximum temperatures of 35 to 40°C were repeatedly recorded and peak temperatures exceeded 40°C (André et al., 2004; Beniston and Díaz, 2004). It caused up to 70,000 excess deaths over four months in Central and Western Europe (Brucker, 2005; Robine et al., 2007; Sardon, 2007).

It struck the elderly in cities 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. The 2003 heat wave prompted a number of countries to develop national and municipality-level heat wave strategies and warning systems including in France, Hungary, Italy, Portugal, Spain and the UK.

Source: EEA, 2012

1.1.2.2 The impacts of flooding in cities

In terms of economic loses, flooding and storms are the most significant natural hazards in Europe. Floods can result in loss of life, loss and damage to infrastructure, residential and commercial property as well as increasing the risk of pollution and disease spread through flood water. Flooding is a potential risk across all European regions and is shaped not only by long term changes in climate but by topography, characteristics of the built environment, weather variability and extreme event occurrences. The nature of flood impacts is also the result of existing vulnerability within a particular city (which may be influenced by socio-economic and demographic trends) and the type of flooding. Flooding in urban areas may be fluvial (river flooding), pluvial (often the result of heavy downpours which can lead to flash flooding) or coastal (often linked to storm surges) in nature. In addition, EEA (2012) recognises two further categories: urban drainage flooding (where insufficient capacity of piped systems leads to excess water travelling down roads, etc during extreme precipitation events) and groundwater flooding (caused by prolonged periods of high precipitation). Since a complex set of meteorological, hydrological and human factors combine to influence the flood impacts that occur, local city characteristics tend to be more significant than regional characteristics (EEA, 2012).

Projections of river flood hazard show that climate change leads to an increase in likelihood and intensity of extreme high river flows for large parts of Europe (EEA, 2012). Some 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). Trends such as urbanisations increase the risk: highest numbers of people affected by severe floods will be in areas with large population density. The projected increase in intense precipitation events across northern Europe may increase the frequency and severity of flash flood and urban drainage flood events in cities, if other urban factors do not improve.

Flooding is an issue which many cities have contended with for centuries and flood risk management has been in place in urban centres for many years. However, climate change may act to change the both the frequency, type and severity of future flood events, thus existing flood management approaches may need to be updated and adapted to respond to a changing picture of flood risk. Table 2 summarises the kinds of urban impacts that can result from flooding.

[5] http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch12s12-6.html

Table 2: Potential flood impacts in urban areas *Source: EEA (2012)*

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.

Factors which can increase the risk of urban flooding include (EEA, 2012):

- Location of city in flood plain, along rivers or low-lying coastal areas
- Relative proportion of impervious surfaces (amount of soil sealing)
- Old drainage and sewage infrastructure which has not kept pace with demands of urbanisation
- Conventional approaches to rainfall and waste water in urban areas, which tend to carry water away as quickly as possible via underground pipes / sewers
- Inadequate maintenance of drainage channels to clear debris and solid waste
- Inadequate discharge of excess water into regional water systems, especially in delta areas

Case study – Surface water flooding in Hull, UK

June 2007 was the wettest month recorded in Yorkshire, UK, since 1882. The month was characterised by a number of heavy down pours and on 25 June over 100mm fell in the area around the city of Hull. The intensity of this rain fall was such that road gullies, sewers and drainage ditches were soon overwhelmed, a situation worsened by the City's low-lying position which limited the speed at which floodwaters could disperse. On the 25 June flood waters flowed from the more elevated land to the west into Hull, inundating large area of the city resulting in over 8,600 homes and 1,300 businesses being flooded and one person being killed. Flood damage to Local Authority property alone, including schools and council houses, was estimated to exceed £200 million. The extent of the flooding was such that only 8 of Hull's 99 schools escaped flooding, affecting over three quarters of the city's 36,000 school children (Coulthard et al. 2010). Yet it was during the long recovery period that followed that the social impacts of such an event became apparent (Whittle et al. 2010), including difficulties in finding alternative accommodation, receiving timely insurance pay-outs and making repairs. Valuable lessons have also been learnt regarding improved co-ordination of flood response between key organisations and the impacts experienced during the flood recovery process.

Source: Adapted from UK Environment Agency, 2007 and Whittle et al., 2010.

1.1.2.3 The impacts of water scarcity and droughts on cities

Fresh water is a basic requirement for any society and its availability, at all times and in sufficient volume, is a social and economic necessity. As areas of high population density and economic activity, cities exhibit high levels of demand for water and consequently often rely on other regions to supply their water. Water scarcity and droughts are not exclusive to the drier areas of Europe but have become an issue in many other regions too. Water resources are expected to decrease in Europe as the result of a growing imbalance between water demand and availability (EEA, 2012). Such an imbalance is determined by both availability (e.g. from precipitation, groundwater storage, glaciers) and use, shaped by a combination of social, economic, environmental and behavioural drivers. Drought refers to a temporary decrease in water availability (EEA, 2012) and can be considered in terms of meteorological drought (rainfall) hydrological drought (river-flow) and agricultural drought (soil moisture content) which can be exacerbated by high temperatures and evapotranspiration rates. Seasonal drought can intensify longer term water stress.

Water stress is already a serious issue in the summer months, especially in Southern and Eastern Europe and projections suggest that the water stress will worsen, increasingly affecting more northerly latitudes. Research has shown an evident trend towards drier conditions in much of the Mediterranean (Sousa et al. 2011) while the total area affected by water scarcity and droughts across Europe has increased from 6% to 30% in the last 30 years (DG ENV, 2007).

This increase in water scarcity, alongside a range of socio-economic drivers such as population growth, is likely to worsen water stress in cities. Drought events and water scarcity can have significant economic impacts including adverse impacts on tourism (often resulting from limited public water supply), energy production (where cooling water is required) and health (where costs of treatment increase), indeed in European drought in 2003 was estimated to have cost €8.7 billion (EEA, 2010). Water stress is likely to generate increased competition between uses including public supply, agriculture, industry and the natural environment.

Case Study – Water scarcity in London, UK

The amount of water available per capita in London is the lowest in the UK by far, due to a relatively low annual average precipitation 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 experienced water shortages in 2003 and 2006. 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 show that rainfall will become more seasonal with wetter winters (10 to 20 % more precipitation by 2050) and drier summers (20 to 40 % less precipitation by 2050). Despite higher winter precipitation, groundwater recharge might be reduced due to increasing evaporation and public water demand.

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. Furthermore, 25 % of the water distributed does not reach its destination due to network leakages. London's water network is more than 100 years old in many areas, and often in poor working condition.

A water management strategy for London has been proposed with the following priorities:

1. Reduction of losses through better leakage management;

2. Improving water efficiency;

3. Grey water recycling and rain water harvesting for non-potable uses;

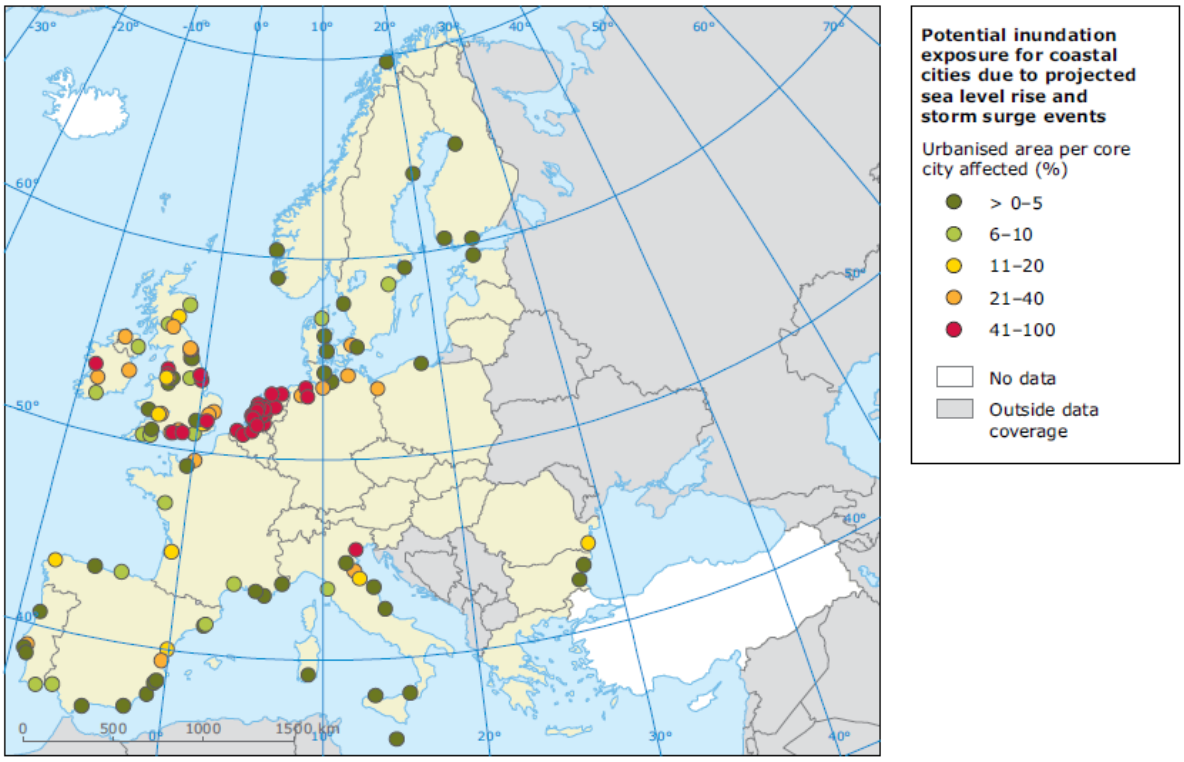
4. Develop the water resources with the least environmental impact.

Source: Greater London Authority, 2010; London Climate Change Partnership, 2002, EEA, 2012.

1.1.2.4 Coastal impacts on cities

Recent sea level rise projections taking into account the impact of artic ice melt suggest that increases of between 0.9 to 1.6 metres above the 1990 level could be expected by 2100 (AMAP, 2011). This is supported by the work of Vermeer and Rahmstorf (2009) who apply the IPCC balanced development scenario (IPCC A1B) in their work. Future projections suggest a decrease in the total number of storms but an increase in the strength of the heaviest storms, with a significant increase in storm surge levels for South East-England and the continental North Sea. Figure 2 shows projected change in potential inundation for coastal cities due to combination of sea-level rise and storm surge events. Cities along the coast of the Netherlands, Germany, Belgium and northern Italy are most affected (EEA, 2012). Thus increased sea levels have the potential to interact with storm surges to present a serious flood threat to Europe's coastal area, where large cities and urban centres are located.

Figure 2: Potential inundation exposure for coastal cities due to projected sea level rise and storm surge events *Source: EEA (2012)*



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).

Coastal cities centres play an important role in maritime trade and the supply of goods and services between cities and nations. Many are experiencing rapid increases in population (EEA, 2012), thus the impacts and risks faced will be influenced not only by sea-level rise and the occurrence of extreme storm surge events but by land use planning decisions. As with pluvial and fluvial flooding, the nature of flooding impacts will be spatially variable and be shaped by the characteristics of each city, including the existing vulnerability of the population. Coastal erosion, resulting from sea-level rise and storm surges, presents an economic risk to some cities. In Pärnu, Estonia, the loss of beaches and natural areas may have a major impact on the economy (Klein and Stuadt) which benefitted from 0.6 million overnight stays in 2009 (Bastis 2012[6]). In addition to flooding and erosion, sea-level rise can present other risks for coastal cities, such as salination of groundwater.

[6] http://www.bastis-tourism.info/index.php/Destination:Estonia

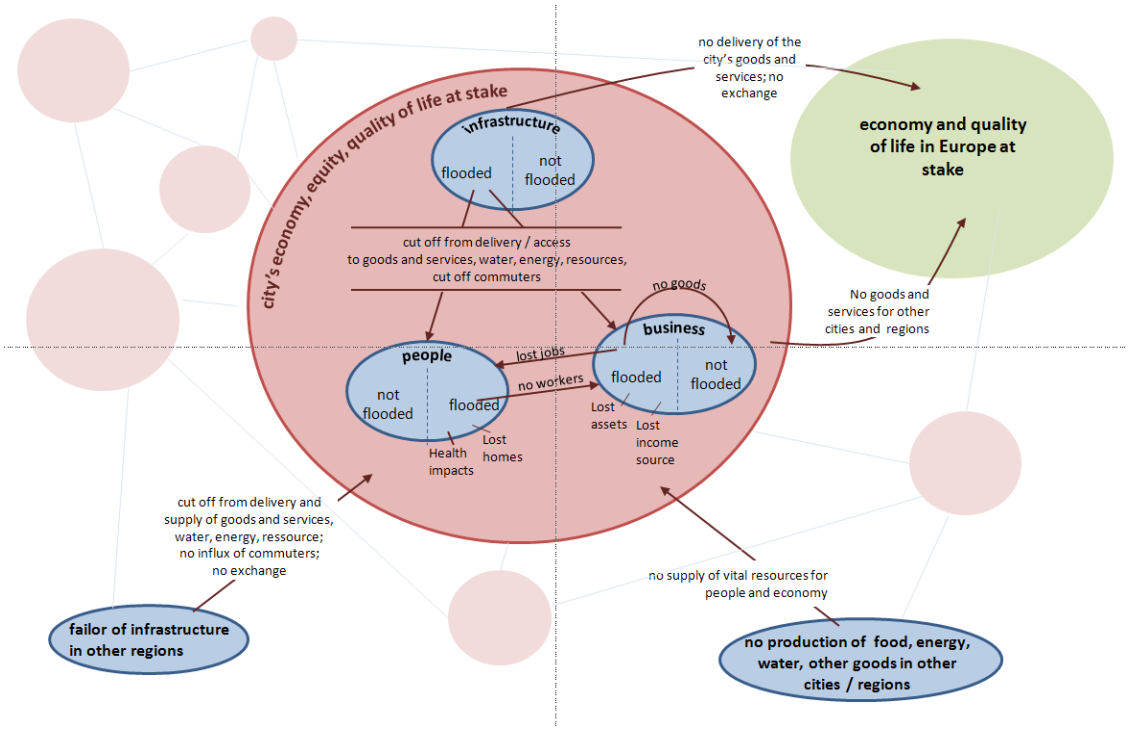
Case study – Potential costs of coastal impacts in Copenhagen

The city of Copenhagen in Denmark faces the threat of sea level rise and, consequently, higher storm surges. If the city is not protected it is estimated that total damage costs will amount to DKK 15-20bn (€2bn to €2.7bn) over the next hundred years, while the current cost of security against this risk is estimated to be just DKK 4bn (approximately €0.5bn) over the same time period. The onset of the most significant impacts of coastal flooding in Copenhagen are currently projected to be in 30 years' time, however the city Adaptation Plan recognises the need to begin preparations now, including a proposal to build a dyke at North Harbour (Nordhavn) and Kalveboderne and raising the coastline at Øresund.

1.1.2.5 Interdependencies and indirect urban impacts

A further trait of cities which can reinforce vulnerability to climate change is their dependency on other cities and regions for provisioning services, including basics such as food, energy and water (EEA, 2012). Access to such services is mediated through a complex web of interdependent infrastructure which itself can be vulnerable to the impacts of increased climate variability and change, including extreme events. Failure of such infrastructure, either within a city or a region upon which it is dependent, can have a significant impact of the ability to provide these essential services to citizens. Such system failures, however small, can have indirect impacts on other aspects of urban life. For example, a flooding event could result in loss of earnings hundreds of kilometres away should a supply chain fail. The complexity of these interactions is illustrated in Figure 3 (from EEA, 2012).

Figure 3: Inter-linkages of direct and indirect impacts of climate change on cities and Europe on the example of floods. *Source: EEA (2012)*



Considering the extent to which cities depend upon their hinterlands, locally and globally, for food, water and other natural and human resources, cities encounter some knock-ons from the impacts of climate change on most non-urban sectors too.

1.2 Identify who is most affected

In this section, first we describe climate vulnerabilities in urban sectors. We then consider the distribution of climate impacts across Europe and within cities.

1.2.1 Urban dimension of sectoral impacts and risks

The prominent role of cities in the economic and social development of Europe is such that many sectors have an urban dimension or have links to cities as important markets for products. Cities are particularly vulnerable to climate change and natural disasters because of the large number of people living in relatively concentrated areas and the complexity of the systems that interact within them: infrastructure networks to transport people and goods, communications systems, water and energy distribution, sewers and waste removal systems, food production, housing and urban green spaces.

Key points include:

- Urban areas intensify the impacts of climate change hazards, for example extreme heat and intense rainfall.
- Urban areas must be viewed as connected to their hinterlands (locally and globally) due to the services provided at these scales and the network linkages that are present.
- The urban dimension to sectoral impacts can be dependent on the physical characteristics or location of different cities.

Table 3 provides more detail on the nature of climate vulnerabilities and impacts in various urban sectors and systems.

Energy system

The energy system is vulnerable to the impacts of climate change on both the supply and demand sides. On the supply side, thermal generation requires transport of fuel and depends on water availability for cooling, both of which can be disrupted by extreme weather events. Wind and hydro generation potentially face changes in the magnitude and variability of the climate drivers on which they depend. Related transmission and distribution infrastructure is also vulnerable to direct impacts of extreme weather. Climate impacts on the demand side are potentially more significant, with temperature trends leading to spatial and temporal changes in the patterns of demand for energy for heating and cooling. In urban areas, cooling demand rises rapidly in response to heat wave events. Failures or disruption to energy systems can have a cascading effect on multiple other systems critical to urban functions, reducing or interrupting key services.

Information and communication systems

The main reason for vulnerability of communication and information systems is that infrastructures may be subject to damage as a result of extreme weather events, or as a cascading effect from a failing energy-supply system with knock on effect on the regional economy. The increasing dependence of many sectors and infrastructures on information and communication technologies (ICT) (e.g., proposals for development of smart cities, smart control of urban transport systems, etc) means that ensuring the resilience of the ICT sector and infrastructure is of increasing importance to avoid knock-on disruption during extreme weather. A key point here is that the critical nodes for ICT (such as data centres) may be located in different regions or even countries from the businesses and urban communities that they serve.

Transport system

Reasons for vulnerability come from increased pressure from extreme weather conditions causing damage to transport infrastructures (e.g. melting asphalt, infrastructure heat buckling and destabilising, destruction by erosion, landslides, floods, or fallen trees after severe storm, etc) interrupting the flow of transportation to and from and within urban areas, a higher risk of accidents, alienation of residents and potentially personal death/injury during and after extreme events. Climate impacts on the transport system have economic effects on cities and the wider region, given the reliance of much economic activity on urban transport and transport hubs.

Water supply system

Reasons for vulnerability stem from changing pressures on supplying, treating and removing water during periods of not enough and too much precipitation affecting the ability of the system to deliver water supply and waste water removal services to the territory under increased costs of treatment and maintenance. Impacts on energy and ICT can have indirect effects on urban water supply given the increasing levels of remote smart technologies in use.

Sewage and drainage system

Impermeable (built-up) areas increase the runoff water, overcrowding the sewage and drainage system and putting pressure on the availability of groundwater increasing the vulnerability of urban sewage and drainage systems. There is a wide range of local level sustainable drainage or flood management measures in use in different European cities (for examples of measures, see Section 3). Exchanging experience and case studies (for example via Climate-Adapt) can be supported at European level.

Solid waste system

Reasons for vulnerability of the solid waste system include the potential for waste treatment systems to coalesce with a city's building conditions and poor sanitation to affect the local quality of life and economic activity of a certain type of cities. Also, failure in the energy or supply or ICT system may cause knock-on disruption of the waste-system and result in accumulated garbage in the city, constituting a health hazard and a nuisance to the population.

Buildings and built-up area

Climate change could exert pressure on existing poor condition of buildings and negatively impact people's livelihoods. Impacts related to higher temperatures and longer hot seasons, and flooding increase damage and failures (structural stability, overheating, maintenance) to building infrastructures due to extreme weather events. Equally, adaptation solutions for cities may be found within the construction sector through improved building design and the application of innovative materials in buildings, which points to potential for European-level intervention to encourage adaptation via building codes.

Urban green (areas) and biodiversity

The impacts to urban green areas and biodiversity include increased summer temperatures and length of the hot season, and the reduction of precipitation in summer, degrading urban green space, increasing maintenance during increased demand for green areas facilitating the supply of fresh air to the city. Another key point is to recognise the role of urban green space in ameliorating the effects of climate change, such as improving urban drainage, and reducing UHI effect.

Health system

Increased temperatures, floods and droughts can harm human health and increase the proliferation of disease and pests, creating a higher demand for the system and possibly saturating it. Severe weather events may cause the demand for health services to soar and collapse the existing health facilities, causing the system to break if no appropriate emergency system is in place. A number of European urban areas now have heat health warning systems in place, in conjunction with national level systems.

Food production & supply system

Negative impacts on crop, grassland and food production from changing climate can have price effects on food and fuels (biofuels). Climate change may also affect trade flows of agricultural goods by reshaping regional comparative advantages and it is possible that climate change will alter the sourcing and processing of agricultural produce, partly for reasons due to increased difficulties and longer times in the transportation of goods and the negative effect that this would have on perishable commodities. Food production and processing are more vulnerable to climate change than other industrial sectors as they are often located in climate-sensitive areas and more directly related to weather.

Governance and management system

By preventing a stable availability of resources, and through extreme weather events, climate change, exerts pressure on governance and administrative systems, demanding quick, yet well-planned, solutions to problems that are in some cases new to the governing structures. This demands preparation (by new sets of tools in their operations including leadership knowledge transfer and capacity building), capacities, expertise and creativity that governing structures may be lacking with negative effects on the environment and pose health/death hazards to the population. Political decision-making that disregards climate change concerns can harm the accountability of local governments and, in turn, reduce the citizens' trust and belief in political institutions—whether or not the decision has evident negative impacts in the ecosystem or the population. Inappropriate/insufficient safety net instruments may worsen the negative impacts of severe weather events (e.g. communication for warning on severe weather events may rely on technologies that may give insufficient warning time).

Social system

Severe weather events can cause instability, disruption of harmony, loss of livelihood and chaos among the population. Severe weather events demand a strong degree of community solidarity to protect those most vulnerable to the weather events. This required solidarity may be lacking, or supporting systems may not be in place to facilitate citizens' desire to live alone (e.g. heat wave in France 2003). The negative effects of climate change can be worsen by reduced social cohesion and diffusion, whether it is due to changing lifestyles, more culturally-mixed cities and towns, etc. High density of population and immigration puts pressure on systems/resources/ecosystems (in the case of systems, particularly if they are not or cannot be expanded), stretching their operation/extraction/use to peaks. This may cause systems, e.g. water supply, to prove insufficient in delivering services to the population, especially in case of severe weather event.

Other themes such as Disaster Risk Reduction also exhibit an urban dimension. For example the most prominent natural hazard in terms of human fatalities since 1980 has been heat waves (EEA 2010), while flooding results in the greatest economic damages. As identified earlier in this report, Europe's cities are particularly at risk due to high concentrations of people and assets, and pre-existing socio-economic vulnerability of some urban communities. This has further consequences for the health sector and social system which will be required to respond to increased demand on services resulting from such events (Leitner et al. 2012).

Table 3 Examples of potential impacts of climate change on vulnerable urban systems *Source: BBSR (2009), IPCC (2007)*

		Climatic threats / issues				
		Higher temperatures and heat wave	**Heavy precipitation and fluvial flood, landslides**	**Heavy precipitation and urban drainage floods**	**Decreased precipitation, water scarcity, drought**	**Sea level rise and storm surge driven flooding and saltwater intrusion**
Vulnerable systems	**Energy supply** (Includes: all energy generating facilities and the infrastructure needed to make fuel, plus transmission lines/systems to make energy and heat available to end-users)	• Results in an increasing energy demand that can cause the overload and failure of power generating plants, triggering an overload-failure effect across the system and causing energy supply failures • Centralised energy generation can compromise energy supply to the territory during and after extreme events • Can have a direct negative effect on crop and biofuel production • Transmission systems can be subject to climate related extreme events • Facilities often located in areas vulnerable to extreme weather events				
		• Increased demands for water supplies and energy supplies related to temperature • Increase costs of cooling and reduce costs of heating • Sensitivity of energy production (including hydropower) to heat waves	• Sensitivity of energy production (including hydropower) to the timing and geographical pattern of precipitation • Energy transmission infrastructure is vulnerable to high winds and ice storms when in the form of suspended overhead cables	• Sensitivity of energy production (including hydropower) to the timing and geographical pattern of precipitation • Failure of flood defences can interrupt power supplies, which in turn puts water and wastewater pumping stations out of action • Energy transmission infrastructure is vulnerable to high winds and ice storms when in the form of suspended overhead cables	• Sensitivity of energy production (including hydropower) to drought • Drought can contribute to rural-urban migration, which, combined with population growth, increases stress on urban infrastructures and socio-economic conditions • Reduced precipitation in areas already subject to water shortages could lead to infrastructure crises	• Sea-level rise will augment summertime energy demand
	Communication and information (Includes: all channels that serve to convey messages to the population and the systems that support them)	• Facilities often located in areas vulnerable to extreme weather events				
		• Increased demands for physical infrastructures	• Transmission systems can be subject to climate related extreme events such as floods and severe storms • Transmission infrastructure is vulnerable to high winds and ice storms when in the form of suspended overhead cables and cell phone transmission masts	• Transmission infrastructure is vulnerable to high winds and ice storms when in the form of suspended overhead cables and cell phone transmission masts		• Transmission systems can be subject to climate related extreme events such as floods and severe storms

		Climatic threats / issues				
		Higher temperatures and heat wave	**Heavy precipitation and fluvial flood, landslides**	**Heavy precipitation and urban drainage floods**	**Decreased precipitation, water scarcity, drought**	**Sea level rise and storm surge driven flooding and saltwater intrusion**
	Transportation (Includes: All roads, railways, waterways and airways that link a city or urban region to and from places beyond its boundaries and which are used for the transportation of people and goods)	• Increased temperatures pose a risk to the health of travelers • Increased demand of energy for cooling on transport • Transport activities are vulnerable to the direct impact of temperature change • Increase in buckled rails and rutted roads, which involve substantial disruption and repair costs	• Transport activities are vulnerable to the direct impact of precipitation change • Can block roads and other transportation routes such as rails, preventing their use and causing, additionally, economic losses • The greatest impact in terms of cost is that of flooding, particularly the damage to property and the inoperability of roads and, underground rail transport systems	• Transport activities are vulnerable to the direct impact of precipitation change • Can block roads and other transportation routes such as rails, preventing their use and causing, additionally, economic losses • The greatest impact in terms of cost is that of flooding, particularly the damage to property and the inoperability of roads and, underground rail transport systems	• Can affect the possibility for people and goods to use water bodies as a means of transport • Can contribute to rural-urban migration, which, combined with population growth, increases stress on urban transportation infrastructures • Transportation of bulk freight by inland waterways can be disrupted	• Transportation linkage systems for industry and settlements can be subject to climate related extreme events such as floods and severe storms • In coastal cities, sea-level rise could jeopardise low-lying transportation systems
	Water supply (Includes: The areas in the territory where water is stored naturally and in man-made structures as well as the infrastructure necessary to bring it to the end-users at a usable quality, such as water treatment facilities, pumping stations, pipe networks, and connections to the sewer system)	• Increase evaporation of surface water bodies, reducing the availability of this resource • Also increase the demand of water by other systems and by people, increasing the pressure on the water supply systems. • Damages cold water ecosystems • In reservoirs increase algal blooms resulting in higher water supply treatment costs • Below average winter temperatures causes damage to water supply pipes increasing the rate of leakage from the system	• Causes the erosion of hillsides and river banks resulting in the deposit of sediment into water bodies with increased water supply treatment costs • Could damage the water supply system itself, including erosion of pipelines by unusually heavy rainfall • Fluvial floods have a high potential to cause infrastructural damage and interrupt the operation of water abstraction and treatment facilities (as these are frequently located near riverbeds)	• Flooding of water supply infrastructure such as treatment plants and pumping stations can interrupt water services and cause costly damage • Could damage the water supply system itself, including erosion of pipelines by unusually heavy rainfall	• Low flows in rivers and reduced rates of recharge for aquifers and reservoirs restrict the amount of water available for abstraction • Low flows from below average rainfall lead to higher concentrations of pollutants in the water affecting wildlife and the cost of water treatment for supply purposes. • Lack of rainfall increases the water demand for the irrigation of crops, parks, gardens and playing fields adding pressure to water supply sources • Low capacity drinking water systems have limited resilience in the face of drought • Reduced precipitation in areas already subject to water shortages could lead to infrastructure crises	• Low groundwater levels and sea level rise expose aquifers to the risk of increased salinity • Water supply systems are not designed to withstand saline intrusion into the lower reaches of a river

		Climatic threats / issues				
		Higher temperatures and heat wave	**Heavy precipitation and fluvial flood, landslides**	**Heavy precipitation and urban drainage floods**	**Decreased precipitation, water scarcity, drought**	**Sea level rise and storm surge driven flooding and saltwater intrusion**
	Sewage and drainage (Includes: The pipe system to collect and transport the sewage and storm water to the sewage treatment plants, as well as the plants themselves and the natural water bodies into which treated effluent and storm water runoff is discharged)		• Intense precipitation can cause overflows from and damage to drainage infrastructure that has been designed to accommodate lower flows based on historical rainfall records • Intense precipitation creates high peak storm water flows that cause erosion and sedimentation when discharged to natural surface water bodies • Sewer outfalls are usually into rivers or the sea, and so they and any sewage treatment works are exposed to damage during floods	• In combined sewer systems intense precipitation reduces the effectiveness of the wastewater treatment process and causes overflows from the system resulting in untreated sewage being discharged to the environment • Flooding of wastewater treatment works stops them from operating and causes the release of raw sewage to the environment, posing environmental and health hazards • Increased precipitation in already well-watered areas can increase concerns about drainage and water-logging • Storm drainage systems will be overloaded more often if heavy storms become more frequent, causing local flooding	• Low flows in water bodies that receive discharges from wastewater treatment works reduces the dilution of effluent thereby impacting on the water quality of the resource • Drought is likely to reduce the amount of flush water used in the drainage systems, potentially preventing the system from functioning properly, or even damaging it. • Drought can contribute to rural-urban migration, which, combined with population growth, increases stress on urban infrastructures • When water supplies cease to function for example due to drought, sewered sanitation also becomes unusable	• Can be subject to climate related extreme events such as floods, landslides, fire and severe storms • Sea-level rise will affect the functioning of sea outfalls
	Solid waste (Includes: Systems of collection, transport, treatment, recycling and/or disposal of solid waste)	• Higher temperatures accelerate the decomposition of organic solid waste, attracting rodents and other organisms, and increasing the risk of health hazards to the population • Higher temperatures may cause waste in landfills or collection centres to ignite and cause fires, representing a hazard to environment and population	• Floods and intense precipitation may result in the release of waste and pollutants from waste centres (e.g. landfills) into the environment. • Can affect air and water pollution and, in cases of extreme events, exposures to wastes that are hazardous to health	• Can affect air and water pollution and, in cases of extreme events, exposures to wastes that are hazardous to health		• Floods and intense precipitation may result in the release of waste and pollutants from waste centres (e.g. landfills) into the environment.

		Climatic threats / issues				
		Higher temperatures and heat wave	**Heavy precipitation and fluvial flood, landslides**	**Heavy precipitation and urban drainage floods**	**Decreased precipitation, water scarcity, drought**	**Sea level rise and storm surge driven flooding and saltwater intrusion**
	Buildings and built-up areas (Includes: Commercial, industrial, residential buildings and stand-alone houses, both public- and privately-owned)	• Buildings are affected by higher temperatures during hot spells	• Severe wind storms can threaten the stability of certain building structures, like roofs, windows. Trees located in the immediate proximity also pose a structural damaging risk during severe wind storms • The rate of deterioration of external shells of building structures is weather-related, depending on the materials used, and buildings are affected by water-logging related to precipitation patterns	• The rate of deterioration of external shells of building structures is weather-related, depending on the materials used, and buildings are affected by water-logging related to precipitation patterns	• Drought can contribute to rural-urban migration, which, combined with population growth, increases stress on urban buildings and built-up areas	IPCC114 115 • Buildings located near a riverbank or on the coast are particularly vulnerable to floods and sea level rise, with potential for damage of the buildings' structures and the underground and lower stories. This also poses the risk of injury or death to humans. • Built-up area located near a riverbank or in a coastal zone may be forced to relocate to a different geographical location due to floods or sea level rise, or a clear threat of them • In coastal cities sea-level rise could jeopardise low-lying buildings • Sea-level rise will affect land uses and physical infrastructures in coastal areas
	Urban green (areas) and biodiversity (Includes: Parks and their inventories, green-covered areas and unmanaged green areas in urban regions, which influence the diversity of plant and animal life within a region)	• The urban heat island effect (UHI) can lead to the formation of smog in cities and the degradation of green spaces • Increased temperatures may give rise to alien and invasive species to proliferate and exert pressure on endemic species, potentially causing their extinction • Introduced invasive species that adapts better to the changing climate can jeopardize the survival of endemic species and unbalance the equilibrium of the ecosystem. • Increased temperatures, heat waves and wind storms increase the risk of wild/bush fires, directly affecting flora and fauna			• Reduced precipitation in areas already subject to water shortages could lead to infrastructure crises • Droughts can have negative impacts on green areas (e.g. dead grass and trees) if they cannot adapt to climate change • Maintenance of urban green in the sense of artificial watering exerts pressure on water availability and on the water supply system	• A long coastline and extensive low-lying coastal areas, projected sea-level rise could endanger natural ecosystems, cover beach areas high in recreational value, and cause environmental contamination

		Climatic threats / issues				
		Higher temperatures and heat wave	**Heavy precipitation and fluvial flood, landslides**	**Heavy precipitation and urban drainage floods**	**Decreased precipitation, water scarcity, drought**	**Sea level rise and storm surge driven flooding and saltwater intrusion**
	Health system and air quality (A health system consists of all organizations, people and actions whose primary intent is to promote, restore or maintain health)	• Heat waves can cause dehydration and pose a health/death risk especially to the elderly • Changes in temperature and humidity can change health care challenges and requirements • Temperature increases can affect air pollutant concentrations in urban areas, which in turn change exposures to respiratory problems in the population, which then impact health care systems • Temperature increases are likely to worsen ozone pollution in many cities, affecting human health and restricting human outdoor activities • In already warm areas exposed to further warming less-advantaged populations are less likely to have access to air conditioning in homes and workplaces	• Floods can give rise to epidemic (e.g. through the proliferation of disease-transmitting mosquitoes or bacteria or viruses) • Intense precipitation can lead to food shortage and cause malnutrition • Changes in humidity can change health care challenges and requirements	• Floods can give rise to epidemic (e.g. through the proliferation of disease-transmitting mosquitoes or bacteria or viruses) • Changes in humidity can change health care challenges and requirements	• Drought can lead to food shortage and cause malnutrition • Changes in humidity can change health care challenges and requirements	• Sea level rise and storm surge pose threats to human live and living conditions
	Food production & supply (Includes: All the production process, from agricultural planting, fishing and livestock rearing to processing to making the product available to the population)	• Increased temperatures may have a negative effect on crops and cause reduced production of food • Increased water temperature in rivers, lakes and at sea can put pressure on species and cause their extinction. This also threatens the fishing production and consumption potential, as well as the livelihoods of fishermen and the related economy	• River floods and intense precipitation can have a negative impact on crops and cause reduced production of food. It would create a need to procure food at distant locations or abroad		• Water scarcity and droughts can have a negative impact on crops, grassland and the amount of food grown, with a direct impact on the amount of food available for the population. This would create a need to procure food at distant locations or abroad • Reduced precipitation in areas already subject to water shortages could lead to infrastructure crises • Changes in precipitation patterns may lead to reductions in river flows, falling groundwater tables. This will in turn have an impact on agricultural activities/food production	• Severe storms may pose a threat to fishermen at sea—and the fishing production system • Sea-level rise will affect food production and supply land uses in coastal areas • In coastal areas saline intrusion in rivers and groundwater will in turn have an impact on agricultural activities/food production

		Climatic threats / issues				
		Higher temperatures and heat wave	**Heavy precipitation and fluvial flood, landslides**	**Heavy precipitation and urban drainage floods**	**Decreased precipitation, water scarcity, drought**	**Sea level rise and storm surge driven flooding and saltwater intrusion**
	Governance and management (Includes: For this purpose, the act of governing, managing and decision-making within a local or regional authority)		• Storms and floods can damage homes and other shelters and disrupt social networks and means to sustain livelihoods; and risks of such impacts shape structures for emergency preparedness	• Storms and floods can damage homes and other shelters and disrupt social networks and means to sustain livelihoods; and risks of such impacts shape structures for emergency preparedness	• Drought can contribute to rural-urban migration, which, combined with population growth, increases stress on urban infrastructures and socio-economic conditions requiring different/more governance and management • Optimal resource allocation of water supply plays an important role in avoiding resource scarcity; often more so than the resource's absolute inefficiency	• Extreme weather events can affect the livelihoods and economies of coastal communities by altering coastal ecosystems
	Social system (Includes: Communities, different social strata and their interactions, existing support systems to favour the inclusion of individuals into society)	• Relationships between weather and climate on the one hand and social stresses on the other, especially in urban areas where the poor lack access to climate-controlled shelters (e.g., the term 'long, hot summers' associated in the 1960s in the United States with summer urban riots) • Areas relying on electric fans or air-conditioning may see increased pressures on household budgets as average temperatures rise	• Storms and floods can damage homes and other shelters and disrupt social networks and means to sustain livelihoods • Changing weather patterns are "likely to raise the actuarial uncertainty in catastrophe risk assessment, placing upward pressure on insurance premiums and possibly leading to reductions in risk coverage	• Storms and floods can damage homes and other shelters and disrupt social networks and means to sustain livelihoods • Changing weather patterns are "likely to raise the actuarial uncertainty in catastrophe risk assessment, placing upward pressure on insurance premiums and possibly leading to reductions in risk coverage	• The disruption of social networks and solidarity by extreme weather events and repeated lower impact events can reduce resilience	• Storms and floods can damage homes and other shelters and disrupt social networks and means to sustain livelihoods • Extreme weather events can affect the livelihoods and economies of coastal communities by altering coastal ecosystems • Globally, coastal populations are expected to increase rapidly, while coastal settlements are at increased risk of climate change-influenced sea-level rise

1.2.2 Distribution of effects across the EU

Not all urban areas or urban populations will be equally affected by climate impacts and adaptation responses. There are two factors in this: There are two aspects to the question of who is most affected with regard to the urban dimension of climate impacts and vulnerability.

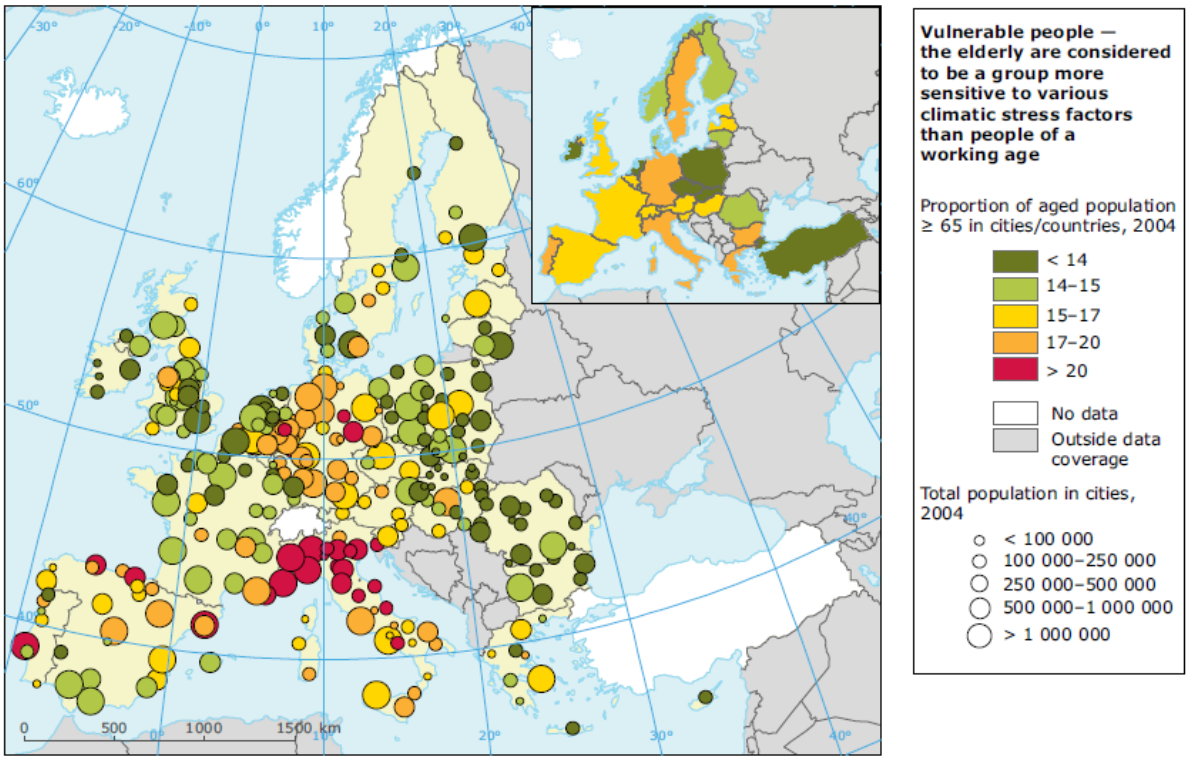
- Across the EU, impacts of climate change will not occur with a uniform geographic distribution
- Within urban areas, different sectors and population groups can be more or less vulnerable

Urban effects of climate change are distributed unevenly across Europe. Different regions will experience differing intensities of the impacts. Furthermore, the particular nature of a city and its population will lead to specific vulnerabilities that in turn require bespoke action to suit these distinctive and particular needs. The impacts of climate change and the adaptive capacity of cities also differ between cities as well as regions.

Key points include:

- Patterns of exposure to climate change hazards differ spatially across Europe. For example, projected extremes of heat are more prevalent for southern and eastern Europe, whereas flooding, sea level rise and storm surges are viewed as key issues for northern and western Europe. As a consequence, different cities face different risks depending on their location within Europe.
- However, while the urban areas face the same large-scale climatic changes as their surrounding regions, the urban setting strongly controls the local impacts that are experienced. 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 within the same geographic region (EEA, 2012).
- Although they are fewer in number, Europe's largest cities and metropolises are a key concern due to their concentrations of wealth and social/cultural influence. The extent of their socio-economic reach into their hinterlands also makes them central to Europe's future prosperity.
- Patterns of urban sensitivity to climate hazards differ across Europe. For example the proportion of vulnerable people in different cities influences the distribution of potential impacts across Europe. Figure 4 shows the proportion of elderly people in major European cities: a number of hotspots where the proportion is higher than average can be identified (e.g. northern Italy), signalling that the experience of climate impacts may be worse here.

Figure 4 Proportion of elderly in major European cities as proxy for sensitivity to climate impacts *Source: EEA (2012)*



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.

The size of the city may be a consideration for policy-setting on adaptation across Europe. There are many more small cities than there are large cities in Europe (e.g., 387 cities of between 50,000 and 100,000 inhabitants, compared to 23 cities of more than 1,000,000), and small cities are frequently those most lacking the resources needed to adapt to climate change impacts and other natural disasters. However, it could be argued that the larger cities and metropolises are more significant concerns in relation to climate change, due to the higher concentrations of assets, wealth, economic activity and political/social/cultural influence that are potentially at risk, in addition to the high proportion of EU population living there (e.g., 12.3 % of EU population lives in cities of more than 1,000,000, compared to only 5.6 % of the population in cities of between 50,000 and 100,000). (Statistics from DG REGIO, 2011, and shown in Table 1, above.)

1.2.3 Distribution of effects within urban areas

Vulnerability is distributed unequally across towns and cities. Urban form and other physical characteristics can increase exposure to climate change impacts and the socio-economic attributes of communities also influence their overall vulnerability. Together, these factors mean that some communities face greater (or lesser) risks from climate change, for example, those located in low-lying areas or with a high proportion of elderly residents.

Climate hazards are increasingly being understood at higher spatial resolutions. For example, the extent of surface water flood risk and the UHI effect can be mapped at the street and neighbourhood scale to reveal significant spatial variations in exposure to major urban climate hazards. Climate change risks to critical infrastructure (including water supply and wastewater treatment, transport, electricity generation and supply) are key issues for cities. There are specific locations, or critical nodes, within cities where infrastructure may be most vulnerable to extreme weather events.

Similar risk factors influence the sensitivity of individuals to different climate hazards. The elderly, young children and people with physical or mental health problems are often most at risk (EEA, 2012). Therefore, the largest effects of climate impacts may be distributed within cities according to the geographies of where such high sensitivity groups live (and work). Socio-economic attributes are also important determinants of adaptive capacity and therefore deprived and marginalised groups can also be more vulnerable to the impacts of climate change.

There is some evidence that there is a correlation between areas of increased exposure to climate hazards and socially disadvantaged and migrant communities who are often concentrated in areas of increased climate hazard. For instance, in the UK, vulnerable groups tend to be located in urban and coastal locations (Benzie et al. 2011, Brisley et al. 2012).

The social and economic characteristics of a community are critical components of their vulnerability and will affect the distribution of climate change impacts across an urban area. Evidence suggests that climate impacts have the potential to reinforce existing inequalities and increase the gap between high and low income groups. For example, disadvantaged households are less able to take measures to make their property resilient to flooding and to respond to and recover from the impacts of floods. The ability to relocate is affected by wealth, as is the ability to take out insurance against flood damage. Measurements of vulnerability, which take account of different dimensions of social and spatial sensitivity, exposure, preparedness and capacity to respond, allow communities who are potentially at higher risk to be identified Lindley et al (2011a). Patterns of vulnerability to climate change exist at fine spatial scale within cities, connected to other urban disparities: every city is unique, and therefore adaptation planning is best undertaken at the city and community level.

1.3 Establish the drivers and underlying causes

Climate change itself should not be viewed as the only (or even primary) driver of climate impacts and risks in cities; rather, it is the way that the changing climate interacts with a wide range of other non-climate drivers (such as contextual vulnerability factors) that results in significant and varying impacts in urban areas. The *Framework for City Risk Assessment* (Mehrotra et al 2009) highlights this by unpacking climate change risk into three vectors. The first, 'hazards', is defined in terms of the climate-induced stresses on cities resulting from the bio-physical impacts of climate change. Significantly, the framework also considers climate risk in terms of 'vulnerability' (determined by the physical and underlying social conditions of the city) and 'adaptive capacity' (the ability and willingness of the city's key stakeholders to cope with the adverse impacts of climate change). This reflects a generally accepted understanding within academic literature, and expressed in tools and guidance, that the underlying causes of adverse climate impacts are shaped not only by changes in climate but by the socio-economic and environmental context in which these changes occur.

The drivers of urban climate impacts are multifaceted, interconnected and occur at different spatial scales. They include approaches and attitudes to urban planning and design (both current and historical), existing social and economic priorities, existing social vulnerability and cultural and behavioural trends. These interact with the biophysical impacts of climate change, topography and biodiversity to shape a range of local impacts and consequences experienced differently by different communities. Adaptation responses need to recognise and respond to this complex myriad of drivers.

The traits inherent in the urban setting, embodied in design, urban form and socio-economic activity can alter exposure and impacts experienced at the local scale (EEA, 2012). The materials and form of the urban fabric and the replacement of natural vegetation can alter temperature, moisture and wind direction creating micro-climates such as the UHI effect. The importance of understanding the interaction between the urban form and local climatic conditions is aptly illustrated in the city of Graz, Austria, where it is now recognised that the tributary valleys to the east of the city play an essential role as sources of fresh, cooling air

(Lazar and Podesser, 1999). Consequently, development in these areas is now restricted, illustrating how city planning and design can, paradoxically, both reinforce and relieve the impacts of climate change.

For example, one recent study identified a wide range of climate and non-climate drivers that can interact to result in heat impacts on human health in urban areas, including (AEA, 2011):

- Higher summer temperatures and increased heat waves
- Characteristics of the built environment
    - Urban heat island effect
    - Amount of waste heat
    - Building density
    - Quality of building stock
    - Quality and status of green spaces and trees
- Socio-economic trends
    - Population distribution
    - Population health
    - Population trend
    - Social disparities
    - Economic Activity

For each city setting and each climate hazard considered, there is a different set of drivers which interact to result in the local experience of climate impacts. While these are locally-specific, there may be a number of European policies which influence key aspects of the urban form and social context and therefore are significant for adaptation. These are identified in Table 4, in Section 1.5, below.

1.4 Identify clearly assumptions made, risks and uncertainty involved

Adapting European cities to the changing climate is an issue that has only received significant attention over recent years. The agenda is evolving, boosted by increasing research on climate change impacts and adaptation (particularly those projects which are participatory and focused at the regional or local level) and also through the development of high level policy statements such as the European Commission's White Paper on climate change adaptation (EC, 2009). Despite recent progress, there are a number of assumptions, risks and uncertainties that remain.

Scientific uncertainties

The future impacts of climate change in European cities are uncertain, although from a policy perspective, decisions have been taken about the climate change scenarios to work with. Significant complexity underlies urban processes, linked to, for example, connections between social, environmental and economic drivers of change. These are reflected in some integrated assessment models, but such models generally operate at the regional or global level, and cannot deal with the urban scale. Urban areas are affected by a wide range of local and global drivers, most recently linked to the ongoing fallout from the 2008 financial crisis. These issues are difficult to predict, and when they do happen have major implications for planning and development in urban areas. Specific factors include:

- Uncertainty in climate change projections: Projections for the future extent of climate change affecting European cities are affected by the greenhouse gas emissions scenario selected, the specific climate model that is used and the timescale over which the projections are made (Christensen et al 2011). Despite this uncertainty, recent research suggests that decisions should be preparing for the upper end of the range offered by current climate change projections (Betts et al 2011).
- Uncertainty in projections of land use and urban development patterns: In the same way that the future climate impacting on European cities is set to change, over the

coming decades European cities themselves will also evolve. This will in turn influence issues including the demographic profile of cities and the nature of predominant economic sectors, with implications for climate change impacts and the development of adaptation responses. As a result, there is a need to understand the processes driving change in European cities better, and to understand how these forces might influence the occurrence of climate change impacts and the development of adaptation responses (Blanco et al 2011, Carter 2012). Scenario planning provides a useful method to address these issues, in the same way that scenarios are used to underpin future greenhouse gas projections data that are a key input to climate change models.

In addition to uncertainty, the UK's Royal Commission of Environmental Pollution adds complexity, path dependency and issues of equity and efficiency to the key challenges that institutions (such as municipal governments) will face when responding to climate change (RCEP 2010). These challenges are highly interrelated.

The Thames Estuary 2100 project (reported in EEA, 2012) provides a good example of a long term planning process that has inbuilt flexibility to respond to uncertainty in the levels in future sea level rise associated with current climate change projections. Projects such as this offer examples of where uncertainty has been communicated and responded to. Further research in this area, and the identification of flexible planning processes in other sectors, would benefit actions connected to adapting European cities to climate change.

Evidence gaps

There are also more basic gaps in the evidence base needed to progress urban adaptation planning in Europe (EEA, 2012). Undertaken as part of DG Clima sponsored the Adaptation Strategies for European Cities project, a review of literature on climate change hazards, impacts and vulnerabilities found a lack of city-specific data to support adaptation planning and policy-making in European cities (Carter et al 2012). Although there are exceptions, there is generally a poor availability of city-scale date on climate change hazards. Cities must therefore rely on climate hazards data produced at higher spatial scales, or commission research to explore potential exposure to hazards at a local scale which some cities have done in the process of developing adaptation strategies. A regional climate change projection can only highlight broad projections in climate variables, which risk missing the local subtleties that characterise levels of exposure to climate change hazards.

Other existing information is focused around guidance, data and case studies in several key areas. These include (although are not limited to):

- Studies on the occurrence and direct impacts of changes to weather and climate variables, for example, flooding, heat stress, water supply constraints.
- Guidance on cyclical adaptation planning processes, detailing key stages involved in developing adaptation plans and strategies.
- Emerging examples of adaptation strategies produced by European cities.
- The role of green infrastructure as an adaptation response. This includes research into the adaptation benefits of green and blue infrastructure and associated case studies.

In terms of quantitative data, there is some existing information to support adaptation planning in European cities, although this data is not always available at the city-scale. While data on climate change hazards is not often available at the scale of individual cities, some datasets to support the development of vulnerability indicators are accessible at this scale through sources such as the Urban Audit and Eurostat, for a limited number of cities.

The question of whether city-scale data on potential climate change impacts will be produced for European cities is open. Climate change hazards are often experienced locally and in spatially variable patterns, for example in terms of specific areas of a city exposed to flooding or the extremes of heat stress. Nevertheless, regional level research outputs on climate change hazards would advance the agenda in many locations.

A more comprehensive hazards database at the scale of European cities (e.g., EVDAB - Box 3) should ideally be accompanied by city-level data on vulnerability and adaptive capacity. Hazards will have different impacts on urban populations and infrastructures depending on issues such as the demographic profile or dominant economic sectors of the particular city that is affected. In comparison to climate change hazards, data on contextual vulnerability at city-level across Europe is more comprehensive. This includes socio-economic data such as from Urban Audit or national level census. However it should be noted that only a fraction of Europe's cities/urban centres are included in the Urban Audit. Reliable and comprehensive data on adaptive capacity at city-level across Europe do not exist.

Box 3 European Database of Vulnerabilities to Natural Hazards in Urban Areas

The European Database of Vulnerabilities to Natural Hazards (EVDAB) aims to collect and integrate relevant datasets for the identification and the evaluation of key vulnerabilities to weather-driven hazards[1]. EVDAB focuses on 305 urban areas across Europe. The collected datasets are merged together on the basis of the Large Urban Zones (LUZ) defined in the Urban Audit. The outputs of the datasets and the indicators which are available to inform urban decision-making and planning in light of changing climatic conditions are shown below.

EVDAB outputs	Examples of indicators available
Climate projections - model output – (from control 1960-1990 to scenario year)	- Annual, e.g. total precipitation; daily mean temperature; daily max/min temperature - Seasonal, e.g. summer days (Tmax> 25°C); tropical nights (Tmin> 20°C)
Climate observations - historical data	- Annual, e.g. total precipitation; daily mean temperature; daily max/min temperature - Seasonal, e.g. summer days (Tmax> 25°C); tropical nights (Tmin> 20°C)
Large forest fires observed	- Total area burned 2000 - 2007 (LUZ with fires larger than 50ha observed within 1km radius) - Total number of fires 2000 – 2007 - Case studies from Braga, Portugal and Marseille, Spain
Flood risk	- Land exposure to flood risk - Population exposure to flood risk: LUZ population exposed to potential flood (%)
Composite indicators	- Exposure of elderly population to summer days frequency change - Exposure of elderly population to heat wave events frequency change

The indicators are currently being updated to include:

- More recent climate simulations;
- More urban areas, following the extension of the Urban Audit;
- More indicators related to issues of relevance for regional development;
- Modelling results derived from the Land Use Modelling Platform, with dedicated simulation targeting scenario of regional funding.

Climate relevant data and indicators will be made available through the European Climate Adaptation Platform. An updated version of the EVDAB is planned for mid-2013

What constitutes good practice for urban adaptation?

Apart from data gaps, a further source of uncertainty surrounds the best way to address adaptation at city-level. The complexities of multiple stakeholders and multi-level governance are crucial here, because different processes for developing adaptation strategies seem to suit different cities, depending upon their administrative, political and knowledge circumstances. Idealised adaptation planning processes (frameworks and guidance) are relatively widely available in Europe, having been developed by national organisations (such as the UK Climate Impacts Programme), EU research projects (such as the GRaBS, or CHAMP projects), or with specific focus on cities and regions (e.g. Future Cities Adaptation Compass). There are numerous examples of urban adaptation planning and actions. However, there is still a lack of *good practice* examples, and a lack of communication of these examples. Better communication of these case studies would support adaptation in European cities.

Spatial scales

An additional challenge facing planners and decision makers looking to develop adaptation responses for European cities relates to spatial boundaries. An adaptation strategy for a city should ideally recognise and respond to the international implications of climate change, which may be at least as significant as the direct impacts of the changing climate (Foresight 2011). Further research on climate change impacts at broader spatial scales would be valuable.

Diverse governance and legal frameworks

The policy and governance contexts in which cities operate are another area of uncertainty for adaptation. There are diverse governance structures across Member States, which result in different modes of collaboration between the organizational and spatial levels of governance. In particular the level of autonomy of cities is important. For example, in Germany, the Laender have a considerable autonomy in setting their own laws and regulations. In the UK, recent changes in governance have placed a strong focus on the local level and dismantling of the regional level. A related risk is the competence of the governments at different levels to consider and mainstream issues related to climate change adaptation.

1.5 Describe how the problem has developed and which existing policies *at Community or Member State [if applicable] level are likely concerned*

Europe's resilience to climate change depends largely on local action. Cities are in a unique position to develop locally tailored responses to the impacts of climate change because they have first-hand knowledge of local conditions and can develop proactive strategies, generate buy-in for ambitious targets and build networks with their peers. However, this adaptation also requires higher-level coordination as cities are ultimately nested within a legal and institutional context established by national and regional governments and the EU. These institutional settings and the interactions between different levels of government and other stakeholders are important in inhibiting or facilitating local adaptation.

Cities are affected by a large number of policies both directly and indirectly, and the links between individual sectoral policies and climate impacts and adaptation should be identified in the relevant sectoral state of play reports. The principle of mainstreaming across a wide range of policy areas is key to ensure that adaptation strategies can be implemented at city level. A number of areas of European policy have been identified as particularly relevant for urban adaptation (EEA, 2012), as shown in Table 4.

Table 4 EU policy sectors relevant to urban adaptation. *Source: Table 4.3 from EEA, 2012*

Policy sector	Importance for urban adaptation
Regional and cohesion policy	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 (current programming period, to be replaced by new tool) Support for local adaptation projects varies depending on MS priorities and operational programmes Support to sustainable urban development as proposed under Cohesion Policy 2014-2020 New focus: Community led-development
Environment	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 LIFE+
Agriculture and rural development	Relevant for urban areas in regional approaches, e.g. upstream flood prevention measures or water management in water scarce regions.
Transport and energy	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. Smart cities initiative Sustainable urban transport and mobility
Industrial / enterprise	Positive responses can be expected from local businesses and their interest in coping with climate change impacts.
Employment / social	Importance of addressing social equity issues and distributional impacts of climate change. ESF
Education	Mainstreaming in Life-long learning programme; Primary, secondary, tertiary education and vocational training
Health and consumer protection	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	Clearly beneficial for local adaptation, but the uptake of many research outcomes remains limited.

Cities play a central role in the economic well-being of Member States, thus policies which seek to strength or enhance social and economic performance will be concerned with adaptation responses in cities. Where climate impacts are not addressed it will be increasingly difficult for Europe to deliver its social and economic objectives embodied in its funding and policy mechanisms, equally, where adaptation is effective and vulnerabilities are reduced the positive impact of these policies will be greater. For example the Cohesion and Convergence Funding streams aim to reduce regional disparities in terms of income, wealth and opportunities across Europe, a challenge made harder if more economically disadvantaged Member States do not have the capacity to adapt effectively to climate change. Equally, by incorporating adaptation responses into these mechanisms they may more effectively reduce differential vulnerabilities and disparities. Investments which may directly impact on climate change, e.g. adaptation infrastructures in urban area, may be targeted under cohesion policy.

Box 4 Cohesion Policy – Implications for cities

What is Cohesion policy?

Cohesion policy is one of the most powerful EU policies, deploying almost 36% of the total EU budget for the period 2007–2013. It was set up as the major instrument at Community level to support modernisation of the Union's economy and support priorities as set up in the Job's and Growth Agenda and reducing the gap in the different regions' levels of development, in order to strengthen economic and social cohesion.. This is done by supporting economic and social development whilst safeguarding the environment, for example, by means of projects concerning urban transport and the revitalisation of city centres. The EU Structural Funds (i.e. the European Regional Development Fund (ERDF) together with the European Social Fund (ESF) and the Cohesion Fund) represent the major instruments of EU cohesion policy.

How has Cohesion policy changed in recent years?

A major overhaul of cohesion policy resulted in new guidelines for the period 2007–2013, under three objectives:

1. **Convergence**: Stimulated growth and employment in the least developed member states and regions with more than 80% of total expenditure, funding projects innovation and the knowledge-based society, adaptability to economic and social changes and the quality of the environment and administrative efficiency.
2. **Regional competitiveness and employment:** Supports the more developed regions, by reinforcing the regions' competitiveness and attractiveness as well as employment, by anticipating economic and social changes. It funds projects including protection of the environment and risk prevention, for example cleaning up polluted areas, supporting energy efficiency, and clean public transport.
3. **Territorial cooperation:** Is financed by the ERDF territorial cooperation targets cross-border activities, transnational and inter-regional cooperation. It aims to promote common solutions for the authorities of different countries in the domain of urban, rural and coastal development, the development of economic relations and the setting up of small and medium-sized enterprises (SMEs). The cooperation is centred on research, development, the knowledge-based society, risk prevention and integrated water management. Programmes funded via INTERREG and URBAN II support, for example, exchanges between cities on sustainable urban development. URBAN II covered the period 2000-2006 and aimed at improvement of city centres by non-construction measures.

The Communication on cohesion policy and cities (EC, 2006c) stressed the importance of cities and towns for growth and jobs in regions. The current regulations applicable to the Structural Funds explicitly include the urban dimension and territorial cooperation. The aim is also to strengthen polycentric development in Europe and cross-border cooperation by promoting joint initiatives at the local and regional level, thus providing cities with huge opportunities.

Past Community initiatives have supported the promotion of projects aiming at sustainable urban development, including the URBAN initiative, URBACT, INTERREG, ESPON, Leader+ and Equal. The URBAN initiative aimed specifically to tackle urban areas in crisis and promoted integrated and partnership approaches not only increasing and distributing knowledge but also cooperation among different stakeholders. LEADER+ supported the economic development of rural areas. 'Equal' aimed at supporting innovative, transnational projects aimed at tackling discrimination and disadvantage in

the labour market.

What does the future hold for Cohesion policy?

The Commission's proposals for the future cohesion policy of the EU during the next programming period, 2014–2020 were adopted in late 2011. The aim of the reform is to align the policy more closely with the objectives of the Europe 2020 strategy, targeting EU investment on Europe's Growth and Jobs agenda, bolster the effectiveness and impact of the Structural Funds and simplify the implementation and accessibility of the regionally-oriented funds.

It is recognised that urban areas are centres of innovation, economic opportunity, and social and cultural diversity, but many also have high rates of poverty, unemployment, and environmental degradation. As such, the new plans for cohesion policy contain a larger role for cities. The measures related to the urban dimension of the cohesion policy proposals are:

- Allocation of at least 5% of the resources under the ERDF to sustainable urban development
- Allocation of around 360 million euro (0.2% of ERDF) to innovative urban actions

In addition to these specific measures on sustainable urban development, the specific urban sectoral investments have been underlined under investment priorities (linked to thematic objectives) which have been set for the new policy.

Implications for cities

Although cities support 70% of Europe's population, when negotiating the new cohesion policy framework for 2014-2020, it will be crucial to avoid isolating urban challenges from their wider context, including cities' relationship with rural areas.

By bringing together the European Regional Development Fund, European Social Fund, European Agricultural Fund for Rural Development and the European Maritime and Fisheries Fund, authorities will be able to translate top EU priorities into action and ensure a better coordination and take-up of EU investment. This should improve cities' accessibility to funds, which is key to ensuring that European cities achieve smart, green and inclusive growth.

Source: EEA (2009), DG Regio (2008; 2011), CoR (2011).

A number of EU directives, such as the Water Framework Directive and the Flood Directive, already promote collaboration between authorities and between different spatial levels. These offer examples which go some way towards the kind of institutional framework needed to support multi-level governance of urban adaptation. However, for urban adaptation, more may be required: features of an appropriate institutional framework[7] might include modes of collaboration between spatial and organisation levels of governance, the policy context, and the nature of the collaboration.

The presence of strongly-regulated and spatially-nested land use/spatial planning systems was seen as crucial to effective climate change adaptation (Resilient Cities Congress 2012, pers.com.). However, it is also recognised that land use policies in different countries can represent climate change adaptation in diverse and contrasting ways, such as encouraging development of greener and more sustainable urban forms, compared with emphasising complex engineering solutions and post-disaster recovery.

At Member State level, not all countries have national climate change adaptation strategies, which may hinder the development of adaptation plans at lower spatial levels. In other countries, while there may be regulations at the national level for larger municipalities to develop adaptation plans, such regulations may not be strongly enforced.[8]

By understanding the cross-sectoral linkages it is possible to identify 'win-win' opportunities and more cost effective adaptation responses. An example of the former is the potential role of coastal ecosystems, such as saltmarsh and barrier beaches, provide natural shoreline protection from storms and flooding, and urban green space can reduce the urban-heat island effect, minimise flooding and improve air quality.

[7] The EEA and ICLEI have centred workshops at the Bonn Resilient Cities conferences in 2010, 2011 and 2012 around this question.
[8] An overview of current national adaptation strategies can be found at http://climate-adapt.eea.europa.eu/web/guest/countries.

1.6 Identify a clear baseline

i.e. describe how the problem is likely to develop in the future without new EU action

According to the EEA, it is clear that adaptation is progressing across Europe, but this is patchy, uncoordinated and of varied quality[9]. The same is true for adaptation across Europe's cities (e.g. EEA, 2009[10]; CoR, 2011). Preliminary findings from the Adaptation Strategies for European Cities (ASEC) survey provide further evidence of the state of play across more than 100 cities in Europe (Box 5).

Box 5 Preparing for climate change in cities, a survey across Europe: Key findings

About the cities

Survey data on city characteristics reveal that of the cities surveyed the top city geographic characteristics include: 1 Land-locked, 2 Coastal and 3 Riverine.

Coverage of 196 responses from the European biogeographical regions include:

Mediterranean	41%	Coastal zones and regional seas	6%
North-western Europe	23%	Mountain areas	3%
Central and eastern Europe	14%	Other	2%
Northern Europe (boreal region)	10%	Arctic	0%

Awareness of evidence relating to weather and climate-related hazards and/or extreme events that occurred in cities over the past 30 years

Cities surveyed for the ASEC project are aware of evidence relating to extreme events that occurred in their city over the past 30 years. The top three reported past extreme events affecting European cities are:

- Periods of very hot weather or heat waves (81% of cities surveyed);
- Flooding from heavy rainfall (78% of cities surveyed) and;
- Storms (69% of cities surveyed).

Awareness of evidence relating to a potential increase or decrease in frequency or severity of weather and climate-related hazards and/or extreme events in cities over the next 30 years

Looking ahead at evidence relating to a potential increase in the frequency or severity of extreme events in the future, one of the top three expected future events is different with:

- 86% of cities expect an increase in periods of very hot weather or heat waves;
- 73% expecting flooding from heavy rainfall to increase over the next 30 years.
- 71% expecting periods of reduced water availability, scarcity or drought and;

Cities with an adaptation strategy

Around a quarter (24%) of the cities surveyed so far report that an adaptation strategy that has been adopted in their city, with only 8% stating that no work is planned or has begun on climate adaptation.

Country support that relates to adaptation at city level

Around a third of the cities surveyed reported that were not aware of national (31%), regional (26%) or local (23%) adaptation guidance or tools in their country to support cities in adaptation planning.

Assessing the risks

As many as one-quarter (10-27%) of cities did not think that climate risk assessments had been carried out across the 11 sectors mentioned in the survey, including city-owned buildings (22%). The risk assessments that respondents were aware of were mainly for shorter timeframes (a 0-10 year period, 19%). Of those few that had looked beyond 50 years, the most common sectors assessed

[9] http://www.eea.europa.eu/themes/climate/national-adaptation-strategies
[10] http://www.eea.europa.eu/articles/cities-of-the-future-2013-how-will-european-cities-adapt-to-new-climate-conditions

were infrastructure, water supplies and sewage.

Engagement

The most common form of engagement with different groups used by cities whilst developing their strategies is workshops (22% across all the 12 groups). Formal partnerships were the most common method for engaging with elected city politicians and also had the highest response across the respondents.

Characteristics important for capacity building and exchange of good practice

72% of cities surveyed felt climate impacts or vulnerabilities and geographic features (68%) were the most important characteristics that would influence their choice of other European cities with which to engage and learn from. Only 22% thought language was an important or very important consideration for knowledge exchange and capacity building (a high proportion of the respondents concerned about language were from Greece, Romania and UK).

While a few (2% of cities surveyed in the ASEC project) cities believe they are pioneers (currently including Rotterdam, Aalborg and Copenhagen) believed that their climate adaptation programme is far advanced), acting above and beyond their respective national governments, there are also cities that clearly need more support and guidance in order to adapt effectively (just under half the cities surveyed believe they are still in the very early stages of work on adaptation). Adaptation remains a new policy area for many city administrations.

According to the discussion at the Resilient Cities Congress 2012 (pers.com.), one key barrier for cities trying to address adaptation is a lack of cross-sectoral collaboration within local authorities and a prevailing “silo mentality”. In particular, lack of communication between planning and risk management departments was observed. This may mean that whilst adaptation plans are developed by the municipalities, they do not filter into e.g. land use planning; thus adaptation may remain a separate, or additional issue, rather than becoming mainstream consideration. For example, for some, flooding in Copenhagen was considered as a blessing in disguise, since the event raised awareness of the problem and provided a strong impetus for development of adaptation plans across the city’s responsibilities.

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 (EEA, 2012). The EEA identifies a number of limitations to local, regional and Member State governance for adaptation in urban areas. These include the complexities of jurisdictional and economic boundaries compared to the scale and location at which effective interventions for adaptation may need to be implemented for increasing urban resilience. There is often a gap between local adaptation action and national level strategies, and competition for resources between policy sectors at the national level can lead to the neglect of funding for urban adaptation.

Without new EU action the gaps in adaptive capacity and in the development of appropriate adaptation responses across Member States will remain or widen. This has consequences for those cities who are not prepared and whose vulnerability will only increase with the impacts of climate change. However, the impacts of climate change on cities are characterised by their interlinked, and often transboundary nature. Thus even those better prepared cities could be affected by other locations which suffer as a result of being poorly adapted.

1.7 Address the necessity for the COM to act

i.e. develop an argument for EU value added

The number of Europeans living in urban areas is set to increase from the current figure of around 70% to around 80% in 2020, due mainly to rural to urban migration, but in the longer term from increasing immigration. Considering the social, economic and environmental significance of cities within Europe, it is clear that Europe's adaptation is (or will be) – to a major extent – urban. Therefore, a European policy framework for adaptation must critically include the urban dimension. Cities are the places where adaptation measures will be planned, implemented and maintained. Local governments are the organisations which facilitate adaptation processes involving citizens and stakeholders and coordinate adaptation measures taken by various actors in all sectors represented in their territory to design, implement, monitor, evaluate and progress effective adaptation.

Urban planning *per se* is not a European policy competence. However, there are a number of key justifications for an EU level role in urban adaptation.

Cross-borders

The EU has an important role to play when climate change impacts cross individual Member State boundaries. Such transboundary impacts may commonly be experienced between neighbouring cities, including cities within the same river catchment, but in different Member States. Cities in different European countries already have very strong links with each other through trade, transport and social links, and these links will also provide the architecture for adaptation. Action (or lack of action) in adaptation at city level can have significant effects on other cities that share similar resources (e.g. water management at the catchment level and energy infrastructure). Coordination is required at the European level to maximise opportunities, exploit efficiencies and reduce the potential for maladaptation.

Cities and city-level stakeholders express some uncertainty about the spatial level at which the responsibility for climate change adaptation should most appropriately lie (Resilient Cities Congress 2012, pers.com). For example, in the Netherlands the demand on limited water supply during droughts can cause tensions between cities and the agricultural areas surrounding them, and potentially across boundaries. Collaboration across national boundaries and different spatial levels is required to support urban adaptation in this context, and European level coordination and facilitation is likely to be helpful.

Cohesion

Perhaps the most compelling argument for EU engagement in urban adaptation is in relation to cohesion policy. Economic, social and territorial cohesion already have a strong urban dimension: cities are a focus for European regional and cohesion policies and are a key area for knowledge exchange and shared learning, particularly in the areas of sustainability and planning (both of which are closely linked to adaptation). However, the effects of future climate change, and the degree to which adaptation is undertaken (or not), all have the potential to exacerbate existing inequalities.

The EU has had a growing impact on the development of cities over recent decades, particularly through cohesion policy. Many studies have shown that the economic growth of cities is frequently embedded in national economic systems and is often strongly related to the development of the latter. 74 % of the differences in growth (in GDP) between individual cities in Europe is accounted for by differences between the growth rates of different countries (DG REGIO, 2011). There is therefore an argument for an EU level role in adaptation to ensure that adaptation can be tackled by all cities, not just those supported by growing national economies.

In some instances, the adaptation plans that are being developed by cities are far ahead of the national legislation (e.g. Copenhagen), thus they exist in a policy/legislative vacuum and have little support from the national level. In other countries, such as Germany, adaptation is not required by a legal act; it is "softly mainstreamed" in planning, but not necessarily in

spatial planning. In Latvia, adaptation is included in spatial planning. In both cases, structured support at EU level may help to provide coherence and consistency.

The legal and policy situation across the EU Member States for cities working on adaptation is varied. The preliminary survey findings from the DG CLIMA Adaptation Strategies for European Cities (ASEC) project showed that only 14% of the respondents' adaptation strategies are, or will be, mandatory due to a legal obligation. 34% of the respondents state that their city's adaptation strategy is a non-legal but required policy document due to a public commitment to produce an adaptation strategy voluntarily. This leaves a majority of cities which may need additional support to engage with adaptation where there is some lack of commitment to the topic at Member State or other political levels.

Adaptation across European cities is currently inconsistent. Solidarity among EU Member States, and between cities in different Members States, is needed to ensure that the regions likely to be most disadvantaged by climate impacts are capable of introducing the adaptation measures necessary. Indeed, lack of adequate adaptation in some regions may fundamentally undermine cohesion across the European territories. The principles of solidarity, social and territorial cohesion and EU cooperation should require that all cities are able to take the measures needed to adapt. The Commission can help this process by facilitating knowledge transfer and experience sharing.

Integration of adaptation in existing areas of EU policy

Coordinated EU adaptation action will be necessary in certain sectors that are closely integrated at EU level, including health, agriculture, water, biodiversity, fisheries and energy networks. These sectors represent a common European interest, with implications for urban populations. Frequently it is in urban areas that such multiple sectors meet and interact, either through markets and consumers, or competition for land and other resources. In order to integrate adaptation into multiple areas of existing EU policy (perhaps notably CAP, cohesion and the single market), the EU is unlikely to be able to avoid engaging with the urban dimension.

For example, as the EU plays a key role in the renewal and coordination of new infrastructure affecting cities, so it can foster improved adaptation through its policies. Planned proactive adaptation as infrastructure is being renewed can save a major overhaul of infrastructure as the impacts of climate change increase in future. In addition to hard measures, the EU can also enhance the adaptive capacity of cities so that they are better able to develop their own locally appropriate responses across multiple sectors and overlapping policies.

Enabling multi-level governance of adaptation

Urban adaptation to climate change in Europe is a task that concerns all governmental levels, from local to European. 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. Similarly, the adaptation choices in some of Europe's megacities could have major regional effects. Urban adaptation to climate change therefore requires regional, national and European approaches to work together.

The EEA's urban adaptation report emphasised the concept of multi-level governance for adaptation. This brings with it challenges of co-operation and collaboration. While municipalities and regions focus on the implementation of place-based adaptation measures, national and European governments have a crucial supporting role (EEA, 2012). Cities and regional administrations can 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.

The top-level institution can provide structure and the reference framework for all governance levels (from community/local to city to regional to national to EU) to support the development of adaptation across Europe. Supportive frameworks could comprise of:

- sufficient and tailored funding of local action;
- mainstreaming adaptation and local concerns into different policy areas to ensure coherence (this may include mainstreaming adaptation into regulations, public management procedures, standards and norms, as well as guidance);
- 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.

Facilitating exchange of good practice

The EU has a role to play in demonstrating leadership to European cities (including those in the Outermost Regions). One aspect of this is in facilitating coordination, good practice exchange and knowledge transfer between cities in different European Member States.

The EU has the resources and influence necessary to promote practical action on the ground across Europe, particularly through knowledge transfer and sharing good practice but also in its role as facilitator and liaison between cities across Europe, enabling learning from the "early movers", making up-take and replication much more efficient, and helping to link up technical competencies for adaptation measures. Exchange may also be formalised in the development and sharing of common frameworks, tools and/or guidance to support urban adaptation. Furthermore, cross-national mutual learning and city-to-city exchange of experiences can help the up-take of successful adaptation approaches and measures, providing additional benefit to the EU level.

In addition, the EU can provide leadership and an example to follow, which can help cities outside Europe to adapt to climate change. This could bring benefits for European trade and economies.

Developing a coherent knowledge base

It is not only knowledge transfer, but also the development of the knowledge base for climate impacts and adaptation, and filling knowledge gaps, that demands a European role. This is particularly important in sectors of common concern with basic climate-related knowledge available (e.g., health). While there is always a need for the generation of some local level information to support urban adaptation strategies, underpinning research can often be best organised at higher levels. Firstly, there is a lack of resources available in many cities to undertake critical research in this field, leaving a large proportion of cities with less access to data, particularly on climate change hazards. Secondly, when cities act independently, the potential for duplicating effort exists.

2 Objectives

The major threats to European cities identified in Section 4 are the impacts resulting from flooding, heatwaves, and water scarcity (or drought), and their interaction with challenges resulting from urban development trends and socio-economic developments and disparities. Impacts in cities are experienced directly and indirectly through multiple sectors. Cities also represent a geographical boundary, or confluence, for cross-sectoral issues that require coverage in developing adaptation strategies.

In response, the key objective at European level in urban adaptation emphasises the unique contribution of the European Union in an over-arching, framework-setting function. The EEA (2012) has also emphasised that the key European role in urban adaptation is ***to enhance an integrated and multi-level governance approach to building climate resilience***. This would support, coordinate, encourage and synergise efforts, and enable enhanced replication of good practices at regional and local levels across Europe. Goals include consistency in the policy and management framework (mainstreaming), development of the knowledge base to support urban adaptation, prioritised and targeted funding via existing channels, establishment of institutional structures and communication channels to promote multi-level engagement and facilitate exchange, and refinement of specific planning, policy and management tools to support urban adaptation. EEA (2012) identified some possible actions at EU level (and by other stakeholders) in the development of this multi-level governance framework for urban adaptation, summarised in Table 5.

Table 5 Possible actions of different stakeholders to develop multi-level governance framework and tools for urban adaptation in Europe *Source: EEA, 2012: Table 4.6*

	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.

The EC's White Paper (EC, 2009) and the Climate-Adapt website already demonstrate an integrated approach to adaptation. From cities' perspective, the additional emphasis must be on enhancing multi-level governance for policy coherence on this topic. Other examples of adaptation integrated into a broader resilience agenda are seen in the UNISDR 'Making Cities Resilient' campaign and other related initiatives, and ICLEI's World Congresses on Cities and Adaptation to Climate Change (the Resilient Cities conference in Bonn) held annually since 2010.

There is some support (ICLEI, pers. com) for reframing the adaptation challenge into a broader aspiration to increase the performance of an urban area, such as is captured in the concept of 'resilience'. This would integrate climate with other disaster risk and sustainability considerations, into urban development projects that are attractive to both private investors and inhabitants and turn challenges into opportunities through harnessing synergies, multiple benefits and fostering collaboration. However, further work is needed to understand how this

would fit within an overarching and explicit European Adaptation Strategy, and alongside developing city-level adaptation strategies.

The European Adaptation Strategy presents a significant opportunity to support and enable multi-level governance in adaptation. The EEA identifies several pillars necessary for multi-level governance of adaptation (EEA, 2012):

- Policy-coherence through climate-proofing
- Development and maintaining multi-level knowledge-base
- Securing access to funding for adaptation measures
- Developing institutional capacities across levels
- Territorial governance (spatial planning)

Not all of these could (or should) be effectively led by the European level, but the EU does have a supporting role in each of these objectives. Indeed, there is potential for a very strong European role in some of these, particularly the first two bullets. These objectives for cities' adaptation align well with the pillars of the European Adaptation Strategy, as they include requirements for knowledge development and sharing, attention to appropriate funding mechanisms (including the ability to focus and tailor support to urban adaptation where it is most needed because of high climate impacts or a low capacity for adaptation) and increased involvement of the private sector (market-based efforts). Spatial planning is not a formal competence of the EU; nonetheless, the allocation of Structural Funds, the EU Transport Policy and other policies have a big impact in stimulating and restructuring existing urban areas and supporting the development of new urban centres.

The interplay between the EU level and the role of Member States still needs further consideration to result in a clear share of tasks and responsibilities in this multi-level governance framework. The critical role for the EU remains that of setting coherent frameworks, with appropriate supporting activities such as knowledge development, while Member States provide the legal basis and standards for urban adaptation and organise knowledge transfer to cities in-country. Throughout, the EU role can also include providing access to knowledge and data relevant at city-scale, facilitating exchange of experiences, and targeted support for cities which currently have weak support in adaptation from their national governments.

There are a number of mechanisms available to promote collaboration between different levels of governance or different stakeholders in urban adaptation, although currently it seems that policy, legislation and guidelines are the most frequently used mechanisms for governance of climate change adaptation (Resilient Cities Congress 2012, pers.com). Given the range of different legal and governance frameworks in member States and at regional and municipal level, a high degree of flexibility, and an emphasis on guidelines, may be important in the EU Adaptation Strategy. One practical way in which the Commission could facilitate this collaboration and cooperation in multi-level governance is by implementing a strengthened second tier of the EU Adaptation Steering Group[11] with focus on cities and regions, to accompany the implementation of the EU Adaptation Strategy.

In addition to physical systems that facilitate the interrelations between the city and its residents, climate change impacts also put pressure on 'soft' systems. These include governance structures and management procedures, in particular decision making processes, which are put to the test when extreme events strike cities, and also the complex grid of social and cultural interactions. To cope with climate threats and non-climate stressors, these soft systems need to be adapted for the new challenges faced by city managers and residents (Morchain and Robrecht, 2012). This is often a key role played by the development of a city-level adaptation strategy.

[11] The current Adaptation Steering Group (ASG) includes two networks (ICLEI and EUROCITIES); the suggestion here is for a greater number of city network representatives, and a broader range of city stakeholders in a second tier of the ASG, which would act as a conduit and sounding board to achieve buy-in from cities and help with more efficient mainstreaming into existing EU initiatives and opportunities directed towards the urban level.

Box 6 Objectives in European city adaptation strategies

A recent review of city-level adaptation strategies undertaken as part of the ASEC project has revealed three common themes for adaptation objectives at the city level:

- To improve a city's ability to cope with projected climate change and the challenges at local level
- To protect and increase the quality of life and enhance the city's attractiveness for its citizens
- The creation of positive effects for the local economy and the attraction of (international) investment

While it is useful to identify common objectives, the detailed review of city-level adaptation strategies highlighted that there is no single approach to the development of adaptation strategies and that each city should identify locally relevant strategic goals and objectives. The research also highlighted the importance of stakeholder involvement and participation from an early stage, which may also influence the objectives established at city-level.

3 Options

This section is arranged following the prescribed headings to identify options as:

- Technical measures for adaptation
- Mainstreaming into EU policies and strategies
- The potential of the market
- Capacity-building and exchange of good practice
- Filling knowledge gaps

Given the objectives described in Section 2, we find that the greatest potential for European action to support urban adaptation is in relation to mainstreaming, exchange of good practice and development of the knowledge base (to an extent). The balance of actions at different governmental levels to support urban adaptation was explored by EEA (2012), and summarised in Table 6, which also emphasises that at European level, the roles is predominantly one of support, rather than implementation.

Table 6 Options at different governance levels for urban adaptation *Source: EEA (2012)*

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 →

3.1 Technical measures for adaptation

Given the large number of sectors requiring adaptation at city level, in different local contexts with differing vulnerability, a very wide range of technical measures for urban adaptation is available. The appropriate options are also dependent on the nature of the local governance and its remit across affected sectors. Adaptation can catalyse existing, needed or desired development, can offer opportunities to promote innovation and enhance entrepreneurial behaviour, and can create new jobs and contribute to education. The majority of these technical measures would be implemented at the local level, and there is a limited European level role, except insofar as they may pertain to European-wide infrastructure affecting cities,

or in respect of European funding for local or regional projects (e.g., through capacity-building or demonstration programmes such as INTERREG or LIFE+).

Work undertaken to inform the ASEC project reviewed publicly available source material based on different climate impacts, identifying over 200 adaptation options relevant to European cities. Using a process of comparing these options to cluster comparable adaptation measures, a shortlist was established. Good practice options were then distilled from the shortlist through the application of the following criteria:

- Has the option been applied in practice?
- Has the option demonstrated a significant reduction in climate impacts in practice, or where effects have not been monitored, does consulted expert judgement expect the option to reduce impacts significantly? To be more concrete, have the realized measures have increased the range of water extremes (abundances, scarcity) and heat extremes that cities can cope with?
- Has the option demonstrated in practice that no significant negative effects on social goals (like wealth, health) occur, or where effects have not been monitored, does consulted expert judgement expect no negative effects?

This resulted in a list of 29 good practice adaptation options linked to four climate hazards, namely heat stress, drought, flooding and storm water run-off. A key theme emerging from this review has been the diversity of the options developed in response to different stressors, a theme consistent with evidence from North America (Birkmann et al 2010). So the good practice adaptation options are arranged into 3 distinctive groups:

- Hard, technical based, adaptation options
- Hard, system based, adaptation options
- Soft options (like governance, regulation, legislation)

The inventory leads to some remarks that might be crucial for enhancing the adaptive capacity of cities and for getting adaptation measures realized;

- Even with the focus on urban areas, the role of ecosystem services is crucial for supporting adaptation: expanding blue-green infrastructure such as parks, forests, wetlands, green walls and roofs, wherever feasible and sustainable, brings multiple benefits. Such infrastructure serves to provide a cooling effect on cities as well as playing a role in managing floods, and will often bring efficiency and mitigation benefits too.
- Implementation of adaptation measures seems to be accelerated by incorporating adaptation into existing and ongoing developments, work plans etc. Quite a number of the measures considered by this study have been incorporated into new development or construction projects. This observation highlights the importance of incorporating adaptation into existing development/redevelopment timescales and work plans. Key factors determining the success of this approach are the availibity of financial resources, added value to the urban habitat, acceptance by stakeholders, cost reducing (added adaptation measures do not significantly effect costs of ‘big’ infrastructural projects. Further analysis will be undertaken on these options.
- On city scale or part of the city there tends to be a movement towards combining the so called ‘technical’ measures (like building dykes, construction of buildings) with more (eco)system based measures (ecosystems services like constructing or restoring wetlands, blue-green infrastructure);

There tends to be a movement in research institutes as well in private companies towards applying a more holistic approach. The possibilities of integrated system approaches are explored to deal with urban challenges. Considering cities as urban ecosystems and learning from ecosystems are essential in many ongoing and new projects. A number of the technical measures considered by this study have been incorporated into new development or construction projects highlighting the importance of incorporating adaptation into existing development/redevelopment timescales and work plans.

The list featured in Table 7 is a summary of some of the key technical adaptation measures currently being considered in European urban areas.

Table 7 Examples of good practice urban adaptation options

	Heat stress	Drought	Flooding	Storm water run off
HARD, TECHNICAL BASED, ADAPTATION OPTIONS				
Construction and design of buildings passive cooling (natural ventilation, increase of wind velocity), thermal zoning, isolating, (bed)rooms on north side of buildings, ceiling fans, double walls (compartments), greening of rooms, evaporating cooling towers, filters in ventilation system, high performance glazing, air quality management system	x			
Increase albedo Increase the albedo of buildings (roof, walls, glazing) and pavement by using light coloured materials and low thermal admittance	x			
Provide shading Shadowing buildings, roads and parking places by putting up shutters, blinds, screens and extending rooftops	x			
Orientation of buildings and open spaces focus on sun and wind, keep H/W ratio <1, promote ventilation in public area, shadowing urban space Ensuring that fresh air from green areas outside the city can flow in and promote ventilation paths alongside large freeways or in between the city districts	x	x		
Green roofs and walls Buildings with green roofs, roof gardens and green walls	x		x	x
Construction and design of buildings to increase water use efficiency		x		
Construction and design of buildings to reduce impact of flood materials, one-way valves in drainage pipes, elevated entrances, building on piles, high buildings, no crawlspace under buildings, locate electrical services and boilers above flood level, raising damp-proof courses			x	
Reinforce flood protection infrastructure Raising flood banks, (sea)walls, glass overtopping, embankments, dykes, dams, barriers, storm sewers, widening the coastal defence			x	
Flood-proof infrastructure Floating road, maintenance and condition of infrastructure, appropriate design and materials, high roads for evacuation routes			x	x
Innovative flood protection options Use of detached (submerged) breakwaters, removable flood barriers, floating sector gates, dyke-in-dune system, closed fixed barrier, storm surge barrier, multifunctional use			x	
Enhancing capacity of waters Shallow canals, isolating wells/springs, enhancing capacity of sluices and weirs, reconnecting water systems, dredging of open waters.			x	
Floating and amphibian housing			x	
Compartmentalization Adaptation of high ways, secondary dikes to create compartments			x	
HARD, SYSTEM-BASED, ADAPTATION OPTIONS				
Green and blue-green areas Expanding blue-green infrastructure, maximizing lbue-green area in cities (fields, parks, gardens, water bodies, street trees, traffic shoulders, nature on undeveloped terrains)	x		x	x
Urban farming and gardening Crops and vegetation: new crops for allotment and vegetable gardens, salty crops, drought-tolerant plants and trees	x	x	x	
Using warmth and cold storage in soil	x			

	Heat stress	Drought	Flooding	Storm water run off
Extend water supply services Spraying and providing water by (fountains)	x			
Water retention Water catchment systems / cistern, rainwater harvesting systems, open water, water retention in parking garage, basins/ fascines, on squares/ streets, water bodies		x		
Water saving measures Water-efficient irrigation in gardens, grey water recycling, ground water recharge, rain water harvesting, supply from more remote areas, reduce waste water discharge, reclaimed water use, grey water system rough out, prevent water leakage from pipelines, separate sewage-drinking-rainwater pipelines		x		
Improve drainage improved drainage into ground		x		x
Reduce hardened surfaces Water passing pavements, penetrable concrete, less paving of private properties, high albedo paving				x
Land use planning to reduce flood risks Moving power plants to coast, planning of (storm) water services, avoid construction in flood areas, urban development in low hazard areas, restricted development in flood risk areas			x	x
SOFT OPTIONS (like governance, regulation, legislation)				
Public education and awareness campaigns	x	x	x	x
Heat health warning system Heat Health Warning Systems predict the risk of dangerous heatwaves using meteorological information.	x			
Flood forecasting and warning systems Tidal and/ or flood forecasting system, early warning system, emergency systems for tunnels and subways			x	
Crisis management assigning responsibility for coordination and liaison on flood risk management to a named officer, increased training in (ecological) fire management, community specific planning – working with vulnerable neighbourhoods, taskforce to protect vital infrastructure		x	x	
Evacuation and contingency management plans Evacuation plans, public contingency plans, maps of flood evacuation zones, heat response plan	x	x	x	
Rules and regulations for water use Limited water consumption, changing consumer behaviour, improved water efficiency standards, reduce water discharge during drought periods		x		
Improve regulations for building			x	
Water management plans Integrated water resource planning / Planning of (storm)water services, trenching, development of a comprehensive water strategy		x	x	x

Even with the focus on urban areas, the role of ecosystem services is crucial for supporting adaptation: expanding green infrastructure such as parks, forests, wetlands, green walls and roofs, wherever feasible and sustainable, brings multiple benefits. Such infrastructure serves to provide a cooling effect on cities as well as playing a role in managing floods, and will often bring efficiency and mitigation benefits too.

3.2 Mainstreaming into EU policies and strategies

Table 4 (in section 1.5, above) identified some of the key EU policy areas relevant for urban adaptation. The following areas are identified as a high priority for mainstreaming:

- Urban development policy, especially current Cohesion policy proposal
- Climate proofing for the EU budget for 2014–2020
- "Climate-proofing" of other Commission urban initiatives
- Spatial planning as the key tool for bridging existing governmental levels and sectoral agendas (along with EIA / SEA)
- Integration of adaptation in standards, norms and guidance (like, for example, a European mirror standard to ISO TC 268 'Communities sustainable development and resilience'
- Integration in education: Life-long-learning programme, primary/secondary/tertiary levels

Cohesion Policy

The EEA suggests that the most relevant policy area for urban adaptation is the EU's cohesion policy with its related structural funds, including the INTERREG, URBACT and LEADER programmes (EEA, 2012). LEADER is for rural development and can only complement the urban-rural interface (related to regional adaptation strategies) but they have the potential to support specific adaptation projects in cities and regions (DG REGIO, 2008). Recent proposals of the Commission to mainstream climate adaptation into EU funding programmes including Structural Funds and LIFE + will also provide funds for urban adaptation. These funds have 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. EU cohesion policy, targeting economic growth, education, technological development and infrastructure provision, can increase the adaptive capacity of cities by promoting learning and broad participatory action (if adaptation is mainstreamed alongside these goals). However, cohesion policy can potentially hinder adaptation long-term 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. One way to achieve this is to include adaptation as a criterion in the application, monitoring and evaluation requirements and procedures.

The European Commission's General Directorate Regional Policy views the urban dimension as a key target for territorial cohesion in the EU as cities and metropolitan areas are seen as the engines of Europe's economic development and to remove barriers to growth and employment and in particular social exclusion and environmental degradation. As a key instrument for doing so DG Regio promoted the integrated approach to urban development and related elements such as citizen participation, planning, delivery of actions, monitoring, and evaluation. DG Regio's view and expectation regarding the role of cities and the impact of the integrated approach was confirmed in a recent survey undertaken by the European Metropolitan Network Institute (EMI) on the urban dimension of cohesion policy and integrated urban policy (EMI, 2012) the most widely shared view of respondents was that "cities contribute to the success of Cohesion Policy" (94 % of respondents agreeing with this statement). When respondents were asked to indicate their views on the most important thematic objectives in their city/region under future Cohesion Policy the most popular shared thematic objective was "promoting social inclusion and combating poverty" (49 % of respondents), while "promoting climate change adaptation, risk prevention and management" was not a widely shared thematic objective (with only 17 % of respondents). This lack of perceived shared interest in adaptation may be attributable to many factors, including current pressing economic concerns across Europe. These findings demonstrate two things: first that cities are vital in the success of cohesion policy, but second that the potential links and opportunities for synergies between cohesion and adaptation policy are not widely understood by city stakeholders.

How can urban adaptation be mainstreamed into the new cohesion policy?

(a) Raised understanding and awareness of the links and opportunities.

It may be a useful immediate step to undertake a study combined with awareness-raising or stakeholder engagement activity to explore the potential links and opportunities between cohesion policy and urban adaptation. Specifically, this project should identify where adaptation can contribute to other cohesion objectives, including social inclusion, poverty reduction and economic growth, similar to new concepts in the international sphere of "climate compatible development" (which looks to produce multiple benefits of poverty reduction, low carbon and climate resilience).

(b) New (proposed) funding lines and instruments for cities

For example, ERDF proposals under plans for future Cohesion Policy identify the intention for an "urban development platform" with a focus on networking and knowledge exchange on urban policy related to sustainable urban development. There is good potential for this to be able to support exchange of experience on adaptation. However, it is also important to ensure it doesn't cover similar ground to other initiatives, such as the urban pages on Climate-Adapt. A short study to review the best way to provide a networking and knowledge exchange platform for adaptation (which is welcomed by cities) may be needed to avoid duplication, and/or increase confusion by having similar functions in several places. The new Integrated Territorial Investments (ITI) implements territorial strategies in an integrated way. ITIs will allow EU Member States to bundle funding from several funds or programme (priority axes of one or more Operational Programmes) for the purposes of multi-dimensional and cross-sectoral intervention for a given territory[12]; this flexible and more holistic approach could offer an innovative instrument for effective mainstreaming of urban adaptation.

(c) New tool for community-led local development[13] (CLLD)

CLLD is a specific tool for use at sub-regional level, complementary to other development support at local level. CLLD can mobilise and involve local communities and organisations to contribute to achieving the Europe 2020 Strategy goals of smart, sustainable and inclusive growth, fostering territorial cohesion and reaching specific policy objectives. It therefore has great potential to support good urban adaptation planning and integration of climate smart / sustainable / resilient goals into broader community development. It also provides a mechanism to enable all five CSF funds to be accessed for urban adaptation activities. In order to implement this level of mainstreaming and integrated adaptation planning, it may be important for the EU to provide information and guidance within the tool and application procedures to help community groups and organisations to understand the issues of urban climate risk and identify appropriate responses. Ideally, this could be linked to specific support on existing portals such as Climate-Adapt, and alongside other sectoral guidance likely to be used by communities in their CLLD projects.

Box 7 Mainstreaming of climate change into regional and cohesion policy

Proposals for the Common Strategic Framework (CSF) were announced in early 2012. The CSF will translate the objectives of the Europe 2020 Strategy on smart, sustainable and inclusive growth into concrete actions for the five EU-funds implemented through shared management, i.e. European Regional Development Fund (ERDF), European Social Fund (ESF), Cohesion Fund (CF), European Agricultural Fund for Regional Development (EAFRD), and European Maritime and Fisheries Fund (EMFF).

The proposal follows-up on the objective of the multi-annual financial framework (MFF[14]) to allocate overall at least 20% of the EU Budget to climate-related expenditure: it includes provisions on

[12] Integrated Territorial Investments factsheet http://ec.europa.eu/regional_policy/sources/docgener/informat/2014/iti_en.pdf
[13] One of the main aims of the CLLD is **assist multi-level governance** by providing a route for local communities to fully take part in shaping the implementation of EU objectives in all areas. It is therefore directly relevant to the key framework-setting objective identified for the EU in relation to urban adaptation in Section2.

tracking such expenditure, the support for the shift towards a low-carbon economy in all sectors, and the promotion of climate change adaptation, risk prevention and management.

Partnership Contracts between the Commission and each Member State will set out the commitments of partners at national and regional level. They will be linked to the objectives of the Europe 2020 Strategy and the National Reform Programmes. Climate change mitigation and adaptation, disaster resilience and risk prevention and management, shall be promoted as part of the preparation of Partnership Contracts and Programmes.

Among the 11 thematic objectives that the Structural Funds are to support[15] there is a specific objective to "promote climate change adaptation and risk prevention"; however a number of other objectives could also be relevant to urban adaptation, including protecting the environment and promoting resource efficiency; and promoting sustainable transport and removing bottlenecks in key network infrastructures. In fact, the Committee of the Regions is encouraging that climate change adaptation-related topics feature in all 11 thematic objectives for the new Structural Funds.

Since problems like climate change or urban sprawl cannot be solved at one administrative level alone, the stakeholders of cohesion policy implementation need to develop further, and apply effectively, an integrated approach. As an example, a binding Code of Conduct will be introduced to provide objectives and criteria for establishing productive partnerships and to facilitate the sharing of best practice between Member States. Partnership increases the legitimacy of investment choices, increases a sense of 'ownership' of the funds at all levels, and improves efficiency by making the most of available expertise. This Code of Conduct and Partnership approach should be used to support adaptation or climate resilience across all investments under cohesion policy.

Climate proofing for EU budget

Beyond Cohesion Policy, there is a need to incorporate climate resilience across the whole EU budget. Large financial resources are needed for investment in buildings and infrastructure across Europe (many of these with direct urban implications), and resilience to future climate impacts is likely to require additional cost (especially related to retrofitting of existing stock). While the climate-proofing of the EU budget goes much wider than the urban dimension specifically, if urban adaptation is to be considered seriously by stakeholders at all governance levels, then it is, nevertheless, essential that the key EU instrument of the Multi-annual Financial Framework (MFF) gives appropriate priority and urgency to adaptation. While the proposal for the period 2014–2020 expects that a higher proportion of the budget (20 %) will be used on climate change, it will be important to retain a strong focus on adaptation as well as mitigation projects. Without this, the overarching policy framework will make it difficult to promote urban adaptation across the many other urban and sectoral initiatives.

Commission urban sectoral initiatives

The Commission regularly announces new initiatives, partnerships and funding opportunities for cities, communities and regions. For example, the Communication (EC, 2012a)[16] on European Innovation Partnership for smart cities and communities presents the convergence of energy, transport and ICT in the urban context. It has an objective to catalyse progress in the links between these sectors and offer new interdisciplinary opportunities to improve services while reducing energy and resource consumption and GHG emissions. There is no reason why this initiative could not seek to promote long term resilience to climate change at the same time. Similarly, initiatives related to sustainable urban mobility (e.g.,

[14] In the proposal for the MFF, published by the Commission mid-2011, the Cohesion Policy accounts for about one-third of the EU Budget 2014-2020 divided between the three funds concerned (ERDF, ESF and CF).
[15] The general regulation lists the following 11 thematic objectives that the Structural Funds are to support, tying in with the Europe 2020 Strategy, and it is up to the Member States to choose the investment priorities towards which they channel their funding: 1) strengthening research, technological development and innovation; 2) enhancing access to and use of information and communication technologies; 3) enhancing the competitiveness of small and medium-sized enterprises (SMEs); 4) supporting the shift towards a low- carbon economy in all sectors; 5) promoting climate change adaptation, and risk prevention; 6) protecting the environment and promoting resource efficiency; 7) promoting sustainable transport and removing bottlenecks in key network infrastructures; 8) promoting employment and supporting labour mobility; 9) promoting social inclusion and combating poverty;10) investing in education, skills and lifelong learning; and 11) enhancing institutional capacity and an efficient public administration.
[16] COM(2012) 4701

announcement[17] of incentives for adoption of sustainable urban mobility plans) could and should incorporate a requirement to address long term resilience to climate impacts.

Other topics in which the Commission may frequently publish incentives or opportunities for cities to act include local air quality and Agenda 21, green energy, resource efficiency including energy and water, urban greenspace and biodiversity, health, food, etc. While some of these will have very limited connection with adaptation, many of them look to enhance long term behaviour change, and can therefore also support building adaptive capacity or increasing climate resilience. At worst, without some form of climate-proofing, it may be that the Commission invests in projects or programmes which have only limited lifetime because of future climate threats.

There is an open question on the most effective way to address mainstreaming, or climate proofing, of these kinds of urban initiatives from the Commission. One option would be to incorporate additional adaptation screening steps into sign off procedures or impact assessments prior to publication. Perhaps a complementary measure would be to improve awareness among policy officers of the opportunities to integrate adaptation into urban initiatives right across the Commission. Alongside the inclusion of adaptation as a criterion in guidance, inter-service groups on the urban dimension could be an effective forum for this.

Cross-cutting initiatives

There are some cross-cutting issues which can benefit adaptation across multiple sectors and geographical scales. These are not specific to the urban dimension of adaptation, but mainstreaming of climate risks and adaptation into these areas will support city level adaptation planning as well as adaptation more widely. Two examples are:

- Establishing strong spatial planning. In many areas of the EU, spatial planning provides the key to the location of assets and people in risky or non-risky areas. Spatial planning is affected by policy at all levels, but adaptation could be supported by stronger guidance 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 other technical adaptation measures). While this would have a positive impact on urban adaptation, it would also support other key sectors influenced by spatial planning, including infrastructure, water and flood management, agriculture, biodiversity, etc.
- Promoting integrated governance and management. Experiences show that cities applying integrated, cyclical governance and management procedures significantly increase resilience preparedness to appropriately respond to extreme events. However, uptake of integrated management is still quite slow and varies between Member States. Broad application of integrated management would equip local governments with appropriate organisation set-up and procedures for developing, implementing, monitoring and updating adaptation strategies.
- Integrating climate risk awareness, robust decision-making, integrated management and adaptation planning into education. In many situations, adaptation planning is an extension of good decision-making supported by the right information. Education levels and awareness of future climate change varies across the EU. If the adaptation agenda is brought closer to citizens through general education, then this can support more targeted awareness-raising and capacity-building initiatives, and help to induce behaviour change, and build a consumer demand for greater resilience, not only in urban areas but across all sectors.

[17] http://ec.europa.eu/commission_2010-2014/kallas/headlines/press-releases/2012/doc/2012-09-03-commission-launches-first-eu-sustainable-urban-mobility.pdf

3.3 The potential of the market

The potential for the market to provide adaptation solutions in Europe was reviewed in a separate "State of Play Report" within the DG CLIMA work[18] to support the development of the EU Adaptation Strategy. Therefore in this section, we draw out highlights of the potential role of the private sector in reducing the vulnerability of cities, the opportunities and incentives for companies to become involved in urban resilience building, the barriers they face and the issues that need to be addressed.

While climate change adaptation is a relatively new field for most private sector organisations, there are considerable commercial opportunities and the potential for contributing to wider societal resilience and economic prosperity as a result. This could also lead to a growth in employment opportunities, such as in the construction and property industry. However the role of the private sector in building urban resilience is complex, and there is currently only a limited amount of research on this topic available.

Morchain and Robrecht (2012) identify that one key way to reduce vulnerability in cities is to incorporate climate change, adaptation and resilience criteria into present investments on urban fixed assets (many of which stem from the private sector). This concept of 'resilience upgrading' looks at enhancing the city's resilience by increasing its performance – its ability to deliver a high quality of life and quality services to its residents. Instead of approaching the topic of adaptation and disaster risk from a perspective of 'escaping risks', it rather looks at the benefits that smart, climate-proof investments can deliver to the city and to the service or product providers (be they public or market-based).

A review of city-level adaptation strategies as part of the ASEC project highlights the potential role of the private sector in the development and delivery of these strategies and need to engage the private sector in the strategy development process. Across European cities, the private sector plays a key role as landowner, developer and user of the urban fabric at risk from adverse climate impacts, placing the private sector at the heart of effective adaptation responses. As outlined by Morchain and Robrecht (2012), the private sector can also benefit from the positive effects on the local economy of effective and sensitive adaptation which can improve the urban fabric, modernise infrastructure and create a more attractive working and living environment.

Box 8 Role of private sector in urban resilience

The Private Sector & Urban Resilience

Climate change may offer new business opportunities for the private sector to develop and offer new products and services that would help people to adapt, such as water management technologies, heat-resistant materials, and new building designs. While this will be motivated primarily by rational self-interest, companies can make a significant contribution to building societal resilience.
The opportunities for the private sector can be grouped broadly under two categories:

1) **Expanding market share** and creating wealth in communities through the development and deployment of a wide range of new and innovative products, strategies and services. This could potentially lead to considerable innovation and job creation in emerging markets.
2) **Accessing new financing streams** from national and international adaptation funds, as well as providing new financial products and services for projects.

In the **built environment**, there are a number of opportunities for the private sector and public sector to collaborate. For example, building and real estate companies can foster innovative design and new design practices to improve the resilience of buildings to the impacts of climate change. Other sectors where there are a number of opportunities around climate change adaptation include:

- Environmental consulting services
- Water management and technologies

[18] *Support to the development of the EU Strategy for Adaptation to Climate Change: Background report to the Impact Assessment, Part I – Problem definition, policy context and assessment of policy options*. (2013) Environment Agency Austria, Vienna

- Insurance markets
- Information services
- Educational and training services
- Climate services (such as atmospheric information)
- Disaster response services
- Banking

Greater involvement of the private sector in urban resilience building could potentially lead to increased economic prosperity and employment in many cities through the provision of jobs and improved living standards. Jobs and employment markets respond to a number of stimuli including, but not limited to, technology development, economic development, demographics, fiscal policies and urbanisation. Increased government focus and investment in city-level resilience building could therefore have a positive effect upon the jobs and employment market.

There is, however, relatively limited research available on this subject aside from a small number of sectoral studies on a regional scale, and the private sector has only recently started to engage with policy makers on climate adaptation issues. As such private sector involvement in urban resilience is still quite low and it is difficult to predict what effect increased involvement would have upon employment opportunities and economic growth.

Market-Based Instruments (MBIs) could potentially provide an option for stimulating private sector opportunities through the careful application of measures such as taxes, charges, subsidies, marketable (or tradable) permits. MBIs have proven effective for stimulating and supporting climate mitigation activities, though how suitable they would be for adaptation has not yet been proven.

A recent study by DG CLIMA has suggested that grants, land use taxes, an Adaptation Market Mechanism, payments for ecosystem services and water markets as the most promising instruments in terms of their potential effectiveness. However these instruments have not been significantly tested as of yet, and require strong institutional structures for them to be effective.

This subject is covered in more detail in the report *Support to the development of the EU Strategy for Adaptation to Climate Change: Background report to the Impact Assessment, Part 1 – Problem definition, policy context and assessment of policy options.* (2013) Environment Agency Austria, Vienna.

Despite the apparent imperative for the private sector to activity engage in the adaptation process, there are a number of barriers which prevent the private sector from taking appropriate adaptation actions and future-proofing their business, including:

- Lack of awareness of climate-change related risks
- Lack of capacity to undertake a risk assessment
- Lack of information, uncertainty and modelling tools
- Short-term vs. long-term horizons
- Policy and regulatory weaknesses and change.
- Cost and reversibility of adaptation action

While these are not specific to the urban context, given the urban setting of much of the EU's business sector, these can be considered barriers to the private sector taking a more active role in urban adaptation. The role of business in adaptation is acknowledged in a number of adaptation support tools. For example the BalticClimate toolkit provides resources for business people which focus on information and exercises to examine the challenges and opportunities faced by the private sector. UKCIP have also developed BACLIAT, which comprises a set of workshops for to help businesses to assess vulnerability to past weather, brainstorm the potential impacts of future climate and consider changing business practices.

Case study: example of private sector engagement in city-level adaptation in Rotterdam

The Rotterdam Adaptation Programme aims to increase the quality of life and make Rotterdam climate proof by 2025. Thus it creates benefits for both citizens and businesses established in the area. Rotterdam pools knowledge and the innovative power of research institutes, technology companies and architectural firms that contribute to new solutions. Consequently, knowledge and innovative approaches are developed, implemented and marketed as an export product. The active

engagement of the private sector is a key factor in achieving the strategic aim of becoming a world-leading, innovative 'water knowledge city' and an inspiring example to other delta cities. Examples of private sector engagement include the development of the 'Stadshavens' (city ports) district; the establishment of the Floating Buildings Pavilion showcasing innovative building solutions; and the development of the Smart Delta City concept (in collaboration with IBM) where various data flows on water and climate in the region are pooled, creating an accurate and dynamic picture of flood risk.

Source: http://www.rotterdamclimateinitiative.nl/documents/RCP/English/RCP_ENG_def.pdf

There is a clear need for collaboration between the private and public sectors to facilitate city-wide adaptation. There may be conflicts between the public and private sectors in terms of financing adaptation. For example, in Copenhagen the water supply/drainage systems are jointly operated by the city (infrastructure) and the utilities companies (service). In particular financing of non-traditional solutions like sustainable urban drainage systems is problematic, as there are no clear guidelines whether the investment should come from public or private money. Also, whilst the need for creating a market for adaptation solutions is recognized, the difficulty remains in persuading the private sector/industry of the feasibility of adaptation products.

3.4 Capacity building and exchange of good practice

3.4.1 Capacity Building

Most available guidance and tools for urban adaptation emphasise the importance of building adaptive capacity as the crucial step in addressing climate risks.

The EEA report (EEA, 2012) provides a valuable assessment of current adaptive capacity across European cities, grouping the determinants of adaptive capacity in terms of awareness (knowledge, including perception of risks and human and social capital), ability (the potential of a society to design and implement adaptation measures) and action (the potential of implementing and maintaining the adaptation solutions). The key messages emerging from this study are as follows:

- Enhancing the adaptive capacity can decrease vulnerability of cities to climate-related risks
- Adaptive capacity comprises several components (e.g. knowledge, equity, access to technology and infrastructure; economic resources and effective institutions) which need to be supported through the longer-term development of structural conditions and the short-term promotion of coping capacity measures in response to specific risks.
- Adaptive capacities vary in European cities, both within and between countries - adaptive capacity is not only dependent on the country and region but also from the city-specific setting.
- Some geographical trends indicate that cities in the North West Europe are characterised by higher levels of equity, access to knowledge and technology, and effectiveness of the government
- The differences between European cities present an excellent opportunity for exchange of experiences and learning

It is possible to draw conclusions about how the needs for capacity building for urban adaptation may vary across Europe. Policy options therefore need to have some flexibility to ensure that the right kind of support is targeted into appropriate regions. For example, awareness-raising activities should be targeted more strongly in the south and east where education and perceptions on climate change are lower. Options that incentivise local government commitment to tackle climate change should also be targeted in these areas. Conversely, initiatives which promote bottom-up action by cities on adaptation are more applicable in the north and west, where commitment, knowledge and wealth are higher. It

may be appropriate to make more direct investment of funds for adaptation into the south and east of Europe where GDP per capita is relatively low. Across the EU, however, capacity building can be enhanced through the exchange of experiences, and city stakeholders engaged in the ASEC project testify to the value they place on learning from real good practice examples from other cities. An opportunity for financial support to exchange and learning particularly related to urban sustainable development is provided with the EU URBACT programme (http://urbact.eu/).

Box 9 Adaptation in the EU URBACT programme

In the period 2007 – 2013, the Commission budgeted for € 68,890,739 in the EU URBACT programme. The programme involves 300 cities including nearly two-thirds of Europe's capitals to build networks, exchange information and to provide concrete help in setting up EU-funded projects. The third and last call for proposals was issued in 2011. The programme concludes in 2013. At the occasion of the 2012 Annual Urbact Conference, DG REGIO Commissioner Hahn, however, highlighted the central role of URBACT in promoting integrated and sustainable urban development in the forthcoming 2014-2020 Cohesion Policy. According to these plans the programme should continue to include new tools for cities to help them further in their integrated urban development and promote participatory processes, such as Integrated Territorial Investments (ITI) and Community-Led Local Development (CLLD) (see section 3.2). Due to the fact that climate adaptation is still only in its starting phase, the previous programme period has not yet included adaptation projects. This, however, is likely to change with the forthcoming programme update.

Regarding future capacity building efforts for cities, there is a need to support cities in the development and management of adaptation strategies and action plans and to mainstream adaptation within existing city-level service delivery mechanisms and stakeholder groups. This support can take various forms covering various aspects of the adaptation planning and management process, including:

- Provision of climate change data at spatial scales appropriate for city planning. The uncertainty associated with climate change remains an obstacle to planning and financing of adaptation.
- Development of tools and databases synthesizing the data and information needed for development and evaluation of adaptation plans
- Training for cities to ensure appropriate organisation and procedural structures for adaptation management
- Training for cities to ensure that the tools and databases available are used effectively.
- Exchange of experiences between cities – learning from others, showing the examples of adaptation (see below)
- Development of legislative tools at regional, national and EU level (e.g. directives) that would provide a clear guidance on adaptation planning
- A performance framework, or indicators, which would allow cities to measure the progress they have made in adapting to climate change.
- Support from the EU in the countries without national legislation/guidelines relating to adaptation (e.g. Italy)

A range of tools and guidance to support adaptation planning are now available which are of relevance to cities (for example, the ASEC project identified 52 different tools and undertook a preliminary screening of these). Existing tools and guidance could be better promoted and their use supported. Climate-ADAPT provides the appropriate platform to support dissemination and use of these tools, but further work is needed to evaluate comprehensively the relevance and potential application of these existing tools in order to advise cities, to identify any remaining gaps and to consider need for designing further tools or guidance.

Case study: Capacity Building through transnational cooperation – the ESPACE project

The European Spatial Planning: Adaptation to Climate Events (ESPACE) partnership (2003-2007) was a groundbreaking project led by Hampshire County Council that had a major influence on the spatial planning agenda across Europe. This transnational partnership of 10 bodies in the UK, Belgium, Germany, and the Netherlands brought together representatives from all levels of civil society to address water management policies – in particular, flooding, water resources, and water quality. At its core, the main goal of ESPACE was to increase awareness for spatial planning systems to adapt to the impacts of climate change, and to provide policy advice on how municipal and regional authorities can mainstream climate change adaptation into planning systems and processes.

Their final report, 'Planning in a Changing Climate', which was released in June 2007, contains 14 recommendations for policymakers to mitigate the impacts of climate change on water management.

ESPACE was funded by the European Commission's INTERREG IIIB Programme, a component of European Cohesion Policy, which tackles economic, environmental, and social challenges in North West Europe through coordinated, transnational action.

Source: http://www.espace-project.org/

Final Report: http://www.espace-project.org/part1/publications/ESPACE%20Stategy%20Final.pdf

3.4.2 Knowledge exchange

As identified by EEA (2012), knowledge exchange can play an important role in raising awareness and building adaptive capacity. The importance of such exchange is reflected in the ASEC project which seeks to facilitate knowledge exchange between cities with differing levels of adaptive capacity through training and a project website.

The European Commission's INTERREG programmes are important financial instruments of cohesion policy to support cooperation, knowledge development and knowledge and best practice exchange on a range of topics, which can include urban adaptation. For example, the strand on transnational cooperation, IVB[19], has supported the Future Cities Project (see box below), while the strand on transregional cooperation, IVC[20] , supports URBACT (see box below). Other similar or related cohesion fund regional programmes[21] are also supporting many projects related to urban adaptation across Europe. Such projects and initiatives have brought together cities and municipalities to share knowledge and experience on adaptation, commonly also interacting with academic, research and consultancy communities to enhance their technical expertise.

[19] http://www.nweurope.eu/index.php
[20] http://www.interreg4c.net/
[21] Related programmes include: Alpine Space Programme, Atlantic Area Programme, Azores, Madeira, Canarias Programme, Baltic Sea Programme, Caraibes Programme, Central Europe Programme, MED Programme, North Sea Region Programme, Northern Periphery Programme, South East Programme, South West Europe Programme.

Case study: Future Cities – urban networks to face climate change

The Future Cities project was a transnational partnership of local authorities, municipalities, public utilities, and urban designers in Belgium, France, Germany, the Netherlands and the UK working on "joint solutions for the adaptation of urban structures to the impacts of a changing climate."

In its drive to build 'climate proof cities', the partners of the Future Cities project shared their expertise in areas of necessary action – green structures, water systems, and energy efficiency – to develop holistic local action plans which addressed all of these concerns. These plans were developed into specific pilot projects and demonstration activities, which were carried out at the regional, public space/city level, business site/quarter level, and building level. Based on this shared experience, the Future Cities project developed a 'guidance tool for developing climate-proof city regions' that will help other cities and municipalities check the vulnerability and assess the adaptation options of key sectors.

The Future Cities project was funded by the European Commission's INTERREG IVB Programme, and is part of the Strategic Initiative Cluster 'SIC-adapt!'. In February 2013 the project hosted its final conference at the Sussex Exchange in Hastings, England, where over 110 delegates shared lessons and insights on practical measures for cities to adapt to climate change in the future.

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

Through this process of exchange, such projects have been able to enhance the knowledge base regarding climate change impacts, vulnerabilities and adaptation options and inform the development of tools for active information exchange and continuous learning. In many cases, such projects also co-fund the implementation of real practical adaptation measures in cities across Europe. This highlights a key enabling role at the EU level in funding and facilitating the exchange of good practice for on-the-ground progress in urban adaptation.

Climate-ADAPT

This exchange process is now supported by a European-level platform in the form of the Climate-ADAPT website which brings together outputs from projects and research programmes as well as case studies and details of country-by-country adaptation planning progress. The urban section is currently rather limited, but following the conclusions of the ASEC project, a stronger presentation of city-relevant material on the website will be provided, potentially including increased functionality to support networking or even "adaptation twinning" (if appropriate). Section 1.4 noted that there is still a lack of *good practice* examples for urban adaptation, and a lack of communication of the examples that do exist. Better communication of these case studies, such as through Climate-ADAPT, would support adaptation in European cities. In addition, evaluation of the good practice examples to develop criteria and identify success factors that can be translated into different contexts should be considered.

3.4.3 Multi-level participation and communication

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, and due to the European subsidiarity principle, local authorities have had limited 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 through alternatives to the traditional structures of domestic policymaking.

Considerable efforts have been made in recent years to engage cities in the development and implementation 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[22] and the Covenant of Mayors initiative[23], which involves more than 3,000

[22] **The Sustainable Cities and Towns Campaign** seeks to meet the mandate established for the local level in Chapter 28 of the Agenda 21 document, aiming to translate to the European level the outcomes of the Rio World Summit 1992. The Campaign combines the expertise of eight local government networks, supporting local governments in their local action towards local sustainability. To date, more than 2,500 European

municipalities making a commitment to reduce greenhouse gas emissions. An extension of this model towards the inclusion of adaptation is in discussion.

These performance-oriented, campaign-type policy processes support motivation of cities to act due to their 'train effect' involving numerous participants focusing on the same topic. Participating cities follow a clear set of goals while receiving guidance for implementation. The campaigns provide platforms for exchange of experiences and benchmarks in regard of the cities' sustainability performance. Participating cities usually receive European or even international recognition.

Another example of more direct involvement of cities in European policy-making is connected to the EU Adaptation Strategy development, and namely, their representation through city networks (in this case ICLEI and Eurocities) in the EU Adaptation Steering Group.

In general, rather than constructing new networks and fora for adaptation, it is preferable to integrate adaptation into existing initiatives as far as possible. For example, where cities are already able to make pledges, or join campaigns on greenhouse gas reduction, or sustainability or disaster risk reduction, it may be possible to incorporate adaptation within the pledge (for example, in the UK, the Nottingham Declaration[24] was successfully extended from covering only climate mitigation to include adaptation, and then further developed to provide action packs and supporting guidance).

The 'Making Cities Resilient' campaign is an awareness-raising initiative of the UN International Strategy for Disaster Reduction (UNISDR) and a number of partners to support cities, towns and their local governments in becoming resilient to the changing climate and to the increasing frequency and intensity of climate manifestations that result in disasters. This and similar initiatives could be considered for support and communication from the Commission, to provide opportunities for cities to take their own actions, and take advantage of networks and partnerships which are appropriate to their political character and context.

City networks through campaigns like the above-mentioned can provide a conduit for communicating experiences at city level up to the EU, to shape the multi-level approach around the EU adaptation strategy.

In the absence of formal procedures, participation in adaptation planning 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. These differences in context and capacity are such that cities will benefit from being able to participate and gain information through a range of different pathways and mechanisms. From the Commission perspective, cities are not only critical centres of adaptation activity; they can also provide feedback on the effectiveness of the Commission's proposals and provide test-beds for policy and technical measures. To ensure smooth interaction, the Commission could provide coordination and facilitation of the communication process and effectively contribute to avoiding competition, confusion and conflicts between the levels. A platform similar to the EU Adaptation Steering Group with focus on accompanying the implementation of the EU Adaptation Strategy beyond 2013 at city level could serve as a means of implementing the before-mentioned facilitation function.

3.4.4 Prioritised and tailored support, access to funding

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

local governments from more than 40 European countries have signed the Aalborg Charter, the 1994 founding document of the Campaign. Information from http://www.sustainable-cities.eu/

[23] **The Covenant of Mayors** is the mainstream European movement involving local and regional authorities, voluntarily committing to increasing energy efficiency and use of renewable energy sources on their territories. By their commitment, Covenant signatories aim to meet and exceed the European Union 20% CO_2 reduction objective by 2020. Information from http://www.eumayors.eu/

[24] The Nottingham Declaration has been succeeded in 2012 by the Climate Local initiative which supports carbon reduction and climate resilience. http://www.local.gov.uk/web/guest/the-lga-and-climate-change/-/journal_content/56/10171/3574359/ARTICLE-TEMPLATE

adaptation to channel tailored support to urban adaptation where it is most needed (because of high climate impacts or a low capacity for adaptation). The ASEC project will help to identify commonalities between cities regarding adaptation challenges and framework conditions, which can form the basis of more effective partnership working and knowledge sharing. National and European funding can play a crucial role in supporting and accelerating urban adaptation and, as with other climate proofing efforts, funding options should be developed jointly between the local and higher levels of governance.

Demonstration projects: LIFE+ programme

The LIFE programme (part of the Commission proposal for the Multiannual Financial Framework for 2014-2020) has a general objective to contribute to the implementation, updating and development of EU environmental policy and legislation by co-financing pilot or demonstration projects with European added value.

Box 10 Bologna adaptation plan funded via LIFE+

In July 2012, the Commission awarded €268.4m to 202 environmental projects under the latest round of LIFE+. 113 projects were related to environmental policy and technology development including 23 focused on climate change. While only four[25] out of the 23 climate change projects have adaptation as their core aim, there is the potential that other LIFE+ projects include some climate resilience considerations mainstreamed within the,. Of those four adaptation projects, just one has a specific urban dimension: developing a Local Adaptation Plan for the city of Bologna, Italy.

Under future LIFE+ proposals, the urban dimension of adaptation could be much more strongly supported – the Bologna adaptation plan project shows that LIFE+ can be used as a suitable instrument to support core work on urban adaptation, and LIFE+ requirements also ensure that learning will be shared and European added value in urban adaptation is demonstrated.

The Commission proposes to allocate EUR 3.2 billion over 2014-2020 to a new LIFE Programme for the Environment and Climate Action. The proposed new programme will build on the success of the existing LIFE+ Programme but will be reformed to have a greater impact, be simpler, more strategic and more flexible and have a significantly increased budget. The future LIFE Programme will include the creation of a new sub-programme for Climate Action, and new possibilities to implement programmes on a larger scale through "Integrated projects" which can help mobilise other EU, national and private funds for environmental or climate objectives. The sub-programme for Climate Action has three strands: climate change mitigation (focus on reducing greenhouse gas emissions), climate change adaptation (focus on increasing resilience to climate change), and climate governance and information (focus on increasing awareness, communication, cooperation and dissemination on climate mitigation and adaptation actions).

Under the new proposals, there is good potential for urban adaptation projects to be funded through LIFE+. Alongside structural and policy projects under the climate change adaptation strand, novel projects which explore, enhance and support the crucial aspects of the multi-level governance for urban adaptation could be funded under the climate governance and information strand. There is an immediate role for the Commission to identify ways to publicise LIFE+ opportunities and support Member States and local governments in the development of suitable project proposals. Climate-Adapt may be one suitable means for dissemination of this information.

[25] These are: Bulgaria – water management and habitat improvements in the face of climate change; Denmark – implementing a flooding-related adaptation toolkit; Greece – implementing a flash flood and forest fire risk assessment and management system; Italy – developing a Local Adaptation Plan for the city of Bologna

3.5 Filling knowledge gaps

Existing research, data, information and resources provide a valuable platform to progress the adaptation agenda in European cities, yet there are areas where additional intelligence would be useful. Major gaps include studies and research addressing issues such as:

- The international implications of climate change for European cities, for example disruption to food supplies, population movements.
- The potential costs and benefits of different adaptation response options.
- The potential for behavioural adaptation responses at the individual and organisational level.
- Guidance on approaches to integrate adaptation planning with other prominent agendas that command the attention of city governors. The links between climate change adaptation and mitigation is a prominent example.

There is great potential for the European level to provide resources and coordinated action for research to fill existing knowledge gaps in urban impacts and adaptation. Projects which involve several cities can enhance peer learning and exchange of experience and good practice while also seeking to address knowledge gaps. Recent lessons from research (Box) also emphasise that participatory and applied research is the most effective way to generate knowledge to support adaptation action – this has already been occurring to an extent for urban adaptation and should be the model for future European-funded research to support knowledge generation for urban adaptation. Projects led at European level, or within a multinational consortium, can harmonise approaches to data gathering, while coordinated research facilitated at European level can exploit opportunities more efficiently.

There are a number of options available here:

(a) Explore with Member States, and with Eurostat, the potential for better and wider reporting of relevant city level data to support assessments of impacts, vulnerabilities, hazards, etc. This would include a review of the Urban Audit and parameters which could be included there. DG REGIO is currently funding an update of the EVDAB database (see Box 3) hosted by JRC which may help here. However, such a discussion should consider key questions such as how the data will be used, and by whom, and the direct benefits of this data collection for implementation of actions to enhance climate resilience at city and European level.

(b) Explore with the EEA and ESPON, alongside JRC, the potential for improved data development for urban adaptation, and joint design of relevant projects. This could contribute to existing interactive maps and data on urban adaptation made available via the EEA-supported Eye on Earth Information Service[26].

(c) Consideration of the inclusion of some degree of urban adaptation data collection under the proposals for the Monitoring Mechanism Regulation.

(d) Continued discussion with DG Research to ensure European level research programmes and projects contribute to identified knowledge gaps for urban adaptation.

Some of the key topics for knowledge generation include:

- Regional projections on impacts and vulnerabilities, alongside global and European information
- Climate change data at the city scale; locally specific information on climate change impacts is acutely needed,
- Research linking climate change with societal and spatial patterns and future scenarios
- Pan-European data on adaptive capacity at city level are completely lacking

[26] http://www.eea.europa.eu/highlights/how-vulnerable-is-your-city

- Further work on indicators of urban vulnerability to identify regions and cities facing similar climate impacts, as well as hotspots for adaptation
- As in many aspects of adaptation, there is a lack of performance indicators or other benchmarks for measuring progress in adaptation in urban areas, or by city authorities.
- As in other areas, further research on costs and benefits of urban adaptation would be helpful for stakeholders building the case for action.

Box 11 Lessons from research on effective knowledge generation

Filling knowledge gaps: lessons from research

A number of lessons about the generation of effective knowledge to support adaptation have been emerging from research:

- Availability of data is no guarantee that it will be used effectively 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. Intermediaries between knowledge and action such as Climate-Adapt platform can help in this regard.
- Practical projects and applied research should be developed through a collaborative approach, where researchers, policy makers and practitioners work together to devise research questions of relevance to adaptation in cities. This should ideally be developed vertically (i.e. with connections through different spatial scales) and horizontally (i.e. with connections to different sectors and institutions working at the same spatial scale).
- Linked to the point above, research outputs developed without the initial involvement of the 'end users' are less likely to lead to effective outcomes. Knowledge gaps identified through research projects risk missing issues that are of greatest significance for stakeholders active in the field, for example municipalities and housing developers.
- Well-designed projects and programmes can address knowledge gaps while also facilitating collaborative peer learning and exchange of experience and good practice (e.g. EU INTERREG projects).

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