

Harnessing the green and blue:

an investigation of ecosystem-based adaptation measures in
four southern Swedish coastal municipalities

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Abstract

Climate change poses a current and ongoing threat to urban areas worldwide. Rising sea levels and the increased occurrence of heatwaves, heavy rainfall and related impacts due to erosion and landslides in particular are risks that are becoming increasingly urgent to address in the near future. Though Sweden is seen as a pioneer in sustainable city development, climate change adaptation is a relatively recent addition to the discourse, with previous focus primarily on mitigation and liveable cities. Where adaptation has been addressed at all, it has often been done by means of technical approaches and 'hard measures' using built structures and traditionally engineered 'grey infrastructure'. The emerging approach of 'ecosystem-based adaptation', which uses ecological structures and the services they generate as part of an overall strategy to adapt to the impacts of climate change, is investigated with regard to its potential to contribute to adaptation and risk reduction strategies and measures in Sweden. This thesis identifies existing and potential measures under an ecosystem-based adaptation approach by means of literature review, analysis of planning documents, and key informant interviews in four coastal municipalities in southern Sweden. The measures identified are categorised and analysed for their potential to contribute to a more integrated climate change adaptation—disaster risk reduction approach, and social, economic, environmental and climate change mitigation co-benefits are identified for each measure. Finally, barriers and opportunities to the implementation of these measures are discussed. While the range of measures planned and implemented show that there is awareness within the municipalities of the underlying principles of an ecosystem-based adaptation approach, integration into climate adaptation planning documents is varied, and adaptation measures in general are still in their infancy. Planners mention a variety of implemented measures which do not in fact have climate change adaptation as their primary focus, showing the diversity of reasons for engagement in ecosystem-based approaches in these municipalities. While this diversity is positive, there are elements from theory could contribute to a more comprehensive ecosystem-based adaptation approach. Examples of these are evaluative techniques for adaptive and risk-reducing structures to make their adaptation services more transparent, including multi-criteria analysis. The integration of stakeholder perspectives and management is a further element which could be harnessed more effectively in this process.

Acknowledgements

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1 Introduction

1.1 Problem framing

Current estimates predict that two-thirds of the world's population will live in urban areas by 2050 (UN 2012). Accelerating urbanisation contributes significantly to many global sustainability challenges including the surpassing of planetary boundaries with regard to the rate of biodiversity loss and climate change (Rockström & Steffen, 2009) particularly through land use change, intensive resource use and GHG emissions (IEA, 2008; Kennedy et al., 2009). Additionally, challenges at the city level include pollution and local health and environmental problems as well as local resource use, access and distribution among different groups of people (Anderberg, 2012). Sustainability challenges are characterised by multiple scales and facets and are complex in nature, with accumulated impacts on both local and global levels as a result of regional and local dynamics (Jerneck et al., 2010; Kates & Clark, 2001; Lüdeke, Petschel-held, & Schellnhuber, 2004). Climate change is one such challenge which is increasingly urgent to address.

Cities both drive and are impacted by climate change. Due to their high density of people, assets and infrastructure, urban areas are regarded as being at particular risk in relation to the impacts of climate change (Dawson, 2007; Hunt & Watkiss, 2010; Wamsler, Brink, & Rivera, 2013). While so-called 'developed' countries has been viewed as being robust to climate change impacts, they have also been impacted by extreme events (Beniston & Diaz, 2004; Robine et al., 2007). Research under the rubric of 'sustainable cities' has for a long time primarily emphasised the need to mitigate climate change, however, there has been a call to 'lift the taboo' (Pielke et al., 2007, p. 597) on the discussion of adaptation as a strategy to cope with the increasingly tangible impacts of climate change at the national and local level. It is now clear that adaptation actions to cope with climate change are unavoidable if we are to avert significant damage to human systems (Adger & Barnett, 2009; IPCC, 2014; Noralene Uy & Shaw, 2012). Sweden has shown a marked increase in the awareness of the need for adaptation across most, if not all, sectors since around 2006 (Dymen & Langlais, 2012). The final report of the Commission on Climate and Vulnerability, which was appointed by the Swedish Government in June 2005 to assess regional and local impacts of global climate change on Swedish society, (SOU, 2007:60) was an important step in bringing the awareness of adaptation onto the public agenda, stating in its conclusions "it is necessary to begin adapting to climate change in Sweden. The main features of the climate scenarios are, despite uncertainties, robust enough to be used as a basis". Following this report, the county administrative boards have been working on the

coordination of climate change at the regional level since 2009 (Swedish Government, 2009). However, in most municipalities, climate change adaptation measures are mainly technology- driven and 'grey' infrastructure-based approaches (Wamsler & Brink, 2014).

In order to address this increasingly urgent sustainability challenge, it is not sufficient to use the same approaches that have led to its creation. Technocratic and command-and-control models lead to lock-in and a pathological approach to natural resource management, (Holling & Meffe, 1996) and increasing competitiveness under the current neoliberal paradigm leads to a search for efficiency where buffers and margins are often minimized for short-term financial gains (Wamsler, 2014) and systems lose crucial redundancy and flexibility. At the local level, addressing sustainability challenges requires both bottom-up and top-down approaches, and new ways of planning that recognise and aid in moving towards sustainability. In particular, approaches are required which develop a more sophisticated understanding of urban social-ecological systems and the ways in which their components interact and are interdependent. Ecosystem services has emerged in recent years as a concept which aims to reframe human-nature relationships to emphasise the dependence of humans on natural ecosystems, defined as "dynamic complexes of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit" (MA, 2005). Although subject to criticism for its supposed economic focus, its potential to contribute to sustainable urban planning is increasingly recognised (Colding, 2011). Ecosystem-based adaptation is a strategy to incorporate ecosystem services to address the impacts of climate change. This approach has received increasing attention in research and in practice and is promoted on the basis of its ability to provide place-appropriate adaptation measures which can integrate local concerns and knowledge and at least in theory have the potential to transcend the limits of technological and hard infrastructure approaches by incorporating multiple benefits and reintroducing redundancy into social-ecological systems. The approach uses natural ecosystems and their components and services to adapt to the impacts of climate change. Ecological structures such as wetlands, coral reefs, mangroves, forest watersheds, and components of other green and blue spaces in rural and urban environments produce important regulating and other ecosystem services which provide enhanced human welfare outcomes in multiple areas (Colls, Ash, & Ikkala, n.d.; Jones, Hole, & Zavaleta, 2012). In Sweden, the Commission on Climate and Vulnerability has acknowledged the important role of ecosystems and their components in climate change adaptation, stating: "access to biodiversity and robust ecosystems is also an important resource for handling and surviving climate-related crises" (SOU, 2007:60).

The latest IPCC report (AR5) stresses the need to tackle urban risk through more effective adaptation planning, and highlights also the need to recognize synergies between climate change adaptation, mitigation, disaster risk reduction, and better ecosystem management (IPCC, 2014; Wamsler, 2014). While ecosystem-based adaptation is being pushed at the international level, there is as yet a lack of systematic implementation and evidence for its effectiveness (Doswald et al., 2014). EbA projects are scattered, and the variety of related terminology hinders systematic comparison of EbA measures (ibid.). Systematic reviews and collation of concrete examples of urban adaptation through improved ecosystem management are lacking (IPCC, 2014; Wamsler, 2014). There is a need to generate knowledge for academia and practitioners on how ecosystem-based approaches can and are being used for climate adaptation, including the extent to which they are integrated in current climate change adaptation planning.

Against this background, the purpose of this study is to generate knowledge on potential ways and benefits of combining climate change adaptation planning with ecosystem service planning.

1.2 Research questions

The overarching research question is : what are ways and benefits of combining ecosystem services and climate change adaptation planning?

Sub-research questions:

- 1) In what ways are ecological structures and their services used worldwide to adapt to climate change?
- 2) To what extent does current climate adaptation planning in Swedish municipalities incorporate ecosystem services?
- 3) What are characteristics of ecosystem-based adaptation measures planned for and implemented in terms of:
 - i) the primary goal of measures and their relation to core municipal work?
 - ii) the ecological structures they use?
 - iii) their contribution to climate adaptation and disaster risk reduction through the ecosystem services they produce?
 - iv) the co-benefits they actually or potentially produce?

These research questions are further operationalised in the analytical framework presented below.

2 Conceptual and analytical framework

2.1 Key concepts

2.1.1 *Ecosystem-based adaptation*

Ecosystem-based adaptation is the use of ecosystem services¹ as part of an overall adaptation strategy to help people adapt to the adverse effects of climate change (CBD 2009). It has been largely pioneered on the international agenda by the Convention on Biological Diversity (“CBD”), but has been recently given increased attention, particularly by the latest IPCC report (IPCC 2014). The concept of ecosystem services as “the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfil human life” (Daily, 1997, p. 3) has expanded rapidly in recent years (Hubacek & Kronenberg, 2013). Extensive literature exists on ecosystem services, their classification and valuation (See for example (Costanza et al., 1997; de Groot, Wilson, & Boumans, 2002; MA, 2005). Ecosystem services can be classified into four broad categories (Figure 1): (i) supporting services such as water cycling and biodiversity, (ii) provisioning services such as the supply of food, fuel and fibre; (iii) regulating services such as water purification and the regulation of local and global climate, and (iv) cultural services such as social relations and good health (MA, 2005).²

1 While some definitions use 'biodiversity and ecosystem services', here biodiversity is conceptualised as a prerequisite for the provision of final services to humans, and not as a service in itself. This is consistent with, for example, the CICES (2013).

2 The most recent classifications of ecosystem services divide them according to the types of ecosystem outputs directly consumed or used by humans as beneficiaries. These categories are 'provisioning', 'regulation and maintenance' and 'cultural' (CICES 2013). Although this represents the most up to date understanding of ES, these categories are less widely used, and municipalities still use the four main categories proposed by the MA. For this reason, the MA categories are used for the purposes of this study.

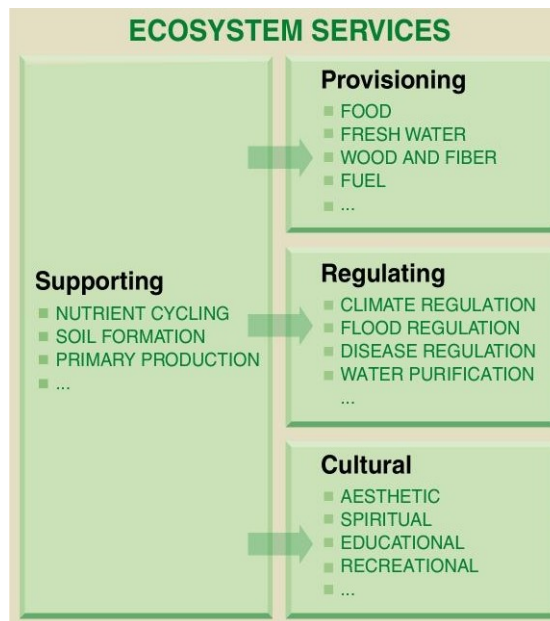


Figure 1: Ecosystem services classification from the Millennium Ecosystem Assessment 2005 with examples given of each of the four categories supporting, provisioning, regulating and cultural. Adapted from MA 2005.

Climate change adaptation is described by the IPCC 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, p. 27), a definition also adopted by the UNISDR (2009, p. 4).³ Under this definition, adaptation can conceivably encompass a range of actions or adjustments, from additions to or changes in physical or built structures, to altering industry practices (Bradshaw, Dolan, & Smit, 2004), to individual behavioural change (Grothmann & Patt, 2005; Lindblad, 2012), to changes in the processes of key institutions dealing with climate policy (Thompson et al 2005). In the context of planning, adaptation addresses key climate change-related risks within a defined geographical area in a cyclical process which involves i) assessing current risk and related vulnerability; ii) reviewing current practices, policies, and infrastructure; iii) assessing potential adaptation measures; iv) prioritising and implementing measures; and v) evaluating and managing implemented measures (Füssel, 2007; Länsstyrelserna, 2012; see also Moser & Ekstrom, 2010). Adaptation actions are often roughly divided into so called 'hard' and 'soft' approaches, with the former focusing on engineered structures, and the latter on information and institutional capacity building (Jones et al., 2012). Green or ecosystem-based measures can be considered either as a 'third way' (Jones et al., 2012;

³ It is contrasted with climate change mitigation, which addresses the causes of climate change through reductions in anthropogenic emissions of greenhouse gases (GHGs) or compensation for these emissions through the creation of carbon sinks (Tyndall Centre 2004; IPCC 2007; UNEP 2009).

Naumann et al., 2011) or as part of a more widely framed 'soft' approach (Kithiia & Lyth, 2011; Sovacool, 2011). In ecosystem-based adaptation approaches, ecological structures, their functions and the services they provide are used to increase the capacity of urban areas and their inhabitants to cope with the extreme events which will become more common in the future (Naumann et al., 2011), as well as providing the potential for multiple social, economic, and environmental objectives or 'co-benefits' to be achieved.⁴ Commonly mentioned adaptation services of ecological structures such as wetlands, vegetation, forests, grasslands, waterbodies and components of 'blue and green infrastructure' in cities such as parks, gardens, street trees and ponds (Bolund & Hunhammar, 1999; Niemelä et al., 2010) include regulating services such as water, soil, local climate and natural hazard regulation. However, further adaptation-relevant services, depending on the context, can include (but are not limited to) food and fibre provisioning, pest control and disease regulation, and preservation of genetic diversity (see e.g. UNFCCC 2012). Ecosystem-based adaptation has been conceptualised as helping to avoid the 'vicious cycle' of resource degradation and loss of human wellbeing (Figure 2).

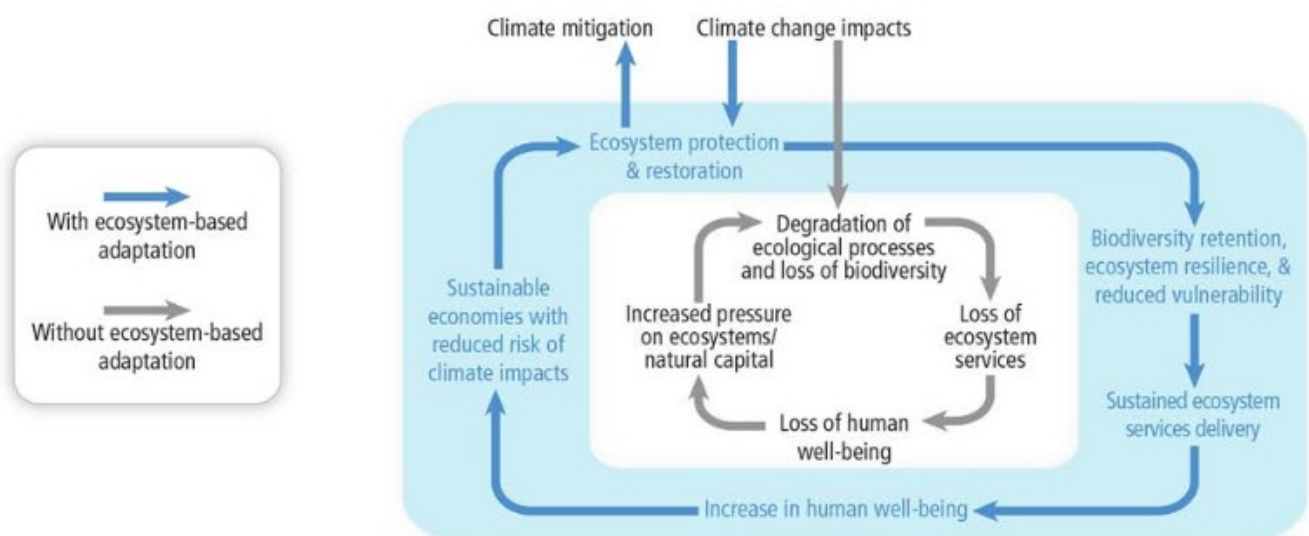


Figure 2: Conceptualisation of how ecosystem-based adaptation uses the capacity of nature to buffer human systems from the adverse impacts of climate change. The central panel represents a feedback processes without ecosystem-based adaptation, and the outer loop a 'virtuous cycle' resulting from ecosystem-based adaptation implementation. Taken from from IPCC AR5, adapted from Munang et al. (2013).

The implementation of an ecosystem-based adaptation approach involves the conservation, restoration and management of ecosystems to provide and sustain services that facilitate

⁴ Note that further elaboration of co-benefit types is given in the results of the literature review, but that these informed the design of the analytical framework.

adaptation both to climate variability and change (Colls et al., n.d.; IPCC, 2014). In this study, the relevant actor for the implementation of ecosystem-based adaptation is the municipality through their responsibility for urban planning, which is understood as place-based approach to problem solving that is aimed at sustainable urban development (Davoudi, 2009). Planning is carried out in an integrated organisation by an assembly of people from many different professional categories, such as urban planners, architects, landscape architects, ecologists, traffic planners, economists and sociologists (Löfvenhaft, Björn, & Ihse, 2002). So far, urban planning has not often been linked with the sustainable governance of ecosystem services, although it can be argued that “many services provided by natural systems resemble those services that urban planning strives for, that is, facilitating and distributing services for the general public, freely enjoyed on a day-to-day basis” (Colding, 2011, p. 229). Ecosystem services planning can be differentiated from conservation planning in that its focus is on evaluating many different functions and values of the ecological structures in the landscape. In practice, ecosystem services planning involves deciding on the amount, character and functioning of sites where natural processes exist and then conserving, restoring or creating these sites (Snep & Opdam, 2010; Staes, Vrebos, & Meire, 2010). The basis for this decision is the value(s), attributed to these sites by different actors such as citizens, entrepreneurs, or politicians (Snep & Opdam, 2010, p. 262).

2.1.2 Disaster risk reduction and climate change adaptation

The field and methods of disaster risk reduction ('DRR') are seen as increasingly relevant to climate change adaptation planning (IPCC, 2014; Wamsler, 2014). The scope of DRR work has expanded in recent decades from dealing with the immediate effects of extreme events to a more holistic approach which addresses the underlying drivers of risk. More and more synergies between the two fields are therefore recognised (EU, 2013; Thomalla et al., 2006), and a special report by the IPCC framed the relationship as follows: “adaptation is a goal to be advanced and extreme event and disaster risk management are methods for supporting and advancing that goal.” (IPCC, 2012, p. 36). In the risk reduction field, risk is commonly indicated by the formula $\text{risk} = \text{hazard} \times \text{vulnerability}$ (Wisner, Blaikie, Cannon, & Davis, 2004). Here hazard combines gradual onset changes or stressors such as sea level rise and increased climate variability and rapid onset or 'shock' events such as cloudbursts or sudden heatwave events (see Groven, Aall, & Berg, 2012). Vulnerability is defined as “the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard” (UNISDR, 2009, p. 30). Highly vulnerable areas are

those which are exposed to one or more hazards, and unable to resist their impacts (ibid).

2.2 Analytical framework

On the basis of the conceptual understanding described above, an analytical framework is presented (Figure 3) to assesses municipalities' adaptive practice on the ground. It is based on concepts used by UNISDR and IPCC, recent outcomes of, and advancements in, municipal adaptation studies (e.g. Wamsler & Brink, 2014; Wamsler, 2014) as well as evaluations of case studies on ecosystem-based adaptation measures (reported particularly in the UNFCCC database on ecosystem-based approaches to adaptation (UNFCCC, 2014)). The section below Figure 3 further explains the components of the analytical framework presented.

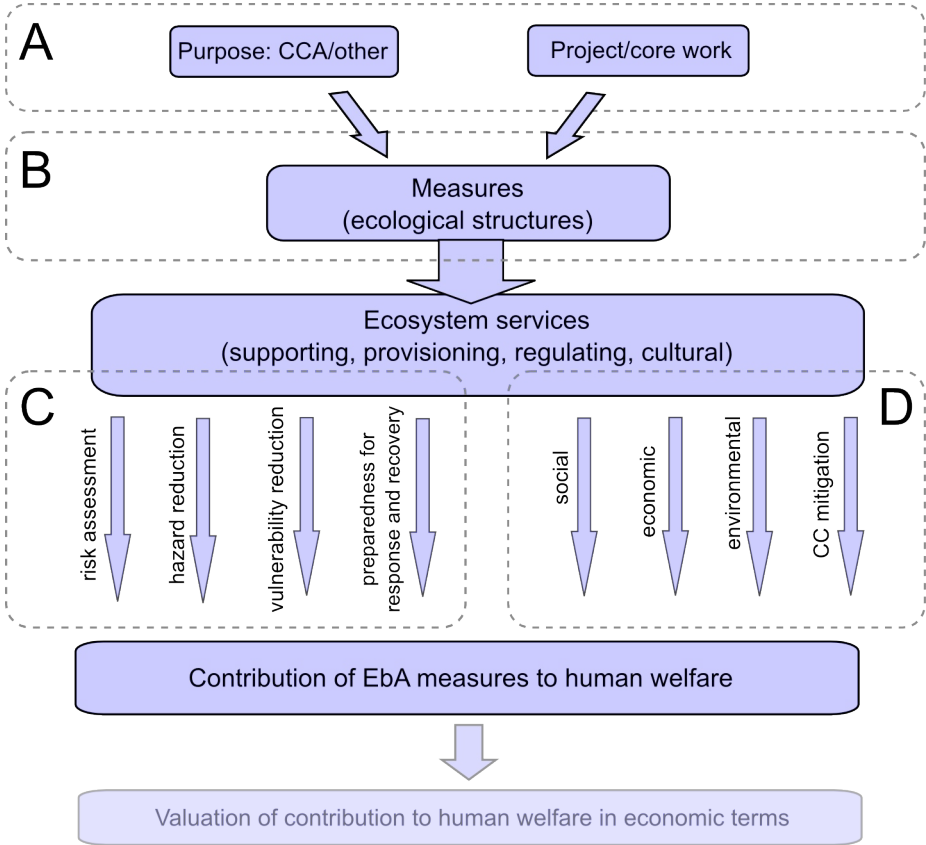


Figure 3: Framework for analysing municipal ecosystem-based adaptation measures on the ground. The small arrows in sections C and D represent the contribution made by different types of ecosystem services to human welfare in different areas. The last box 'valuation' is shaded to indicate that it is a potential, but not necessary, continuation of human welfare outcomes.

Figure 3, section A: The focus of this study is on actions undertaken in the context of urban planning by the relevant planning body, in this case the municipality. It is relevant in

this context to look at two things: firstly, 'planned' actions for adaptation which specifically target particular climate change impacts, which are represented by measures included in the climate change adaptation plans, as well as some of the measures mentioned in the interviews. Also relevant are actions undertaken for another purpose which have an adaptation outcome or 'co-benefit' (see e.g. Smith et al 2000; Eisenack & Stecker, 2011). Measures mentioned in the interviews are therefore categorised according to whether their purpose is climate change adaptation or another goal. This is considered relevant as many adaptation measures are taken without being explicitly framed as such (Berrang-Ford, Ford, & Paterson, 2011; IPCC, 2014; Tompkins et al., 2010). Additionally, as both ecosystems services and climate adaptation are ideally 'mainstreaming' topics (Vignola, Locatelli, Martinez, & Imbach, 2009), it is appropriate to analyse whether ecosystem-based adaptation measures are commonly implemented as part of core work or as 'add-on' projects.

Figure 3, section B: The recognition and maintenance of diverse ecological structures is an important part of retaining system functioning, and for this reason it is also useful to look at which ecological structures are conserved, restored or created in ecosystem-based adaptation. Urban ecosystems that are relevant to ecosystem services provision to urban areas can be classified as blue and green areas (Bolund & Hunhammar, 1999; Niemelä et al., 2010) and can include parks, cemeteries, gardens, urban allotments, urban forests, wetlands, rivers, lakes, and ponds. For the purposes of this study, these categories were used as a starting point, and subsequently adapted and expanded to a total of 15 different ecological structures.⁵

Figure 3, section C: The measures were analysed according to which of the four risk reduction stages they contribute to through the services they generate. Climate change adaptation measures to address risk can include the following⁶:

- (1) Risk assessment: measures that are aimed at assessing current and future risk⁷
- (2) Hazard reduction and avoidance: measures that reduce or avoid current and future hazard exposure (e.g. building walls to stop coastal surges reaching inhabited areas)
- (3) Vulnerability reduction: measures that reduce current and future susceptibility of the affected location so that it can withstand hazards (e.g. providing floodable basements in

⁵ For a detailed typology and description of ecosystem service providers developed for use in this study, see Appendix C.

⁶ Steps adapted from a categorisation developed in Wamsler 2014.

⁷ Although risk assessment does not in itself lead to reduction of risk and is rather an inherent part or precondition of identifying and designing risk-reducing measures (Coppola 2011; Wamsler 2014), it is here necessary to include it separately as several ecosystem related actions are still in the initial phases of assessment and have not progressed to the implementation of measures.

newly built houses)

(4) Preparedness for response and recovery: measures that establish or improve mechanisms and structures for disaster response and recovery (e.g. early warning systems and cooperative network formation)

Figure 3, section D: The articulation and evaluation of co-benefits of adaptation and increasing perceived benefits is considered to be a prerequisite for effective adaptation actions and helps identify the most efficient use of municipal resources, as well as motivating the provision of additional resources (Füssel and Klein 2004; Füssel 2007). For the purposes of this study, co-benefits are divided into the following categories: social, economic, environmental, and climate change mitigation. These categories reflect a co-benefit assessment structure that has been applied to many existing examples of EbA measures in practice, and the first three categories also reflect the stated aim of municipalities to balance social, economic and environmental interests in their planning process. Climate change mitigation is included as it is considered to increasingly important to examine the 'mitigation-adaptation interface' (Davoudi et al 2010; Howard 2009; Wamsler 2014; IPCC 2014) interrelationships between actions for climate change mitigation and adaptation and their synergies and conflicts. Many measures for ecosystem-based adaptation that involve creating or restoring natural structures will have climate change mitigation co-benefits due to carbon sequestration, for example.

3 Methodology

3.1 Research design

The study is a 'multiple case study' (see e.g. Cresswell, 1998; Yin, 2009). Data triangulation is used in comparing adaptation measures planned for and implemented, in this way the interviews (primary data) allow for comparison of the data from the planning documents (secondary data). The study focuses on the outcomes of municipal planning processes, and the unit of analysis is the ecosystem-based adaptation measures themselves, to which the analytical framework is applied.

A mixture of epistemological foundations underpins the research. The underlying philosophy blends positivism with interpretivism and constructivism through a blend of examination of scientific understanding of ecosystems and their components with an acknowledgement of multiply situated, culturally rooted perspectives that influence the

nature-society interaction (Bolin et al., 2000). Valuation processes in social-ecological systems use multiple and often conflicting languages, whereby values may be combined to inform decisions but may not be reduced to single metrics (Chan, Satter, & Goldstein, 2012; Martínez-Alier, Munda, & O'Neill, 1998).

3.2 Case study selection and description of case study area

Purposive sampling was used to choose the case study areas under consideration (Silverman, 2005). The study investigates measures in four municipalities: Lomma, Helsingborg, Kristianstad and Malmö. Municipalities are suitable for consideration as actions for adaptation are most appropriate for implementation at the local level where the specific effects of climate change are evident, and depend on context-specific geographical, political, social and environmental factors (Huq et al. 2006; Agrawal, Chhatre, & Hardin, 2008; Satterthwaite et al., 2007).

These municipalities are located in the Region of Scania in southern Sweden (Figure 4). Cases were sampled as likely 'success' cases for incorporating ecosystem services in climate change adaptation measures based on the profile of the municipalities within the region for their environmental or sustainability aims and initial contact with persons knowledgeable in the field in the Scania region. The use of extreme cases lowers the generalisability of findings. However, the identified variables (characteristics of measures, reasons for implementation, barriers and drivers) can aid in the understanding of the investigated cases and can also become the starting point for similar investigation of other cases. Firstly, Sweden was chosen due to the fact that the national level already acknowledged the importance of ecosystems and their components for climate change adaptation in 2007 (Swedish Commission on Climate and Vulnerability, 2007). Proactive civil servants have been identified as a key factor in the mainstreaming of climate change adaptation (Roberts, 2010). Selected municipalities have shown to be proactive due to their participation in two major research projects, namely "Ecosystem Services as a Tool for Climate Change Adaptations in Coastal Municipalities" (project period 2013 – 2016) and "Sustainable Urban Transformation for Climate Change Adaptation" (project period 2012 – 2017). Further indicators of environmental and sustainability performance and engagement are shown in Table 1 below.

Table 1: Indicators of environmental and sustainability related performance of the municipalities selected.

Municipality	Factors relating to environmental and sustainability performance
Lomma	Participation in Climate Alliance Pilot Group “Smart Cities and Communities”; sustainable urban development projects; Fairtrade City
Kristianstad	Participation in Climate Alliance Pilot Group “Smart Cities and Communities”; sustainable urban development projects; Fairtrade City
Malmö	LIFE-projects BUCEFALOS and BIOGASSYS on renewable energy; sustainable urban development projects; pledged to become carbon neutral; Fairtrade City
Helsingborg	Sustainable urban development projects including H+; Member of ICLEI network; biogas plant; Fairtrade City

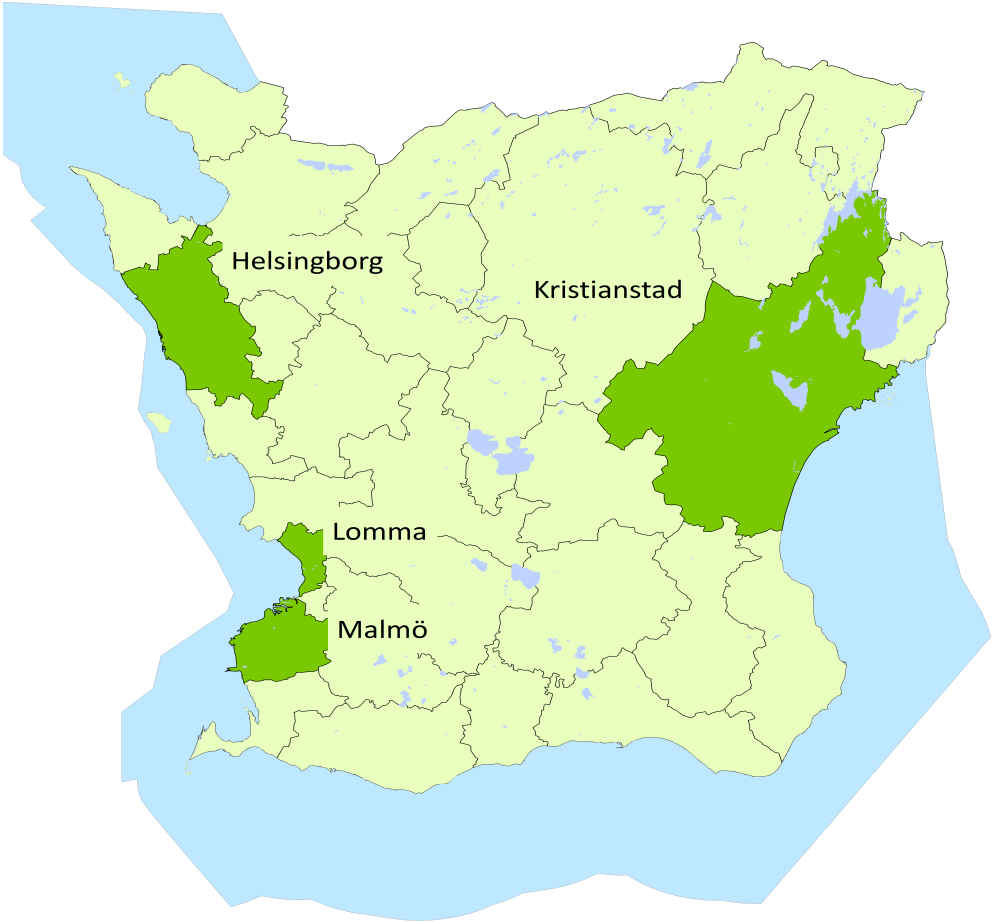


Figure 4: Map of Scania County and the location of the selected cases. The four municipalities (indicated in dark green color) are located at the coast of Scania, bordering the Baltic Sea (computed with ESRI (2011) based on data from the Centre for Geographical Information Systems at Lund University (n.d.))

The cases selected have common criteria of position in the same political Region (Scania) and coastal location, and therefore similar exposure to particular climate change related risks. Scania County is located in the southern most part of Sweden, and contains 33 municipalities (Region Skåne, 2014) ranging between 7000 (Perstorp municipality) and 300,000 (Malmö municipality) with an average of 38,000 inhabitants (Statistiska centralbyrån, 2013). Further information on population and geographical size is given below (Table 2).

Table 2: Overview of key statistics for selected case studies. Data sourced from Statistiska Centralbyrån (2010, 2013).

Municipality	Inhabitants	Land area in km ²	Inland water in km ²	Sea water in km ²	Total area in km ²
Lomma	22 496	55.52	0.82	33.86	90.2
Helsingborg	132 989	344.01	1.35	78.61	423.97
Kristianstad	81 009	1246.25	94.09	477.9	1818.24
Malmö	312 994	156.87	1.52	174.25	332.64

3.2.1 Planning context

Sweden has three democratic levels of governance: municipalities, county councils and the national parliament. The principle of self-governance has a long tradition in Sweden, and municipalities have an important role as employers, service providers and supervisory authorities (SALAR, 2013). A system of financial equalization ensures all municipalities and regional councils have equal economic conditions for pursuing their activities, regardless of size or population (ibid.). Swedish municipalities have a very long tradition of land-use planning, and the relationship between the central and local governments has changed from an emphasis on state control to greater decentralization (Khakee, 1996). They play key roles in addressing climate risk through their responsibility for local physical planning (Johansson, Svedung, & Andersson, 2006). County administrative boards supervise municipal planning and have a right to reject development plans if they insufficiently address health and security as well as, since 2008, erosion and flooding (Carina & Keskitalo, 2010). The key legislation for municipal planning are the Planning and Building Act, which specifies procedures in spatial planning, and the Environmental Code which concerns environmental aspects in spatial planning. Key spatial planning documents are i) comprehensive plans that provide strategic, non-legally binding orientation, generally focus on a time horizon of between 10 to 25 years, and are updated every four years (Sandström, Angelstam, & Khakee, 2006) and ii) detailed plans for built-up areas, which are legally binding. Table 3 provides an overview of the relevant legislation for ecosystem-based

adaptation.

Table 3: Legislation identified as relevant for ecosystem-based adaptation from government documents. The relevance of this information was confirmed through discussions in interviews.

Legislation	Implication for municipality	Source
The Law of extraordinary events	Identification of how risks and vulnerability will be decreased regarding preparedness for extraordinary events and report to the County Administrative Boards.	Lagen om extraordinära händelser 2006:544
Civil Protection Act		Lagen om skydd mot olyckor 2003:778
Planning and Building Act	Consideration of climate change risk in new development projects; counteract flooding and erosion and building permits should only be given if proactive measures are considered.	Plan- och bygglag (SFS 2010:900)
Environmental Code	For natural protection, building permits for relevant areas require environmental assessments	Miljöbalk (SFS 1998:808)

3.2.2 Climatic factors

Recent high profile climatic events in Sweden include a severe storm 'Gudrun' in 2005, which caused an estimated 21 billion Swedish Crowns (2.23 billion Euro) of damage in southern Sweden (SOU 2007:60). Sweden has been affected by several major floods in recent years (ibid.), and events like last year's Hurricane Sven point to ongoing vulnerabilities to the increasing risk of frequent and extreme storm events, although there is still uncertainty as to how much more likely these will be (ibid.; Länsstyrelserna, 2012). The five key climate change related risk areas identified for Sweden are higher temperatures, increased precipitation and higher sea levels, risks of landslides and erosion, and increased wind and storms⁸ (Länsstyrelserna 2012). For Scania, climate projections show a gradual increase in mean annual temperature, but with considerable variation between years. Average annual rainfall will gradually increase, again with considerable variation between years. At the end of the century the median of the estimates shows that annual rainfall will increase by about 20% compared to the reference period 1961-1990. Intensity of rainfall will also significantly increase. The number of days with dry soil

⁸ This last was, however, considerably caveated by Länsstyrelserna in their report, where they effectively said there was too much uncertainty to say for sure whether wind and storms would increase, but that "one should be prepared for new research results to alter this conclusion in the future"

conditions during the growing season will increase, with 50-80 more dry days by the end of the century. Water flows in the rivers will change over time, with increases in flow at the beginning and end of the year and decreases in spring and summer. Average water flow in summer will decrease by about 30%. The likelihood of a 100-year flooding event will increase by about 20% at the end of the century for the River Helge. In Scania, although the land level is rising by about a millimetre per year, the sea level is rising by about three millimetres per year, meaning that effectively, Scania is sinking (SMHI, 2011).

3.3 Data collection and analysis

3.3.1 Reviewed literature

A review of ecosystem services, climate change adaptation and ecosystem-based adaptation academic and 'grey' literature was carried out prior to designing the interview guide, to:

- i) elicit areas of interest for investigation;
- ii) to design the conceptual and analytical frameworks, and
- iii) to identify the types of measures being used in ecosystem-based adaptation approaches worldwide.

Targeted searching in the Scopus database with the keywords "ecosystem-based adaptation" produced 42 articles which were checked for the range of EbA relevant interventions they covered. The initial search uncovered several review articles, and these provided useful information of key characteristics of the research being undertaken in this field. Key findings from these review articles are presented in the results section as conducting an original systematic review was considered both unnecessary and beyond the time constraints of this study. To focus the scope of EbA measures to the Swedish context and bring in one of the few studies which makes systematic links to the disaster risk reduction framework, data from an existing recent review (Wamsler and Brink 2014) was used. This review identified a range of measures for ecosystem-based adaptation which are mentioned in the academic literature in relation to Sweden.

3.3.2 Planning documents

3.3.2.1 Identification of documents

Information collected through the initial literature review, complemented by publications of the Swedish Association of Local Authorities and Regions (SALAR), and information from the municipality websites helped to provide a background on the responsibilities and

planning processes of the municipalities. From this the important overarching planning documents, the Comprehensive Plans, were identified as a first step. Comprehensive Plans (Översiktsplaner) are publicly available for all municipalities and provide a good starting point for the strategic direction of the municipalities in question. For the purpose of the analysis, policy documents and plans related to climate change adaptation were identified through references in comprehensive planning documents and targeted searching on the municipal websites, starting with the sites of the planning departments. During the interview process, interviewees were further asked about the documents identified to get an impression of the practical importance of these in the work of municipal employees. Only the most recent municipal planning documents were examined (Table 4) to get the best impression of the current work being done in the target areas. All documents identified were accessible through the websites of the municipalities.

Table 4: List of climate change adaptation planning documents by municipality and planning department.

<u>Municipality</u>	<u>Name of document</u>	<u>Publishing department</u>
Helsingborg	Promemoria Climate Adaptation 2012	City planning and technical services department
Kristianstad	Climate strategy, goals and action plan 2011	C4 Technical administration
Malmö	Dialogue Memorandum 2008: Climate, sea level and planning	City planning office
Malmö	Action plan for climate change 2011-2014	Environment department
Lomma	<i>Action plan overdue, content discussed in interview</i>	Planning department, Municipal management office

3.3.2.2 Identification of relevant material within the documents

Climate adaptation documents were searched using ecosystem services related keywords to identify relevant extracts. For a comprehensive list of terms used for searching, see Appendix A. Where sections mentioned specific measures, these were extracted for later analysis.

3.3.3 Interviews

Data for the identification and analysis of the ecosystem services planning, climate change

adaptation, and general environmental policies or strategies in the study areas was collected through interviews carried out during January and February of 2014 in Lund, Helsingborg, Kristianstad and Malmö at the municipality offices and the municipalities under study, and in one case at Lund University. Names, municipalities and departments and job titles of the 10 interviewees are given below (Table 5).

3.3.3.1 Selection of interview subjects

Interview subjects were identified through their participation in research circles on both ecosystem services and climate change adaptation mentioned in the case study description. They were selected not to be representative of all planners or ecologists but as 'key informants' due to their particular expertise in the areas of overlap between climate change adaptation planning and ecosystem services planning. The interviews were semi-structured in nature, using a predetermined interview guide but allowing for many digressions and follow-up questions (Arksey & Knight, 1999) and a natural flow of discussion on the interrelated issues. The interviews varied in length depending on the available time of the interviewee but ranged from around one to two hours. Interviewees were asked to give background information about the use of the concepts ecosystem services and climate change adaptation planning, and what measures were carried out under the overlapping area defined as ecosystems based adaptation.⁹

In order to avoid the danger of misinterpretation of verbatim data, interviews were recorded with interviewee permission. Interviews were transcribed for further analysis according to the protocol developed by (McLellan, MacQueen, & Neidig, 2003). All direct quotes used were sent to interviewees for confirmation prior to publication, resulting in the amendment of several statements. Information given by interviewees in relation to ongoing measures, projects and plans was complemented with further information from documents referred to during interviews such as project descriptions, websites, or other reports or presentations which were provided by interviewees or accessed online after the interview. This material provided substantial further information on the measures implemented.

⁹ For the interview guide, see Appendix B. Interviews were conducted as part of an ongoing project with other researchers, therefore not all questions are directly related to this study, but provide information for other research and general background information. For the last interviewee in Table 5, interviewers were Ebba Brink and Christine Wamsler. For all others, interviewers were Christopher Luederitz, Lisa Niven and Christine Wamsler.

Table 5: interview subjects according to municipality, department and job title.

Name	Municipality	Department	Job title
Helena Björn	Lomma	Municipal management office, Planning department	Environmental strategist
Widar Narvello	Helsingborg	City planning and technical services department	Municipal ecologist
Fredrik Bengtsson	Helsingborg	City planning and technical services department	Municipal ecologist
Emilie Björling	Helsingborg	City planning and technical services department	Water planner
Claes Nihlén	Helsingborg	Environment department	Environmental strategist
Monica Axelsson	Kristianstad	City planning office	Planning architect
Rasmus Fredriksson	Malmö	Environment department	Project manager
Michael Palmgren	Malmö	Marine Science Centre	Founder and head of marine development
Annika Kruise	Malmö	Environment department	Sustainability strategist
David Snällfot	Malmö	Environment department	Project secretary

3.3.4 Analysis of measures identified

Measures identified in the planning documents and the interviews were systematically analysed through the following steps, which apply the analytical framework described earlier (Figure 3).

Step 1 – The measures mentioned were collated and categorised according to their primary goal, which could include climate change adaptation as a primary or secondary purpose, or not at all, and whether they are part of the core municipal work or part of a project (Figure 3, section A).

Step 2 – Measures mentioned were categorised according to the ecological structures they used (Figure 3, section B)

Step 3 – The measures are were classified according to their contribution to the elements of the four step disaster risk reduction approach as outlined in the analytical framework, and the ecosystem services generated by the measures which fulfil this function are given according to the classification in Wilkinson, Saarne, Peterson, & Colding, 2013. The primary hazard or climatic driving factor which they address is also given (Figure 3, section C).

Step 4 – The measures are analysed according to the co-benefits that they actually or potentially produce. These are divided into the following categories: social, economic, environmental and climate change mitigation (Figure 3, section D).

there is still no common and agreed definition for EbA, attempts have been made to articulate some of the underlying principles of the approach. A recent UNFCCC technical report on ecosystem-based approaches listed these as:

- (a) Understanding that maintenance of ecosystem services can be achieved by conserving ecosystem structure and function;
- (b) Recognizing that ecosystems are complex, have limits and are interconnected;
- (c) Understanding that ecosystems evolve and change over time and that ...ecosystems are naturally resilient and adaptable to some rates of change;
- (d) Ensuring participatory decision-making that is decentralized to the lowest accountable level, and is flexible and adaptive;
- (e) Managing ecosystems at the appropriate spatial and temporal scales;
- (f) Using information and knowledge from all sources, including traditional, local and contemporary scientific sources, and recognizing that such information needs to be gathered and validated.

A recent academic review of ecosystems based approaches to climate change for evidence of their effectiveness provides a useful starting point to systematise the range of EbA interventions on the global level. This review considered both peer reviewed academic literature and a selection of 'grey literature', mainly consisting of UNFCCC case studies. Interventions were not limited to those which explicitly used the term 'ecosystem-based adaptation', but used a wide range of search terms to retrieve examples which fitted the conceptual approach.¹⁰

4.1.2 Elements relevant to the analytical framework

Some key findings which relate to the elements of the analytical framework outlined above, and were used to inform the design of the framework, are presented below.

4.1.2.1 Purpose of ecosystem-based adaptation measures

The aims of measures identified in the review spanned multiple categories (Figure 6). 'Biomass growth and protection' is the most frequently mentioned aim, followed by 'water regulation' and 'disaster risk reduction' are the most frequently occurring categories. It is interesting to note that disaster risk reduction is shown as a separate category to aims such as flooding regulation. This represents a narrower 'sectoral' view of disaster risk reduction, in contrast to the broader definition used in this study.

10 For a full review protocol see Munroe 2011.

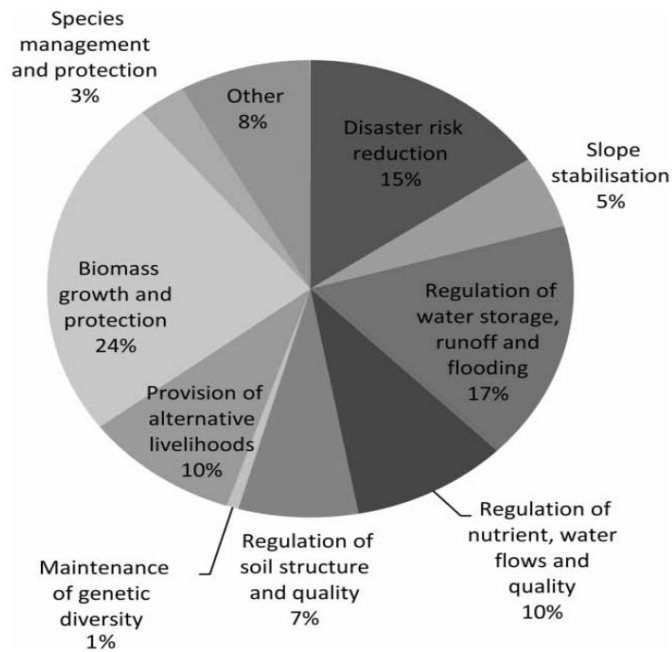


Figure 6: Aims of ecosystem-based adaptation-relevant interventions addressed in the articles, adopted from Doswald 2014.

4.1.2.2 *Ecosystems examined in ecosystem-based adaptation measures*

Worldwide generally, the major dominant 'habitat type' in relation to which EbA measures were found was 'arable/agroforestry', with wetlands, forests, and coastlines also significantly represented (Figure 7).

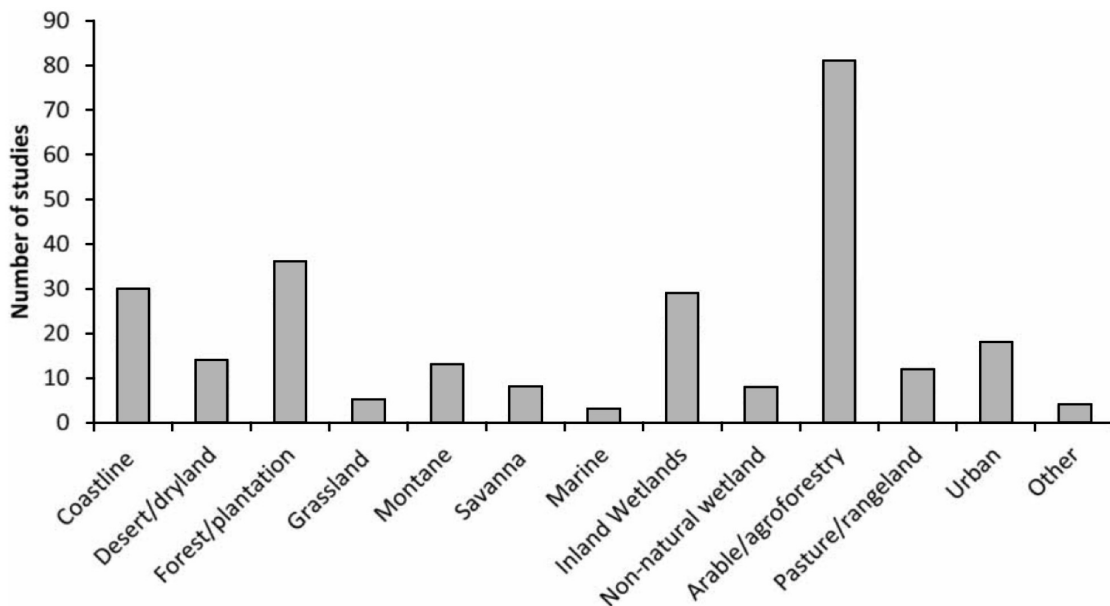


Figure 7: Major habitats from which evidence for ecosystem-based adaptation-relevant interventions was found in the literature. Adapted from Doswald et al 2014.

The results of the review above would appear to show that ecosystems based adaptation is not commonly applied in urban areas, and Figure 7 shows 'urban' as a separate habitat category. While it may be the case that urban areas have been understudied in relation to EbA approaches, urban areas and their surroundings can contain many different habitat types. These these are not always as easy to categorise as they can often be highly modified to suit the needs of urban dwellers (Sandhu & Wratten, 2013) and have not traditionally been recognised as 'pure' habitats or ecosystems. An important category of applications of ecosystem-based adaptation in regard to the urban environment is the use of 'urban green infrastructure', (Gaffin, Rosenzweig, & Kong, 2012) comprising all natural, semi-natural and artificial networks of multifunctional ecological systems within, around and between urban areas, at all spatial scales (Gómez-baggethun et al., 2013; Tzoulas et al., 2007), which deliver a range of ecosystem services which enhance the wellbeing of urban dwellers. This approach is frequently employed without use of the term 'ecosystem-based adaptation', and climate change adaptation is often not the primary purpose of its use, but the green and blue spaces in and around urban environments can provide many important services to aid in adapting to climate change and climate related impacts (Depietri, Renaud, & Kallis, 2011; Gaffin et al., 2012).

4.1.2.3 Contribution of ecosystem-based measures to climate change adaptation-disaster risk reduction

The review showed that EbA-relevant measures were undertaken to address a wide range of climatic hazards (Figure 8). Hazards addressed are obviously contextually driven and must be assessed in relation to the given location. The hazards identified in the review are all potentially relevant with regard to urban areas, but only one – urban heat island – applies exclusively in urban areas.

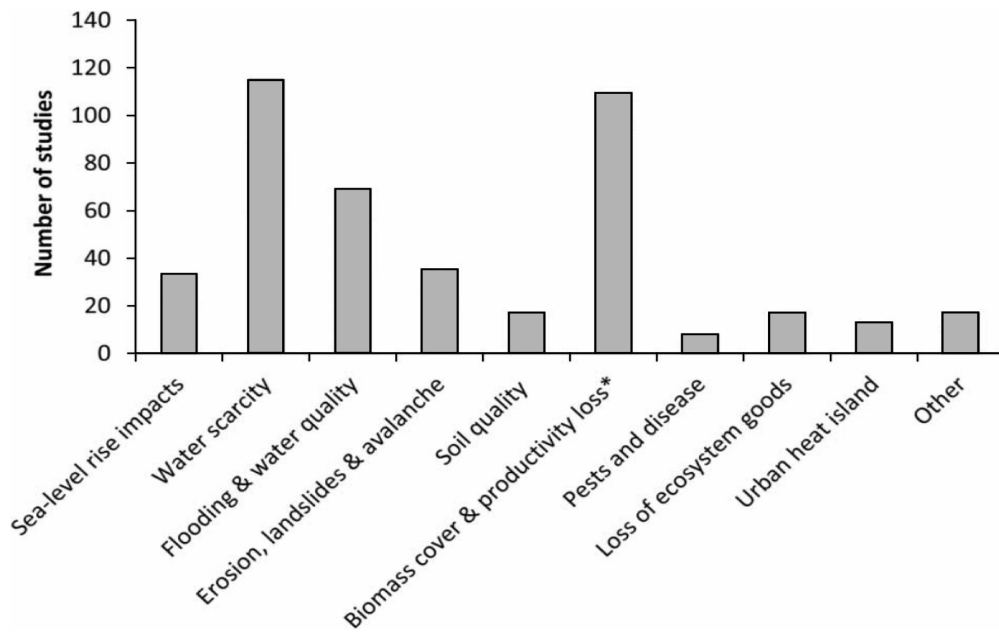


Figure 8: Hazards addressed through EbA-relevant interventions in the analysed articles in a recent review by Doswald et al 2014. There is no 'multi-hazard' category as measures which addressed more than one hazard were included in multiple categories

The review did not analyse in detail the contribution of particular measures to disaster risk reduction, however another recent review of academic literature by Wamsler and Brink (2014) applied this framework. This review described climate change adaptation measures undertaken by Swedish municipalities, showing that 'environmental measures' were the second most common type of measures after 'hard' or grey infrastructure measures when dealing with climate change. 'Green' measures described in studies are detailed in Table 6 below.

Table 6: 'Environmental' measures found in academic literature relating to Sweden. Adapted from Wamsler and Brink 2014

Measure	Hazard	CCA-DRR contribution
Beach nourishment (artificial sand supply) to prevent erosion	Erosion; Flood	Hazard reduction
Using certain types of vegetation to reduce erosion and floods	Erosion; Flood	Hazard reduction
Strengthening of natural coastal defenses (such as dunes or bays between headlands)	Erosion; Flood	Hazard reduction
Making a combined erosion control barrier and beach promenade along the coastline	Erosion; Flood	Hazard reduction (multi-purpose)
Measures to prevent damages from runoff water from upland neighboring municipalities with help of national grant (because neighboring municipalities did not want to contribute to the financing)	Erosion	Hazard reduction; Vulnerability reduction
Monitoring erosion-related changes in the coastline	Erosion	Risk assessment and awareness raising
Open stormwater management	Flood	Vulnerability reduction
Using the principle that stormwater should be handled locally, as close as possible to where it falls (green roofs are an example of this, see below)	Flood	Vulnerability reduction
Having an agreement with owner of a golf course to allow it to be temporarily flooded in case the city is threatened	Flood	Vulnerability reduction
Green roofs	Flood; Heat	Vulnerability reduction
Using bio-swales, rain-gardens, porous pavement in car parks, open water channels and ponds so that stormwater is treated separately from wastewater, and in an open system	Flood; Heat	Vulnerability reduction
Use of clean stormwater in green spaces—both as blue element or for irrigation	Flood; Heat	Vulnerability reduction
Having an existing buffer in the form of wetlands and floodable meadows surrounding the city (and giving higher importance to these)	Flood; SLR	Hazard reduction

In terms of hazards addressed by the measures presented above in relation to Sweden, flooding erosion and heat are the most dominant, with sea level the least often addressed. The 'environmental' measures identified contribute to hazard and vulnerability reduction, as well as occasionally to risk assessment and awareness, but are not considered to contribute directly to preparedness for recovery and response.

4.1.2.4 Co-benefits attributed to ecosystem-based adaptation measures

The global review identifies common social, economic, environmental and climate change mitigation benefits of ecosystem-based approaches worldwide, which are presented below (Table 7). These are supplemented with commonly mentioned specific co-benefits of urban green infrastructure identified in the literature.

Table 7: Common social, environmental and economic benefits of ecosystem-based approaches relevant for adaptation to climate change reported in the peer-reviewed and grey literature. Adapted from Doswald 2014.

	Social	Economic	Environmental	Climate change mitigation	Source
Co-benefits described in the global review	Improved and secure livelihoods; new or preserved recreation areas; social cohesion and community; empowerment; better quality land for food/cattle; better water security; and protection from damage and loss	Damage costs prevented; new or improved income; profits; savings compared to alternative adaptation approaches; and income from subsidies	Biodiversity conservation; land erosion and degradation prevention; habitat creation and restoration; and mitigation of micro-climatic variability	Carbon sequestration and mitigation benefits;	Doswald 2014
Supplementary significant UGI co-benefits	Positive physical and psychological health effects in humans; educational values; aesthetic value; contribution to food security	Increased property values	Air filtration and pollution mitigation; eutrophication reduction; noise attenuation		Maas et al. 2006; de Vries et al., 2003; Takano et al., 2002; Tanaka et al., 1996; Colding 2011; Tzoulas 2007; Stoffberg et al. 2008, 2010; Luttik 2000; White & Gatersleben 2011

4.2 Climate change adaptation documents

4.2.1 Overview of plans and planned measures

Of the municipalities investigated, Helsingborg, Malmö and Kristianstad have existing climate change adaptation plans. Lomma does not have an existing climate change adaptation plan, but is in the process of creating such a plan. This is overdue, but should be finished around in summer 2014. The content of this plan was discussed in the interview.

Throughout all of the documents, there is an awareness of multiple climate related hazards including sea level rise, cloudburst and flooding, coastal erosion, drought, and heatwaves. Measures addressed in the adaptation plans cover a range of types including 'physical' or hard measures -- such as (moveable and permanent) coastal barriers, dykes and walls, expanding traditional stormwater systems and district cooling infrastructure -- 'soft' or institutional, social and economic measures, such as inventories of vulnerable infrastructure, establishment of cooperative councils with neighbouring municipalities to coordinate disaster response, revising food distribution and communication systems -- and green/ 'environmental' measures which can be classified as measures for ecosystem-based adaptation.

In the Kristianstad Climate Strategy of 2011, the biggest risk is identified as risk of flooding and there is a strong focus on walls and pumping systems to address this risk. Actions listed in the Climate Strategy document can be roughly divided into 'hard', 'soft', and 'green' measures to get an initial overview of 'on the ground' actions being planned for, however examination of the documents reveals that most of the measures proposed in fact relate to inventory of existing infrastructure, monitoring of climatic conditions and initial risk assessment actions. Of the measures mentioned in the Kristianstad climate strategy, roughly 40% can be described as risk assessment and awareness and infrastructure inventory, 20% represent 'hard' measures such as dikes and walls, pumping systems, expansion of district cooling infrastructure and expanding stormwater pipe dimensions, 30% can be described as 'soft' institutional, behavioural and socio-economic measures such as warning systems for heat waves, coordination of groundwater management via a water council, providing advice to landowners on flood protection measures, revisiting of communication routines during power outages and so on (Kristianstads kommun, n.d., pp. 15–19). The remaining approximately 10% of measures can be called 'green' or environmental measures, and are listed in the table below for further analysis.

In Malmö, the 2008 Dialogue Memorandum deals overwhelmingly with 'hard' measures against flooding and sea level rise such as dikes, permanent and moveable walls, and culverts (with 70% of measures mentioned falling into this category), however the Memorandum states that it is to be considered as a "preliminary sketch for installations for Malmö's coastline" (Malmö stad, 2008, p. 16) and that Malmö still needs a comprehensive strategy for sustainable protection. Although the Memorandum is not a plan with a fixed 'end date', it is to some extent superseded by the 2012 'Action Plan for Climate Change' which is more detailed and adopts some of the recommendations from the 2008 Memorandum. This Action Plan suggests a wider range of measures for adaptation. The plan makes connections to ecosystem-based adaptation principles, with multiple linkages to the importance of green and blue spaces and also makes explicit links to other planning documents considered to be relevant to adaptation planning in the future, such as goals in the environmental programme, and stormwater policy. In terms of concrete measures that are proposed, the plan is less detailed than the Kristianstad climate strategy, making direct comparison difficult, but lists seven measures which are the first steps on climate adaptation in Malmö and have the highest priority. Of these, two relate to EbA measures, three are higher level 'soft' institutional measures, one risk analysis, and one relates to hard coastal protection measures (Malmö stad, 2012, p. 5)

In Helsingborg, the Climate Action Promemoria was commissioned to fulfil a requirement in the current Comprehensive Plan, and this was written in 2012 following the Plan's adoption. The promemoria describes some impacts on farming and forestry, but the main focus is water, flooding and rising sea levels, especially in relation to urban areas. The PM lists "Measures to address the climate" (Helsingborgs stad, 2012, p. 36) and "Suggestions for action plan" - the former lists a large number of measures, but more speculative in nature and subject to "investigation and many considerations" (p. 38), and the latter provides the intended ongoing work. A rough breakdown of specific measures mentioned shows about 10% risk assessment, awareness and infrastructure inventory and monitoring, 40% 'hard' measures, and 25% each for 'soft' and 'green' measures in the first part of the document, but with regard to ongoing action plan it is 40% risk assessment 20% hard measures, 30 'soft' and 10 'green'.

In Lomma, the adaptation plan is overdue. The municipal website states that it will be available in 2012, but during the interview it was made clear that it is now being finalised and is due for release in summer 2014, after the time of writing. The plan will divide adaptation measures to be taken by sector and assign different departments responsible.

An important part of the plan will be the setting of a minimum building height for the coastal area, as is the case in other municipalities. This will be at a height of three metres above sea level. The plan will recommend inventory of existing infrastructure such as bridges and built structures which could be affected by future climatic hazards such as rising sea levels. Measures considered in the adaptation plan include built structural protection for the Lomma Bay coast, including a significant bulwark structure in the south of the bay. The Interviewee in Lomma was the responsible for the adaptation plan and CCA in general in Lomma, and stated that there were not likely to be ecosystem-based measures in the plan, but that the plan was likely to contain primarily built 'grey infrastructure' measures. It was the Interviewee's opinion that "adaptation in Sweden is engineering based somehow, and everything we learn, we learn from Holland, and there everything is concrete". Measures for preparedness for response and recovery were also intended to be part of the upcoming plan.

4.2.2 Ecosystem-based adaptation measures

Each of the adaptation documents examined contained descriptions of measures which fall within the outlined definition of ecosystem-based adaptation, with the exception of the Malmö Dialogue Memorandum 2008. The term 'ecosystem services' was present three times in the Malmö Action Plan for climate change (in which context the services 'better stormwater management', 'increased biodiversity', 'recreation', 'microclimate' and 'other ES' were mentioned). The term was not used at all in the 2008 Dialogue Memorandum, the Helsingborg climate adaptation PM or the Kristianstad climate strategy. Nonetheless, using other key terms to aid in searching, such as 'green space', 'biodiversity', and key ecological structure terms such as 'forests' and 'wetlands' (see Appendix C), the following measures were identified in these plans as contributing to an ecosystem-based adaptation approach according to the definition given in the conceptual framework (Table 8).

Table 8: Measures mentioned in climate change adaptation documents analysed according to analytical framework. Partly adapted from (UN 2013) with information from this study.

Municipality	Measure	A		B	C			D
		Primary goal CCA?	Separate Project/core work?	Ecological structure	Hazard addressed	DRR-CCA contribution	Relevant DRR-CCA ES	Co-benefits: social, economic, environmental, CC mitigation
Kristianstad	Preservation and planting of trees for shade and cooling in urban areas.	Yes	Core work	Street furniture; gardens	Heat	Hazard reduction; vulnerability reduction	Local climate regulation	Aesthetic, health, property value, habitat provision, carbon sequestration
	Planning for an amended forestry on municipal land, for example less spruce, preparedness for drainage and erosion control, for humus leakage.	Yes	Core work	Forests	Flooding; erosion; increased nutrient leakage due to increased rainfall	Hazard reduction; vulnerability reduction	Erosion regulation and soil retention; water regulation	Increase capacity of forestry industry and sustain profits
	Actions against erosion for example strengthening sand dunes and beaches with sand	Yes	Core work	Coastal areas	Erosion	Hazard reduction	Erosion regulation and soil retention	Recreational, aesthetic
	Development of conservation with respect to a change in the natural environment.	Yes	Core work	Multiple	Multiple	All	Multiple	Recreation, habitat provision
	Comprehensive and detailed planning take into account the need for shade, vegetation, and amended stormwater management	Yes	Core work	Multiple including trees, vegetation, ponds and ditches,	Heat; flooding	Risk assessment; vulnerability reduction	Multiple including local climate regulation and water regulation	Aesthetic, health, habitat provision
Malmö	Riseberga stream as a pilot project for Malmö to become a national demonstration area of climate adaptation.	Yes	Project	wetlands, rivers, ponds and ditches	Flooding, sea level rise	Risk assessment; hazard reduction; vulnerability reduction	water regulation, natural hazard regulation,	water purification and waste treatment; nutrient cycling (N and P); habitat provision

Municipality	Measure	A		B	C			D
		Primary goal CCA?	Separate Project/core work?	Ecological structure	Hazard addressed	DRR-CCA contribution	Relevant DRR-CCA ES	Co-benefits: social, economic, environmental, CC mitigation
Malmö	Models for new construction and refurbishment, which rewards greenery and recognises more qualities such as green area.	Yes	Core work	Multiple including trees, vegetation, gardens, green roofs and walls	Multiple including flooding and heat	Vulnerability reduction	water regulation; local climate regulation	Health and aesthetic values; property value; habitat provision; carbon sequestration
	Advice to property owners on how they can increase the level and quality of green space	Yes	Core work	Multiple including trees, vegetation, gardens,	Multiple including flooding and heat	Risk assessment, Vulnerability reduction	water regulation; local climate regulation	Educational, health and aesthetic values; property value; habitat provision
Helsingborg	Design and creation of new wetlands on agricultural land which can be used as irrigation dams to balance the increased heat and drought of summer	Yes	Core work	Wetlands	Drought, heat	Vulnerability reduction	Water regulation	Habitat provision
	Restoring wetlands and retaining reservoirs in the landscape for plant and animal life	Yes	Core work	Wetlands	Flooding	Hazard reduction; Vulnerability reduction	Water regulation	Habitat provision
	More trees and fountains in the urban environment	Yes	Core work	Street furniture, vegetation, ponds	Heat	Vulnerability reduction	Local climate regulation	Health and aesthetic values; property value; habitat provision; carbon sequestration
	Good prevention plans for green areas, forests and parks to prevent major tree loss as a result of heat/drought and new diseases and insect infections	Yes	Core work	Forests, parks, other green areas	Heat, drought, pests and disease	Risk assessment, hazard reduction, vulnerability reduction	<i>More info needed on specific management measures and related ES. Could involve pest and disease regulation functions of ecological structures</i>	<i>More info needed on specific management measures and ES involved</i>

Municipality	Measure	A		B	C			D
		Primary goal CCA?	Separate Project/core work?	Ecological structure	Hazard addressed	DRR-CCA contribution	Relevant DRR-CCA ES	Co-benefits: social, economic, environmental, CC mitigation
Helsingborg	Green roofs; Green roofs which involve an extra layer of green plants	Yes	Core work	Green roofs	Flooding, heat	Vulnerability reduction	Water regulation, local climate regulation	Habitat provision
	Preserve green space/avoid building in green areas	Yes	Core work	Multiple including parks, coastal areas	Flooding, heat	Vulnerability reduction	Water regulation, local climate regulation	Aesthetics, health and recreation, habitat provision
	Beach nourishment and protection of existing beaches and dunes from erosion	Yes	Core work	Coastal areas	Erosion, coastal surges	Hazard reduction	Erosion regulation, natural hazard regulation	Recreation, habitat provision
	Nature reserves in coastal areas	Yes	Core work	Coastal areas	Multiple including erosion, SLR	Hazard reduction, vulnerability reduction	Erosion regulation, natural hazard regulation, water regulation	Recreation, habitat provision
	Information campaigns and new routines to reduce climate-related risks to outdoor recreation in forests and fields, such as the prevention of forest fires and falling trees and insect-borne infections	Yes	Core work	Forests, parks	Forest fires related to drought and heat, pests and disease	<i>More info needed on specific management measures and ES involved</i>	<i>More info needed on specific management measures and related ES. Could involve pest and disease regulation and natural hazard regulation functions of ecological structures</i>	Recreation, education, habitat provision
	Construction of corridors/blue-green streaks in the landscape and fauna passages under highways	Yes	Core work	Multiple including parks, forests, vegetation	Multiple including flooding and heat	Vulnerability reduction	Water regulation, local climate regulation	Recreation, habitat provision

4.2.2.1 Ecological structures used in ecosystem-based adaptation measures

EbA measures mentioned in the climate adaptation plans were assumed to have a primary goal of adaptation, and to be intended as part of the municipality's core work. With regard to the remaining elements of the analytical framework, measures covered a wide range of ecological structures, with trees and vegetation (the most generic category), combined with forests, coastal areas and parks making up over half of structures mentioned (Figure 9).

Ecological structures used in planned measures

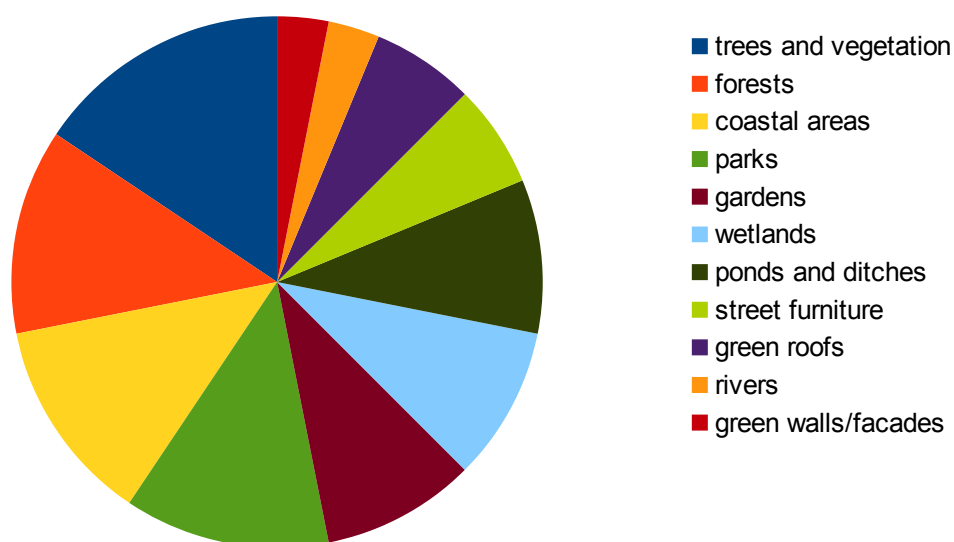


Figure 9: Overview of ecological structures used in relation to ecosystem-based adaptation measures mentioned in climate change adaptation planning documents.

4.2.2.2 Contribution of ecosystem-based measures to climate change adaptation-disaster risk reduction

Heat and flooding were dominant in terms of hazards addressed by EbA measures (Figure 10), and measures contributed most frequently to vulnerability reduction and hazard reduction, and occasionally to risk assessment.

Hazards addressed by planned measures

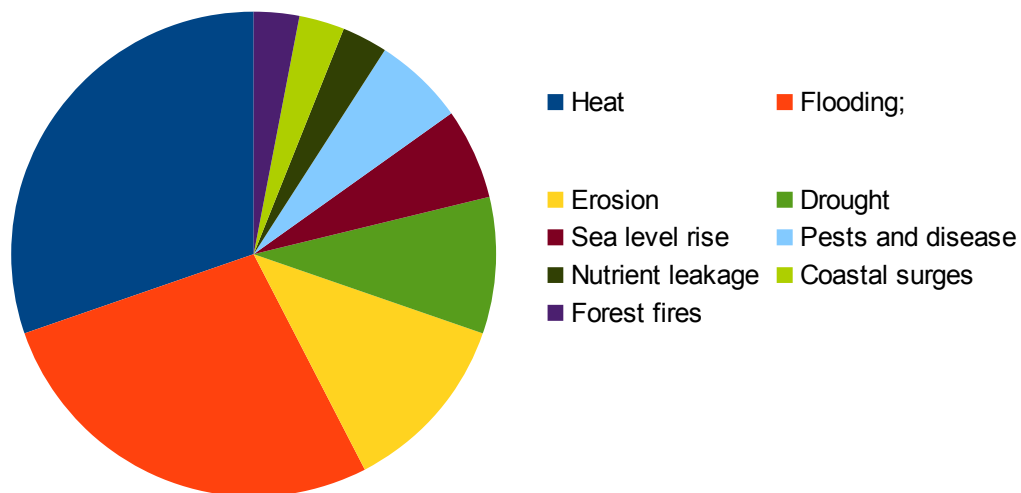


Figure 10: Overview of hazards addressed by ecosystem-based adaptation measures mentioned in climate change adaptation planning documents.

4.2.2.3 Co-benefits of ecosystem-based adaptation measures

Many co-benefits were identified in relation to the measures found in the planning documents. The ones that were identified as potentially the most significant contributors were habitat provision, recreation, aesthetic and health values.

4.2.3 Perspective on CCA documents

The adaptation plans examined reflect the fact, supported by information from the interviews, that climate change adaptation planning is still in its infancy in the municipalities under examination, with little adaptive action having been undertaken as yet. An exception is Kristianstad, which has an already implemented infrastructure of pumps and drainage systems, however these are designed not primarily in reaction to climate change related hazards but due to geographical and historical context of that municipality which involved drainage of low lying land for agriculture.

The measures identified above are useful in generally identifying the types of strategies being considered by the municipalities with regard to climate change adaptation, however they are quite highly varied in terms of their specificity, making direct comparisons difficult. It is also not always easy to find information to assess the extent to which they have been implemented. In Helsingborg, it was felt that departments attempted to follow the plan (although this was not successful always and everywhere) and a working group was established in December 2013 to ensure follow up on the plan (Interviewee, Helsingborg).

In Malmö, the existing climate adaptation plan was created by the Environment Department as a deliverable for an international project called 'GRaBS', Green and Blue Space Adaptation for Urban Areas and Eco Towns, which explains its much higher focus on green and blue qualities. This was an EU funded project aimed at integrating climate change adaptation into regional planning and development. However, the climate change action plan is "not really being used" (Interviewee, Malmö), and work with the GRaBS project has come to an end. As another interviewee put it: "At the planning stage a lot of things can be activated, but when it comes to concrete implementation it can look very different" (Interviewee, Malmö). For this reason it was considered appropriate to complement the examination of the plans with interviews, to see in what ways the visions and actions articulated in the plans resulted in concrete, 'on the ground' measures, and what measures were implemented with EbA relevance, outside the immediate context of CCA planning.

4.3 Interviews

4.3.1 Overview of climate change adaptation work, and incorporation of ecosystem services

Interviewees expressed that climate change adaptation was a recent development and was still subject to different or unclear understandings. Often, there was no clear responsible party and work was done by whoever took responsibility: “no one has been assigned a formal mandate to structure the work on climate change adaptation ... and it may therefore be unclear where responsibilities lie” (Interviewee, Malmö). Where responsibility had been allocated, this was often to physical planning rather than environmental departments, resulting in a focus on built structures and specific types of risk. In general where work was being done there was still a lot of focus on risk and vulnerability assessments and gathering data on climate impacts, which is supported by the focus on these aspects in the planning documents. The connection between adaptation work and ES was recognised by all interviewees, but none claimed to explicitly use the term 'ecosystem-based adaptation'. Other related concepts such as 'blue and green infrastructure' and 'multifunctional spaces' were spontaneously mentioned. Often, climate change adaptation was mentioned as being only one of the many benefits of creating and restoring natural structures, with one interviewee stating: “when you use green and blue infrastructure, you get all, or most of the ecosystem services at once ... not only in adaptation but you get health, biodiversity, you get everything” (Interviewee, Malmö). Multiple interviewees expressed that ES terminology described what many considered themselves to have already been doing for a long time, but also the ability of the concept to differentiate types of values was considered to add additional supporting arguments for their work (all Interviewees) and is “very pedagogical” (Interviewee, Malmö). When asked about municipal responsibility for ecosystem services and ES planning, interviewees expressed that this was not necessarily the domain of one person or group, but that the aim was to make it a cross-cutting topic with relevance for the every day work of multiple departments and devolved responsibility. It was clear, however, that interviewees located in environmental departments and with backgrounds in ecology felt that “strong pushing” and continuous advocacy from their departments was necessary to keep raising awareness of ecosystem services in planning.

4.3.2 Ecosystem-based adaptation measures identified

Measures for EbA that were mentioned in the interviews divided according to the categories in the analytical framework (Table 9). Additional related measures which did not fit within the framework yet are considered to be relevant for EbA approaches are described afterwards.

Table 9: Measures mentioned in interviews analysed according to analytical framework. Partly adapted from (UN 2013) with information from this study.

Municipality	Measure	A		B	C			D
		Primary goal CCA?	Project/core work?	Ecological structure	Hazard	DRR-CCA contribution	Relevant DRR-CCA ES	Co-benefits: social, economic, biodiversity, CC mitigation, other
Malmö	Risebergabäcken project – ecological stormwater management and runoff water mitigation; using TEEB method to value ES	Primary goal of water quality, stormwater management, and evaluation of ES. CCA as a co-reason	Project	wetlands, rivers, ponds and ditches	Flooding, erosion	Vulnerability reduction	water regulation; natural hazard regulation;	Skogholms meadows as a national demonstration area - significant education and knowledge value, combined with recreational values; water purification and waste treatment; nutrient cycling (N and P); habitat provision
	Creation of 'urban habitats'	Primary goal is biodiversity increase. CCA mentioned as a relevant co-reason	BiodiverCity project	multiple structures e.g. trees, vegetation	Multiple hazards including increased precipitation and heat waves	Vulnerability reduction	Water regulation; local climate regulation	Aesthetic values, health values; habitat provision
	Planting of trees in streets	Primary goal is biodiversity increase. CCA mentioned as a relevant co-reason	BiodiverCity project	Street furniture	Multiple hazards including increased precipitation and heat waves	Vulnerability reduction	Water regulation; local climate regulation	Aesthetic values, health values; habitat provision, carbon sequestration
	Installation of green facades and walls	Primary goal is biodiversity increase. CCA mentioned as a relevant co-reason	BiodiverCity project	Green walls/facades	Multiple hazards including increased precipitation and heat waves	Vulnerability reduction	Water regulation; local climate regulation	Aesthetic values, health values; habitat provision
	Installation of green facades and walls	CCA as primary goal	Green tools for urban climate adaptation project	Green walls/facades	Increased precipitation and heat waves	Vulnerability reduction	Water regulation; local climate regulation	Aesthetic values, health values; habitat provision

Municipality	Measure	A		B	C			D
		Primary goal CCA?	Project/core work?	Ecological structure	Hazard	DRR-CCA contribution	Relevant DRR-CCA ES	Co-benefits: social, economic, biodiversity, CC mitigation, other
Malmö	Design and implementation of green roofs	Primary goal is biodiversity increase. CCA mentioned as a co-reason	BiodiverCity project	green roofs	Multiple hazards including increased precipitation and heat waves	Vulnerability reduction	Water regulation; local climate regulation	habitat provision, carbon sequestration
	Design and implementation of green roofs	CCA as primary goal	Green tools for urban climate adaptation project	green roofs	Increased precipitation and heat waves	Vulnerability reduction	Water regulation; local climate regulation	habitat provision, carbon sequestration
	Design and implementation of green roofs	Primary goal is enhanced stormwater management No aim of CCA originally	Ekostaden Augustenborg since 1998 (originally funded by national level investment program)	Green roofs	Flooding	Vulnerability reduction	Water regulation	habitat provision, carbon sequestration
	Design and implementation of 'mobile plant systems'	Primary goal is biodiversity increase. CCA mentioned as a relevant co-reason	BiodiverCity project	Vegetation	Multiple hazards including increased precipitation and heat waves	Vulnerability reduction	Water regulation; local climate regulation	Aesthetic values, health values
	Three-dimensional greenery (3 sites)	Primary goal is biodiversity increase. CCA mentioned as a relevant co-reason	BiodiverCity project	vegetation	Multiple hazards including increased precipitation and heat waves	Vulnerability reduction	Water regulation; local climate regulation	Aesthetic values, health values

Municipality	Measure	A		B	C			D
		Primary goal CCA?	Project/core work?	Ecological structure	Hazard	DRR-CCA contribution	Relevant DRR-CCA ES	Co-benefits: social, economic, biodiversity, CC mitigation, other
Malmö	Miljöbyggprogram Syd – use of 'green space factor' to put environmental demands on builders who want to build on municipality land.	Primary goal is reduced environmental impact. Mitigation is a main reason, but not adaptation. Program mentions 'dealing with future climate change' as a co-reason	Core work, applies whenever municipality land is sold	green roofs, gardens, vegetation, trees	Multiple hazards including increased precipitation and heat waves	Vulnerability reduction	Water regulation; local climate regulation	Aesthetic values, health values; habitat provision
	Management of mussel banks in the sea outside of Malmö	Multiple investigations in relation to mussels, primary aim to develop a nutrient cycling loop: mussels absorb runoff nutrients and could be harvested to return nutrients to farmland. CCA not directly mentioned as a goal.	Project funded by state and EU money (no municipality money)	Marine area	Sea level rise (?), coastal water surge	Hazard reduction	Natural hazard regulation	Mussel farming, provision of biogas and fertiliser from organic material, which are provisioning services – food and fuel; significant ecosystem to protect as northern Europe's largest mussel bank, A6; nutrient cycling (N+P); water quality regulation; global climate regulation in reducing fossil fuel emissions
	Stormwater management – ecological/ open stormwater systems	Primary goal is improved stormwater management	Projects such as Augustenborg, increasingly part of core work	Rivers, ponds and ditches	Flooding	Vulnerability reduction	Water regulation	Economic: sharing of costs with other municipal departments, such as streets and parks; reduces need for expensive replacement and upgrading of traditional pipes
	Stormwater management – incentives for water users to alter their practices, including disconnecting downspouts and installing water features	Primary goal is improved stormwater management	Core work of municipal water utility	Gardens	Flooding	Vulnerability reduction	Water regulation	Educational and knowledge value. Aesthetic value for gardens with added water features. Creation of ponds or bird baths can give new habitat for bird or aquatic species

Municipality	Measure	A		B	C			D
		Primary goal CCA?	Project/core work?	Ecological structure	Hazard	DRR-CCA contribution	Relevant DRR-CCA ES	Co-benefits: social, economic, biodiversity, CC mitigation, other
Malmö	Redirection of water from stormwater system to Ribersborg area on the waterfront	Primary goal of area is use as a recreational area; CCA not directly mentioned as a goal	Core work	Park, coastal area	Flooding; SLR	Hazard reduction; vulnerability reduction	Water regulation	Highly valued recreational area; park; related biodiversity values in terms of habitats for birds and other coastal species
Lomma	Preservation of underwater eel grass meadows to prevent coastal erosion	Primary goal to conserve marine ecosystem and prevent erosion. CCA not directly mentioned as a goal	Core work	Marine area	Erosion, coastal water surge	Hazard reduction; vulnerability reduction	Erosion regulation; natural hazard regulation	Important habitat for marine species especially in terms of nurseries
	Green infrastructure – 'recreating parts of the old landscape'	Primary goal of reducing flooding. CCA not directly mentioned as a goal	Core work	Multiple including vegetation,	Flooding	Vulnerability reduction	Water regulation	Health, carbon sequestration
	Höjeå project and related river and catchment-based projects – many measures at multiple sites including construction of dams and wetlands, river restoration, habitat-care measures, construction of walkways.	Primary aims are to increase opportunities for recreation along the river, improve water quality and reduce eutrophication and to promote plant and animal life in the species-poor agriculture-intensive catchment area.	One of many large projects in the watershed, lots of EU funding but also based on inter-municipal cooperation	Rivers, wetlands,	Flooding	Hazard reduction, vulnerability reduction	Water regulation, natural hazard regulation, erosion regulation	Recreational values, cultural; important habitat creation for e.g. white stork
Lomma and Helsingborg	'Compensation/balancing principle' □ assessment for detailed plans which requires compensation for impact on ecological structures, e.g. if you cut down a tree, replace it somewhere else. Climate related impacts and factors and mitigation of these are considered in the checklist, alongside ES	Primary goal is to halt the reduction of green space. CCA considered relevant in interview	Core work	Multiple including e.g. trees, vegetation	Heat waves, flooding, erosion, sea level rise	Risk assessment; vulnerability reduction	Water regulation; local climate regulation	Aesthetic, health; economic value of land in greener areas; habitat provision

Municipality	Measure	A		B	C			D
		Primary goal CCA?	Project/core work?	Ecological structure	Hazard	DRR-CCA contribution	Relevant DRR-CCA ES	Co-benefits: social, economic, biodiversity, CC mitigation, other
Helsingborg	Ecological/open stormwater management	Primary goal is improved stormwater management combined with nutrient reduction	Core work, integrated into stormwater plan	Wetlands, rivers ponds and ditches	Flooding	Vulnerability reduction	Water regulation	
	Green roofs and walls	Primary goal is 'greening the city' for various purposes, CCA seen as a relevant co-reason	Core work	Green roofs; green walls	Heat	Vulnerability reduction	Local climate regulation	Aesthetic and educational values in public squares and on public buildings; contribution to pollination services by bees, carbon sequestration
	Making nature reserves	Primary goal is biodiversity conservation and recreation, CCA and 'creating resilience in the landscape' mentioned as an important side-reason	Core work, green plan an important planning tool	Multiple including parks, forests, lakes	Multiple including increased precipitation and flooding, heat, erosion	Hazard reduction, vulnerability reduction	Water regulation, natural hazard regulation, erosion regulation	Strong recreational values and health, habitat creation
	Wetland creation and restoration	Primary goal was historically dealing with eutrophication	Core work	Wetlands	Drought, heat	Vulnerability reduction	Water regulation, local climate regulation	Water purification and waste treatment, CC mitigation through biogas production from waste products collected and recycled (provisioning services of fuel)
Kristianstad	Work in the Biosphere Reserve	Primary goal is to preserve important biodiversity and natural heritage values	Core work	Wetlands, grasslands forests	Flooding	Vulnerability reduction	Water regulation	Provisioning services in terms of products such as biogas for local buses, high recreational, aesthetic values, ecotourism, habitat creation, eutrophication reduction

4.3.3 Elements relevant to the analytical framework

The section below gives an overview of how the measures are broken down according to the categories of the analytical framework. The figures are aimed to give a representation of the different categories which arose and how measures are generally distributed across these, but detailed quantitative analysis of measures is not the goal.

4.3.3.1 Purpose of ecosystem-based adaptation measures

The primary objectives of measures mentioned in the interviews were split about half and half between climate change adaptation and other goals. Figure 11 below shows the range of objectives in relation to the measures mentioned (including all goals listed, not just primary objectives). The most common objective apart from climate change adaptation was biodiversity increase or preservation, which was the primary objective of many projects and also one of the most frequently mentioned secondary objectives. Other significant primary goals were improved stormwater management, reflecting the long existing history with this topic especially in Malmö.

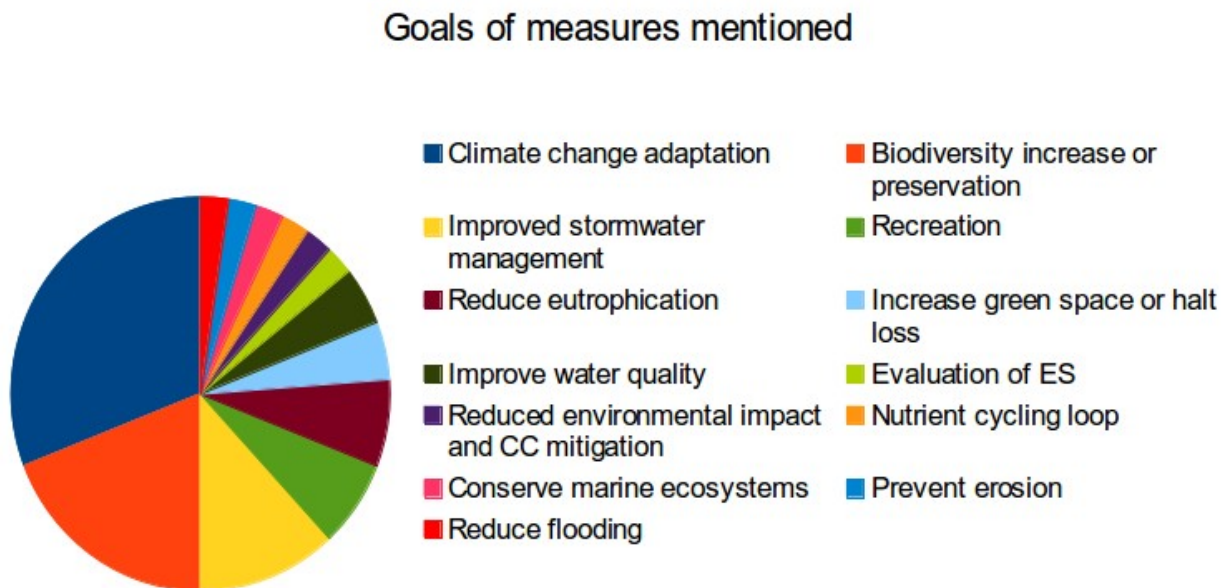


Figure 11: Representation of the frequency with which various objectives were stated in relation to measures mentioned in interviews. Note that many measures had multiple objectives.

In terms of relation to the core work of the municipality, overall the measures mentioned were split almost exactly half and half between externally funded, limited duration projects and measures which were integrated into the ongoing core work of the municipality.

4.3.3.2 Ecological structures used in ecosystem-based adaptation measures

The range of ecological structures used in EbA measures are shown in Figure 12 below. As in the CCA planning documents, a range of structures were used. Green roofs are prominently represented, as are wetlands, which were used in a variety of projects.

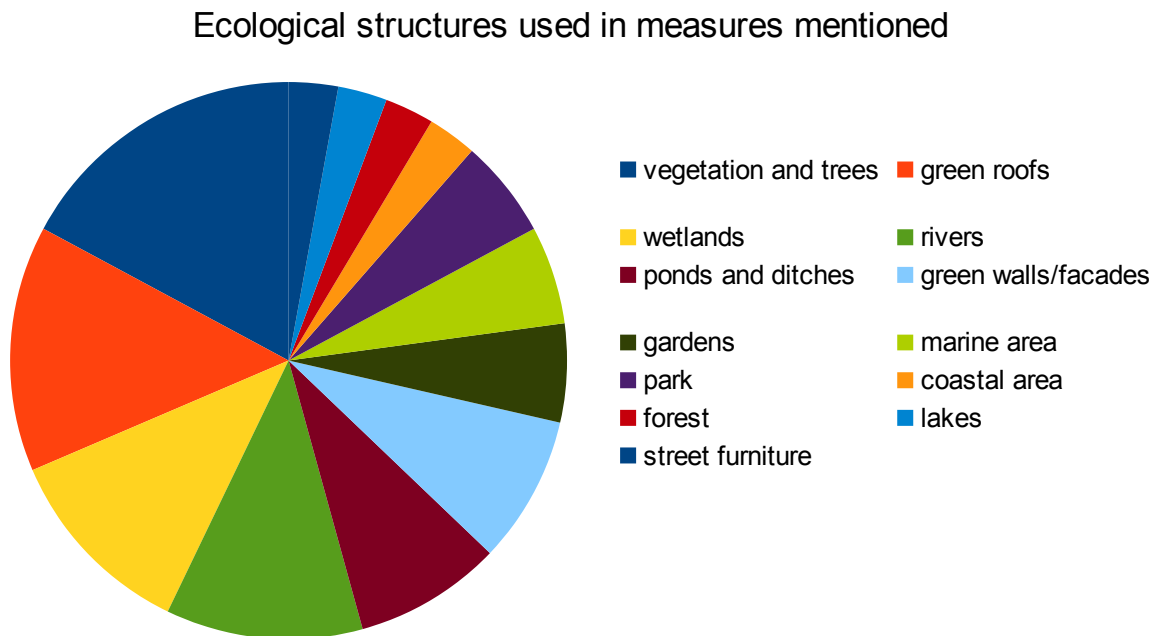


Figure 12: Representation of the frequency with which different ecological structures were used in measures mentioned in interviews. Note that some measures used multiple ecological structures.

4.3.3.3 Contribution of ecosystem-based measures to climate change adaptation-disaster risk reduction

The most common hazards identified EbA measures addressed were heatwaves, flooding and increased precipitation. These last two can be considered in most circumstances the cause and effect elements of what is essentially the same hazard in the urban environment, and so it is more accurate to say that increased precipitation and consequent flooding risk are the most frequently addressed hazards. Drought was the least often addressed hazard. Many measures could contribute to the reduction of multiple different hazards. For example green roofs, a commonly implemented measure, can contribute to lowering the risk of flooding through providing extra infiltration capacity in their structure and substrate, but also contribute to the reduction of excess heat in the urban environment via the process of evapotranspiration. In terms of the CCA-DRR framework, the EbA measures, as in the CCA plans, primarily contributed to vulnerability reduction, with occasional hazard reduction and risk assessment contributions.

Hazards addressed by measures mentioned

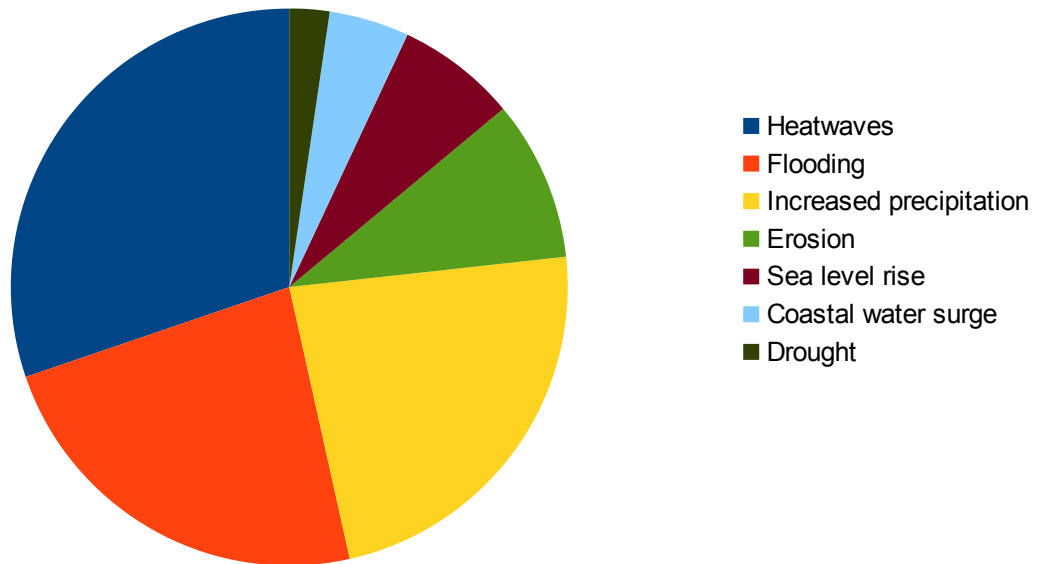


Figure 13: Breakdown of hazards which identified ecosystem-based adaptation measures contribute to reducing. Note that single measures could contribute to the reduction of multiple hazards

4.3.3.4 Co-benefits of ecosystem-based adaptation measures

Many co-benefits were identified through the interviews, supporting documentation and related literature. Some of the most common were aesthetics and recreation, public health and habitat creation. While many co-benefits were identified in plans, interviews, supporting documentation and literature, these were not specifically prioritised or evaluated in relation to the specific measures.

4.4 Summary and characterisation and comparison of municipal ecosystem-based adaptation measures

Climate change plans examined show variation in terms of their scope, level of detail and ongoing relevance to municipal work. Considering the criticisms of municipalities for incorporating too many 'hard' structures, there was a considerable number of different ecosystem-based measures mentioned in the planning documents. The largest focus on EbA measures was evident in the Malmö and Helsingborg plans, although many were also mentioned in Kristianstad.

Generally, the municipalities exhibited slightly different focus areas in their use of EbA measures. Lomma and Kristianstad had a strong focus on coastal areas and coastal

planning processes, and gave high importance to inter-municipal and also international collaboration processes. In Kristianstad, there are already many implemented 'hard' measures to aid in reducing flooding, but these primarily address historical and existing risk rather than future climate impacts. However, as noted in the case description, the Helge River, on which Kristianstad is situated, is predicted to have a 20% increase in the risk of a 100-year flooding event, so any measures designed to reduce future flooding impacts are also climate change adaptation measures. In Lomma there was a particular focus on collaboration with regard to rivers and watershed issues, which provide the biggest hazard risk, and again this work was long-standing in nature, although tools to incorporate changing climatic conditions were also being implemented in these collaborations. Malmö was notable for its high percentage of project-based measures and a strong trend of working with large amounts of external funding. Malmö also had the most variety in terms of urban green infrastructure components, and already a long tradition with open stormwater management. Flagship projects like Augustenborg, which have also facilitated the spreading of knowledge about the advantages of open and local stormwater management. Although demonstrating many showcase areas for these techniques, staff expressed difficulty with the transition to retrofitting of existing city areas. Helsingborg had a strong focus on its waterfront and technical solutions for protecting the 'H+' area, an urban regeneration project which is currently being developed there. It was also notable for its historical and ongoing use of wetlands for different functions, recognition of climate impacts on commercial and recreational forest areas, and more explicit strong urban-rural linkages than other areas in terms of ecosystem services provision and consumption.

4.5 Further related actions outside the framework

In addition to the 'on the ground' measures outlined above, interviewees also mentioned ongoing processes which are relevant to ecosystem-based adaptation planning, but which have not yet resulted in concrete outcomes. Many initiatives were mentioned which aim at better assessing ecosystem services provision and gathering information relevant for ecosystem-based measures, fostering knowledge sharing processes, and developing methods and tools, including planning and assessment tools. Although these process have not yet resulted in the implementation of measures and ecosystem-based adaptation is still in its infancy, these steps are likely to be supportive of future ecosystem-based adaptation planning.

In all municipalities, coastal planning processes are currently underway which have

long-term implications for the way the coastal area is dealt with. These are influenced to a large extent by the EU level Marine Directive and the Swedish Coastal Environment Directive (Havsmiljödirektivet) which requires municipalities to produce coastal plans, and aims at improving the environmental status of the Baltic and North Seas (Swedish Agency for Marine and Water Management 2014). In Lomma, the Living Coast project involves collaboration and knowledge exchange between Baltic municipalities in many different states in relation to planning of the coastal zone. The process of coastal zone planning, which was said to be in the initial phases at the time of the interview, was considered to be a process which, in contrast to the hard measures likely to be addressed by the upcoming climate adaptation plan, would incorporate more soft and green measures into an overall vision of how the coastal area and the related ecological values should be treated in the future to preserve important functions. Various tools and systems were mentioned relating to a more sophisticated analysis certain types of risk in particular areas, for example the use of the MIKE tool in Helsingborg to predict areas in the city that are particularly vulnerable to flooding. In Kristianstad, a large and significant project called 'RISC-KIT' (resilience increasing strategies for coasts – toolkit) has recently started. This is an EU funded collaborative project involving partners from 10 different countries, with the objective of developing methods, tools and management approaches to reduce risk to hydro-meteorological events in the coastal zone. The toolkit aims to address all stages of the disaster risk framework from risk assessment to preparedness for response and recovery. The process includes assessment of ecosystem services and how to support and use them best, with a particular focus on tourism and recreational values. The project has only recently begun, and a future working package will involve developing potential prevention, mitigation and preparedness measures and evaluate the effectiveness and acceptance of these with local inhabitants.

Additional projects were also mentioned in interviews, for example the 'Living City' project in Malmö, which was described as a knowledge forming project on how to use green space to bind the city together socially. However, as this project is just starting, there was a lack of information as to concrete measures that would be carried out and what would be the relation to climate change adaptation.

5 Discussion

The discussion is organised with sections relating to specific research questions first, followed by cross-cutting discussion topics.

5.1 RQ1 – How are ecological structures used worldwide to adapt to climate change?

The conceptual underpinnings of ecosystem services and climate adaptation cover a range of interventions, shown in the results of the global level review earlier. Comparing the international examples with what is going on on the ground in the evaluated case studies, things look quite different. This is partly due to the necessarily contextual nature of EbA interventions. While mangroves and reefs get a lot of attention in international literature, these are naturally not considered in southern Sweden, where wetlands and rivers form a more natural part of the indigenous terrain. Agriculture and agro-forestry was highly represented in the global review, though forests were barely mentioned in relation to the case studies. Further investigation would be necessary to ascertain whether this is due to the particular expertise of the interviewees selected. The Swedish forestry sector has been highlighted as vulnerable to storms due to domination by spruce (Ministry of the Environment, 2013). The Helsingborg and Kristianstad CCA documents did make a connection to forested areas, although this was primarily in their recreational as opposed to provisioning services.

5.2 RQ2 – How are ecosystem services incorporated into climate change adaptation?

In theory, the benefits of combining the field of ecosystem services with climate change adaptation has a role to play in helping firstly to understand the linkages between ecosystems, their structures and the adaptation relevant services they provide, and making these services communicable to decision-makers from different backgrounds who are involved in planning. In practice, although ecosystem services has become an increasingly popular term in recent years, it has not yet been fully integrated into adaptation planning processes. The proportions of 'green' measures mentioned in the adaptation plans varied from none (Malmö PM, forthcoming Lomma plan) to around 20% (Helsingborg PM). However, plans were difficult to compare directly, given that the measures were often mentioned in a non-systematic and speculative way, and that adaptation planning was generally in the early stages. Where the two areas overlap in practice, this is often due to motivated and scientifically educated staff members, primarily in environmental

departments, who either take responsibility for integrating adaptation into their existing work, or attempt to communicate to others. Ongoing research circles provide significant forums for exchange of knowledge and experiences between the municipalities in this regard.

5.3 RQ3 – characteristics of ecosystem-based adaptation measures

5.3.1 Primary goals

Adaptation appears rarely to be undertaken solely in response to climate change (Tompkins et al., 2010). Of the measures that have been implemented on the ground, many focus on other primary goals than adaptation. One of the most common goals is biodiversity, which came through equally strongly in all municipalities. Although here categorised separately to climate adaptation, biodiversity is closely linked to the conceptual underpinnings of ecosystem-based adaptation, contributing to resilience through the provision of genetic diversity and redundancy (Elmqvist et al., 2003). In applications such as agriculture and agro-forestry EbA interventions, the linkage between diversity and climate adaptation services is clear, however in the urban context the link is more indirect. In essence, the approach is a case of 'the more, the better', however questions remain as to whether this approach is sufficient to systematically address the climate risks faced by these municipalities.

5.3.2 'Mainstreaming' of EbA components in municipal work.

Both conceptual components of ecosystem-based adaptation – ecosystem services and climate change adaptation – are considered to be 'mainstreaming' issues (Vignola et al., 2009). This means that there is a perceived need for these concepts to be integrated into core work of decision-makers rather than being seen as an 'extra' consideration to be weighed against others (Holden, 2004; Wamsler et al., 2013). In relation to Sweden, there is a lack of comprehensive adaptation mainstreaming and related processes of inter-sectoral communication and co-learning (Wamsler & Brink, 2014, p. 17). Although it was not the purpose of this study to assess the level of mainstreaming that has been achieved, some observations on this topic can be made based on data gathered. As previously shown, ES work was considered to be more integrated into municipal work than CCA. As in previous Swedish studies, this was mainly due to an unclear division of responsibility (Storbjörk, 2007).

Whether EbA measures mentioned by interviewees are judged to be part of the municipality's 'core work' or part of a project is a further indicator for EbA mainstreaming. As shown, roughly half of measures implemented were undertaken as part of projects, and half were perceived to be integrated into the core work of the municipality. It is interesting to see that project work is responsible for many varied EbA-relevant implementations, and has been successful in generating interest and raising the profile of these measures. Malmö's measures in particular are distinguished by a high number of projects of varying duration which draw from different funding sources. Municipal staff characterised their work as highly dependent on project funding, and for several of them this is the normal means of operation and is even reflected in job titles such as 'Project Leader' for what are in fact permanent positions in the Environmental Department. Many of the projects are undertaken with EU and/or national level funding, and in collaboration with research institutes and industry actors with the aim of creating and extending technical know-how. This represents an interesting trend which could be characterised as a diversification in the governance regime, with external agencies being the main action takers, and municipal staff in a planning and coordinating role. As one interviewee in Malmö noted "we don't actually build anything, our project partners build things". These projects can be seen as evidence of an 'experimental' approach to climate governance which changes the traditional dynamics of urban authority (Bulkeley 2013). Whether or not these 'niches' support or hinder the development of ecosystem-based climate change adaptation approaches would require further study of the dynamic relationship between flagship projects and innovative practices and cross-cutting integration of core concepts and competencies into day-to-day municipal work. Some measures that formed part of core municipal work, such as the incorporation of the 'green space factor' in the Environmental Building Programme South (Miljöbyggprogram Syd) in Malmö had in fact been developed as part of another flagship project in Västra Hamnen. Others, such as the compensation/balancing principle have arisen as part of standard environmental impact assessments to incorporate more adaptation related aspects.

5.3.3 Disaster-risk reduction

The framework applied uses the categories of disaster risk reduction to aid in the assessment of the measures' contribution to climate change adaptation. The merging of CCA and DRR, while it is increasing in theory (Wamsler 2014; Uy and Shaw 2012), is still limited in practice so far. This point emerged both from the literature review and through discussions in the interviews. Where the link is recognised, there are often still barriers to effective integration, including a lack of required scientific knowledge: "the person

responsible for risk assessments was not very familiar with the scientific side of the subject.” (Interviewee, Lomma). Where there is not necessarily a lack of knowledge, timeframes involved in climate change adaptation are too long to enable risk reduction to systematically integrate future climate risks. In Malmö, current work on a risk profile as part of the Resilient Malmö project is “observation based” and does not make any assumptions about future change (Interviewee, Malmö). While EbA measures could address both currently occurring and future climate risks, it was believed that their contribution is undervalued by those responsible for risk reduction, and there is little evidence of a systematic application of risk reduction categories to EbA measures. Further integration of the three concepts of ES, CCA and DRR is necessary for more adaptive and proactive disaster risk reduction work.

Primary risks that were addressed by measures were flooding and heat. In Kristianstad and Lomma, historical flooding events make measures designed to address that hazard justifiable “I sort of use flooding more because it’s easier [to communicate]” (Interviewee, Lomma). In contrast to the uses of EbA worldwide, there was not much focus on sea level rise, even though it was a primary identified hazard in the case study areas, especially in waterfront areas of Helsingborg. Where measures are linked to sea level rise, their contribution is arguably minimal and relates to vulnerability reduction as opposed to more large scale coastal measures (see e.g. coastal realignment) which occur frequently in the literature.

Ecosystem-based disaster risk reduction is said to be most relevant to the steps of hazard mitigation or regulation as well as enhancement of livelihood capacities and resilience (Gupta & Nair, 2012; N. Uy, Takeuchi, & Shaw, 2012). There is a strong focus in the international context on the provisioning and livelihood aspects of EbA, which also contribute to vulnerability reduction and preparedness for response and recovery. This is not just limited to rural areas and developing countries, with increasing studies focusing on the contribution of, for example, urban agriculture to food security in cities (Dixon, Donati, Pike, & Hattersley, 2009) While this link is made in theory, it is not necessarily made in practice, with social goals of such projects being aims in themselves, rather than contributions to disaster risk reduction. Only one measure – the conservation and restoration of mussel banks – was identified as providing food provisioning services. Some minor projects, such as 'edible walls' in Malmö, were found in supporting materials, however there was no link made to climate-related urban food insecurity. Although there is a strong focus on regulating services in relation to climate change adaptation, other

services can also be relevant. For example, the role of social networks and community bonds in buffering the impacts of extreme events is recognised (Nakagawa and Shaw, 2004; Pelling 1998) and many of the cultural services identified in relation to the measures assessed could be measured to better understand how these different blue and green spaces can support social cohesion and social network formation through identity creation and the provision of meeting spaces to support community activities and how related practices contribute to social-ecological memory (Barthel et al 2010). As well as contributing to a wider definition of vulnerability reduction, this would link the measures to the stages of preparedness for response and recovery, whereas in the analysis above no direct linkages could be made due to lack of information.

5.4 Scale of ecosystem services generation and use

In evaluating the CCA-DRR and co-benefit contributions of measures identified in terms of the ecosystem services they produce, scale is an important consideration in evaluation and planning of measures (Borgström, Elmqvist, Angelstam, & Alfsen-norodom, 2006; Elmqvist, Angelstam, & Alfsen-norodom, 2006)). Some interviewees demonstrated awareness of this, giving examples such as the fact that, in relation to green areas used for water retention, while recreational benefits must be assessed locally, stormwater management is assessed mainly at the city level (Interviewee, Helsingborg). This is an inherent part of ES assessment, to make explicit the levels at which services are generated and consumed. A green roof may reduce energy demand for a particular building, but not in itself contribute to the reduction of the urban heat island effect at a city level. For this, a network of green roofs throughout the city, combined with other measures, would be required. Additionally, with regard to the ability of green walls and roofs to contribute to vulnerability reduction in terms of reduced water run-off, while it is true to say that they do contribute to this goal, in many cases these may make only a very minor contribution overall. As one interviewee pointed out, when evaluating the contribution of green spaces to stormwater management, scale considerations are important, and “it may not be an appropriate risk mitigating response to have fractions [of green space] spread out across the city, it might be more logical to address it in certain high risk areas.” (Interviewee, Malmö).

5.5 Understanding, valuing and valuation

Use of the concept of ecosystem services is often associated with economic valuation. While it is true that much research has focused on this aspect (Costanza et al. 1997; TEEB 2010), so that ecosystem properties can be more readily included in cost-benefit analyses, a significant amount has emphasised that monetisation is not always necessary or appropriate (MA, 2005; Pascual et al., 2010). Scholars have argued that the ecosystem services concept can have differentiated applications, (see e.g. Chan et al., 2012; Luck et al., 2012) focusing on its worth as a pedagogical tool, as well as its use, outside the context of valuation, for policy formation and the evaluation of trade-offs. In these roles it has the potential to function as a 'boundary object' (Abson et al., 2014; Schröter et al., 2014), facilitating cooperation between groups or disciplines with different paradigms or interests without necessarily achieving consensus (Strunz, 2012). Planning, as an intrinsically inter-disciplinary field, can arguably benefit from a concept with this interfacing ability. Where some sort of valuation is appropriate, there is growing literature in the field of ES which emphasises the spectrum of evaluative techniques that can be applied using the ecosystem services concept as a foundation, focusing not just on the economic value of services but on biophysical production, socio-cultural values as well their contribution to resilience and adaptive capacity, based on insurance values (Gómez-Baggethun, de Groot, Lomas, & Montes, 2010).

It has been argued that “planners and designers seek standardized indicators and metric that are understandable, transferable, robust and defensible” (Ahern, Cilliers, & Niemelä, 2014, p. 3) and that the development of such indicators can contribute to transferability of lessons from implemented projects and exchange of knowledge between different contexts. It is clear from discussions in the interviews that the ES tool is valued for its pedagogical worth in communicating the value of ecological concepts to both the general public and to other municipal employees, however there is an unresolved question of to what extent valuing and evaluation of services in a structured way is necessary. With regard to the nutrient cycling services provided by wetlands, the Environmental Department in Helsingborg “tried to find ways to communicate this in terms of money and the cost of cleaning, comparing it with [the treatment plant] and other ways”. While in some cases the approach to using ecosystem services in planning work was “the more we can get in, the better” (Interviewees, Lomma and Malmö), others expressed that, while the concept itself has been frequently incorporated into planning documents such as the comprehensive plans, “we're not really doing ES planning yet” (Interviewee, Helsingborg). This shows a

differentiated understanding of what “doing ES planning” means among those who are using the concept in their everyday work. Generally, ecosystem services planning in the sense of a structured process of assessment, trade-off, implementation and evaluation was not used, but the concept was used as a communicative and pedagogical tool. However, one interviewee stressed that “If [ecological structures are] to fill a significant function of storm water management you need to be able to quantify and model its contribution to the whole system as an integrated component. In addition, uncertainties about capacity at different levels of saturation should be accounted for and efforts made to make this measurable and predictable.”, and expressed scepticism regarding the increased popularity of particular measures such as green roofs: “it's quiet cheap to have a green roof, so a lot of property developers are choosing this measure. You need to ask... does it solve the problem that we have identified?”. These concerns clearly relate to the need to more explicitly evaluate the regulating functions provided by certain structures as opposed to simply assuming that more is better. However, another interviewee expressed the opinion that the appropriateness of valuation must be assessed in the particular context as “it could put a burden on planning that would not be proportional to the gain from it” (Interviewee, Malmö).

Only one example was mentioned in the interviews of a systematic approach to evaluating and incorporating ES into a climate change adaptation project. This was as part of the Risebergabäcken project in Malmö which is currently in stage 3 of the TEEB¹¹ approach, which involves assessing the informational needs and valuation methods for the ecosystem services identified. However, while one interviewee stated that this was a test to “implement something so we can use it for the whole city”, another stated that it was unclear whether the whole processes would be attempted before the project was due to end. While the TEEB tool is associated strongly with economic valuation, and there is a push on the national level towards this (Borgström, 2013), it is not a necessary outcome of using the framework, which aims to “make the benefits of ecosystem services visible” (TEEB 2011). Other examples include in Helsingborg 'example areas' as part of the green structure planning process examples are given of how specific areas and the services they provide could be assessed. Although these are interesting attempts, so far they only serve as proposals of how things could be done, rather than defining an evaluative strategy to be applied to all natural areas and their services.

11 The Economics of Ecosystems and Biodiversity, 2011.

5.6 The citizen-municipality interface

One interviewee stated that what climate adaptation planning currently lacks in comparison to climate change mitigation is the ability to “get citizens on board” by providing information about how they can contribute to addressing the challenge. An example was given of how climate change mitigation awareness raising gives people information of actions that they themselves can take to help, such as turning off their lights, driving less, and similar behaviours. This apparent difference is not only related to the apparent lower status of adaptation in comparison to climate change mitigation, but also a natural result of the fact that actions for climate change mitigation are generally more easily understood and have less complex interactions than actions for climate change adaptation. In terms of citizen groups, academic literature on ecosystem services in Sweden gives increasing prominence to the role of non-municipal actors in managing informal urban green spaces to influence the sustainable generation of services, (Colding 2006; Andersson et al 2007; Ernstsson et al 2009) however this message did not come through very strongly in the planning documents or the interviews as being a strategy for climate change adaptation.

There are, however, some existing examples of initiatives involving citizens in the vulnerability reduction process, for example in Malmö, the water utility company offers economic incentives to those who are willing to disconnect their downspouts and divert water onto their lawn or into water features to aid in the management of the stormwater load. Information is also provided on how to do this in a way which contributes to the aesthetic qualities of the garden. The preference of inhabitants of the municipalities for paved areas over gardens or green areas with higher infiltration capacity is seen as an obstacle by planners, and was emphasised by interviewees particularly in Lomma and Malmö. There are attempts to remedy this by providing information to inhabitants on how they can increase the green qualities of their domestic garden and the contribution this will make to climate change adaptation. This is listed as an important action in Malmö's climate change Action Plan. On a community level, there is an acknowledgement evident both in the planning documents and in the interviews that there is a need for citizen and community involvement in climate change adaptation planning, particularly in the process of risk assessment. Existing networks of citizens in coastal areas, and processes such as coastal councils were prominently mentioned in Kristianstad and Malmö, and were seen as useful ways to exchange information and get people interacting with municipal employees on an 'eye to eye' level as opposed to 'citizen to bureaucratic institution' level (Interviewee, Malmö). In Kristianstad, as part of a Kustrådsprocessen (coastal council process), coastal

residents were asked about the relative importance of different goals in relation to the coast, and it was found that residents most prioritised prevention of pollution, better capitalisation on natural assets, and preparing society for future climate change above even fundamentally important issues such as schools (Larsson 2012).

The dialogue process in relation to the development of the Risebergabäcken project in Malmö involved a variety of stakeholders in discussions on how the area should evolve and adapt to a changing climate, however although a wide range of private and public interests were represented, there was an emphasis on the need for further dialogue with local residents.

While there is mention in planning documents of involving local residents and some examples of substantial citizen involvement exist, these fall short of the goal of 'citizen science' which is considered by some to be necessary for transdisciplinary problem solving (Dickinson et al., 2012). The networks that currently exist are useful starting points for bringing citizens into valuation processes, but also still a lack truly 'bottom up' approaches and citizen-initiated projects, which are considered to be important for promoting resilient and sustainable cities, and are considered a key principle of EbA strategies as well (UNFCCC 2012). Small urban community greening projects, have been valued for "[promoting] resilience through innovation, adaptive management and social learning" (Lovell & Taylor, 2013, p. 1458). Many of the 'co-benefits' identified in relation to EbA measures can have feedbacks into increasing adaptive capacity and reducing vulnerability not only in institutions but in urban communities. For example, opportunities for community gardening can support social capacity building through knowledge transmission and sharing of management strategies, allowing for feedback loops in the management of ecological structures to fulfil different functions (Lovell & Taylor, 2013). A lot of recent ES research emphasises participation in valuing/evaluating and management of ES and ecological structures. In contrast, climate change adaptation planning is arguably still largely seen as an institutional/technical area, with an emphasis on the need for accuracy in predictions, technical solutions and structures.

5.7 Barriers and drivers for ecosystem-based adaptation measures

General barriers to the adoption of climate adaptation strategies have already been identified in the literature. Such barriers include a lack of financial resources, data availability, coordination, political will, participation and public awareness; fragmented knowledge bases on risk reduction and adaptation; goal conflicts; and unclear

responsibilities (Wamsler, 2014). Barriers to the use of ecosystem-based approaches include current conceptual unclarity, which hinders the integration of EbA into adaptation planning (Doswald et al. 2014), and a lack of studies aimed at providing information to decision-makers and policy-makers about points of difference to other adaptation measures in terms of costs and benefits (UNFCCC 2013).

During interviews, interviewees identified some salient barriers and drivers to the implementation of EbA measures. These are not considered to be an exhaustive list, but show that the barriers identified here in relation to EbA measures fall under many of the same categories discussed in the literature, including some which have been identified as “of repeated and cross-cutting importance” (Moser & Ekstrom, 2010, p. 22029) such as resources, knowledge and information, and (especially political) leadership.

The factors below (Tables 10 and 11) provide more context-specific detail related to the particular context in southern Sweden.

Table 10: Barriers to the implementation of ecosystem-based adaptation measures identified by interviewees.

Political	Lack of political will for climate change adaptation, despite the 'adaptation turn' of 2008 onwards.
	Lack of support for incorporation of green space factor and green roofs into building requirements: “Unfortunately, the [national] government doesn't ... want the municipalities to have their own requirements beside the Planning and Building Act, so even though we have been using this for a couple of years now, it's not really sure whether we're allowed to do this.” (Interviewee, Malmö)
	Open stormwater management and increase in green spaces can compete with other aims such as densification
Legal	No legal basis for designing green façades for adaptation purposes, only aesthetic justifications are valid (Interviewee, Helsingborg)
	Lack of legal guarantees that green areas used for risk reduction will not be built on, difficulty of incorporating into detailed planning (Multiple Interviewees)
Institutional/organisational	Current inter-municipal water utility ownership means that projects which only benefit one municipality are unlikely to be funded (Interviewee, Malmö)
	Measures which have multiple benefits can lead to unclear financial responsibilities and arguments over who will pay. E.g. providing benches in an open stormwater pond with recreational benefits (Interviewee, Helsingborg)
Knowledge	Difficulties with planners who may lack 'scientific' knowledge (Interviewee, Lomma)
Financial	Mechanisms not available for private housing owners to put away money for future renovations without paying significant tax, so difficulty of incorporating EbA measures in existing areas (Interviewee, Malmö)

Table 11: Drivers for implementation of ecosystem-based adaptation measures identified by interviewees

Political	ES were seen to have high political popularity: “if anything is cool in the political world, it's ecosystem services” (Interviewee, Malmö)
	Supportive politicians enable planners with ecological knowledge to take initiative (Interviewee, Lomma)
Financial	Some measures, such as green roofs “cheap to implement for developers” (Interviewee, Malmö)
	Sharing of costs for open stormwater management between public and private actors (Interviewee, Helsingborg)
Institutional capacity/ knowledge sharing	Collaboration with research institutes such as the Scandinavian Green Roof Institute leads to improvement of technical knowledge

5.8 Limits to ecosystem-based adaptation measures in adaptation to climate change

Adaptation can reduce the adverse impacts of climate change considerably but cannot reduce them to zero. Thus, there are limits to what can be achieved with planned adaptation actions. Certain places become permanently beyond adaptation (e.g. coastal zones inundated by sea-level rise), and the number of these places (and the populations at risk) obviously rises without successful mitigation (Satterthwaite et al., 2007). There are many ways in which EbA measures can reduce the adverse impacts of climate change, but in most cases they will form only one part of an overall adaptation strategy. Difficult decisions will need to be made in the future, and in some places decisions will need to be made about whether to 'fight', 'defend' or 'retreat' from rising sea levels. Municipalities have not got to the stage of explicitly delineating 'no build zones' on the coasts, and there is not much discussion of strategies such as coastal realignment and other 'letting the water in' approaches which occur commonly in the EbA literature. This is something that may need to be addressed in the future in combination with the general public/residents of coast-near areas to enable socially appropriate long-term adaptation planning to occur.

6 Conclusion

As ecosystem-based adaptation gains prominence on the international level, it is necessary to generate knowledge about the ways in which the conceptual underpinnings – ecosystem services and climate change adaptation – are combined in practice. Examination of climate change adaptation documents in the case studies shows that they do in fact consider the use of ecological structures in planned measures, most thoroughly in Malmö and Helsingborg, however due to the sporadic nature of the plans' implementation and the lack of clear responsibility for adaptation generally, the extent of implementation is unclear. Implementation of EbA in practice shows a mixture of 'experimental' project-based applications, focusing on high-tech green infrastructure components especially in Malmö, and established techniques such as wetlands (especially in Helsingborg) and open stormwater management which address historical risk, and have the potential to address future climate impacts. Many measures are implemented which do not in fact have climate change adaptation as their primary focus. Across all municipalities, biodiversity and stormwater management were key goals, along with recreation and tourism values in Lomma and Kristianstad. While this diversity is positive, the framework applied shows that multiple benefits of EbA measures exist which are not systematically examined. Multi-criteria analysis and evaluative techniques for assessing the services of adaptive ecological structures is a way in which ecosystem-services research can aid sustainable climate change adaptation. Further integration of stakeholder management and perspectives and the use and development of existing social networks could be used to make the benefits and co-benefits of ecosystem-based adaptation measures more explicit and contribute to a societal based discussion on the nature of adaptation, what is to be adapted and the extent to which traditional versus EbA measures should be used. The process of explicating and evaluating co-benefits should be a prerequisite to this discussion.

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Appendix A – Codes for planning document analysis

Codes were developed based on Rivera & Wamsler (2014) codes, adapting to suit the altered focus of this study. Due to the variety of vocabulary for similar concepts and the translation of English terms into Swedish, it was not feasible to get a comprehensive classification from the start. Codes were added as document analysis progressed.

Codes for EbA measure identification in CCA plans

“ecosystem services” (ekosystemtjänster)

“ecological services” (ekologiska tjänster),

“biodiversity” (biologisk mångfald; biologiska mångfald*),

“green areas” (grönområd*, grönytor)

“green and blue/ blue and green values” (gröna och blå/ blå och grön kvaliteterna)

“green structure”(grönstruktur)

“ecological values” (ekologiska värden)

“ecological functions” (ekologiska funktionerna)

“ecosystem based adaptation” (ekosystembaserad anpassning),

green infrastructure (grön infrastruktur)

blue and green/ green and blue infrastructure (blå och grön/ grön och blå infrastruktur),

regulating ES (reglerande tjänster),

multifunctional spaces (multifunktionell yta) or mångfunktionella ytor

Appendix B – Interview guide

Interview guide: Ecosystem services planning, Climate Change Adaptation, and Ecosystem-based Adaptation

1. Understanding / definition

- Do you have a working definition of/what is your understanding of the term:

I) Ecosystem Services Planning II) Climate Change Adaptation III) Ecosystem-based Adaptation Planning

2. Institutional responsibilities

- In your municipality, who/which department is responsible for doing I), II), III)
 - Since when and why do they work on I), II), III)
- What are the key policies, laws, frameworks etc. that are important for your work with regard to I), II), III)

3. Projects and measures

- What projects are currently being undertaken by the municipality with regard to I), II), III)
- What tools are you using or developing and what procedures are you following with regard to I), II), III)

4. Actor dimension

- With whom outside your municipality do you work and for what reasons with regard to I), II), III)
- Which groups/persons do you see as supporting or conflicting with your work in relation to I), II), III)

5. Benefits and Challenges

- In your view, what are the benefits of I), II), III) approach to planning?
- What are the difficulties or challenges that you have experienced with I), II), III) approach to planning?

Appendix C – Ecological structures

Ecological structures are defined as collection of species individuals, communities, functional groups or habitat types that deliver an ecosystem service (Kremen, 2005; Liu, Daily, Ehrlich, & Luck, 2003; Luck et al., 2009). The classification was developed based on existing literature (e.g. (Bolund & Hunhammar, 1999; Niemelä et al., 2010) and includes 15 categories, namely coastal areas, marine areas, wetlands, lakes, rivers, forest, grassland, street furniture, parks, gardens, cultivated land, green roofs, green walls/facades, trees and vegetation, ponds and ditches. Some important components of green infrastructure are here not mentioned as separate categories but are considered to combine some of the categories described above. For example 'bioswales' combine the vegetation and 'ponds and ditches' categories. 'Urban habitats' are assumed to fall under the generic category 'trees and vegetation' where no further details are given.

Ecological structure	Definition
Coastal area	Coastal areas are “part of the land adjoining or near the sea” (Oxford Dictionaries, n.d.). Cities in coastal zones are very vulnerable socio-ecological systems that are pressured by increasing damages of natural disasters which also results from the insufficient placement of ecological infrastructure (Robert Costanza & Farley, 2007).
Marine areas	Marine areas are the areas of sea or seabed which contain ecosystems that exist in the ocean environment outside the immediate coastal area. In the context of this study, the marine environment referred to is the Baltic Sea and the Öresund (“the Sound”) between Denmark and Sweden
Wetlands	Wetlands are areas that are “inundated or saturated by surface water or groundwater with vegetation adapted for life under those soil conditions” (State of Florida, 2011). Urban wetlands include natural or artificial constructed forms and often function as a buffer for city contaminated runoff (Gilbert, Fulthorpe, & Kirkwood, 2012).
Lakes	A lake is a “relatively large [temporary] body of slowly moving or standing water that occupies an inland basin of appreciable size” (Lane, 2013). Urban lakes can be natural (referred to as ‘indigenous blue infrastructure’ (Deak & Bucht, 2011) but are often artificially created. Water bodies in urban environments are rather shallow and small in surface area, gain their water supply from paved watershed or a stormwater pipelines (Naselli-Flores, 2008).
Rivers	Rivers are “natural watercourses, flowing over the surface in extended hollow formations [and are] critical components of the hydrological cycle, acting as drainage channels for surface water” (Hebert, 2013).
Forest	Forests are “complex ecological system[s] in which trees are the dominant life-form” (“Forest,” 2013). Tree species composition varies with climate conditions and altitude (ibid). Urban forests refer to woody vegetation which can be privately or publicly owned land including parks, and residential areas or commercial sites (McGee, Day, Wynne, & White, 2012).
Grassland	“Urban grasslands are ecosystems dominated by turf-forming” (Groffman, 2013) native and non-native species. Grasslands can be managed or

	unmanaged but mostly share characteristics of unmown, ungrazed, unirrigated, open land patches (Groffman, 2013; Hinners, Kearns, & Wessman, 2012).
Street furniture	Street furniture refers to ecological components that line city roads. Typical ecological street components include trees, green strips, and green pavements, as well as flowerbeds. Components are characterized according to the predominate native or invasive plant species (White, Antos, Fitzsimons, & Palmer, 2005).
Parks	Urban parks are city "feature[s that] serve many functions as providers of passive and active recreation, environmental benefits, and wildlife habitat" (Solecki & Welch, 1995, p. 95). Parks can be found at the urban fringe or at central locations and include a vast amount of different characteristics such as playgrounds and -fields, camping areas, botanical gardens, and green and blue infrastructure (Cranz, 1982).
Gardens	Urban gardens are "private [owned or rented] spaces adjacent to or surrounding dwellings, which may variously comprise lawns, ornamental and vegetable plots, ponds, paths, patios, and temporary buildings such as sheds and greenhouses", forming a "complex and heterogeneous mosaic" in urban landscapes (Cameron et al., 2012; Loram, Tratalos, Warren, & Gaston, 2007, p. 602).
Cultivated land	Agriculture is the "practice of farming, including cultivation of the soil for the growing of crops and the rearing of animals to provide food, wool, and other products" (Oxford Dictionaries, n.d.-a) Urban cultivated land refers to professional farming activities in urban and peri-urban areas (Mougeot, 2000) as well as residents engaged with farming activities in allotment gardens (Sharp & Smith, 2003).
Green roofs	Green or living roofs consist of a growing medium and vegetation layer, over engineered roof membranes, and can be divided into 'intensive' and 'extensive' types depending on depth of substrate, vegetation type, and primary purpose (Oberndorfer et al., 2007, p.824)
Green walls/facades	Green walls are components of urban green infrastructure which contribute a range of ecosystem services. They tend to be divided into 'Green façades' where plant-root balls are placed in the ground or in pots and the shoots grown up the side of a building, and 'Living walls' which support plants that either root into the wall or have cells of substrate embedded in/on the wall (Cameron, Taylor, & Emmett, 2014)
Vegetation and trees	Vegetation is a non-specific term for plants or plant communities in various forms and composition. It can refer to small species of herbs, ground cover plants, grasses and bushes as well as larger species such as trees (MarkInfo, 2006). It is used here as a generic category where no more specific information is given.
Ponds and ditches	Components of open or 'ecological' stormwater management, including ponds which, for example, filter waste from human activities and reduce the level of pollution in urban waste water (Karathanasis, Potter, & Coyne, 2003)

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