Socio-economic Impacts—Urban Complexes

22

Sonja Deppisch, Sirkku Juhola, Holger Janßen, and Michael Richter

Abstract

This chapter examines observed and potential future climate change impacts on socio-economic fields concerning urban complexes in the Baltic Sea basin. This is based on the literature review that focused mainly on English publications on climate change impacts, but included some publications in other languages on adaptation. In the Baltic Sea basin, there appears to be an imbalance between cities and towns that have been well studied with reference to climate change impacts, and cities or even regions for which there is hardly any published literature. For those publications that do exist, most concern the impact of a specific climate change effect (temperature rise, extreme events, sea-level rise) on a particular socio-economic field of an urban complex. The results of the literature review indicate that urban complexes in the Baltic Sea catchment are likely to experience climate change impacts within wide-ranging contexts: from urban services and technical infrastructure, to buildings and settlement structures and to the urban economy or population. Impacts will differ depending on the location of the urban complex: northern versus southern and coastal versus inland.

22.1 Introduction

This chapter examines observed and potential future climate change impacts on socio-economic fields concerning urban complexes. Urban complexes are human-dominated settlements with relatively higher population density than rural settlements. The term comprises cities and towns. Urban complexes are further characterised by high concentrations of buildings and built-up areas with consequent soil sealing, high concentrations of people and infrastructure as well as specific economic and cultural roles and activities. These factors render urban complexes particularly vulnerable to climate change impacts (Hunt and Watkiss 2011).

As every urban complex is characterised by a specific mix of social, ecological and economic interdependencies and its own settlement and building structure, it is difficult to generalise on scientific findings concerning urban complexes. Moreover, in the Baltic Sea basin, there seems to be an imbalance between cities and towns that have been well studied with reference to climate change impacts, and cities or even regions for which there is hardly any published literature. For those publications that do exist, most concern the impact of a specific climate change effect (temperature rise, extreme events, sea-level rise) on a particular socio-economic field of an urban complex. Systematic case studies are available but are mostly on the impacts of climate on human health (Analitis et al. 2008; Hajat and Kosatky 2009; Michelozzi et al. 2009; Rocklöv and Forsberg 2010; Baccini et al. 2011) and do not address the impact of sea-level rise on the various regions and cities of the Baltic Sea basin

S. Deppisch (✉)
Global Change and Land-Use Strategies, HafenCity University Hamburg, Hamburg, Germany
e-mail: sonja.deppisch@hcu-hamburg.de

S. Juhola
Department of Environmental Sciences, University of Helsinki, Helsinki, Finland

H. Janßen
Leibniz-Institute for Baltic Sea Research, EUCC—The Coastal Union Germany, Rostock, Germany

M. Richter
plan B:altic, HafenCity University Hamburg, Hamburg, Germany

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(Schmidt-Thomé 2006), or are global studies that happen to include cities from the Baltic Sea region (Nicholls et al. 2007). The impacts of climate change on the different socio-economic elements of urban complexes were mainly assessed through studies using global and regional climate models driven by the Intergovernmental Panel on Climate Change (IPCC) SRES scenarios. These scenarios were mainly combined with specific impact models. Only few studies drew conclusions from qualitative statements about how the future climate could evolve.

Climate change impacts are determined not only by specific features of the urban complexes themselves, but also by the general vulnerability of urban society, its socio-economic and institutional structure as well as infrastructure and its capacity to cope with impacts (IPCC 2007). A key challenge in the urban context is to identify the main future climate risks and vulnerabilities, both physical and social (Hallegatte et al. 2011b) and to develop and implement adaptation measures. The IPCC defines adaptation as 'adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities' (IPCC 2007). Thus, adaptation is a response strategy to climate change that involves a reduction in vulnerabilities and avoids potential damage, but also takes advantage of opportunities that arise from climate change (Smit and Pilifosova 2001). Because this chapter focuses on climate change impacts, it mainly assesses literature concerning impacts; less focus is given to adaptation.

Climate change is not the only phenomenon affecting climate in urban areas of the Baltic Sea region; the urban areas themselves influence their climatic conditions. Average temperatures rose due to urbanisation in the twentieth century in Uppsala (Bergström and Moberg 2002), Stockholm (Moberg et al. 2002) and St. Petersburg (Jones and Lister 2002). Furthermore, city growth, together with more heavy rainfall, can increase flood risk in urban areas, as in Helsingborg (Semadeni-Davies et al. 2008a). Urban areas are usually characterised by higher temperatures than the surrounding countryside; this urban heat island effect has been identified for various cities such as Stockholm (Moberg and Bergström 1997; Bolund and Hunhammar 1999; Gustavsson et al. 2001; Moberg et al. 2002), Malmö (Bärring et al. 1985), Gothenburg (Svensson 2002) and Uppsala (Moberg and Bergström 1997). Urban cold islands, where built-up areas were colder than areas outside the city core, have also been observed, for example in Gothenburg (Svensson and Eliasson 2002). These effects depend on urban land use. In Gothenburg, there are differences of up to 6.8 °C between land-use categories (Eliasson and Svensson 2003).

Moreover, climate change is not the only driver of change in urban complexes; they are also affected by demographic change, land-use change (see Chap. 25) and political and economic change, which themselves interact with climate change impacts. This chapter reviews the literature on climate change impacts on urban complexes; non-climatic drivers of change are not considered. Section 22.2 assesses the literature addressing past, current and future climate change impacts on urban complexes. Consideration is given first to the literature concerning urban services and technical infrastructure with an emphasis on wastewater management, drinking water supply systems and transport (Sect. 22.2.1), this is followed by an assessment of the small volume of data on climate change impacts on buildings, housing and settlement structure (Sect. 22.2.2), and then climate change impacts on different sectors of the urban economy and the urban population, with a brief consideration of adaptation measures, acknowledging that this is not the focus of the chapter (Sect. 22.2.3). The final conclusions of the assessment are outlined in Sect. 22.3.

22.2 Past, Current and Future Impacts of Climate Change on Urban Complexes

22.2.1 Urban Services and Technical Infrastructure

Infrastructure is the collective term for systems designed to meet human needs or, in other words, perform a service for the urban population by for instance delivering drinking water, carrying electricity or disposing of wastewater (IPCC 2007). The vulnerability of infrastructure to climate change depends on its state of development, resilience and adaptability (IPCC 2007). The climate change impacts reported to affect technical infrastructure the most (by physical damage) are sea-level rise, extreme events such as storm surges and changing precipitation patterns, particularly flooding caused by more frequent heavy precipitation events. Less research has been undertaken on the impacts of heat and drought in cities in the Baltic Sea basin, possibly due to the lack of risk for urban services and technical infrastructure in this region of moderate climate.

Sea-level rise is expected to be greater in the southern Baltic Sea than in the northern part (see Chaps. 9 and 14), and coastal cities such as Gdansk are expected to be particularly at risk. Dikes, port facilities, industrial areas, warehouses, transportation routes, drainage water systems, sewage plants, ground water recharge areas and energy infrastructure (such as heating pipes and power plants) are vulnerable (Schmidt-Thomé et al. 2006; Staudt et al. 2006; Virkki et al. 2006; Hilpert et al. 2007). Due to isostatic uplift in northern Baltic Sea areas (Chap. 9), net sea-level rise along northern coastlines over the next few decades is expected to be less than along southern coastlines, with less risk for cities such as Stockholm (Meier and Broman 2003; Graham et al. 2006; Viehhauser et al. 2006), Helsinki (Lehtonen and Luoma 2006), Pärnu (Klein and Staudt 2006) and Loviisa (Virkki et al. 2006). The projected increase in heavy precipitation and rapid snow melt events (Chap. 11) could cause surface flooding due to undersized urban drainage and sewage systems such as in Porvoo (Virkki et al. 2006), Loviisa (Virkki et al. 2006), Helsingborg (Semadeni-Davies et al. 2008b), Kalmar (Olsson et al. 2009), Lund (Niemczynowicz 1989), Stockholm (Sverige 2007) and Uppsala (Viehhauser et al. 2006). For Lithuania, as well as snow, frozen ground was considered to affect roads, communication infrastructure and buildings (Taminskas et al. 2005). Less attention has been paid to the impacts of storms and heat on urban infrastructure and services. Much of the literature on climate change impacts on urban infrastructure in the Baltic Sea region concerns coastal cities. This is probably due to concern over the combined threat of climate impacts such as sea-level rise and storm surges.

22.2.1.1 Wastewater Management

In Scandinavia, the projected increase in maximum precipitation would cause an increase in maximum discharge from urban areas (Arnbjerg-Nielsen 2011, see also Chap. 11) and the projected increase in mean temperature would alter the hydrological cycle (Chap. 5) owing to the higher water-carrying capacity of warmer air. Consequently, urban areas, which are characterised by fewer storage elements than rural basins, would respond with further decreases in storage capacity and enhanced run-off (Niemczynowicz 1989). The impacts of changing precipitation patterns on drainage and sewage systems have mainly been assessed by studies using hydrological modelling systems with various assumptions about future precipitation amount (Niemczynowicz 1989; Semadeni-Davies et al. 2008a, b; Nie et al. 2009). The modelling studies usually use climate scenarios based on different global and regional climate model results (Semadeni-Davies et al. 2008a, b; Olsson et al. 2009). Time scales range from single rainfall events to annual precipitation amounts (Niemczynowicz 1989; Semadeni-Davies 2004; Semadeni-Davies et al. 2008a, b; Nie et al. 2009; Olsson et al. 2009). In addition to climate change, other developments such as population growth and ongoing urbanisation can influence urban drainage systems due to increased soil sealing and removal of vegetation, among others (Semadeni-Davies et al. 2008a).

Inflow volumes to drainage and wastewater systems are likely to increase under a warmer climate and to increase the occurrence of surface flooding and overflow of sewage systems and associated environmental problems if current systems remain unchanged (Niemczynowicz 1989; Semadeni-Davies et al. 2008a; Nie et al. 2009; Olsson et al. 2009; Plósz et al. 2009). For Lund, although the storm water system is designed to accommodate further development of the city, increased rainfall intensity of 20–30 % would result in significant flooding problems for the city's sewage network (Niemczynowicz 1989). Semadeni-Davies et al. (2008b) showed that for Helsingborg, the impacts of urbanisation and climate change could be more than met by implementing current developments in urban water management. For coastal cities, high rainfall in combination with sea-level rise can cause further problems, for example sea water inflow into sewer and drainage water networks and into wastewater treatment plants (Lehtonen and Luoma 2006).

22.2.1.2 Drinking Water Supply Systems

Climate change may affect drinking water supply and lead to reductions in river flow, lower groundwater tables and, in coastal areas, to saline intrusion into surface water and groundwater systems. Climate change could also affect the system itself, including damage to pipelines through erosion caused by unusually heavy rainfall (IPCC 2007). Drinking water supply systems are at risk in several urban areas of the Baltic Sea catchment. Research has largely been undertaken for coastal cities only (Klein and Staudt 2006; Lehtonen and Luoma 2006; Schmidt-Thomé et al. 2006; Staudt et al. 2006; Virkki et al. 2006). This is possibly due to the threat of saltwater intrusion (through sea-level rise) into coastal aquifers serving as drinking water reservoirs. The level of risk depends on geographical location and thus on the rate of sea-level rise and distance of the drinking water aquifers from the coast. These risks were assessed using different sea-level rise scenarios (Klein and Staudt 2006; Staudt et al. 2006; Virkki et al. 2006). Studies did not identify risk of salt water intrusion into groundwater reserves important for drinking water supply in Helsinki (Lehtonen and Luoma 2006), but did identify a risk of contamination of drinking water wells in Pärnu (Klein and Staudt 2006).

Water quality and availability can also be affected by flooding, changing precipitation patterns and higher temperatures. Increasing precipitation amounts could be expected to result in a higher rate of groundwater recharge. Yet seasonal conditions can be very different. Less rainfall combined with higher temperatures in summer could affect the quality of drinking water; another risk factor is the impact of flood waters on water quality (Meier et al. 2006;

Ekelund 2007). More frequent heavy rainfall and rapid snow melt events are considered major risk factors for water quality in many Baltic cities due to strong soil erosion and the possibility of contaminants entering drinking water reservoirs (Klein and Staudt 2006; Meier et al. 2006; Schmidt-Thomé 2006).

22.2.1.3 Transport Infrastructure and Services

Transport and its various sub-sectors—road, rail, air and sea—are affected by changes in precipitation, thunderstorms, temperature, winds, visibility and sea-level rise. Within the transport sector, the main impacts of climate change are likely to be felt through extreme events, more so than through a steady rise in temperature (Love et al. 2010). To date, research on the impacts of climate change on transportation has been overshadowed by research on the mitigation of greenhouse gas emissions from this sector. Few studies specifically address impacts of climate change on transport in the urban context within the Baltic Sea catchment. Consequently, the impacts of climate change on transport infrastructure considered here are limited to sea-level rise and flooding caused by heavy precipitation or storm surges. Possible impacts from higher temperatures, such as damage to rail and road surfaces are conceivable, but according to the IPCC (2007), among all possible impacts on transportation, the greatest in terms of cost concerns flooding.

An ongoing rise in sea level would first affect roads and railways situated near the coastline of the southern Baltic Sea where the topography is low and flat, as in Gdansk (Schmidt-Thomé et al. 2006) or Malmö (City of Malmö 2011), but also in Tallin and Pärnu (for an 0.85- to 0.95-m sea-level rise in Pärnu; Kont et al. 2008), although Klein and Staudt (2006) stated that most roads and railways were safe in the 'high case' sea-level rise scenario for 2071–2100 (+1.04 m) in Pärnu (IPCC 2007 projected lower rises, see also Chap. 14). Sea-level rise combined with higher storm surges may cause more serious damage in coastal cities than a gradual rise in sea level alone (Klein and Staudt 2006; Schmidt-Thomé et al. 2006; Staudt et al. 2006). In more northern cities such as Stockholm, where sea-level rise is not considered a major problem, floods caused by heavy rainfall or rapid snow melt can inundate parts of the traffic infrastructure, independent of the rate of sea-level rise (Graham et al. 2006; Meier et al. 2006; Viehhauser et al. 2006; Ekelund 2007). Even for Gdansk, where the rate of sea-level rise is projected to be relatively high compared to more northern coastal cities, infrastructure is more vulnerable in the case of river floods or flash floods as experienced in 2001 when the central railway station and main streets were seriously affected (Staudt et al. 2006).

There may also be benefits associated with higher temperatures. Less salting and gritting would be required, and railway points would be likely to freeze less often (IPCC 2007). This may reduce municipal costs in winter.

22.2.2 Buildings, Housing, Settlement Structure

Extreme weather events associated with climate change pose particular challenges to human settlements because assets and populations are increasingly located in coastal areas, slopes, ravines and other risk-prone regions (IPCC 2007). The current and future location as well as the extent of settlement structures and infrastructure depends on many factors such as land-use planning, policy and jurisdictional decisions, and demographic and socio-economic developments. Such factors affect the scale of climate change impacts on settlement structures. In terms of buildings, housing and settlement structure in cities of the Baltic Sea basin, sea-level rise and changing precipitation patterns are likely to be the most significant impacts of climate change. In combination with potentially more frequent and intense storm surges, several cities are at risk. Some cities are already experiencing storm and flood damage (Virkki et al. 2006); for example, in 2005, a surge during the storm 'Gudrun' flooded densely populated areas of Pärnu and Haapsalu for about 12 h (Tonisson et al. 2008). Housing facilities and residential areas are at risk in cities where buildings are located close to the shore, such as Tallin (Hilpert et al. 2007), Malmö (City of Malmö 2011), Loviisa (Virkki et al. 2006), Gdansk (Staudt et al. 2006) and Aalborg (Hansen 2010). Cities such as Helsinki (Lehtonen and Luoma 2006) and Pärnu (Klein and Staudt 2006) may be only slightly affected by sea-level rise, if at all. In Helsinki, the impact of rising sea level on new housing areas is expected to be low because future sea-level rise is already being factored into the planning processes (Lehtonen and Luoma 2006). In Pärnu, the 'Shores and Banks Protection Act' helps to lower the impact of sea-level rise on housing (Klein and Staudt 2006), because construction closer than 50 m to the shoreline is prohibited in cities (HELCOM 1996). With regard to existing structures, the example of Pärnu demonstrates that the combination of sea-level rise and storm surges will increase vulnerability. If the projected sea-level rise is combined with a projected 100-year flood, 21 % of the area for single family houses and 9 % of the apartment house area of Pärnu would be in the flood affected area (Klein and Staudt 2006). Independent of sea-level rise, heavy rains and rapid snow melt are also expected to put settlements at risk due to the lower water infiltration capacity in urban areas and associated rapid surface run-off and/or overloaded drainage systems for cities such as Odense (Zhou et al. 2012), and as is already the case in Stockholm (Viehhauser et al. 2006).

Climate change could also have some benefits for this sector. For example, lower heating costs for buildings in winter. In Finland, winter heating costs are projected to decrease by 10 % in the period 2021–2050 (Venäläinen et al. 2004) and 20–30 % by the end of the century (Kirkinen et al. 2005). For urban areas, these cost savings could become even higher due to the urban heat island effect.

22.2.3 Socio-economic Structure

22.2.3.1 Impacts of Climate Change on Different Sectors of the Urban Economy

Estimating the impact of climate change on the urban economy is complex, and scientific studies on this subject are few. Hallegatte et al. (2011b) distinguished between direct and indirect impacts; the former related to the change in mean temperature or increases in extreme weather events. Indirect effects, such as disruption of the transport system, have knock-on effects on other economic sectors, often with economic losses. Indirect impacts of climate change are difficult to assess, even when the direct impacts of climate change can be estimated with some level of confidence. Although a systemic approach to assessing the impacts of climate change in cities is advocated, very few examples of this exist (Mechler et al. 2010). See Box 22.1 for a case study on the economic costs of climate change in Copenhagen.

Box 22.1 Case study of Copenhagen

Systematic assessments of the costs of climate change impacts are rare. A study by Hallegatte and co-workers illustrated the methodology for assessing the costs associated with climate change impacts in the urban context (Hallegatte et al. 2011a). The researchers adopted a simplified catastrophe risk assessment to calculate the direct costs of storm surges in Copenhagen, coupling this with an economic model.

The analysis concluded that, at present, Copenhagen is not highly vulnerable to coastal flooding owing to its high level of defence, while in the absence of protection, the losses would increase in the future. Thus, with no protection and a rise in mean sea level of 25 cm, total losses due to a 100-year event could be close to EUR 4 billion. With 100-cm mean sea-level rise, the costs could increase to EUR 8 billion.

Primary Sector

The primary sector of the Baltic Sea area economy is relatively unimportant in the urban context, as little agriculture, mining and forestry takes places in the cities. *Fisheries* have been an important source of economic revenue in the Baltic Sea region, although the importance of this sector has decreased. There are many uncertainties concerning the impact of climate change on fisheries in the Baltic Sea that relate to the physiological, ecological and social response (Mackenzie et al. 2007). *Agriculture* is not a significant source of economic revenue in the urban context but is important in the Baltic Sea region as a whole (see Chap. 21).

Secondary Sector

The secondary sector includes those industries that create a finished or a usable product, such as production or construction.

The *Industrial sector* can be impacted by climate change. A study of regional industries and the economic effects of climate change in the coastal and estuarine zone of north-western Germany found that industries were vulnerable to ongoing climate change impacts (Wang et al. 2010). These can affect regional gross net production through primary and secondary impacts. Extreme weather events and sea-level rise can have severe effects on industrial sites located at the coastline; an example being the former uranium enrichment plant in Sillamäe in Estonia which can pose a threat to society in a storm event (Kont et al. 2003).

The *Energy sector* is expected to be impacted by climate change on both the supply side and the demand side, although it is acknowledged that the impact of climate policy is likely to be greater than changes in mean temperature, for example (Mideksa and Kallbekken 2010). Impacts on the supply side are likely to be regionally specific (Mideksa and Kallbekken 2010). The availability of renewable resources is also affected by climate change, and the trend may be positive or negative. For example, the availability of forest biomass may increase (Lundahl 1995; see also Chaps. 16 and 21). Changes in wind and solar energy are not easy to project due to uncertainties concerning variability in winds and changes in cloud cover (Lundahl 1995, Chap. 11). Vulnerability of electricity companies to climate change impacts varies by country and is determined, among other things, by differences in national regulation (Inderberg and Løchen 2012).

Tertiary Sector

The tertiary sector consists of the service part of the economy.

Tourism is an important sector impacted by climate change. Urban complexes contain either integrated or remote areas for recreational activities as an intrinsic part of their system. Within the Baltic Sea region, the number of overnight stays is clearly linked to urban complexes and regions containing larger urban complexes show a significant increase in the number of overnight stays. Climate change has direct impacts on the physical, environmental and social resources for tourism as well as on the comfort, perception and safety of tourists (Patterson et al. 2006; Moreno and Amelung 2009). This affects the economic value of tourism. Tourism is of major importance for many coastal areas especially in the southern and south-western Baltic Sea area. For Mecklenburg-Vorpommern, for instance, tourism is the most important economic sector (StatA-MV 2010). As southern and south-western Baltic Sea regions dominate this sector, climate change impacts and the tourism-relevant characteristics such as sandy beaches are best studied in these regions. The literature mentions the following impacts in relation to the tourism sector:

- Beach wrack: organic material such as kelp and sea grass left on beaches by surf, tides and wind impairs the quality of tourist beaches. Beach cleaning is common but expensive (Dugan et al. 2003; Fanini et al. 2005; Davenport and Davenport 2006). Changes in water temperature may increase the occurrence of such material on beaches (Björk et al. 2008), but this has not yet been shown for the Baltic Sea.
- Demand: some aspects of future climate change within the Baltic Sea region (Matzarakis and Amelung 2008) might increase visitor numbers to Baltic Sea resorts. Demographic change may counteract this development but may also lead to more elderly and more climate-sensitive visitors (Coombes et al. 2009).
- Erosion: relative sea-level rise together with coastal abrasion and accumulation processes could lead to changes in the Baltic Sea coastlines (BACC Author Team 2008; Harff and Meier 2011; Chap. 20). These changes would differ from region to region (influenced by vertical crustal movement, sediments, coastal typology, exposure and protection status, for example) and may decrease the attractiveness and tourism capacity of coastal areas and/or increase costs for coastal protection measures.
- Changes in the terrestrial cryosphere (see Chap. 6) in terms of extreme winter conditions (both extremely high and extremely low temperatures, strong winds, rain or severe snowfall) would affect winter recreation and winter sports and are a problem for tourism operators in the northern Baltic Sea basin, as it was shown in a Finnish study (Tervo 2008).

The relation of tourism and recreational activities to climate change shows a broad variety of direct (e.g. sunbathing) and indirect links (e.g. habitat change for ecotourism). To date, there has been little research on this and especially on threats and opportunities for tourism due to climate change at the regional level (Moreno and Amelung 2009), including for the Baltic Sea region. As a result, quantitative statements concerning the effects of climate change on further development of the tourism sector are not available. In general, it is considered likely that the impacts of climate change for the tourism industry will be largely positive in the Baltic Sea region although the costs of maintaining the attractiveness of this region as a tourist destination may increase in the southern and south-western coastal areas (e.g. costs for beach cleaning, coastal protection and beach nourishment).

Private tourism operators have short planning horizons of 1–5 years. Adaptation to long-term processes such as climate change is therefore rarely discussed. At the same time, tourism plays a major role in the spatial development of many Baltic Sea regions, which have planning horizons of 10–30 years. According to Schumacher and Stybel (2009), tourism adaptation strategies are discussed at senior policy level, but there are few examples of adaptation strategies in practice. The wide range of possible adaptation measures (Schumacher and Stybel 2009) necessitates cooperation with adjacent sectors such as urban and regional planning, coastal protection, nature protection, health, water management and forestry.

Transport and its various sub-sectors of road, rail, air and sea play an important role in all economic sectors and are all affected by climate change. The costs of climate change on the transport sector are uncertain and difficult to calculate (Koetse and Rietveld 2009). There are likely to be changes in passenger and freight transport, as well as damage to existing transport infrastructure causing congestion in urban complexes. For example, a heat wave may have costly impacts on rail systems. The costs of a heat wave in London and surrounding areas in 2003 were estimated at GB 750,000 (Love et al. 2010). Maritime transport within the Baltic Sea would also be affected. Coastal transportation infrastructure is vulnerable to sea-level rise and more frequent storm surges. Disruption in supply chains can have a devastating impact on the regional economy. For example, it is estimated that Hurricane Katrina caused damage estimated at USD 1.7 billion and affected business in over 30 US states (Becker et al. 2012). In a global review of sea ports, port authorities stated that sea-level rise is likely to have negative impacts on their port that systematic adaptation is not taking place and that more research is needed (Becker et al. 2012).

The *insurance sector* is the part of the *financial sector* that is likely to be most important in terms of climate change as it can be a means to limit damage and spread risk. The insurance sector can help society to reduce the costs of adaptation by risk sharing, but climate change can also affect the insurance sector itself, causing the sector to consider heightened risk in setting premiums and risk management (Mills 2005). Insurers must therefore set premiums in a way that is financially viable by attempting to predict the frequency and severity of insured losses based on expected, rather than historical risk (Gasper et al. 2011). Insurance practices vary by country. Within the Baltic Sea region, flood damage is privately insurable in Germany, while there is no insurance for storm surges (Botzen and van den Bergh

2008). Although private flood insurance is common, most of the flood risk is carried by the government. In Germany, the government paid out EUR 9.1 billion for flood damage in 2002, while the private sector paid out EUR 1.8 billion (Botzen and van den Bergh 2008).

Retail and commercial services are likely to be affected by climate change through effects on the efficiency of the supply chain and distribution network, as well as on the health and comfort of the workforce (Gasper et al. 2011). To date, case studies have focused on effects on the transportation network with little research on the retail or consumer sectors (Gasper et al. 2011).

22.2.3.2 Impacts of Climate Change on Urban Population

The urban population is vulnerable to the impacts of climate change around the Baltic Sea. This section reviews the current literature, with a focus on human health and the well-being of different groups of society. Vulnerability differs between these groups, based on gender, age and race (Gasper et al. 2011). For example, children and the elderly can be more vulnerable to natural hazards. Health is an important factor of social well-being, and climate change can have both immediate and lasting impacts on the urban population with the main stressors being severe weather events and extreme heat and disease; for example an increasing incidence of tickborne encephalitis in endemic regions (Lindgren 1998; Gasper et al. 2011; Jaenson et al. 2012).

Thermal Stress

Even if cold stress seems more likely for northern countries such as Sweden (Svensson et al. 2003), under a changing climate, heat stress and the demand for air conditioning in houses, health-care institutions, schools and work places may increase in summer (Svensson et al. 2003; Rocklöv et al. 2009; Baccini et al. 2011; Thorsson et al. 2011). In general, the rate of climate change projected for the coming decades under most scenarios makes future acclimatisation uncertain and society may become more vulnerable due to increasing urbanisation and an ageing population (Hajat and Kosatky 2009).

Baccini et al. (2011) analysed the impact of heat on mortality in 15 European cities including Helsinki and Stockholm. They concluded that high summer temperatures affected European population health and that this impact is likely to increase in the future due to the projected increase in ambient temperature and the frequency, intensity and duration of heat waves. Several studies in the Baltic Sea catchment examined the effects of heat on human health and well-being. These include the impacts of moderate changes in ambient temperature on human health in Copenhagen (Wichmann et al. 2011), the relationship between high temperature and hospitalisation for cardiovascular and respiratory disease in the elderly population of twelve European cities including Stockholm (Michelozzi et al. 2009), the effect of heat on mortality in Stockholm and the Stockholm area (Rocklöv et al. 2009; City of Malmö 2011) and the link between the intensification of thermal and humidity conditions with unfavourable bioclimatic effects including heat stroke on the urban population of Cracow (Piotrowicz 2009). Seasonal differences were examined for Cracow (Piotrowicz 2009) and Gothenburg (Thorsson et al. 2011). Results indicated more problems with excessive temperature in summer and different outcomes for other seasons. A future decrease in temperature stress and better outdoor thermal comfort in winter, spring and autumn was announced for Gothenburg (Thorsson et al. 2011). A study in Cracow found that more frequent mild winters could cause the human body to lose the ability to adapt in colder winters (Piotrowicz 2009).

The *costs of heat events* can be significant. For example, preventing the loss of 18,000 lives in the 2003 European heat wave could have rendered benefits of up to USD 72 billion (Halsnæs et al. 2007). The heat waves across Europe in 2003 and 2010 indicate the vulnerability of urban populations. This is despite the high levels of development in Europe (Lass et al. 2011).

Identifying *social vulnerability* to heat waves is important. Urban populations are generally more vulnerable to heat waves than rural populations. Within the urban population, particularly vulnerable groups include elderly people and those suffering from cardiovascular and respiratory diseases (Piotrowicz 2009). A study on the effects of temperature on the elderly in Sweden confirmed the impact of heat on mortality (Rocklöv and Forsberg 2010). The study also showed that the effects of high relative humidity and high temperature were greatest in the most densely populated area, Stockholm (Rocklöv and Forsberg 2010). In circumpolar regions, the populations at greatest risk from the adverse health effects of cold are children, elderly people or people suffering from cardiovascular or respiratory diseases. Factors such as ageing and urbanisation may contribute to the rise in cold-induced health problems (Mäkinen 2007). Svensson et al. (2003), referring to Gothenburg, argued that climate at high latitudes presents a number of particular bioclimatic problems, both physiological and psychological, and cold stress is perhaps more important, since people in Scandinavia seldom complain that conditions are too hot.

Changes in Air Quality

A decrease in air quality is a health-related effect of climate change in cities. Cities often have higher concentrations of air pollutants than surrounding rural areas (Eliasson and Holmer 1990; Jacob and Winner 2009). During 2005–2007 in Sczcecin, thermal stress and overheating, together with high levels of air pollutants, accounted for a significant and direct threat to human health, especially for people suffering from circulatory diseases and problems with blood pressure (Czarnecka et al. 2011). Climate change may also have positive effects. For example, Tang et al. (2011) reported a trend towards lower average nitrogen dioxide concentrations in Gothenburg and concluded that changes in weather and climate had contributed to this reduction. See Chap. 15 for information on changes in air quality.

Storms and Floods

Storms can affect the urban population through property damage, through injury and loss of life, and may leave sections of the population homeless (Gasper et al. 2011). Early studies suggested that wind damage and related economic losses in Europe over the coming decades are likely to be caused by rare events rather than interannual variability (Schwierz et al. 2010). Insurance can act as a buffer to reduce losses. Insured storm-related losses depend on the frequency, nature and dynamics of storms, the vulnerability of values at risk, the geographical distribution of these values and the conditions of the risk transfer (Schwierz et al. 2010).

Flood events also pose a threat to urban populations. A social vulnerability index of river floods in Germany demonstrated that irrespective of climate change, the vulnerable populations currently include the elderly, the financially weak and urban populations (Fekete 2009). A study of two cities in Denmark concluded that increasing the urban drainage infrastructure was financially beneficial but that larger adaptation measures were not yet financially viable (Arnbjerg-Nielsen and Fleischer 2009).

22.2.3.3 Adaptation to Climate Change in the Urban Context

Many cities in the Baltic Sea region, such as Stockholm (Deppisch and Albers 2012) and Malmö (City of Malmö 2011), have identified particular climate change impacts and are now in the process of developing adaptation strategies, as for Rostock (Deppisch and Albers 2012).

Adaptation policy affecting urban areas around the Baltic Sea has been developed at the EU, national and regional level. An EU White Paper on adaptation was published in 2008 with the aim of developing a knowledge base for adaptation (Commission of the European Communities 2009). With the exception of Lithuania, Poland and Estonia, countries around the Baltic Sea have all published a national adaptation strategy. The extent to which national strategies affect urban areas depends on the legislation and planning systems of the individual countries.

Regional or local adaptation strategies are most important for planning adaptation at the city level. The regional level is important because this is the level at which policy is developed to regulate issues related to the built environment, buildings and the maintenance of infrastructure, especially in terms of drainage and piped water and the provision of services, such as fire protection, public transport and disaster response (Gagnon-Lebrun and Agrawala 2006).

Many Baltic Sea regions have developed adaptation strategies, but the processes involved can be hindered by uncertainties in the timing of climate change impacts as well as by a lack of knowledge and expertise (Ribeiro et al. 2009; Dannevig et al. 2012; Hedensted Lund et al. 2012; Jonsson et al. 2012; Juhola et al. 2012a; Nilsson et al. 2012). Further barriers include social and cultural inertia on individual and collective action and low priority of adaptation in relation to other policy agendas (Carter 2011) such as financial, economic and social aspects, as well as climate change mitigation (Deppisch and Albers 2012). In addition, weak links across policy and administrative levels and lack of a coherent policy agenda can also slow the adaptation process, as in Finland (Juhola and Westerhoff 2011) and Sweden (Storbjörk and Hedrén 2011), see also Annex 2.

Adaptive capacity plays an important role and is a prerequisite for a region's ability to adapt to climate change (Brooks et al. 2005). Adaptive capacity—the ability or potential of a system to respond successfully to climate variability and change—includes adjustments in behaviour, resources and technologies (IPCC 2007). This varies greatly at the regional level within the Nordic countries (Juhola et al. 2012b). Knowledge facilitated by links with universities and research projects funded by the EU plays an important part in enabling adaptation at the sub-national level, for example in Germany (Frommer 2001), Finland (Westerhoff and Juhola 2010) and Sweden (Deppisch et al. 2011). Although this has enabled some regions to pursue adaptation strategies, the uncertainty of climate change impacts has slowed overall action on adaptation (Storbjörk 2007; Carter 2011). Tools such as participatory vulnerability assessments and scenario workshops have been useful in communicating adaptation challenges to local stakeholders (Baard et al. 2012; Jonsson et al. 2012).

Examples of city level strategies in the Baltic Sea area are summarised in Table 22.1. A review of adaptation strategies at the city level found that climate change is likely to exacerbate existing urban problems as well as to create new ones (Committee of the Regions 2011). The report made several recommendations: (1) urban adaptation strategies must be developed and build on existing sectoral and cross-sectoral agendas; (2) urban adaptation requires new governance structures and innovative new solutions with the help of a wide range of stakeholders; and (3) no single type of measure is able to eliminate vulnerability to climate change, but a portfolio approach is likely to be most effective (Committee of the Regions 2011). Finally, the report emphasised that that approach should be staggered and iterative to achieve progress in the short term.

There are many gaps in research concerning adaptation in urban complexes. These include how to better understand

Table 22.1 Examples of city adaptation strategies in the Baltic Sea region (City of Copenhagen 2011; Committee of the Regions 2011; Albers et al. 2013)

City	Details
Copenhagen	Main climate change impacts and consequences: sea-level rise, intense precipitation, severe drainage problems and flash flooding. The city adaptation strategy is comprehensive and cross-sectoral. Key measures include expanding the sewer grid, establishing a sustainable drainage system, reservoirs to store rain and wastewater and green roofing. Copenhagen developed its climate adaptation plan in 2011
Helsinki	Main climate change impacts and consequences: sea-level rise, intense precipitation, drainage problems and flash flooding, wind and storm damage. The adaptation strategy for the metropolitan area of Helsinki is comprehensive and cross-sectoral. The strategy was approved in 2012
Stockholm	Main climate change impacts and consequences: river floods, intense precipitation, drainage problems and flash floods, drought and potential drinking water problems, higher temperature, heat waves and wind and storm damage. The city adaptation strategy, which goes further than an existing policy paper from 2007, will be comprehensive and cross-sectoral. Key measures are not yet agreed and the strategy is still pending (as of 2013)

Table 22.2 Expected impacts on urban complexes

Climate change effects	Northern Baltic Sea region		Southern Baltic Sea region	
	Coast	Inland	Coast	Inland
Ongoing change				
Temperature rise	Drinking water quality and availability affected			
	Less salting and gritting necessary and railway points will freeze less often			
	Lower costs for heating buildings			
	Greater heat stress and demand for cooling in summer			
	Affected concentration of air pollutants; may be positive or negative for population			
Temperature rise			Positive development of tourism sector but increasing costs for coastal protection	
Precipitation patterns	Drinking water quality and availability affected			
Sea-level rise	Lower net sea-level rise with resulting minor challenges		Increased vulnerability of main infrastructure	
			Further problems in combination with high rainfalls (e.g. sea water inflow into sewer and drainage water networks)	
			Drinking water quality and availability affected by saline intrusion in freshwater reservoirs	
			Roads, railways, housing facilities, residential and industrial areas near shoreline may be affected, with economic consequences	
Extreme events				
Heavy precipitation	Surface floods due to undersized urban drainage and overflow of sewage systems			
	Drinking water quality and availability affected by flooding			
	Threats to settlements due to missing water infiltration capacity of the urban ground			
Heavy precipitation	Inundation of traffic infrastructure		Inundation of traffic infrastructure	
Heat waves	Specific vulnerable groups in urban complexes, especially in bigger and more densely populated cities			
	Effects more severe in the southern Baltic Sea region			
Storm surges	Threats to industrial sites		Serious damage of transport infrastructure, especially in combination with higher sea levels, with economic consequences	
			Threats to infrastructure, buildings and life	

the governance frameworks and stakeholder networks to implement adaptation measures as well as addressing barriers to adaptation, while keeping in mind the possibility of maladaptations (Carter 2011).

22.3 Conclusion

Urban complexes in the Baltic Sea catchment are likely to experience climate change impacts within wide-ranging contexts: to urban services and technical infrastructure, to buildings and settlement structures and to the urban economy or population. Impacts will differ depending on the location of the urban complex: northern versus southern and coastal versus inland. Table 22.2 summarises the expected impacts on urban complexes.

It is difficult to draw general conclusions from the available literature. This is for two main reasons. First, in the Baltic Sea region, there is a lack of studies on specific topics that cover a number of urban complexes. Second, because every urban complex is a unique mix of infrastructure and urban services, inhabitants, natural resources and green spaces, built structures, location and economic and societal factors, it is difficult to generalise on the potential extent of climate change impacts from single case studies. Further generalisation would need an analytical reference framework that makes it possible to categorise the urban complexes under study.

It would be very useful to develop a typology for cities in the Baltic Sea basin that identifies the main potential climate change threats for each. This would imply cross-city studies focusing on the most comparable cases or on the most different cases, using typologies of cities built in line with specific characteristics such as location, size or socio-economic character. Such cross-city studies might have the goal of identifying the specific characteristics that render them more or less vulnerable to climate change impacts in the Baltic Sea basin.

It would be good for any follow-up assessment of climate change impacts on urban complexes to include aspects of urban ecology, as this is a very specific habitat. Also, food supply for urban complexes could be integrated into the socio-economic impact studies, as urban food systems, are likely to be affected by climate change, not just in relation to primary production (Tirado et al. 2010). For example, impacts on food processing, transport and trading are largely unknown, as are issues related to food security (Miraglia et al. 2009).

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