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Integrating flood risk reduction, river basin and resilience management in planning: A case study of Kristianstad, Sweden

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Cover photo: Biking and walking on a bridge to the Naturum, in Kristianstad, a flood-proof building on stilts that embodies the concept of living with the water.
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ABSTRACT

This case study, part of Baltic COMPASS, a project that aimed to improve environmental and agricultural policies and management practices across the Baltic Sea Region, examines flood risk and river basin management in Kristianstad, Sweden, in terms of progress towards and barriers to adaptive river management. Through interviews with 15 key stakeholders, a focus group discussion and a regional workshop, the case study examined flood risk management, river basin management and resilience management at both the national and local levels. The results indicate that flood risk management remains too narrowly focused, on flood control in the city, neglecting aspects such as flood abatement in the river basin or flood alleviation downstream. Underlying this situation is a lack of cross-sectoral integration and synergy between the different sectors and communities of practice, e.g. in forestry, agriculture, environmental and urban planning, that could supplement flood protection strategies. Integration is further hindered by the fact that the municipality's mandate reaches only to the municipal border, and there is no river basin-wide governance structure focusing on water flows or floods, only on quality. This means that there is no governance or management framework for activities which increase flows downstream, and no active coordinated investment in flood retaining activities, such as rehabilitating the catchment and compensation to farmers' land use to dampen flood peaks. At the same time, the legal instruments for water flows, i.e. centred on the joint property societies who operate them, are very inflexible and outdated. There are potential synergies between the future implementation of the EU Water Framework Directive (WFD) and the EU Flood Directive, but currently it is unclear how plans for integration will be implemented in practice. However, there is increasing alignment between risk managers and urban planners in Kristianstad, emerging from local dialogue and learning. Extending the lessons from Kristianstad to all of Sweden will require an active political process that recognizes growing risks due to climate change and highlights the value of ecosystem services.

CONTENTS

1. INTRODUCTION

This case study is part of Baltic COMPASS, a project that aimed to improve environmental and agricultural policies and management practices in order to support healthy ecosystems across the Baltic Sea Region.[1] The focus here is Kristianstad municipality, in the Lower Helge River (*Helge å*) basin, which is Sweden's most flood-exposed urban area (MSB 2011).

The origin of the flood exposure is historical, from being located in the wetland in 1614. Furthermore, in the Helge River basin, land use practices such as embankments, lowering of lakes, straightening of flows and dredging have reduced the wetland areas and the landscape's overall capacity to retain water. These practices have also severely affected animal habitats (Jordbruksverket 1994), and contributed to nutrient leaching and release of hazardous substances leading to eutrophication and ecological decline in the Helge River and Baltic Sea. Climate change projections suggest that the challenges that Kristianstad faces today will also affect many other places in Sweden in the future. With more extreme weather events expected, Kristianstad will not only have to combat eutrophication, but also cope with and adapt to greater uncertainty as well as sea-level rise and difficulties draining water into the sea (Dahlman 2007).

While the ecological impacts on the Helge River are well known, the impact of human activity on water flows is perhaps less known. However, we do know that altered landscapes influence the character of water flows, where the amplitude between high and low water is known to rise with human interference. For example, in the Rhine at Lobith (on the border between Germany and the Netherlands), the variation in water level was only 1.5–2.5 metres around the year 1000, but now the amplitude is 7–10 metres (Knaapen and Rademakers 1990). The change has been caused by the construction of levees along the river as well as the removal of a large number of smaller and larger side branches and their floodplains, some of which were reclaimed and filled. The amplitude of the Helge River at Kristianstad is not as great (around 1–2 metres), but the nature of the challenges is similar, and there is an opportunity to learn from the situation in the rest of more developed Europe. Given the projections of future sea-level rise, this opens up questions about the need to explore new solutions, perspectives and paradigms of flood risk management: a topic already being discussed at European and international levels.

Kristianstad currently takes a traditional approach to flood control: the city is surrounded by embankments to protect it from an extreme flood scenario, and a few (lower) embankments protect agricultural land close to the river. With climate change, however, the question arises: How long can the water be kept out of the city and agricultural lands in this way? Might other approaches be more cost-effective in the future? And how does the cost-benefit equation change when one considers flood management in the broader context of river basin management and resilience (nutrient management, new priorities of nature conservation, etc.)?

There are in principle three possible future strategies: 1) business as usual – build better and higher embankments to reduce the flood hazard; 2) relocation (not a real option); or 3) adaptive river management ("living with floods"), a new approach in which flooding is allowed in certain areas, but land use is adapted to minimize the adverse impact of flooding. This sometimes means a compromise to sacrifice productive land for buffer zones, but it also means synergies with nature and landscape development, having the "river as a partner" and

[1] See http://www.balticcompass.org.

benefiting from ecosystem services, cultural heritage and scenery (Nienhuis and Leuven 2001; Vis et al. 2003).

Some areas have begun to adopt the latter approach, which is now viewed as the only sustainable solution for rivers in the Netherlands and Germany. Compared with traditional approaches it works on a larger landscape scale, recognizing the river basin as a unit and the potential cascading effects of ecosystem management (Veraart and Bakker 2009). For example, wetland creation in upstream forests could potentially retain more water, thus helping to mitigate floods and perhaps benefiting a city downstream.

Adaptive river management also acknowledges issues of resilience. There is a growing recognition that shutting out the (flood) hazard is not a resilient strategy, as it creates a risk of catastrophic consequences if the hazard cannot ultimately be contained (Walker et al. 2004). Indeed, water flows have a tendency to "break out" if they reach a certain level of pressure – and the precise level is often impossible to predict (Remmelzwaal and Vroon 2000). Rather than try to protect all agricultural fields, for example, a more resilient strategy might be to reserve some land in low-lying places as a flood buffer.

Using wetlands[2] as buffers also brings multiple benefits: not only do they store flood waters, allowing them to spread out over a larger area, but they also support a rich habitat for biodiversity (birds, fish, insects, etc.); enhance water quality through pollutant and nutrient retention; and provide recreational and cultural value. As another Baltic COMPASS report has noted (Andersson 2012), wetlands – and the people who maintain them – provide multiple ecosystem services and goods. These services provide cost-effective alternatives to human-made structures, which need operation, maintenance and, in the event of damage, repairs or reconstruction. They are also safer, as human-made structures are known to fail (Hollnagel and Fujita 2013; Rosenthal 2011).

Water systems planners and managers in Kristianstad have begun to explore these complex issues and are moving towards a more holistic way of addressing them. This study focuses on how "adaptive river management", defined here as an approach that aims to integrate flood risk, river basin and resilience management, which is being adopted in local and national spatial planning frameworks. The goal is to identify gaps, barriers, and opportunities for better implementation, and to recommend additional research, policy measures and stakeholder engagement activities to advance this work.

1.1 Policy context

At the policy level, two EU Directives are currently being implemented in Sweden that are relevant to this study: the EU Floods Directive (EU 2007) and the Water Framework Directive (EU 2000).

The EU Floods Directive

The EU Floods Directive aims to reduce and manage the risks that floods pose to human health, the environment, cultural heritage and economic activity. It emerges from the observations that even though flood protection investments have increased, they are not enough to stem a substantial rise in economic and insured losses (Munich RE 2005). This rise

[2] Sweden uses a slightly different definition of wetlands than the International Wetland Commission, which also includes open waters and seas (in Sweden, these are classified as marine or limnic systems). The Swedish definition of wetlands, per Löfroth (1991), is "such grounds where water is present during a large part of the year, under, at or over the ground surface, including water covered with vegetation. At least 50% of the vegetation should be hydrophilic, i.e. thrive in wet environments to be able to call it a wetland. An exception is temporarily dry bottom areas of lakes, seas and water courses; they count as wetlands in spite of not having vegetation."

has been due to economic development, enabled by spatial planning policies that increased the total property value exposed to floods (Munich RE 2005; EEA et al. 2008); given the appeal of flood-prone areas such as coasts and riversides, it is likely that this exposure will continue to grow. The objective of the Floods Directive is to establish a framework for the assessment and management of flood risk in Europe, emphasizing the frequency and magnitude of floods as well as their consequences. There are different types of floods, and the directive addresses floods from rivers, the sea, ephemeral watercourses, mountain torrents, and floods from sewage systems (de Moel et al. 2009).

The Swedish Civil Contingency Agency (*Myndigheten för samhällsskydd och beredskap*, or MSB) is responsible for the implementation of the EU Floods Directive in Sweden, in close cooperation with county administrations. The work is being carried out in three steps during 2009–2015. Step 1, completed in December 2011, included a preliminary assessment identifying the river basins and associated coastal areas at risk of flooding. In Step 2, flood risk maps for such zones were drawn up, and in Step 3, flood risk management plans focusing on prevention, protection and preparedness are now being established. It is expected that in implementing the EU Floods Directive and the Water Framework Directive, government agencies will coordinate plans for flood risk management and river basin management, as well as the procedures for public participation in the preparation of these plans.

The EU Water Framework Directive

The EU European Water Framework Directive (WFD) was enacted in 2000 and incorporated into Swedish legislation in 2004. It focuses mainly on water quality, but also addresses water quantity to the extent it affects quality, with goals for all water bodies (including marine waters up to one nautical mile from shore) to be met by 2015. River basin planning is a key part of the directive, which also highlights the need to explore links between land use planning and water pollution and flooding (White and Howe 2003). Sweden is divided into five water districts, with five County Administrative Boards appointed as River Basin District Authorities (*Vattendistrikt*). The national authorities – the Swedish Environmental Protection Agency (*Naturvårdsverket*) and the Geological Survey of Sweden (*Lantmäteriet*) – issue regulations and guidance, and the authorities have the overall responsibility for implementing the WFD, coordinating the work within each district and ensuring that the different organizations work towards the same goal.

2. METHODOLOGY

This study first describes the Kristianstad area and provides a historical overview, followed by a description of the current governance system for managing flood risk (water quantity) and water quality risks (mainly nutrient risks) in the river basin (urban, agriculture, natural environments, forest systems). Then it provides an analysis and discussion of the identified gaps, barriers and opportunities in the governance system.

2.1 Data-gathering

The study included semi-structured interviews, a focus group discussion with local decision-makers, a workshop with a wide range of regional stakeholders, and a literature review. It also derived some information from a workshop that was held on integrated flood management in November 2013 organized by the Swedish Water House, and advance conversations with several planners. The interviews were held between November 2011 and August 2012 and aimed to get an overview of the main problem areas concerning flood and nutrient issues, as perceived by stakeholders. Farmers were heavily represented in the interviews, while other stakeholder types were more strongly represented in the focus group discussion, written documentation and the workshop. The interviews were held mostly over the phone, recorded and transcribed, and were based on the following questions:

1. How do you perceive the role of wetlands (both natural and constructed) in nutrient management and flood-control?
2. Which measures do you consider to be important and strategic in the long term?
3. Are these measures being implemented? If not, why are they not taken into consideration? What are the possible catalysts/barriers?
4. Who is responsible for taking on these suggested interventions?

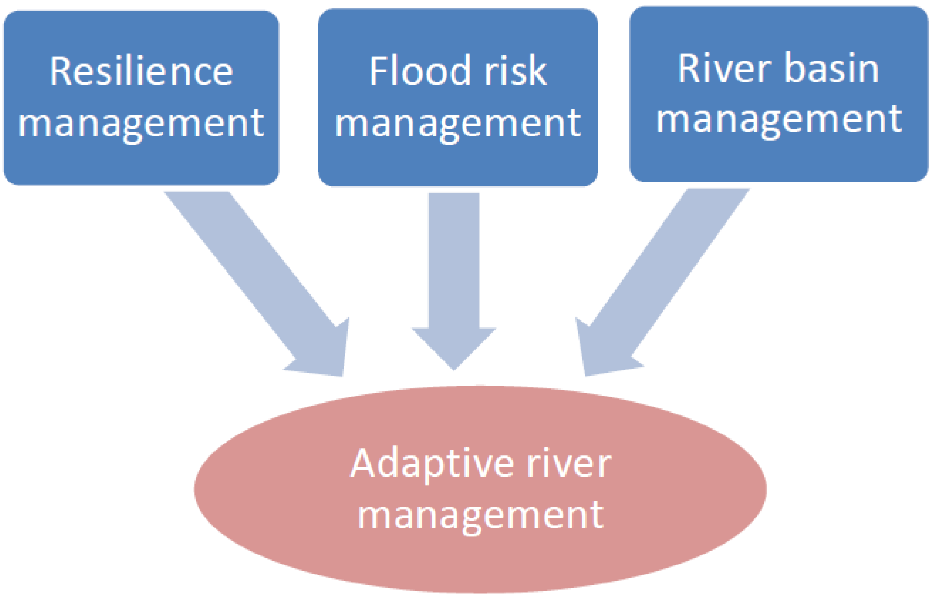
The key results from the interviews are summarized in Annex A. They were presented to the Baltic COMPASS project team, to a local focus group, and at a workshop on 25–26 September 2012 in Kristianstad. Feedback from this process was incorporated into the final study.

The literature review, meanwhile, focused on nutrient and wetland management in the Helge River; linkages between nutrient/wetland management and flood management, including experiences and best practices from other countries; and conflicts and inconsistencies in the mandates for flood and nutrient management under the EU Flood Directive, the EU Water Framework Directive, and other policies.

2.2 The analytical framework

The EU Floods Directive requires member states to introduce a "framework for the assessment and management of flood risks, aiming at the reduction of the adverse consequences for human health, the environment, cultural heritage an economic activity". This may include measures that could contribute to meeting the goals of the Water Framework Directive (EU 2012). A conceptual framework along those lines is developed below, illustrating the need to integrate three relevant approaches to water governance – river basin management, flood risk management, and resilience – in order to contribute to adaptive river management (see Figure 1). Below, each of the key elements of the analytical framework is briefly described.

Figure 1: Analytical framework for this study: Elements of adaptive river management



River basin management

The importance of river basin management was adopted as part of the Integrated Water Resource Management (IWRM) model launched around 1992.[3] River basin management follows the water's natural flow by focusing on the river basin as a management unit. Within this geographic area, all waters, via lakes and rivers, flow out to the sea. In Sweden, river basin management encompasses lakes, rivers, coastal water and groundwater. The coastal water includes all water within one nautical mile – 1,852 metres – of the skerries and islets farthest from the coasts and archipelagos (Vattenmyndigheterna 2009).

River basins are very large-scale management units, often going beyond administrative borders, and realizing the WFD's ambitious goals implies adjustments in planning, land use and behaviour by a range of actors who share the water resource. In addition to the water sector, diverse changes in forestry, urban planning, architecture, agriculture, infrastructure planning and landscape management will be required (White and Howe 2003). This, in turn, requires collective action, resolution of conflicts, and recognition of people's interdependence and their differences, which they must learn to deal with constructively (Tippett et al. 2005).

River basin management activities as part of the Water Framework Directive are carried out in six-year cycles. The management cycle starts by a characterization of the waters. The River Basin District Authorities use this basic data to develop suggestions for environmental quality standards (i.e. quality requirements) for each of the district's existing water bodies. If the evaluation indicates that the water will not meet quality requirements on time, measures have to be taken. Water quantity, including measures to address flooding, is also included under the WFD, but in practice the focus is on quality (Vattenmyndigheten 2010). It is above all the responsibility of the municipalities and County Administrative Boards to carry out the measures presented to them by the River Basin District Authorities. At the end of the management cycle, a river basin management plan is developed, and the results of the work are reported back to the European Union (Vattenmyndigheterna 2009).

Flood risk management

The adoption of the EU Floods Directive shows recognition of the need for a risk-based approach to flood management as emphasized by recent research (Hooijer et al. 2004; Petrow et al. 2006; van Alphen and van Beek 2006). The aim of such strategies is to reduce the overall flood risk to human life and assets, which is defined as the probability of an event multiplied by its consequences (Helm 1996). Some European countries have already adopted this approach instead of traditional flood protection strategies, including Germany (DKKV 2004), the Netherlands (Vis et al. 2003) and the UK (Tunstall et al. 2004).

In general, flood risk management focuses on three aspects: 1) flood abatement, to prevent peak flows by, for example, improving the water retention capacity of the catchment; 2) flood control, to prevent inundation using structural measures such as embankments or detention areas; and 3) flood alleviation, to reduce flood impacts through non-structural measures such as hazard zoning and flood-adapted spatial planning, flood-proofed buildings, development or upgrading of early warning systems, insurance, awareness campaigns to improve the preparedness of people at risk, training, and establishment of rescue units (Parker 2000; de Bruijn 2005; Petrow et al 2006).

[3] For a brief introduction to IWRM, see the Global Water Partnership website: http://www.gwp.org/The-Challenge/What-is-IWRM/.

Resilience management

Resilient strategies use preventive approaches such as adaptive planning paradigms to avoid the build-up of vulnerable systems. As such, they often allow for smaller disturbances, rather than shutting them out, so that the system can learn how to absorb those disturbances (Walker et al 2004, Klijn et al. 2004). Resilient management strategies are relevant to both risk management and river basin management, and can be included in both at times of increasing uncertainty and variability. They not only build buffer capacity or robustness, but also the capacity for learning, self-organization and adaptation (Folke 2006), allowing systems to not only “bounce back”, but also “bounce forward” (Davoudi et al. 2012).

Resilience management approaches assume that spontaneous learning will naturally occur at all levels of an organization, and recommend social learning as a way to boost adaptive capacity in a deliberate and systemic fashion, providing feedback to the management system which can be continuously adapted to better fit reality (Kolb 1984; Kim 2004; Walker et al. 2004; Schusler et al 2003; Johannessen and Hahn 2012). Such social learning achieves a change in understanding that goes beyond the individual to become integrated within wider social units or communities of practice through social interactions between actors within social networks (Reed et al. 2010). But it is up to the organization to internalize such learning and make active use of it (Westley 1995).

3. KRISTIANSTAD IN CONTEXT

3.1 Spatial planning in Sweden

In Sweden the local level plays an important role in planning, since there is a “planning monopoly” – that is, municipalities mainly are responsible for planning the use of land and water within a legal framework set up and supervised by national government. They develop comprehensive plans for the current and the long-term aims for land and water management. The detailed development plan covers parts of the municipality and is binding (MEFNA 2004). The municipality also has responsibility to deal with risk issues. However, in practice, municipalities have a longstanding tradition of offering attractive near-shore areas for development to stimulate an influx of people (and taxpayers) and, in so doing, increasing exposure to floods (SOU 2007).

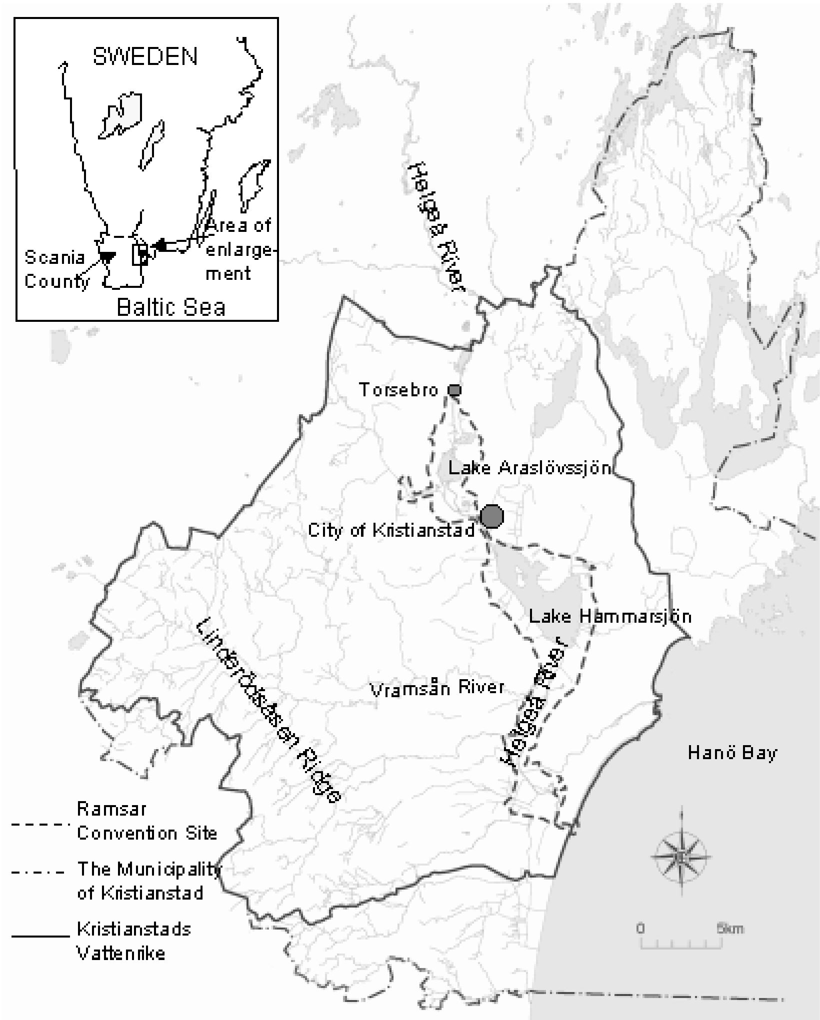
New legal provisions have been created to make sure that natural hazards are considered in construction permits and zoning (PBL 2008). However, local politicians often need to make rapid decisions as they act close to the economic realities and the result is not always sustainable (MEFNA 2004) or not always risk aware. Another challenge is the tradition of spatial planners not tackling long-term risk issues, which often are owned by the more operative technical departments. Cross-sectoral integration of risk consideration is difficult to implement because the departments want to promote their own working areas and not others (Storbjörk 2009). Furthermore, land and water are valuable for a spatial planner in terms of contributing to “attractiveness, character and beauty” (Uggla 2010) but not as a functional space for water to flow.

3.2 Kristianstad

Kristianstad is a city in southern Sweden, in the province of Skåne (Scania) that was Danish territory until 1658. It has about 36,000 inhabitants in the city proper, and 80,000 in the municipality, with large areas of natural wetlands.[4] It includes Sweden's lowest point (2.41 metres below sea level). The municipality is in the lower third of the Helge River basin, which has a catchment of 4,749 km^2 (Helgesson et. al 1994; SMHI 2002).

The Helge River is under the governance of the Southern Baltic Sea River Basin District Authority (*Södra Östersjöns vattendistrikt*), hosted by the County Administration Board in Kalmar County. The Helge River basin is a richly branched river system. Its upper and main reaches run through a forested area, while the southern parts run through an agricultural area on the chalk-rich Kristianstad plains before ending in the Baltic Sea. The Helge River basin has in total 172 water bodies: 30 lakes, 83 rivers and 59 groundwater aquifers. Figure 2 shows the Lower Helge River catchment, including Kristianstad.

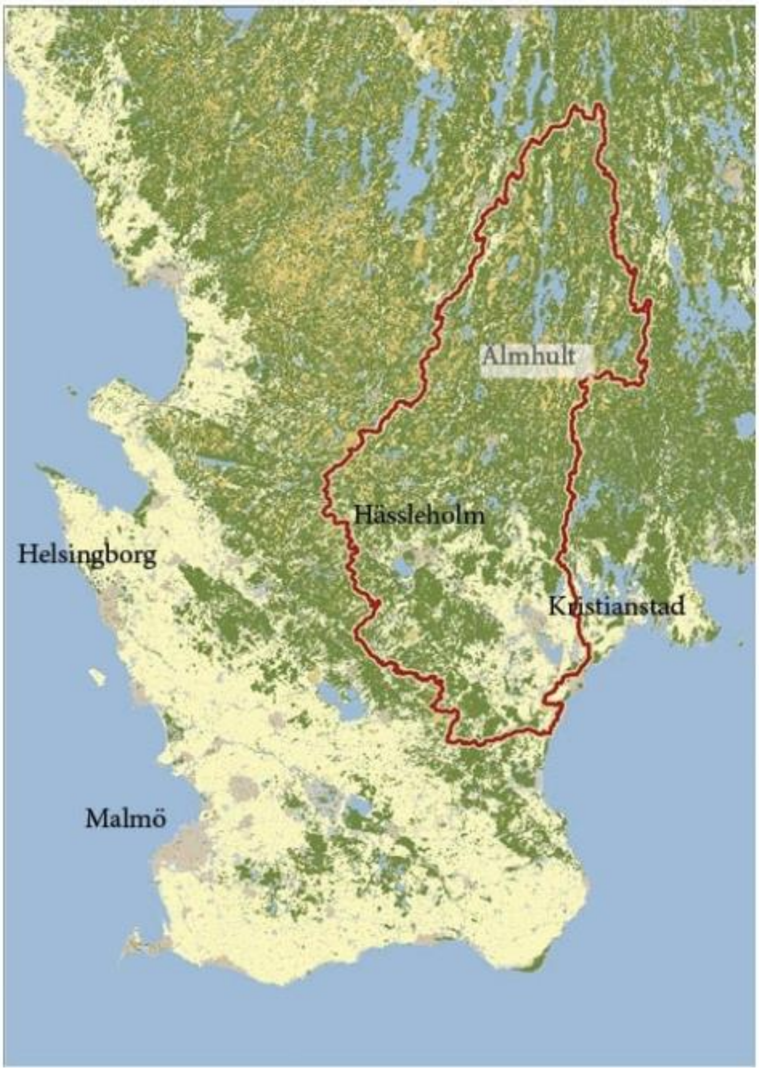
Figure 2: The Lower Helge River catchment



Source: Olsson et al. (2004).

[4] See Kristianstad website, http://www.kristianstad.se/sv/Kristianstads-kommun/Sprak/English/.

Figure 3: Map of Southern Sweden with Helge River Basin and Kristianstad Municipality



Historical background

Historically, people often settled along rivers, because floodplains provide fertile farmland, resources for economic development, drinking water and transport (Smith and Ward 1998). Kristianstad's is no exception, but its extraordinary exposure to floods is also due to having been founded as a fort in the middle of a wetland, in 1614, to protect its inhabitants from military raids. Also, the whole landscape around Kristianstad following the Helge River is part of an old sea bay, with a long history of flooding.

An attempt at flood control by farmers in 1775 (at Gropahålet) had great consequences for the development of the city and the upstream wetland. A ditch to the Baltic Sea that was being dug was accidentally widened by the wave action and spring floods, causing the river to break through and expand the ditch to 90 metres, taking a different route to the sea (A:son-Näs 1986) and lowering the water level in lakes near Kristianstad by about 60 cm. New land thus became available for cultivation along the shores of the Helge River, and a great part of the wetland became dry. Trade decreased after the lowering of the river at Yngsjö, as the river was no longer as navigable as before (Kennedy 1899). Kristianstad lost its military status, and the fort was closed in 1847 (Mårtensson 1999). When the restriction on house-building outside the fort walls disappeared, the city grew quickly and immediately. In less than 50 years, the city expanded in the wetland over a surface many times that of the original fortified area (Cederström 1923).

As communities sought to increase productivity from agriculture and forestry, they paid little attention to the impact on the rivers. As in many other places in Sweden (and Europe), land use management in Kristianstad in the 19th and early 20th centuries involved creating new land for agriculture and housing by building embankments and lowering lakes (Kristianstads kommun 2000b). This meant a "dewatering" of the natural environment to increase productivity from sectors such as agriculture and forestry and also to improve navigation on the river. Many times this was financed by the state through grants and loans. During this time, as much as 90% of the original wetlands were transformed in the Skåne region (Tonderski et al 2002).

Many wet grasslands for hay-making and grazing were also laid dry during this period, while others were created when lakes were lowered. Today the area of farmland and grazing land is considerably smaller than what it was at its greatest extension in the 1930s, but only a fraction of the original wetlands have been restored (Svanberg and Vilborg 2001). Historically, wet grasslands for hay-making and grazing (*Strandäng*) have been part of the agricultural practice in Skåne, and they are still maintained today for their biodiversity value (eligible for EU support) and for producing valuable fodder for animals. At the end of the 18th century wetland ecosystems were actively flooded or dammed to maximize fodder production (*silängar och dammängar*) but these practices are not maintained today (Elveland 1979).

Draining by ditches to increase forest productivity started in a greater scale at the beginning of the 20th century (Hånell 1990), often with state subsidies. Forestry is responsible for most drainage of wetlands in Sweden; an estimated 1.5 million hectares have been drained in Swedish forestry (Hånell 1990). Yet the benefit to forestry has been marginal, and there have been negative impacts on the rivers and wetlands. In 1986, legislation required every new ditch project to be approved by the County Administration. In 1994 it was prohibited to drain by ditches in some parts of Sweden, and that, together with the removal of the state subsidy, reduced the number of ditches considerably (Naturvårdsverket 2009b).

Notably, the wetlands around Kristianstad were long considered a health hazard, for good reasons. No sewer system existed, and all sewage ended in the blocked canals around the old fort, creating a terrible situation. In 1857–58, a cholera epidemic killed about 600 people, 10% of the Kristianstad population at the time (Cederström 1923). A professor in hygiene at the Royal Karolinska Institute, E. Almqvist, made a statement in 1897 about the "hygienic importance" of drying large areas of wetland: "the water levels get less ability to fluctuate ... Watersick ground is viewed for good reasons as unhealthy, the fog that spreads chill and damp, as well as the fevers that we suspect is associated to such grounds" (Kennedy 1899).

One of the largest embankments in Kristianstad, Hammarslund *(Hammarslundsvallen),* was built in 1868, cutting off the former Nosaby lake area from the Helge River water system (Mårtensson 2001). The building of Hammarslund's embankment was part of initially grand plans to build a canal all the way through the municipality from Torsebro to the sea at Åhus; to build embankments surrounding the entire Helge River; and to drain Araslöv Lake, Nosaby Lake and Hammar Lake (Magnusson 1981). The vision was, apart from creating agricultural land for food production, to make it possible for big ships to sail all the way from the sea to Kristianstad, and recreate the trading city as it was before 1775. The area of the lakes and other "water sick" ground was estimated to contain 8,500 ha of potential agricultural land, valued at 5.7 million SEK (Kennedy 1899). However, the dry lake's sediments made it unsuitable for agriculture, and the area lay unused for a long time.

In the 1970s, the Hammarslund embankment provided a welcome opportunity to address a pressing the need for housing in an expanding city. Between 1971 and 1982, 1,300 apartments were built in the dried-out Nosaby Lake area (Friström 2000). The city planners knew about the flood risk, but land was in short supply, and extreme weather events were considered to be so improbable, "*perhaps once in 300 years*", that they were willing to take the risk (Friström personal communication).

Between 1940 and 1945, large-scale dredging was done from Torsebro and in the Araslövs Lake and Hammar Lake (Magnusson 1981). The aim was to make the water withdraw more quickly from the land after high peak flows, and the average level was in fact lowered by 35 cm at Kristianstad (Rooswall 2002).

The development of a UNESCO Biosphere Reserve in Kristianstad

In 1974 Kristianstad was designated as an internationally recognized biodiversity area, listed under the Ramsar Convention. A local initiative developed during the 1980s to protect roughly 100,000 ha of what was named Kristianstad's Water Kingdom (*Kristianstads Vattenrike*) contributed to changing the view of the wetlands from "water sick" to "water rich". This area includes one of Sweden's largest areas of wet grasslands, about 1,600 ha (Naturvårdsverket 2009a). See Annex B for a map. In 2005 the Kristianstads Vattenrike Biosphere Reserve (KVBR) was formed as the first UNESCO Man and Biosphere reserve in Sweden, fulfilling the 1995 criteria (Olsson et al. 2004; Hahn et al. 2006). The area is also part of the EU Network of Natura 2000 (Magnusson 2004).

Figure 4: Natural variation in water levels outside Kristianstad

Both photos show the same meadow during summer and winter, with the natural variation in water levels. Photo by S-E Magnusson, Biosfärområde Kristianstads Vattenrike.

4. FLOOD AND NUTRIENT RISKS IN KRISTIANSTAD

4.1 Flood risks

The Swedish Commission on Climate and Vulnerability proposed in 2007 that municipalities be obliged to take greater account of flood and landslide risks in physical planning through clearer legislation and guidelines. The limitation period for the obligation of the municipalities to pay compensation should be increased from 10 to 20 years (SOU 2007). The goal was to better protect individuals and create stronger incentives to adapt to longer-term climate risks instead of making short-term investment decisions. However, more than seven years later, the Swedish government has not acted on this suggestion, nor has Sweden seen practical implementation of these ideas on the ground in the municipalities (Svedberg and Lindenius 2012). In spite of this, Kristianstad has been taking the initiative in several areas to reduce the flood risk to the city.

The flood risks in Kristianstad originate in different places and combine to exacerbate one another. In the rural parts of the river basin, there is a flood risk to the surrounding land (e.g. agricultural fields) and wetlands due to an annually fluctuating water level in the river; where there are (more low-lying agricultural) embankments, the land is vulnerable to flooding if they break. The urban areas are in the same way vulnerable to flows coming from upstream in the river basin, and when the flows are dammed by the Baltic Sea, drainage speed is reduced. With sea-level rise this damming effect will be greater, providing a great flood risk to Kristianstad. This is in combination with the city's low-lying location, where central parts of the city are located behind embankments and dependent on pumps in constant operation. Rainfall in the city constitutes another flood risk, as stormwater is difficult to drain from a low-lying area.

Urban flood risk – embankments and pumps

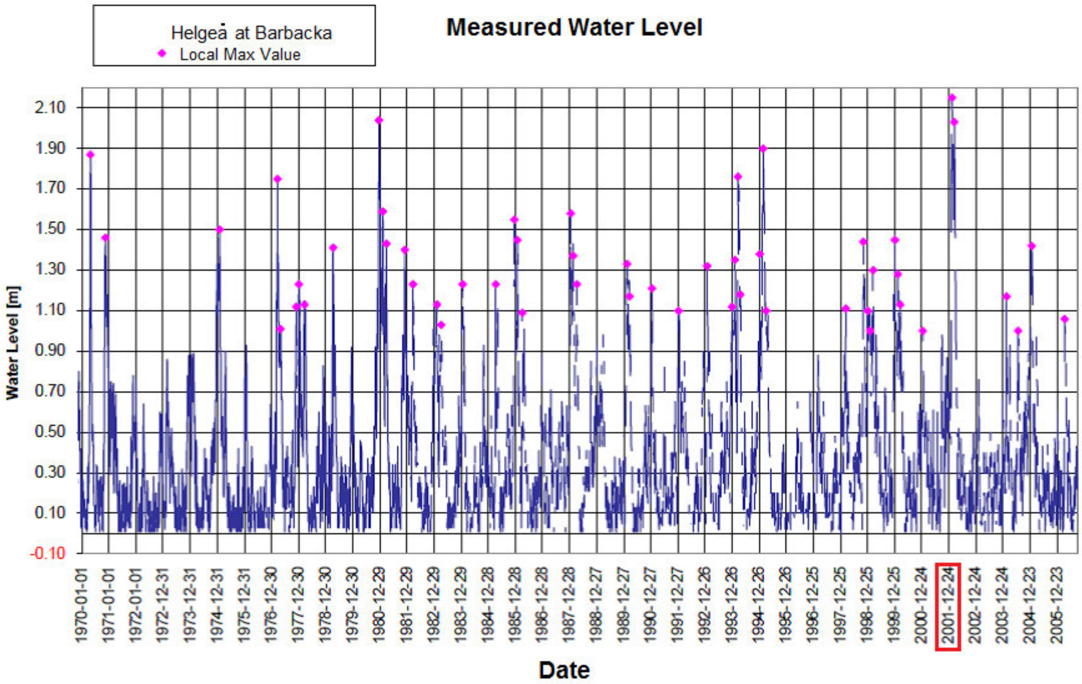
Kristianstad is considered a leader in flood risk reduction in Sweden, because it has taken the initiative to mitigate risks – facilitated in part by an extreme flood in 2002. The city is also part of the United Nations International Strategy for Disaster Reduction (UNISDR) "Resilient Cities" campaign.[5] From 2002 to 2020, Kristianstad's existing and new embankments are to be rebuilt, although delays and cost estimate increases are concerns.

Several new embankments are being built, along with six large pump stations to remove water from different parts of the city; otherwise natural groundwater flows would fill up the area. The embankments are designed to cope with a water level of 3.71 metres above sea level in the city centre. This is regarded as a good margin to the recurring extreme floods (an extreme flood is defined as more than 1.90 metres above sea level). The highest recorded levels were in 1905 (2.23 metres), in 1980 (2.04 metres), 1995 (1.90 metres), and 2002 (2.15 metres). The most recent extreme flood was in 2007 (1.96 metres), which occurred in the summer, an unusual phenomenon.

Figure 5 below gives an overview of the water variability of the river water levels. The flood risk in Kristianstad is a consequence of flood waters coming from the catchment, but mainly is a problem of the low altitude difference and hence slow drainage into the Baltic Sea, especially at high sea water levels. See Annex C for maps of flood risk with and without new embankments (Johannessen and Hahn 2012).

[5] See http://www.unisdr.org/campaign/resilientcities.

Figure 5: Variation in water levels in the Helge River at Barbacka (Kristianstad city centre)



Source: Kristianstads kommun (2007).

Although ongoing dredging and small improvements to the embankments have mitigated flood risk, it was only in the mid-1990s that flood risk concerns raised serious questions about the safety of the city – initially focusing on the Hammarslund embankment. Box 1 shows the consequences of a potential break in that embankment. This concern was triggered by an insurance company and local managers and driven by an "embankment group" consisting of two persons from the rescue service and two from the technical department (C4 Teknik 2010) in the municipality who considered the old embankments not safe enough. They initiated a process which resulted in a project mainly rebuilding embankments, which should cope with 10,000-year flows and build new pump stations. As a result, the flood issue became more integrated into municipal management, and the flood risk was communicated more openly to the public.

Input from the Swedish Civil Contingency Agency (MSB) shifted the focus from a shorter temporal perspective (500 years) to longer-term ones (10,000 years), which influenced the spatial scale at which the flood risk was considered. This in turn shifted the focus from strengthening only the 1.5 km Hammarslund embankment to several embankments (currently under construction) of about 10 km, as the water could enter the city from new directions. Although the initiative came locally, important partners for providing technical expertise were the Swedish Meteorological and Hydrological Institute (SMHI) and Swedish Geotechnical Institute (SGI), the Danish Hydraulic Institute (DHI), and local consultants. The main support, including funding, has come from the MSB, with a national level mandate for flood risk management working under the Civil Protection Act (2003:778). This is part of the MSB's mandate for protection of the population from emergencies of all types, emergency management, and civil defence. At the municipal level, the rescue service carries out this mandate (Johannessen and Hahn 2012).

Box 1: Consequences of a break in the Hammarslund embankment

- A great surge of water and a quick (five hours) filling of Nosaby Lake.
- 700 ha of the city will be flooded.
- The sewage treatment for Kristianstad and 18 other cities would cease to function.
- The central hospital will flood and need to be cleared.
- Large areas with housing, day-care centres, schools and health care have to be evacuated.
- 12,000 people are affected in the worst-case scenario.
- The supply of electricity, heating and water will be affected.
- The municipal rescue service station will be flooded.
- Important routes of communications will be blocked.
- The city is abandoned; restoration time is estimated to be six months.

Source: Risk analysis by Anders Pålsson, Kristianstad rescue service.

Urban planning

Today, responsibility for flood risk reduction falls mainly on three players: the municipality, private homeowners, and insurance companies (Moberg 2012). Urban planning is governed by the Swedish Planning and Building Act (PBL 1996), which since 2008 requires consideration of natural hazards in construction permits and zoning. The Swedish National Board of Housing, Building and Planning (Boverket) is mandated to monitor the implementation of this act. It provides, for example, online guidelines of planning in flooded areas (Boverket 2001).

Within the embankments, Kristianstad's central areas continue to expand without flood adaptation, where spatial planning assumes that the barriers will hold. Risk managers, technical and urban planners have discussed the need for continued risk awareness although there are embankments in place. The national agency MSB has criticized the persistent "business as usual" in housing construction and development, which increases vulnerability and exposure to an unexpected break in the embankment, or failure of the pumps.

There is also a difference in views on how the city should expand into the wetland. The "Naturum" is a combined conference venue, café and wetland museum. It is the only example of a building in Kristianstad that is designed to co-exist with the floods. This was initiated by the Biosphere Office, a department in the municipality which advocates for the adequate use of the wetland values in the city and for approaches such as "living with the floods". For example, it contested the proposed urban development in 2006 in a near shore location using landfill, arguing that the approach showed a lack of understanding of how the wetland can be utilized (Magnusson and Svensson 2012). On several other occasions, building permits have been approved for inappropriate places (with high flood risk), and without adaptations (such as stilts) which has triggered a reaction from the rescue service and the technical office. Here the city planning office reacted in the right way and corrected the approach. One interviewee even considers the city planning office to have become a positive factor in the area of risk management (Interview 14).

In case of a flood threat, some preparedness measures have been taken, including an early warning system with monitoring stations in the municipality and access to SMHI monitoring in the Helge River basin, and a website, Flood Watch Kristianstad,[6] that offers real-time

[6] See http://floodwatch.kristianstad.se/.

updates. Escape routes exist for housing situated below the critical level of 3.5 meters, and sensitive equipment in cellars should have been moved or flood-proofed (Interviewee 14).

The overarching strategy for multi-sectoral development is the municipal comprehensive planning (*översiktsplanering*). This planning is satisfactory, but can always improve to integrate municipal planning even more, which one interviewee mentioned, and also stressed that it is one of the most important measures to address nutrient and flood issues (Interview 2). At the moment, in relation to flooding, only embankments are mentioned and stressed in this planning. However, in the focus group discussion informing this study, staff of the Kristianstad city planning office said they realize this limitation and are willing to take a more holistic and integrated approach to flood management in the next planning cycle.

More coastal erosion is expected as a result of climate change. The shoreline will, if no other actions are taken, be shifted inland with sea level rise. During the focus group discussion, concerns were raised about the amount of beach space available for tourism (and the revenues it brings) especially also since private settlements could be even closer to the shoreline in the future. The risks at the coast and the marine spatial planning are one of Kristianstad's next priority areas for planning.

Urban stormwater

A policy to adapt stormwater systems and urban drainage has been drafted for the city, including a focus on retention areas as a way to prepare for more extremes in rainfall (C4 Teknik 2010). The policy is described more in detail further below.

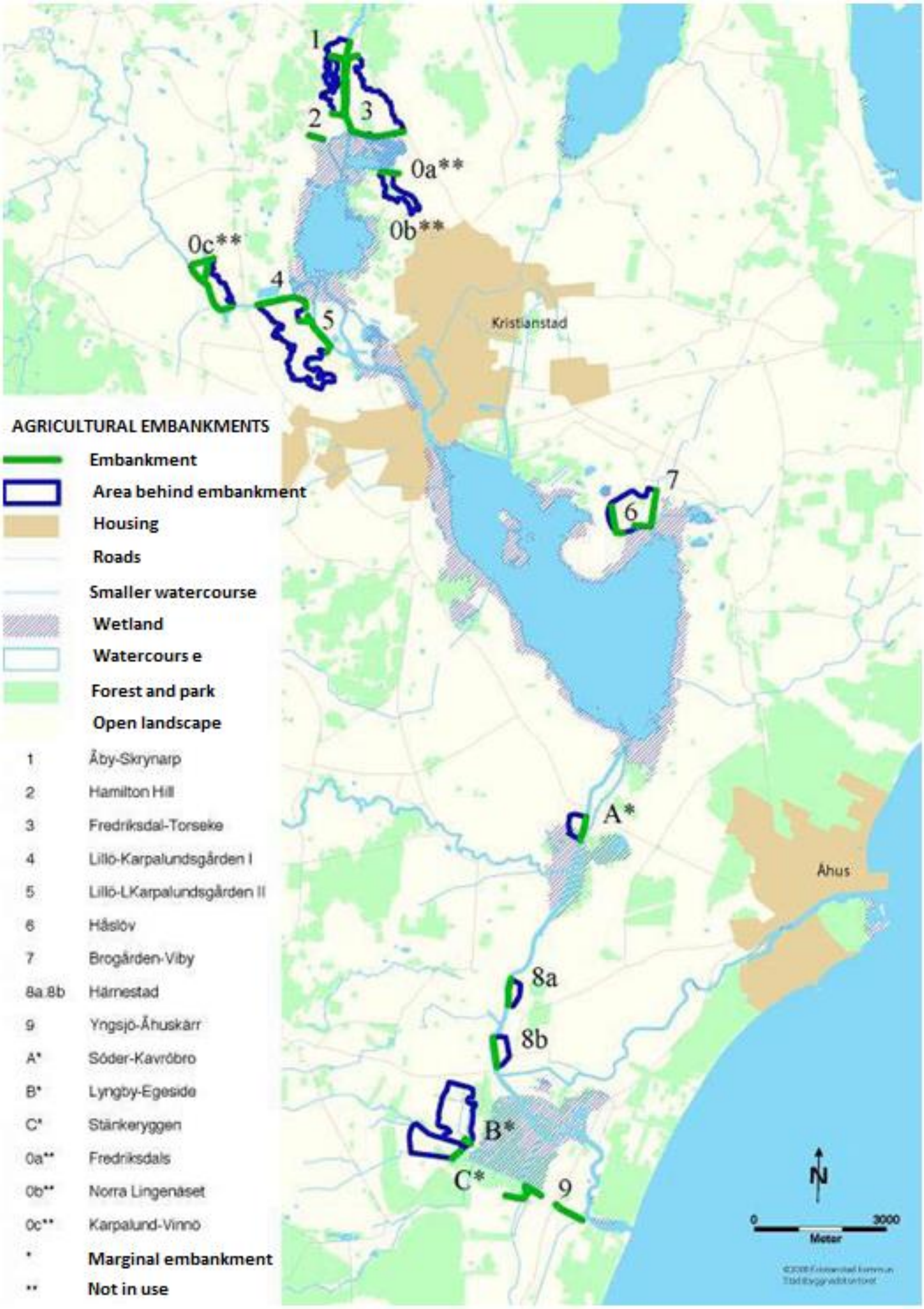
Agriculture and the wet grasslands for haymaking and grazing

Many agricultural lands in Kristianstad surrounding Helge River have as one part wet grasslands for haymaking and grazing. The long-term landowners of these lands are very accepting of floods in this natural environment, where they can have grazing animals (Magnusson, personal communication). Some farmers have however chosen to put up an embankment to shut out the floods to enable an increase in crop production. Embanked areas of around 1,200 ha are spread over 13 different places, as shown in Figure 6 (Magnusson and Svensson 2012). The wet grasslands for haymaking and grazing capture sedimentary nutrients carried by the floodwaters that contribute to the production of hay in the growing season. They also provide buffer zones for floodwaters.

Mostly, floods occur in late winter and early spring, when the grass has not yet started growing. However, when floods come in late spring/early summer – the "wrong" time of the year – the grass already has started growing, and the organic substances carried by the water are deposited like a brown film over the vegetation. "Normal" summer water levels are approximately 20 cm above sea level. On 11 July 2007, an unusual summer flood arrived, with water levels 1.76 m above sea level. Such a flood was last measured in 1927, although it did not last as long (Kristianstads kommun 2007).

This flood had a considerable impact on the farmers: harvests were low to non-existent, as new grass was prevented from growing and the land was too wet to be harvested by machines. The grass was not considered suitable for fodder and was rejected by the grazing cows. Grass that was not grazed in 2007 was also left untouched after the 2008 season. Hay harvested in 2008 also contained some old grass, which reduced the quality of the fodder (Tuvendal and Elmqvist 2011).

Figure 6: Agricultural embankments in Kristianstad



Source: Berglund (2008).

Summer floods may affect farmers' willingness to maintain the wet grassland by grazing and haymaking, also influencing the bird habitat (Kristianstads kommun 2007). One farmer mentioned this in an interview: "The summer floods are problematic, and if they continue, it will be more difficult in the future to use these lands. We are used to winter floods – that is less of a problem" (Interview 4). Long-lasting effects of the summer floods on the farmers are due to dead vegetation or lowered productivity (Oveson 2002). However, this does not seem to be important, as an inventory of the wet grasslands for haymaking and grazing (Oveson

2002) showed an increasing trend despite the 2007 flood. However, with sea-level rise, wet grasslands for haymaking and grazing bordering the river will increasingly lie under water. The higher water levels will also challenge those fields with agricultural embankments, which would need to be strengthened, or they would breach more frequently. An increase in sea level may not initially have an effect as in many places the agricultural land is slightly elevated in relation to the wetland. This natural "bank" (*strandhak*) which surrounds the fields provides a natural shoreline where the water does not flow further horizontally.

Many farmers are convinced that floods are taking longer to withdraw and would like the river to be dredged in the lower sections. A joint property society established in 1936 (*Nedre Helge åns regleringsföretag*) is responsible for maintaining the flow – in practice the depth and width – of the river under the local water regulations (*vattendom*), but it has been exempted of this responsibility. This is because a hydrological modelling commissioned by the municipality concluded that dredging would have very little effect because of the small elevation difference with the sea level during extreme floods. This includes dredging in the middle of the Helge River from Torsebro to the sea (DHI 2009a; DHI 2009b; DHI 2010). As individual landowners would have to pay for the dredging, they feel the cost is too high for the benefits, which are not certain. Although the area to be dredged would be limited, ecosystem management concerns are that some habitats for river molluscs, fish, insects and mammals could be affected (Interview 9).

Although some farmers in Kristianstad are exposed to very variable and unpredictable water fluctuations, government payments to farmers for managing wet grasslands for haymaking and grazing is not adapted to fit this reality. For example, there is a lack of flexibility in terms of the estimation of the area to be compensated as well as the timing of the harvest. If the farmer estimates a specific area to be managed there is a risk of a penalty if nature provides for a few years of flooding more than the provided estimate. One interviewee thinks the compensation needs to tolerate a year without grazing, provide suitable timing for harvest, and allow for more variation (Interview 10). As it is now, variability in water levels imposes financial risks on the farmer. Reviewing the compensation system to farmers (part of the EU agri-environment support for biodiversity) is considered to be a way to deal with this gap (Interview 10).

Although the area is abundant with water, there are also indications that water scarcity could be an issue during the summers, especially in dry years. Irrigation in the lower reaches of the Helge River is known to create lower flows in the summer and impacts on plant and animal life (Jordbruksverket 1994).

Water retention upstream in the forest ecosystem

An extreme flood situation, or "worst case scenario", would normally occur in the early spring. It combines conditions of frozen ground with rapid snowmelt. The embankment group deliberated on ways of reducing floods and concluded that as there are no major dams regulating the flow of the Helge River, measures upstream would either be inadequate or controversial (e.g. building a large dam in another municipality). Water retention capacity from increasing wetlands upstream was also considered inadequate, as the ground would be frozen. However, these were conclusions not based on hydrological modelling, which has the potential to calculate the principal effect on the flow regime from more ecosystem related measures such as reduced drainage and increased share of wetlands for the Helge River. In such a model, scenarios of additional wetlands, ditches and meandering can be imagined, and the effect modelled on downstream landscapes. The cost for such a calculation would depend on the level of ambition, e.g. requiring about 6–12 weeks of work = 150,000–250,000 SEK for an area of 10–100 km^2, or 250,000–500.000 SEK for an area of 100-1000 km^2 (Gustafsson, personal communication).

Not focusing on the worst-case scenario, but also looking at other flow frequency scenarios, the dewatering (ditches, reduction of wetlands, culverts, etc.) of the upstream forest ecosystems is a lost buffer capacity for flood and nutrient management, at least in the summer. One interviewee said that in comparison to farming, the forestry sector has had less pressure to reduce nutrient leaching through, for example, control of ditches (Interview 5). This is confirmed by SEI research in the sense that the production goal in forestry continues to have priority over environmental goals, where this imbalance is related to the fact that the environmental goals and objectives are voluntary and not fully translated into practical rules connected with sanctions (Ulmanen et al. 2012). A district water authority employee confirms that the ditches constitute a great source of dewatering, and this has been discussed, but it is a complex issue and difficult to hold someone accountable.

A great responsibility lies on the Swedish Forest Agency (*Skogsstyrelsen*). Were the district water authority to approach the issue of dewatering of the forest, this would have to be coupled with other important management areas, such as effects of clear-cutting. The water holding capacity of the landscape should be increased to mitigate floods and capture nutrients, but this would need to be complemented with measures in other sectors, such as transport, agriculture, and sewage systems, as one interviewee from the river basin authority mentioned (Interview 6). Implementing measures which concern water flows is however challenging in Sweden, as current regulations still requires a joint property society (*Dikningsföretag*), which says that all land owners with access to the structure are to keep existing ditches or drains functional. All members of such a society must agree to change the regulation. However, flows are often influenced by upstream measures which have not involved or even informed the joint property society, so many argue that further reforms are needed (Lennart de Maré, personal communication). The joint property societies which already collaborate on managing the drains would be a good candidate to be mobilized to restore wetlands instead.[7]

The Biosphere Office is part of a project called the Baltic Landscape, which is led by the Swedish Forest Agency. This project is implementing a pilot in the lower part of the Helge River basin with the aim to create "Model Forests". Based on a Canadian concept acknowledging the multiple uses of forests, this is a partnership-based approach to the sustainable management of forest-based landscapes and natural resources. It is as much about the people who sustain themselves from the forest, the effects they have on natural resources and their human development, as it is about trees and forest products.[8] The pilot is the first step towards Model Forest certification of the Helge River basin. This is a way for the Biosphere Office to expand upstream. In the same way that the Biosphere Office has worked with "outdoor museums" to inform how to manage the wet grasslands for haymaking and grazing, it will work in the forest to show the value of forest wetlands and different options to improve sustainable practices, such as to manage erosion, nutrient leaching, and digging ditches.

[7] Anna Wolfhagen, Scania County Administration, comment in the workshop 25–26 September 2012.
[8] See project website, http://helgeamodelforest.se/.

4.2 Water quality risks

Baltic Sea and Hanö Bay

This HELCOM Initial Holistic Assessment shows that the environmental status of the Baltic Sea is generally impaired. None of the open basins of the Baltic Sea has an acceptable environmental status at present (HELCOM 2010).

Eutrophication is the result of excessive nutrient inputs and is an issue of major concern almost everywhere in the Baltic Sea Region. Biomass production is so high that it leads to decreased water clarity, exceptionally intense algal blooms, more extensive areas of oxygen-depleted sea beds, degraded habitats, and changes in species abundance and distribution. The transport of nutrients depends on precipitation and the flow in rivers. The phosphorus and most of the nitrogen enters the Baltic Sea as waterborne inputs (i.e. via rivers or as direct discharges). The atmospheric deposition of nitrogen directly onto the Baltic Sea comprises about one quarter of the total nitrogen load to the Baltic Sea.

Table 1: Nitrogen and phosphorus loads and riverine flow to the Baltic Sea, 2006

Country	Flow (m^3/s)		Nitrogen (N) total (tonnes)		Phosphorus (P) total (tonnes)	
Denmark	320	2%	53,000	8%	1,520	5%
Estonia	440	3%	20,400	3%	790	3%
Finland	2,050	15%	79,000	12%	3,490	12%
Germany	110	1%	16,900	3%	490	2%
Latvia	890	7%	59,500	9%	2,800	10%
Lithuania	430	3%	28,000	4%	1,240	4%
Poland	1,650	12%	152,600	24%	10,240	36%
Russia	2,120	16%	107,600	17%	4,070	14%
Sweden	5,610	41%	121,000	19%	3,730	13%
Total	**13,620**	**100%**	**638,000**	**100%**	**28,370**	**100%**

Note: The figures include transboundary loads but data from coastal areas in Russia and industries in Poland are missing (HELCOM 2011).

In all parts of the Baltic Sea, living organisms and bottom sediments are affected by hazardous substances such as PCBs, heavy metals, TBT, dioxins, DDT/DDE, PAHs and alkylphenols. The status of biodiversity appears to be unsatisfactory in most parts of the Baltic Sea. According to the preliminary results of the biodiversity assessment, 82% of the coastal areas assessed exhibit an unfavourable status. Most prominently, the marine environment is under pressure by anthropogenic loads of nitrogen, phosphorus, organic matter, and hazardous substances. But commercial fishing is also a strong and widespread pressure that severely impacts the Baltic Sea ecosystem, especially the widespread and destructive practice of bottom trawling. The seabed also is disturbed by construction works, dredging and the disposal of dredged material, which can have large impacts on local marine environments (HELCOM, 2010).

The HELCOM Baltic Sea Action Plan (BSAP) is an ambitious programme to restore the good ecological status of the Baltic marine environment by 2021. The strategy, adopted by all the coastal states and the EU in 2007 at the HELCOM ministerial meeting in Krakow, is a stepping stone for wider and more efficient actions to combat the continuing deterioration of the marine environment resulting from human activities (HELCOM 2010).

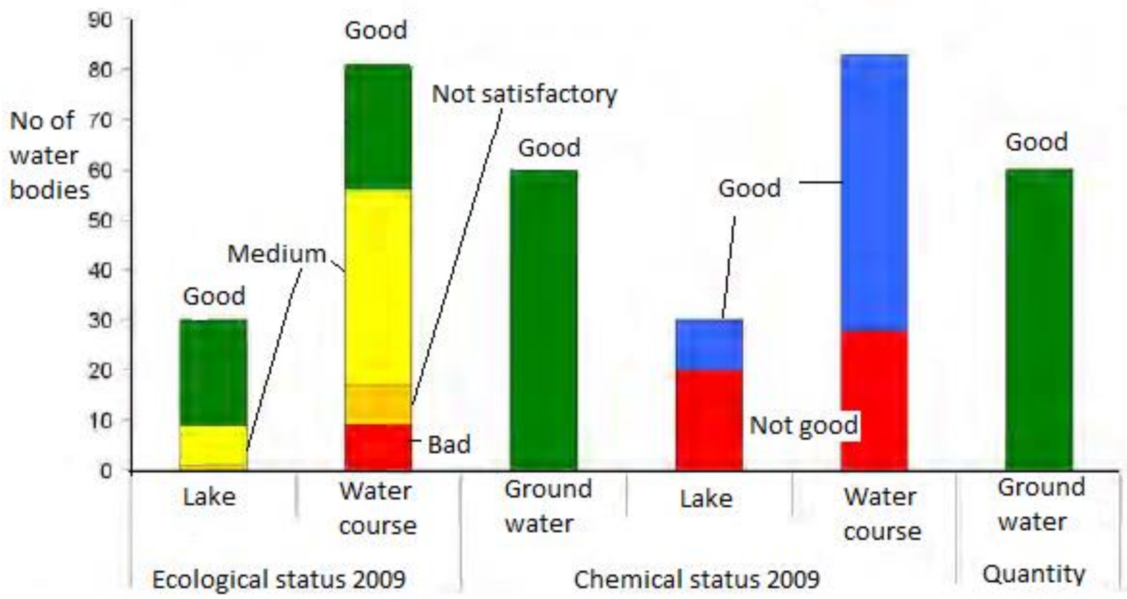
Many interviewees stressed the importance of Baltic collaboration as crucial for achieving better water quality. There seems to be a perception that countries other than Sweden are most responsible for the nutrient inputs to the Baltic Sea – for example, by dumping sewage and fertilizer into the sea and in the forest, a problem they have seen reported on TV (Interviews 11 and 12). However, as shown in Table 1, Sweden has a substantial part in nutrient release to the Baltic Sea – even more when calculated per capita.

In 2010, Hanö Bay was relatively far from the goal of "good ecological status 2021" with an overall rating of 3 out of 5, medium status (BKVF 2010). Recently, Hanö Bay has been the focus of special investigations responding to reports of local fish migrations, deaths, wounds and bad water quality. However, current results indicate that there does not seem to be a specific cause to the observed problems. It was concluded that the water quality in Hanö Bay is affected by eutrophication: annually, the Helge River contributes about 24,000 tonnes of organic substances, 36 tonnes of phosphorus, and 2,390 tonnes of nitrogen to the Hanö Bay. The river water also has very high organic content, though there are no areas with low levels of oxygen or without oxygen. Further investigations will be carried out to look, for example, at combined "cocktail effects" from several different hazardous sources: pesticides, historical discharges from the paper mills, dumped chemical weapons, and shipwrecks. Wind conditions in the bay also affect quality. Simulations with the SMHI Hiromb-model show that the water of the Helge River at high discharge and strong easterly winds can be concentrated near the coastline, south of the mouth of the river, which could concentrate substances and affect fish behaviour (HaV 2013).

The Helge River

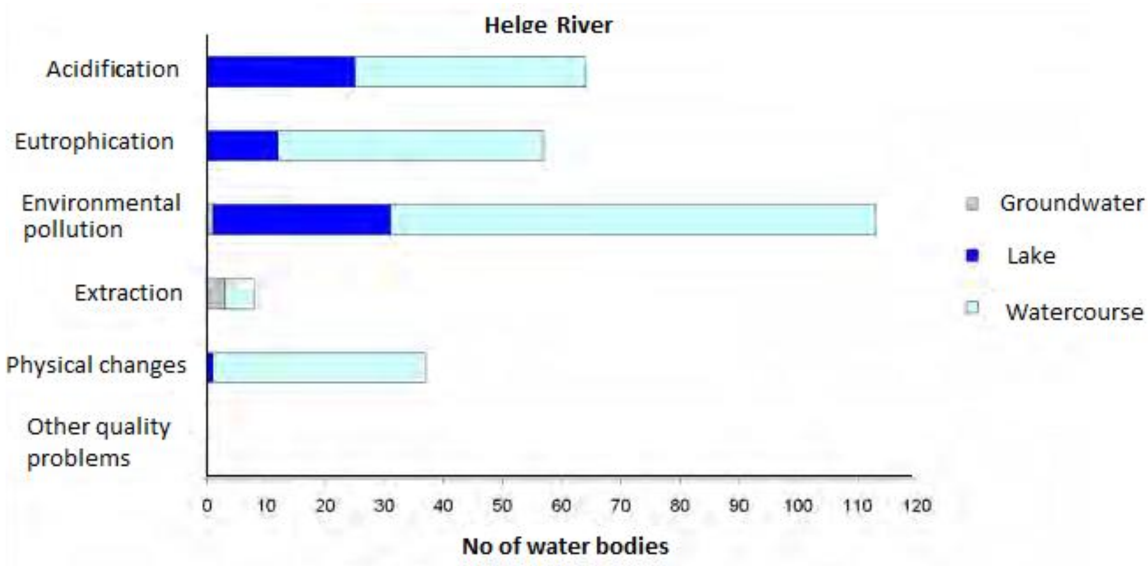
The ecological and chemical status of the Helge River's lakes, watercourses and groundwater is mixed, as shown in Figure 7. In the Helge River basin, 58 rivers and 9 lakes are expected to *not* reach good ecological status in 2015 if no actions are taken. Issues include eutrophication, acidification and brownification, physical changes in the natural flow and pollutants, including heavy metals (e.g. mercury) industrial pollutants and pesticides (see Figure 8).

Figure 7: Ecological, chemical and quantity of water for the Helge River, 2009



Source: Vattenmyndigheten (2009).

Figure 8: Environmental problems in the Helge River



Source: Vattenmyndigheten (2009).

Eutrophication in water bodies in Sweden is caused by a combination of diffuse sources from agriculture and point sources, including discharges from municipal sewage treatment plants and storm water. Other major contributors include forestry, pulp industry (paper) and sewage from individual households (Vattenmyndigheten 2010). Table 2 summarizes the different sources of phosphorus and nitrogen in the Helge River.

Table 2: Sources of phosphorus and nitrogen in Helge River

Source to Helge River	N (Total 3,600,072 kg/year)	P (Total 55,091 kg/year)
Private sewage systems (*enskilda avlopp*)	1.2%	10.6%
Wastewater treatment	9%	5.3%
Industry	0%	0%
Agriculture, background	18.3%	19.8%
Agriculture, anthropogenic	41.5%	23%
Forest	12.1%	13.4%
Mire	3.2%	1.9%
Open ground	4.3%	15.8%
Water	5.5%	1.6%
Clear cutting, background	0.6%	0.6%
Clear cutting anthropogenic	2.6%	0.4%
Storm water, background	1.1%	3.6%
Storm water, anthropogenic	0.5%	3.9%
Total Helge River nutrient load (per Kristianstads Miljöbarometer): Phosphorous: 0.060 kg/ha Nitrogen: 3.10 kg/ha		

Source: SMED in Vattenmyndigheten (2009).

Urban nutrient risks – wastewater

The water quality in the Helge River declined during the 20th century, due to a great extent to untreated wastewater from the city and industries and a waste dump that was established in the 1960s (Vattenmyndigheten 2009). Improvements in wastewater treatment have substantially reduced its contribution to eutrophication mainly in Hammarsjön. Growing reed beds are a sign of eutrophication (Andrulewicz 1997), and reed cover in the lake has been seen to decline; however, old nutrient-rich sediments may still exist. Great efforts have also been made to connect all households to a municipal wastewater treatment system. The Helge River currently receives discharge from 34 municipal wastewater treatment works, eight industrial facilities, and a few municipal waste dumps (Vattenmyndigheten 2009). Kristianstad's sewage treatment plant receives sewage from 18 other towns through an extensive network.

Respondents mentioned that in case of great floods, the system may lack capacity and risk overload as well as provide less-effective treatment (Interview 14). The sewage treatment and storm water systems are separate, but in some places connections have been made by private owners. During heavy rainfall the sewage treatment facility receives more water than normal. Treatment in the facility during these times may result in discharges into the Helge River that contain more nutrients than normal (Interview 2). There are perceptions that the discharges are sometimes unhealthy to grazing cattle. One interviewee said that after an extreme flood the "unpleasantly smelly substance" which ended up on his farm fields caused pregnant cows grazing there to miscarry (Interview 1).

Urban stormwater

About 7% to 11% of the phosphorus pollution in the Helge River is considered to come from stormwater, with equal origins of human activity and "natural" sources. Other hazardous substances also reach the river water from stormwater. Thus, practices such as filtration, sedimentation and other treatment of stormwater should be adopted to protect ecosystems.

Increasingly, efforts are being made to retain the rainwater where it falls in sustainable urban drainage systems – SUDS (*systematiskt lokalt omhändertagande LOD*) – with water retention within the urban areas to reduce pollution, and also to mitigate the overload to the stormwater system and wastewater treatment facility, which receives sewage from households and some stormwater. Two of the respondents mentioned stormwater management as a key solution (Interviews 2 and 8.) During projected extreme rainfalls in the future, the capacity of the stormwater/treatment systems will not be enough.

A new policy is in place to improve practices for stormwater retention, especially relevant for new developments. It stresses the important role of knowledge and awareness within the municipality and among developers and homeowners throughout the planning and building process to reserve space for infiltration surfaces and design these correctly. Management of stormwater is more challenging in low-lying locations and where there are embankments, such as in Kristianstad, as efforts to convey or pump out the stormwater are needed (C4 Teknik 2010). Implementation of this policy will likely affect the quality of the stormwater and significantly reduce water pollution through different ways of filtration through the urban substrates (HaV 2013).

Groundwater

The strongest risk to Kristianstad's groundwater, which provides the drinking water, comes from the high amount of nutrients from agriculture. According to the Swedish Food Agency, pesticides should not be present in drinking water and water with concentrations above 10 mg/l NO_3-N should not be given to children under one year old. Locally, traces of pesticides have been found and as well as nitrate concentrations of 20 mg / l NO_3-N. Mitigation of pollution from fertilization (by N) can be done by protecting the local water body/groundwater source, arrangements with the land owner or land acquisition (Kristianstads kommun 2000a). There are also issues with drinking water production capacity and high consumption that create drinking water scarcity risks (Interview 14).

Agriculture

Nutrient leaching from the agricultural lands is substantial from the lower areas of the Helge River basin. Practices have changed to the better due to research and information campaigns. For example, the research and knowledge programme VÅRDA Vatten[9] (manage/treat water) is focusing on modelling of nutrient transport. It was initiated by the Southern Baltic Sea River Basin District in 2010 to contribute with decision-making tools for the next management programme 2015. Financial incentives also are very important. About 30 years ago chemical fertilizers were cheap, while manure was something to get rid of year-round (Interview 12), but today there is awareness at a different level.

Several other instruments are in place to encourage the nutrient reduction in farming in Sweden in general. Farmers consider nutrients more and more as a resource because of increasing cost due to its limited supply. For example, fertilization in winter is not allowed, and research and information is provided about how different crops take up nutrients so that fertilizer application can be adjusted accordingly. The manure from the farm is analysed – different animals' manure has a different nutrient composition – and are distributed on the fields accordingly. The free advisory service Focus on Nutrients (Greppa näringen) – a joint venture between the Swedish Board of Agriculture, the County Administration Boards, the Federation of Swedish Farmers and several farming businesses – has had a great impact on nutrient management in Swedish farms.

One respondent mentioned such research and development programmes as the most important ways to further develop more efficient ways to recycle and use nutrients: for example, the potential reuse of nutrients from sewage treatment plant sludge, although issues there include contamination and food industry rejecting crops grown with sludge as fertilizer (Interview 12).

Reduction of the use of fertilizers and pesticides can be achieved through further voluntary actions by the farmers (Interview 7) – e.g. meadows with seepage water (*översilningsängar*) where the water is retained and is releasing nutrients to the soil (Interview 8). That said, these meadows cannot replace fertilization in intensive agriculture, as it would mean more leaching than capturing of nutrients (Heeb personal comment). A farmer mentioned that his practice of growing Salix near the water, which efficiently takes up nitrogen, (studied by SLU) ought to be something to stimulate e.g. through EU subsidies (Interview 5). Another farmer has built a new reticulation system of drainage water from agricultural fields; however, this is being delayed in court as this type of "exploitive" development needs to be trialled. In this context, respondents mentioned the need for clarity in regulations to avoid extensive legal processing. One issue is the interpretation of all activities as "exploitation", even though this may be an activity aimed at reducing nutrients, for example, or creating awareness.

[9] See http://www.vattenmyndigheterna.se/Sv/sodra-ostersjon/projekt/varda-vatten/Pages/default.aspx (in Swedish).

Loss of buffer capacity in the agricultural landscape

Wetlands provide important flood buffer capacity, but are also important to promote a rich agricultural landscape and reduce eutrophication (Jordbruksverket 2004). The value of wetlands for nutrient retention is very well known in Sweden. Wetlands' water cleaning functions and importance for biological diversity have led to the establishment of environmental subsidies to promote the creation and management of wetlands in agricultural landscapes (Albertsson 2004; Jordbruksverket 2004). Reintroduction of wetlands for biodiversity and nutrient retention is also high on the political agenda. Sweden's 11th environmental quality goals called for "thriving wetlands" (m*yllrande våtmarker*), with the aim that at least 12,000 ha wetlands and small water courses be reconstructed or constructed in Sweden by 2010 (Jordbruksverket 2000). Half of these areas were to be in the southernmost provinces (Skåne, Halland and Blekinge) and the other half in Götaland and Svealand. However, in an evaluation of the environmental goals published in 2012, only 7,500 ha were found to be in place; another 484 ha were added in 2012 (Naturvårdsverket 2013). The slow progress was attributed mainly to a lack of resources, given that the administration takes up a lot of time. A challenge has also been that land owners who are in the most critical areas are not all willing to convert their land, due in part to the low compensation (Naturvårdsverket 2012; Andersson 2012).

For the wetland subsidies to achieve their environmental goals, the new wetlands must be sited to achieve effective nutrient retention, which means they need to achieve more than 1% relative retention to be cost-effective (Arheimer and Wittgren 2002). There currently are many types of wetlands and other ways to adapt the landscape to perform more nutrient retention. Some measures to mitigate nutrient leaching in agriculture in the Southern Baltic Sea River Basin District are found in Table 2.

Information on how much phosphorus (P) and nitrogen (N) can be retained in a wetland varies greatly. Jordbruksverket estimated that on average 200 kg N/ha per year could be retained in Skåne, Halland and Blekinge (Jordbruksverket 2000). Open dams in the agricultural landscape can take up even more – between 400 and 1,000 kg N/ha per year (Wittgren et al 2002). In the wetland ecosystem, many vegetation types capture nutrients, e.g. wet grasslands for haymaking and grazing, wet forests, and reeds. Three processes contribute to nutrient retention in wetlands: denitrification, uptake by plants and sedimentation (Saunders and Kalff 2001; Leonardsson 1994). In areas where there is no harvest, N is removed foremost by denitrification (Gumbricht 1993). The wet grasslands for haymaking and grazing are a key ecosystem, as they provide a net nutrient retention effect particularly by the harvesting of grass for fodder from the meadows.

A study showed that 400 ha of wet grasslands for haymaking and grazing in Kristianstad capture 24 tonnes or 60 kg of nitrogen per ha (Cronert 1990). Potentially, the wet grasslands for haymaking and grazing could capture in total 4% of the nitrogen that would otherwise flow into Hanö Bay, almost 100 tonnes. This is less than half of the contribution by wastewater treatment discharges to the Helge River (which is 9%), and a modest figure in comparison to agriculture (see Table 1).

For the Helge River to reach good status in terms of nutrients, a reduction of 10 tonnes (total) N per year is needed. Sweden will need to reduce 8,100 tonnes nitrogen to the Baltic Sea until 2021 to achieve good status (Vattenmyndigheten 2009). Potentially this would require the ecological services of wet grasslands for haymaking and grazing of another 80 Kristianstad wetlands. While meadows are used only for haymaking, some are also used for grazing after the annual hay harvest (Cronert 1990). Without the harvest, the grass would decompose and some of its nutrients would return to the water (Tonderski et al 2002). This effect is not achieved when the wet grasslands are only grazed, as the main part of the nutrients is returned to the meadow as manure.

Table 3: Measures to mitigate nutrient leaching in agriculture under the programme of measures in the River Basin District of the Southern Baltic Sea

Measure	**Effect (kg total P/ha/yr)**	**Cost (SEK/kg total P/yr)**	**Effect N to the sea (kg total N/ha/yr)**
Wetland	2 – 31 (12)	550 – 9500 (1600)	8 – 248 (82)*
Catch crop/spring processing (*fånggröda/vårbearbetning*)	0,05 – 0,15 (0,1)	3300 – 10000 (5000)	3,9 – 12,8 (5,9)**
Protected zones (*Skyddszoner*)	0,25 – 0,75 (0,5)	2400 – 15200 (5600)	1,6 – 14,1 (7,9)**

*Notes: *Modelled net effect on the sea with consideration to retention in inland waters. **Estimated net effect on the sea assuming that an average retention in inland waters in about 29% of nutrient load, i.e. the part of nitrogen load which is captured in inland waters or is captured by denitrification processes before reaching the sea. Average values are presented in parentheses. Source: Vattenmyndigheten (2009).*

The wet grasslands for haymaking and grazing represent an interface between the wetland and agricultural activities in the Helge River area. Many farmers with a long history in Kristianstad have avoided cultivation in the annually flooded areas (Magnusson, personal communication). Instead, they may graze cattle and harvest hay; this maintains and manages the wet grassland buffer zone in the wetland, which harbours a rich biodiversity. The practice of such a transition zone prevents the leaching of considerate amounts of nutrients during floods through nutrient retention. The regulations in Sweden prescribe a six-metre buffer zone to open water to reduce diffuse pollution. A 10-metre buffer strip (a requirement in Denmark) is known to capture up to 95% of the phosphorus load from e.g. agricultural land mainly as sediments (Vought et al 1995). The wet grasslands for haymaking and grazing also capture nutrients when they are flooded, mostly through sedimentation. In southern Sweden, the floods and high water flows occur during autumn and winter, which means that a lot of nutrients are suspended in these volumes without being captured (Löfroth 1991).

Cooperation with farmers is necessary to achieve improvements (Interview 2). Under the EU programme Natura 2000, the municipality has worked with farmers to safeguard the most valuable areas. The key reason given has been biodiversity/conservation (not nitrogen retention or flood protection). However, farmers who rely only on farming for their livelihood often need to use even the land close to annually flooded areas. In such cases they have built embankments (*invallningsföretag*) that protect the land from the annual floods, but not the extreme floods. Measures are also in place to encourage more new wetlands, both for nutrient retention and for biodiversity. Harvesting of hay and maintaining grazing lands is compensated for with the aim to maintain and strengthen natural and cultural values.

The Board of Agriculture (*Jordbruksverket*) administers the EU agricultural support, while the County Administration administers the applications and determines which animals are allowed and the appearance of trees and shrubs. Currently, this support for maintaining the pastures and meadows makes it financially viable if it fits with the farmers' livelihood activities. For example, the combination of dairy and beef cattle and pastures provides a proper livelihood where cows do the work, as manual mowing would not be economically viable. One farmer said: "If I had not been producing beef cattle, I would have had a problem." The financial support is an effective way of making sure there is no bush overgrowth (Interview 5).

Box 2: Compensation for management of pastures and meadows, as applied to wet grasslands for haymaking and grazing

1) Single farm payment (*Gårdsstöd*) 1200 SEK (~€140) per ha/yr – for minimum of 4 ha

2) Pasture (*Betesmarker*) – There are two levels of compensation: a) "Special values", 2,650 SEK (~€310) if the land has high natural or cultural value and is in need of special management; b) "general values", 1,250 SEK (~€150) per ha.

3) Mowed meadow (*Slåtteräng*) 4200 SEK (~€ 500) per ha/yr, with special values.

Furthermore, crop land that has been transformed to wetland can receive a payment of 4,000 SEK (~€ 470) per ha. This can be complemented with 1,000 SEK (~€ 118) per ha as an extra payment for loss of harvest. For wetlands on former grazing land the payment is 1,500 SEK/ha (~€180) (Andersson 2012).

Farmers mentioned in interviews that there is a lack of flexibility in the compensation conditions given for the wet grasslands for haymaking and grazing, not accounting for the unpredictable variations of the water levels. The County Administration has set fixed harvest dates between 15 July and 31 October, when the meadow in fact may be too wet to harvest and machines can cause structural damage (Interview 1). There is a penalty system for noncompliance, but there is a perception that the administration of penalties varies widely among individual County Administration representatives (Interview 1). The two County Administration interviewees said that this is not a major issue affecting many farmers – and indeed, only one of six farmers interviewed mentioned this.

The conditions for compensation should be individually tailored to the local setting to avoid such situations. Sometimes exceptions are indeed issued so that harvesting is not needed in a specific year. However, there is an understanding in the County Administration that farmers may see the system as inflexible. The County administrators themselves admitted in the interviews that one reason for this situation may be that they are too busy, but they said they would welcome that farmers get in touch and discuss their concerns (Interview 7).

Another more common issue is that the system of compensation to the farmers is not flexible in terms of estimating the area to be compensated. Almost all farmers between Torsebro and the sea (i.e. the land owners along Helge River in Kristianstad municipality) have at some point expressed that they feel uneasy about estimating a figure, which they cannot guarantee due to uncertainty in weather conditions (Interview 10). The respondent at the County Administration, who often hears these complaints, says:

> "All the support to farmers which they manage relates back to the environmental goals of Sweden, but they are not always aligned. The support to pastures and haymaking meadows is quite considerable, however the conditions do not allow for a few years of flooding during the five-year period it is given out. The rules are quite strict that the fields have to be managed. In this way there is a financial risk for the farmer as it can cost money not fulfilling the conditions. Most of the farmers also express a worry when applying for the support as they are uncertain of how large areas will not fulfil the conditions, and therefore do not apply for it for some areas.

> There is a need to mitigate the uncertainty for the farmers as these types of fields are not fitting into the support system. It would have been easier if the single farm payment would not have been there. Other types of support tolerate a year without grazing, and allows for more variation, but there are no good solutions. This support also has a strange definition when it comes to water, some years the waters can be regarded as permanent and some years the waters have withdrawn. It would be better to treat the fields with flooding as special lands, but it is not easy as there are a lot of grey zones and no clear definition of what is a flooded meadow and what is not." (Interview 10)

In recent years, farmers have observed a decrease in hay harvested, which they say is caused by the lower amounts of nutrients in the Helge River. The farmers also cite overgrazing and a large population of geese as severe pressures on the flooded meadow hay production. One said, "The fields which earlier gave about 2,000 bales of hay now only give 200 bales; the geese eat the rest" (Interview 1). The geese arrive in early March and start grazing when the first grass emerges, greatly reducing the grass available to the cows (Oveson 2002).

Extreme water levels (as part of natural variability) provide a nutrient leaching risk to the wetland, as intensive agriculture is ongoing behind embankments which may break from time to time. One interviewee suggested a ban on farming in the low-lying fields which are regularly flooded (Interview 3). Another interviewee said it would be better to try to get back the old grazing lands which better coexist with a flooded environment (Interview 10), though this would be difficult to finance. A farmer said that paying for an ecological service of flood retention would be quite a lot to replace a farmer who grows commercial crops such as sugar beets or potatoes (Interview 4).

Kristianstad municipality allows farmers to build agricultural embankments to protect farmland from flooding to a certain level but not higher, as during extreme floods these lands can then act as a flood buffer. However, the practice of growing near the water leads to considerable diffuse nutrient leaching; when there are extreme levels and the area is flooded, leaching is severe. The Biosphere Office initiated a study in collaboration with the landowners and land users to document existing embankments and to investigate the relevance of maintaining all of them (Berglund 2008).

One interviewee said that the open question of whether cultivating low-lying land is legal is due to the lack of a system for local interpretation and enforcement of the regulations. A potential candidate to provide a locally tailored interpretation would be the municipality's Environmental Health Protection office (*Miljö och hälsoskyddsnämden*), the municipal authority for enforcement according to environmental legislation (*Miljöbalken*), which works according to the guidelines and directives from the County Administration and the central authorities, i.e. the Swedish Board of Agriculture (*Jordbruksverket*) and the Swedish Environmental Protection Agency (*Naturvårdsverket*) (Interview 3).

Forestry and brownification

Leaching of terrestrial metals and organic substances is substantial in the northern reaches of the Helge River, partly due to acidification. The Southern Baltic Sea District River Basin Authority has identified that nutrient leaching in the Helge River is partly due to the substantially canalized, culverted and drained river system. It concludes that to achieve the desired nutrient reduction, physical changes in the river system are needed, such as recreating meandering and wetlands, breaking up existing culverts, etc. These changes would also impact the flow of water and possibly extreme water levels (Vattenmyndigheten 2010).

A slow increase in dissolved organic carbon (DOC) results in brownification of the water, which has been observed in southern Sweden and in Helge River during the last two decades. The source of DOC in rivers and streams is mostly terrestrial humus substances from the catchment (Sachse et al. 2005). The cause or causes of this increase is unknown, but could include the change in land use patterns, developments related to climate change (e.g. change in precipitation patterns), change in water origin (draining) and decrease in acid rain with its subsequent recovery from acidification (Kaién 2007b, p. 3-4 in Radtke 2009). Similar effects are seen internationally, as in Canada. Another theory is that the process of lowering the ground pH through sulphur emissions in the 1960s and 1970s is now being reversed, releasing previously buffered manganese (Interview 9). Research has indicated that the brownification shows a constant increase in concentration in the drainage basin of Helge River. This increase occurs in all rivers and streams of the Helge basin, although it is stronger in some regions than others (Radtke 2009).

5. CLOSING GAPS IN FLOOD RISK AND RIVER BASIN MANAGEMENT

5.1 Risk reduction needs to go beyond flood control to protect the city

The municipality's approach to flood risk reduction has focused only on flood control, and not considering flood abatement in the catchment or reduction of impacts of an eventual flood. However, Kristianstad has implemented an early warning system. The focus of flood risk reduction in Kristianstad is on peak flows and extreme scenarios, while small to medium floods and all associated land use issues and related socio-economic and environmental impacts are not currently seen as relevant. This is in line with the approach of the current implementation phase of the Flood Directive in Sweden. Using extreme water levels this process has identified 18 hotspots in Sweden, including Kristianstad city, which puts the focus on the downstream urban risk. Prior to this study MSB approved funding of the embankment construction project protecting the city without requiring other types of measures.

Flood abatement and alleviation in the catchment could be addressed, for example, by improving retention capacities in the catchment or through legal provisions that discourage settling in risk areas. However, municipal officials see this option as too controversial, as measures would need to be taken in other (upstream) municipalities. Municipalities in Sweden are responsible for ensuring, through climate and vulnerability analysis, that new housing is not built in risk areas. Such assessments are already the norm in Denmark, but in Sweden, no instruments prohibit further development of flood-prone areas. Instead, the trend in practice has been the opposite towards municipalities offering more attractive near-shore areas for development to stimulate an influx of people, and as such increasing exposure to floods. Mitigating floods in these areas would require efforts in spatial/urban planning.

However, as said above, the municipality has indicated (personal communication with focus group in August 2012) that it wants to take a more holistic approach to flood risk reduction in future comprehensive municipal planning exercises (*översiktsplanering*). To support this, national agencies such as HaV, MSB and Boverket could actively provide guidance to address flood risk from a broader risk management perspective, inclusive of river basin aspects and urban planning.

5.2 Risk management does not incorporate resilience thinking

Kristianstad faces flood risks both inland and from the sea. One way to avoid the flood risk altogether would be to relocate the city, but this is not an option. Also, relocation of all critical infrastructure, houses moved or rebuilt, cannot be done without incurring enormous costs. Instead, the city planning is assuming safety from the new embankments. However, experiences in other parts of the world have proved that a firm belief in the safety of a human-made structure such as an embankment can be a dangerous assumption. For example, in New Orleans during Hurricane Katrina, in 2005, the population behind the levees was never warned to evacuate, as it was assumed the levees would hold (Rosenthal 2011). Similarly, in Fukushima, Japan, in 2011, management assumed that the recurring earthquakes and tsunamis would never cause damage to the nuclear power plants (Hollnagel & Fujita 2012).

The question is, how much risk are managers and politicians willing to take? Transparency in decision-making is vital when there are many stakeholders involved. This includes the assumptions that supported the analysis, the uncertainties involved, and the communications that follow the decision (U.S. DHS 2011). Business as usual, with continued development behind embankments, may not be the wrong approach, but there needs to be more clarity and transparency about the way that decision-makers and planners have arrived at that conclusion. Risk management should not be a “black box” exercise; those affected by a risk management approach should be able to validate the integrity of the approach (U.S. DHS 2011). If the assumptions are not well grounded, the risk for catastrophic consequences means political risks if something does happen after all.

If the public is well informed, there is also a greater opportunity to build dynamic public responses and, thus, resilience. However, it is not always easy to convey the full scale of the risk to the general public, and for them to validate it in turn. Often expert knowledge is needed, which the public also expects the municipality to provide. As such, adaptive city planning is a practical way to be open about flood risks and about allowing the water to enter from time to time. Such planning concepts are already exemplified by the Naturum building, standing on stilts in the wetland, acknowledging the fluctuating water level (Johannessen and Hahn 2012).

5.3 Urban planning needs to be more aligned with risk management

Kristianstad’s new stormwater policy reflects an awareness of more adaptive concepts such as flood-proofing: emphasizing the importance of infiltration and retention zones, which also can capture nutrients and pollution (C4 Teknik 2010). However, serious efforts to implement this policy need to be visible on the ground. There seems to be different approaches to the flood risk depending on the community of practice involved. While people working on risk issues within the embankments on a day-to-day basis recognize the continued risk, Kristianstad central areas continue to expand, without flood adaptation, assuming that the barriers will hold. Still, although there are different levels of awareness and motivation among groups of practitioners, there seems to be an increasing alignment between urban planners and risk professionals, emerging from a series of discussions where urban planners have begun to shift their approach to align with flood risk management, through learning by doing.

5.4 Risk management is not aligned with river basin management

The governance structures at the river basin level, i.e. the Southern Baltic Sea River Basin District Authority and a recently formed water council for stakeholder engagement, focus their work on water quality, not risk management. Consequently, there is the lack of a river basin-wide framework for flood risk management. Instead, this is the responsibility of the municipality, but as noted, water flows beyond municipal borders. Also, socio-economic objectives may take precedence at the local level, and upstream or downstream management of water resources may not be a priority for the concerned municipality. But also, it is a matter of how flood risk is currently being framed in terms of extreme flows, making ecosystem-based solutions regarded as inadequate, also by the national level agency MSB.

For example, the mapping of land vulnerable to less extreme floods in the river basin is not yet seen as a relevant resource by MSB for their implementation of the Flood Directive. On the other hand, the River Basin Authority, has been interested in this data (Rimne, personal communication). This is partly why the risk management strategy is not all-inclusive, focusing on protecting the city without aiming to develop synergies with river basin management. Although not threatening to life and property, these floods still have socio-economic impacts (Kling, personal communication).

To promote the measures in the river basin, which would also potentially benefit nutrient management, more knowledge would be needed to understand exactly how measures could reduce the water levels relevant for farmers and city dwellers. Would increasing wetland areas be able to buffer for the worst case scenario in Kristianstad and elsewhere in the river basin? It is unknown how much flood storage the areas behind agricultural embankments could provide, and what effect it would have on the flood risk to the city and other development. The buffering service provided by the wetlands and farmlands would also have to be subsidized at the national or local level, as the newly acquired buffer areas likely would not be eligible for EU support of biodiversity. Because although farmers may be compensated for managing the ecological services for biodiversity, the ecological services of buffering for floods are not paid for in the same way.

Flood risk management which encompasses the river basin also raises concerns of top-down versus land ownership (bottom-up) management. In relation to this, a question about what is feasible to include as part of the regulatory framework was raised in the interviews. On one hand, private land owners have made investments and have certain rights. On the other hand, representatives for national agencies would argue, the land use needs to consider larger issues that transcend private and local interests.

In addition, legislation for drainage and water is often outdated, established at a time when Swedish society was still mainly agrarian, and it is indefinitely protecting structures until there is unanimous agreement on how to change it. For river basin coordinated actions, the regulations also mean inflexible arrangements. In order to change the management objectives of these joint property societies, the consent of the majority of the property owners is required. Swedish legislation is set up to require action by each joint society, in isolation, but there are so many – about 50,000 responsible for drainage and about 1,000 for hydropower – that it takes decades to implement change (de Maré, personal communication).

In terms of nutrient management, zoning would be a cost-effective way of discouraging further establishing of activities that leach nutrients to the water course. Currently, no legislation protects the watercourse from farming on low-lying grounds. People benefiting from these near-river fields and their fertile soils and good access to water are in principle free to use ecosystem capital upstream, which has negative effects for other downstream users of the ecosystem, such as Baltic Sea stakeholders (Interview 15).

At the same time, established settlements will be more difficult to relocate or compensate for. Land swapping, i.e. receiving compensation if giving up land in a sensitive area, is done in Denmark but does not exist in Sweden. However, with time, these issues may slowly be addressed by the landowners themselves. Being located on low-lying ground requires investments, and at some point in time there may be a financial breaking point where it pays to recreate wetlands. But there are gaps in knowledge in terms of what this point is, when it will be more cost effective to utilize land as a flood buffer rather than for agriculture. Also, with sea-level rise, planners may need to think ahead to be able to support the farmers to put aside more land as wet grasslands for haymaking and grazing (to maintain biodiversity and cultural services).

In the Water Framework Directive, the introduction of wetlands is suggested as a measure to reduce nutrient leaching in the entire river basin. Currently, recreating wetlands is mainly financially supported for farmlands, but no state-subsidized larger financial incentive exists for wetlands to be located in forests. Here is a policy gap which needs to be filled by, for example, a support system like LOVA, or with funds from the rural development programme.

5.5 Traditional paradigms need to change to enable resilience management

The old paradigm of the "dewatered environment" of dredged forests, lowered water tables, lakes, erected agricultural embankments and digging of ditches, where the focus is on livelihood security through forestry and agriculture, is slowly being replaced by a new paradigm acknowledging the role of wetlands for biodiversity, recreation, nutrient and flood (risk) management. Still, high-risk activities in terms of nutrient leaching are encouraged by the legal framework and customary priorities to ensure agricultural productivity and food security. This is a remnant from a time when farming was of highest priority to society without much consideration to the consequences.

Food security is a priority in, for example, Belarus (Pakhomau, personal communication), but not so in Sweden, and so a revision of the legal instrument would be in order. Reviewing the Swedish environmental regulations governing the rights of the farmer to cultivate near flood-prone environments would be a necessary and cost-effective way to deal with eutrophication. The role of the state is being contested in this matter, but the state has historically paid to dredge to feed a growing population; and now society needs the water again to increase retention times, reduce nutrients and provide flood buffer zones, among other things.

Expertise and capacity are needed to change regulations and existing governance structures in order to enable a new balance of priorities, which also acknowledges the importance of functioning ecosystems. An emerging paradigm includes approaches such as "living with floods", which suggests society should embrace variability instead of ignoring it or trying to control it. In the current EU subsidy to farmers, water variability is not factored in; in fact, one of the persons administering this support had never thought of this as an important function of the wet grasslands for haymaking and grazing (Interview 7). The flood buffer service is often removed, as it does not have a direct economic value to someone, with the land utilized for another purpose. Society in this situation requires the political will and leadership to venture in a different direction and discourse compared to previous developments and investments. But how this should be done or financed is one of the most open questions. It is more a political and social issue than a natural science issue (Interview 6), one which requires a willingness to learn from previous experience and, with an open mind, to discuss alternatives with the relevant stakeholders.

Table 4: Summary of gap analysis

Gap	Description
Risk reduction needs to go beyond flood control to protect the city	Flood risk management focuses on only one of three aspects: flood control on the urban area (not abatement in the catchment or reducing impact of floods, except for early warning system). Kristianstad has however indicated it wants to think more holistically about risk reduction.
Flood risk management does not incorporate resilience thinking	The approach to risk is to "shut out" the water, to focus on resistance and not resilience, which is more allowing of smaller disturbances not to build up vulnerability to catastrophic consequences. Planning and building business as usual behind embankments assuming they will hold, and not investing too much in adaptive management or preparedness behind them.
Urban planning needs to be more aligned with risk management	The new stormwater policy reflects an awareness of more adaptive concepts such as flood proofing (infiltration and retention zones, which also can capture nutrients and pollution). However, serious efforts to implement this policy need to be visible on the ground for it to take effect. An increasing alignment between risk practitioners and urban planners is a positive trend emerging from deliberations about past mistakes.
Flood risk management is not aligned with river basin management	The governance framework at the river basin level focuses only on water quality, not flood risk. Planning for flood risk management, meanwhile, stops at the municipal border. It also focuses on extreme flows, which often makes ecosystem measures inadequate. However, socio-economic effects of smaller floods are not captured. There are knowledge gaps in calculating benefits of measures. River basin planning for floods may conflict with individual interests. Legal instruments need updating to account better for ecosystem aspects and enable coordination. Substantial funding not available for reconstructing wetlands in forest lands.
Traditional paradigms need to change to enable resilience management.	The old paradigm of the "dewatered environment" is still dominating to secure the production of food and timber for the economy. However, a new paradigm is emerging of acknowledging the role of ecosystem services such as biodiversity and nutrient retention. Approaches such as 'living with floods', which embrace variability rather than shut it out, need to be operationalized. For this, political will is needed to provide the incentives and legal frameworks to shift paradigms.

6. TOWARDS ADAPTIVE RIVER MANAGEMENT

6.1 How to make flood risk management more inclusive?

Implementing the EU Floods Directive includes plans to integrate with the EU Water Framework Directive (WFD) with many potential synergies. For example, recommended measures to reduce nutrient load in the river basin under the WFD include wetland (re)creation, increasing meandering, breaking up existing culverts, etc. which also have an effect on the water flows and flooding dynamics (Vattenmyndigheten 2010).

Reviewing the trade-off between the value of the flood buffering capacity of the landscape (*översvämningsytor*) against physical structures which require construction and maintenance such as embankments and pumps would need to engage MSB or another relevant ministry at the national level, such as HaV. The options ought to be similar across the country, making national coordination necessary, as measures would depend on how flood mitigation and other ecosystem services are valued and synergize. This raises questions for the future implementation of the Flood Directive in Sweden, where MSB will be central to make this integration happen, through a dialogue with HaV and other affected stakeholders. The interviewees also mentioned that in the 2015 administrative cycle the Southern Baltic District Water Authority will probably pay more attention to the synergies with the Flood Directive (Interview 6). This is because the implementation of the EU Floods Directive (EU 2007) has triggered an interest from the authority to work in a more integrated fashion in the river basin with activities relevant for floods in the next administrative cycle. But how this will be done is not yet clear (Interview 6).

MSB's lack of interest in floods other than the extreme ones, and consequently excluding relevant ecosystem based solutions is a concern, needs to be addressed actively by HaV. This dialogue would benefit from an early start, but seems not to be very active. MSB was invited to the regional workshop on 25-26 September 2012, part of this project, but indicated that the Flood Directive did not reflect thinking in these directions, and so did not see the point in participating in the workshop. The Swedish National Board of Housing, Building and Planning (Boverket) was also invited and did not attend, without giving a reason. In a workshop organized by the cluster group for water and disaster risk reduction at the Swedish Water House in November 2013, both HaV and MSB mentioned they welcome more dialogue between them in the future, which indicates that this is not currently happening.

Kristianstad municipality's city planning office is willing to take a more holistic and integrated approach in the comprehensive planning. Local planners are also willing to take on board lessons directly from other countries such as The Netherlands, where they already have had some exchanges. Particularly since Kristianstad is sometimes called "little Holland," it is a suitable source of adaptive flood proofing in building and planning.

6.2 How to align urban planning and risk reduction?

The Swedish National Board of Housing, Building and Planning (*Boverket*) has an important role to play in ensuring the implementation of the PBL, and to encourage more water based planning concepts, including zoning practices. Depending on how well and how convincingly they manage to incorporate resilience thinking in their work with municipalities, the less work MSB and the local risk managers will have during crises. But there seems to be a lack of coordination at the national level that can trickle down to the local level. Partly this could be explained by Sweden's tradition of delegated responsibility, where municipalities have more decision power. The result is a gap in responsibility, where actors look at each other to take initiative. The national level expects the municipality to take initiative, but some issues would benefit from national oversight. To overcome the "organized irresponsibility", a new multilevel learning and governance approach could still allow local adaptations to emerge while providing greater national coordination of learning and resources (Johannessen and Hahn 2012).

Perhaps the insurance industry will offer some incentives. However, the privately insured flood damage in Sweden is mostly a result of old municipal water and sewerage networks, probably combined with a lack of risk based spatial planning. In a scenario where more and more damages occur in a flood risk zone, the insurance industry will probably revise their policies for different products, such as housing insurances. The insurance industry is however a player to help initiate other risk-reducing processes within society, as seen in the Kristianstad embankment project.

6.2 How to align flood risk management with river basin management?

It will be essential to develop research tools for risk reduction and resilience building to assist in decision-making on preventive actions. For example, it will be important to know more about the role of the wetland as flood buffer, as well as to have a basket of measures, tools and provisions in place for how this can become operational. If certain investigations are necessary for adequate planning, there needs to be requirements, otherwise alternative measures may not be given a proper chance in flood risk planning.

Taking Kristianstad's extreme flood conditions seriously could be an opportunity to become a role model for better ecosystem service considerations in planning in general in Sweden. The Kristianstad city embankment project will cost 300 million SEK in total, which does not include costs for continued operation and maintenance. It has until now demanded most of the annual budget from MSB allocated for these types of measures. What is affordable to implement in other places in a future with a lot more land, in urban areas, in the whole of Sweden challenged by sea level rise? With such future scenarios, there is a good rationale for investigating alternatives and options closer, especially preventive and mitigating ones, for the benefit of Kristianstad and other cities. Alternative measures and tools to help implement them will be increasingly important in the future, especially cost-effective ones that meet many different societal goals and address multiple benefits. Perhaps an interesting comparison is the total budget through the RDP for wetland restoration/construction in Skåne, which was 25.2 million SEK/year in 2010–2013. This budget was expected to add about 280 ha of wetlands per year (Skåne CAB 2011). According to this, 300 million SEK would be enough to construct/restore 33km^2 of wetland area, not considering the agri-environment payment for maintenance.

Some of these wetlands could be constructed with support from the state, but this is not a solution for all ecosystem services, as the coast and the sea generate revenue from tourism and fishery. In terms of money-generating activities, tourism is a big sector in Kristianstad, with about 700 million SEK every year in revenues; the 35 km coastline can host 2,500 to 3,000 visitors in one day. In those terms, fisheries generate very little in terms of monetary value but are highly valued by Kristianstad residents and tourists alike. In that respect it would be important to identify those sectors which generate revenue from ecosystem services and which should contribute to their maintenance. For example, energy production could contribute to the continued migration of fish; forestry could contribute with measures which mitigate the brownification that impacts the downstream ecosystems.

6.3 How to introduce more resilience management?

Regardless of the solution at hand, there is a need for proactive planning and strategic thinking about preventive actions. The longer these actions are postponed, the more development there will be and settlements will most likely be located with flood exposure risk and vulnerability. As these preventive measures ultimately are about investments, risk and resilience thinking needs to be mainstreamed in critical functions including electricity, wastewater, connectivity and transport such as roads and railway, so these are not disrupted in times of flooding.

Good relationships among the local stakeholders is a key. For example, farmers need to be involved in a legitimate bottom up process, to realize the benefits or trade-offs of collaborative water management. The issue of cultivation in areas close to the wetland may, especially in light of climate change and sea-level rise, come in a different light. What is a good strategy moving forward? Should the farmers continue to raise their agricultural embankments to keep the flood waters out, or are there alternatives? The different stakeholders would benefit from meeting and sharing ideas with an open mind and hearing each other's arguments. A dialogue with farmers would also enable them to raise issues such as coping with variability to enable the building of better provisions into the existing (EU) support system.

Another opportunity for synergy is with the help of the stakeholder platforms under the WFD, "water councils" (*Vattenråd*). The Helge River basin has just started up such a group. However, at the Swedish Water House seminar on national integrated flood risk management, a representative for the farmers' union stated that such arrangements still do not provide adequate facilitation. A more specific, local and professionally facilitated dialogue is sought that includes all the key stakeholders. Generally, farmers are positive towards collaborative activities, but to gain their support (and the support of other groups) it is important to identify societal and economic benefits in order to balance ecological and economic incentives (Johannessen and Granit 2014).

A barrier to learning from Kristianstad is that the city is seen as a unique case in Sweden due to its very high flood exposure. This is often used as an argument to disregard the lessons from the city as irrelevant to other places in Sweden. This consequently does not motivate any active coordination or general provisions at national level. However, with future climate change, such variability and uncertainty displayed in Kristianstad is expected to increase, also becoming relevant for other parts of Sweden. For example, in August 2012, Emån experienced floods that negatively affected farmers in low-lying areas. Even without climate change, the challenges experienced in Kristianstad are likely to occur in other places on a smaller scale.

It may be too costly to change existing arrangements, but imposing conditions on new developments may be feasible, for example for new owners of houses, fields and forest lands. However, there is no incentive system for payment of ecosystem services to drive such a development. Sanctions and legal instruments also need to be in place, and such developments are likely to meet resistance by powerful players using economic arguments. Forestry, for example, is one of the largest industries in Sweden, accounting for 3% of GDP and about 10% of export value (Keskitalo 2008). Up until now, forestry has not been as strictly regulated in terms of nutrient management as farming. But with serious issues of brownification, originating from forest practices, this has to be reconsidered, and the Southern Baltic District Water Authority seems to have a key role here to put pressure on the relevant actors in the next management cycle of 2015 as well as to consider the results of the pilot of the model forests.

As discussed above, the integration of flood risk and river basin/nutrient management has a great potential to increase the water holding capacity of the landscape. In order to do this a change is needed in the developmental drivers in sectors such as forestry and agriculture, acknowledging that we do not only need (ecosystem) goods from the land, we also depend on ecological services such as flood and nutrient retention. Such a change is unlikely to happen through self-regulation but demands a change of course at the political level and political will to pull it through, especially in terms of staking out the direction for policy, legislation and financing. In any case, it demands political ambition at different levels, from municipal to national. At present, there may be local political will to take a bold leap forward in terms of local experimentation. However, short term economic priorities may counteract the established positive precedent, requiring a constant reminder and awareness raising to politicians to point out the economic feasibility and social benefits of adaptive river management.

7. CONCLUSIONS

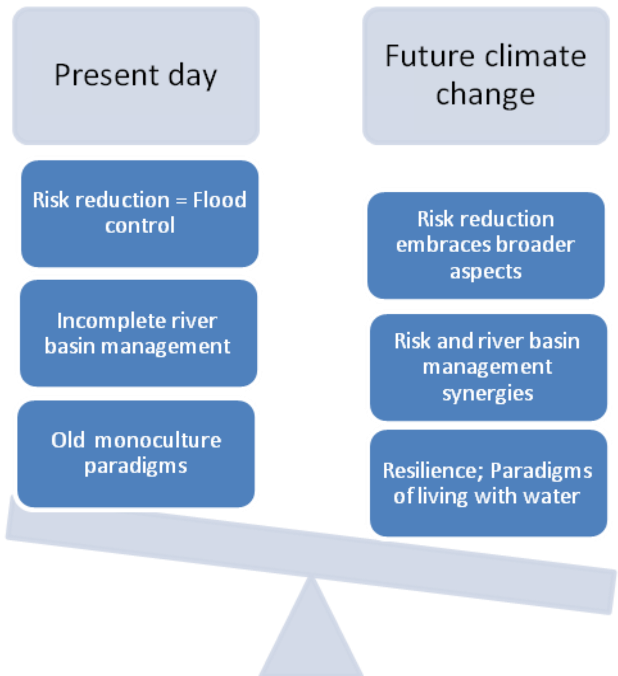
Kristianstad municipality is an interesting case study of Swedish flood management, in the sense that its co-existence with the highly variable water tables of a wetland clearly illustrates the gaps and challenges within the different sectors to cope and adapt. These gaps and challenges link to national policy and legislation. It thus illustrates where Sweden may have challenges to implement adaptive river management – integrating flood risk management, river basin management and resilience management in current planning frameworks.

In Kristianstad, the priority in flood risk reduction is flood control, for a number of reasons. The local planning framework of municipal comprehensive planning stops at the municipal border, reducing incentives to work on flood risk reduction at river basin scales. In addition, a flood risk reduction planning framework does not exist at the river basin scale, as the river basin authorities under the Water Framework Directive focus on water quality. Consequently there is a gap, where management of floods as prescribed by the international community since 1992, with the initiation of integrated water resources management (IWRM), is not practiced or even institutionalized in Sweden.

The lack of alignment between the water quality and water quantity governance aspects (EU Water Framework Directive and Flood Directive) may be corrected by future coordination. However, the fact that two separate agencies are responsible for coordination (MSB and HaV) may create challenges. Still, many potential synergies exist, such as encouraging upstream flood abatement through e.g. multiple uses of forests which may also have a nutrient retention effect downstream.

The need to adapt to climate change as well as take serious measures to revive the Baltic Sea will probably be important factors which will work in synergy to promote a more adaptive river management paradigm, as shown in Figure 9.

Figure 9: How adaptive river management could shift with climate change



Kristianstad offers many lessons in terms of these potential synergies. Its local operational drive and political will to take an active initiative and drive the development in a certain direction is also encouraging. However, to learn from Kristianstad, agencies need to acknowledge that Kristianstad is not just a special case. With future climate change scenarios with rising sea levels, the situation in Kristianstad is likely to reflect other places in Sweden. This requires a shift in mindset which may be the biggest barrier to overcome – especially in terms of convincing national agencies this is an important issue with some urgency. The Swedish Civil Contingency Agency (MSB), HaV, and the Swedish National Board of Housing, Building and Planning (*Boverket*) have key roles to play – and to coordinate – in finding synergies between different types of water management and integrating it in planning.

In addition, many tools are needed to justify measures and support planning decisions, and crucial for this will be a robust method of valuing and paying for ecosystem services such as flood and nutrient retention. Kristianstad welcomes these, but incentives are lacking to invest in these valuations. Not the least, participatory processes will be crucial to balance private local interests with value chains for planning in an entire river basin.

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- Focus group discussion members: Charlotte Lindström, Head of C4 Teknik; Anders Pålsson, rescue service; Sven-Erik Magnusson, former head of Ecomuseum; Anders Siversen, Head of city planning; Martin Risberg, strategic planner. August 2012.

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ANNEX A: SUMMARY OF KEY POINTS FROM INTERVIEW ANSWERS

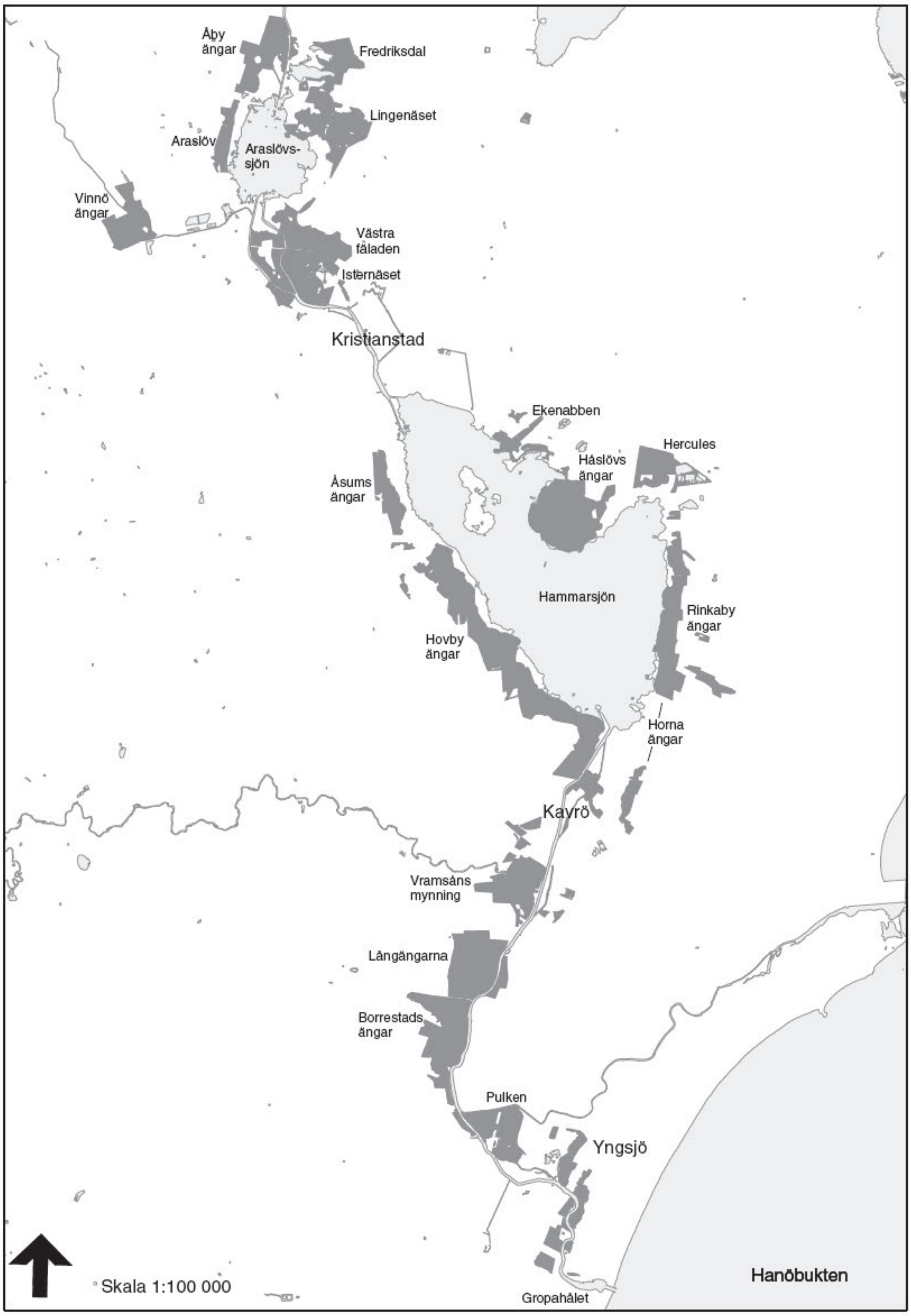
Stakeholder	Role of wetlands for nutrient management	Role of wetlands for flood control	Most strategic and long-term important intervention	Being implemented? If not, why? Possible catalysts/barriers	Responsibility for suggested intervention
Farmer (Interview 1)	Wet grasslands for hay making and grazing collect nutrients from flood. Farmers do not contribute except a few who farm too close to the water. Cow manure is being washed away but this is natural.	Wetlands are lowlands where flood waters can spread out. Sedimentation in lower part of Helge River reduces outflow speed.	1) To have extra capacity in Kristianstad sewage treatment plant for extreme floods, not to end up on farmland (smelly, cause of calf abortions) 2) More flexibility in dates for when to cut the wet grasslands for haymaking and grazing, sometimes too wet for machines and risk of structural damage. 3) Dredging to increase the speed of the outflow to the Baltic Sea. The speed has reduced during the last 30 years.	1) Do not know why it is not implemented 2) Depending on common sense with the control person from the county administration 3) Too costly to do dredging	1) Kristianstad municipality 2) Skåne County Administration
Municipality (Interview 2)	Land use along the wetland is important for nutrient retention. Traditional wet grasslands for hay making and grazing on farmland but nutrients can leach into the wetland.	Wet grasslands for hay making and grazing are good as areas where the water can spread out. In the city we don't have them but other areas such as parks can help to infiltrate so we don't get it in the stormwater.	1) Overview in urban planning of all that plays a role (tool is comprehensive planning) 2) On-site infiltration of stormwater 3) Working with farmers to make them have a buffer zone along the wetland	1) Cannot redo old developments. New developments are informed of the risk. 2) Limited space, and lack of capacity of the system, sometimes it overflows 3) Good relations with the farmers	1) -3) Kristianstad municipality 3) Farmers
Municipality (Interview 3)	Yes, but we don't know what volume they absorb and what is the consequence should they be removed. We assume they play a role.	A study of reduction of N by 400 ha wet grasslands for hay making and grazing. 1% of N contribution to Hanö bay.	Should not be allowed to farm in the low lying fields which are regularly flooded. Should be limits in how a field for farming is defined.	Unclear responsibilities. Importance of farming for society. Helge River special case as other rivers has less variation of flows. Newcomers with other views on farming farm close to the water.	Unclear. The Swedish Board of Agriculture? The Swedish Environmental Protection Agency? the Swedish Environmental Code, the municipality's Environmental Health Protection office

Stakeholder	Role of wetlands for nutrient management	Role of wetlands for flood control	Most strategic and long-term important intervention	Being implemented? If not, why? Possible catalysts/barriers	Responsibility for suggested intervention
Farmer (Interview 4)	Capturing the nutrients in the waters	The wetland sediments and stops the water from flowing out and needs to be cleaned.	To dredge in the wetland to maintain the flow according to the water ruling.	Municipality was against dredging, ask them about it, because of negative effect on wet grasslands for hay making and grazing?	Kristianstad municipality
Farmer (Interview 5)	Fertilizing the fields. Zero sum game as cow manure on the meadows	Such a small percentage of wetland is buffering the great masses of waters coming from upstream, but buffer ensures lower level of water	1. Growing leguminous cover crops (*vall*) and salix near the water, for maximum uptake of nutrients. Should be EU subsidy to stimulate 2.Looking upstream in the forest to see what to do to regulate to increase water retention 3. "Clean the drain", get waters to drain faster	1. Need knowledge and interest, and someone to look at it 2. Powerful export industry interests? Not as opportunistic as targeting farmers. Not enough resources put aside 3. Costly and uncertainty of the effectiveness of dredging. The municipality is only interested in the worst case scenario of floods	Researchers and EU policy-makers Research and national policy Private landowners, the Kristianstad municipality and state
District Water Authority (Interview 6)	All wetlands have a positive effect, (apart from wetlands on organogenic soils releasing P).	Such big volumes that they have to be taken care of higher up in the system, bigger wetlands needed, also a matter of available land and costs.	More water is needed in the landscape to increase retention times, e.g. forestry ditches, but also measures in other areas transport, agriculture, discharge from sewage.	Complex issue how to finance it where the political system has once incentivized the development of ditches etc and now want to do opposite – a political issue to choose a direction to take also a question of the difficulty of making someone responsible – e.g. forestry sector.	Mainly politicians at all levels
Skåne County Administration (Interview 7)	Uptake of nutrients during floods	Has not thought about it in that way. Vegetation takes up a little.	Complex issue, there is quite some fertilization and pesticide use reduction is preferable	A trade off with livelihoods. It would be best self-regulated by the farmers themselves.	Farmers
Municipality (Interview 8)	Purifies and takes up nutrients, the closer to the source the better	Wetlands put aside for flooding along Helge å, where flooding is allowed to happen	1. Meadow with seepage water (*översilningsäng)* where the water is retained and can release nutrients. 2. In the urban areas water needs retaining so nutrients do not discharge in the river.	1. Not her area 2. We are working on this now.	Urban planners
Municipality (Interview 9)	Wetlands are efficient in reducing mainly nitrogen but also phosphorus	Water retaining capacity is increased, is going towards a more natural previous state	That the water retaining capacity is recreated in different types of farm areas and forest areas to keep the water longer in the whole system.	Farming is an important livelihood, and we need food so it is a conflict there. If you are to use the land you have to drain it, to drive with machines and it is about finding the sustainability in that. We are on our way, it only takes time.	Different stakeholders

Stakeholder	Role of wetlands for nutrient management	Role of wetlands for flood control	Most strategic and long-term important intervention	Being implemented? If not, why? Possible catalysts/barriers	Responsibility for suggested intervention
County Administration Skåne (Interview 10)	A lot of wet grasslands for hay making and grazing which can take up quite a lot as they have vegetation	Can handle a lot of water, but only problem is proximity to the city where water is not allowed to fluctuate, and sensitive functions on low lying grounds (e.g. treatment plant)	Remove the number of old embankments towards agricultural land to try to reclaim the old grazing lands	This depends on financial support as these lands are not very productive for fodder. Private individuals would not do it themselves. These would have to be protected areas (through cashing in) and getting the old vegetation back takes time.	Municipality/ County administration – environmental court
Farmer (Interview 11)	We don't know but they say it is good for nutrient capture through sedimentation	Through dredging we get it to drain better	Releasing sewage treatment water on the east side of Baltic Sea	Difficult to do more within farming, already so much done	Other countries
Farmer (Interview 12)	The water added nutrients, but I don't think so anymore. Better grass without floods, due to less nutrients in the water?	Some buffer capacity but the sea level plays a bigger role.	Information programmes, like Focus on Nutrients, and continue research and development, for example investigate reuse of nutrients from treatment plants which today is lost. Appreciation of fertilizer in other Baltic states that have "riddance problem" dumping in the forest and lagoons.	With time it will happen	Generally in Sweden and other countries
Farmer (Interview 13)	Retention of nutrients not to end up in Hanö bay	Buffer capacity	Get clarity on regulations (mentioned in context of his own conflict with the county administration/ municipality of reticulation of drainage water)	Difficulty with Natura 2000 as everything needs to be tried in court. Does not encourage letting go of more such space in the future.	Municipality/ County administration ("they are the same people")
Municipality (Interview 14)	Nutrients from upstream areas are taken care of the wetland vegetation.	Important as they can store a great volume of water, as the flood surface covers more of the wetland, and increases infiltration and evaporation.	Go to source of activities that spread nutrients and reduce or take care of substances on site (e.g. farms and treatment plants). Flood-proof sewage network from 18 municipalities around Kristianstad to avoid overload of treatment plant and direct discharge into river during floods.	Responsible leaders and managers do not bring up issues at political level. Operational project managers are busy doing their job and not have the luxury of pushing internally for issues outside their work descriptions.	Kristianstad municipality – managers to raise issues to political level
Municipality (Interview 15)	I think and hope wet grasslands play a role in flood mitigation.	I know wet grasslands play a big role in nutrient (N) retention.	Work on a plan to recreate the wetland where there is now embanked areas to extend the wetland. In the same way one should aim to restore wet forests and bogs upstream and get a strategy for this via the WFD.	The WFD is being implemented but it takes time. Water councils and model forests are ways to do this and speed up. Lack of legislation to avoid cultivation on low lying land next to the wetland.	National level (legislation) Water authority and the districts

ANNEX B: DISTRIBUTION OF KRISTIANSTAD WET GRASSLANDS

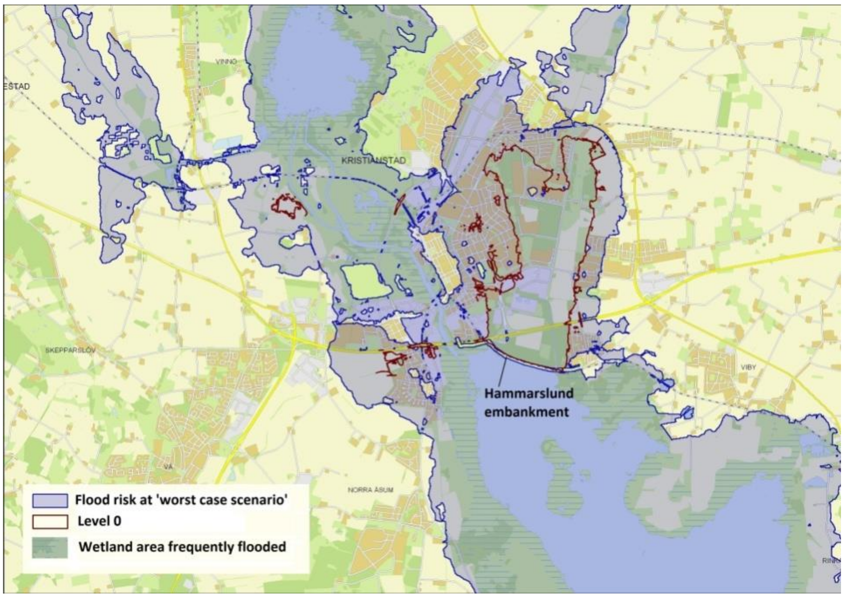
Wet grasslands used for haymaking and grazing in lower Helge River wetland area



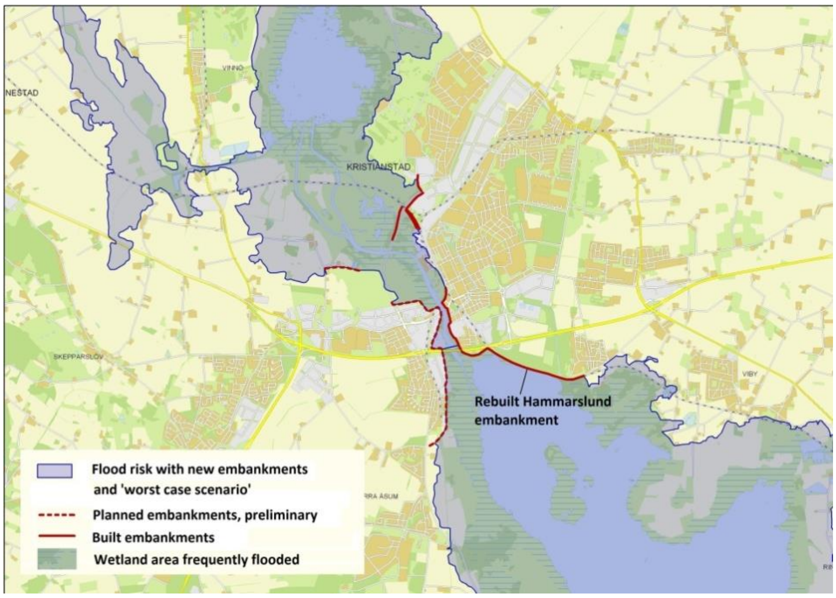
Source: City engineering office, Kristianstad municipality (Oveson 2002).

ANNEX C: WORST-CASE SCENARIOS FOR KRISTIANSTAD FLOODING

Flood risk at worst case scenario without new embankments (probability one in 10,000 years) with central parts of Kristianstad flooded



Flood risk at 'worst case scenario' with new embankments, where central Kristianstad is protected



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