Skåne's constructed wetlands, 30 years of environmental measures

Skånes våtmarksanläggningar, 30 år av miljöåtgärder

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Abstract

For over 30 years, constructed wetlands (CW) have been proposed and used as multi-functional environmental measures in Skåne, Southern Sweden. CW continue to be proposed and implemented as a cost-effective measure to reduce eutrophication and improve biodiversity. The continuation of CW projects in Skåne requires adaptation of the factors: technology, policy and stakeholders to remain in connection with societal and climatic changes. This requires an understanding of the developmental trajectory, and therefore, the CW developmental trajectory is reviewed focusing on technology, stakeholders, policies and climate since the emerging of CW in Skåne.

Stakeholder collaboration is essential in CW projects and has been building and expanding since the emerging of CWs. Within policies, the Baltic Sea Convention and Water Framework Directive provide strong incentives for increasing CW efforts. Landowners are keystakeholders, driven by a variety of reasons, economic, environmental and recreational. In 2018 a strong drought sparked a shift of focus towards irrigation purposes, portraying a rise of importance of climate. Future successes of CW projects are determined by the adaptation of stakeholders, technology and policy to balance the traditional objectives, related to eutrophication and biodiversity, with water quantity management.

Key words: Constructed wetlands, nutrient retention, biodiversity, stakeholder collaboration, developmental trajectory, policies

Sammanfattning

För mer än trettio år sen började miljödammar dyka upp i Skåne. Miljödammar eller våtmarksanläggningar, föreslogs som en kostnadseffektiv åtgärd som minskar övergödning i Östersjön och samtidigt stödjer den biologiska mångfalden. För att kunna fortsätta att anlägga våtmarker i Skåne är det nödvändigt att teknologi, policy, och hantering av intressenter anpassas till förändringar i klimat och samhälle. Förståelse av våtmarksanläggningars historiska utveckling kan bidra till de anpassningar som främjar användning och effektivitet i framtiden.

Samarbete med intressenterna har stärkts och breddats sedan starten. Samarbetet är essentiellt när man konstruerar våtmarker. Teknologin har utvecklats till mer naturliga designs som smälter väl in i landskapet. Helsingforskommissionen, förkortat HELCOM, samt EU:s vattendirektiv har stimulerat myndigheterna

att genomföra våtmarksanläggningar. För att uppnå framtida lyckade våtmarksanläggningar behövs anpassning till dagens utveckling. Sedan 90-talet har våtmarkernas funktioner utökats så att de också inkluderar hantering av vattenkvantitet och stöttar friluftsliv. Vattenbristen under 2018 har initierat ett intresse bland markägarna för att anlägga bevattningsvåtmarker. Förutsättningar och framgångar för våtmarksanläggningar i framtiden avgörs av hur intressenter, teknik och policy anpassas för att balansera de traditionella målen, som rör eutrofiering och biologisk mångfald, med förvaltningen av vattenkvantitet och strävan efter ett naturligt landskap.

Introduction

In Sweden a total of 65% of the natural wetlands have disappeared and 80% are affected by human activity (Gunnarsson & Löfroth, 2014). Since the 1800s landscapes were drained through land reclamation and flood control measures, such as lowering lakes and excavating ditches in wetlands (Hansson et al., 2012). Often the drainage aimed to increase available land for agriculture and forestry to maintain population growth. Predominantly, the river and freshwater wetlands in the temperate zone which can be found in Southern Sweden have been massively drained (Verhoeven, 2014). Especially the Skåne region faced a heavy decline (Gunnarsson & Löfroth, 2014; Hansson et al., 2012). The drainage in the Kävlinge river catchment in western Skåne has been detrimental, with mostly main streams and parts of the lakes being left, see figure 1.

Wetlands areas are described as areas covered by water at least periods of the year or having near-surface water levels. The massive decline in wetland areas due to drainage has detrimentally impacted natural processes connected to wetlands. Wetlands contribute to carbon sequestration, biodiversity, water quantity regulation and nutrient retention (Verhoeven, 2014; Hansson et al., 2012; Silva et al., 2007; Blackwell & Pilgrim, 2011). Skånes naturally occurring wetlands were mainly supporting good water quality through nutrient retention, water quantity regulation both as floodplains and water reservoirs, and biodiversity as species habitat.

High nutrient loads coming from rivers into the Baltic Sea is a major cause of eutrophication (Arheimer et al., 2004). Wetlands can retain nutrients through

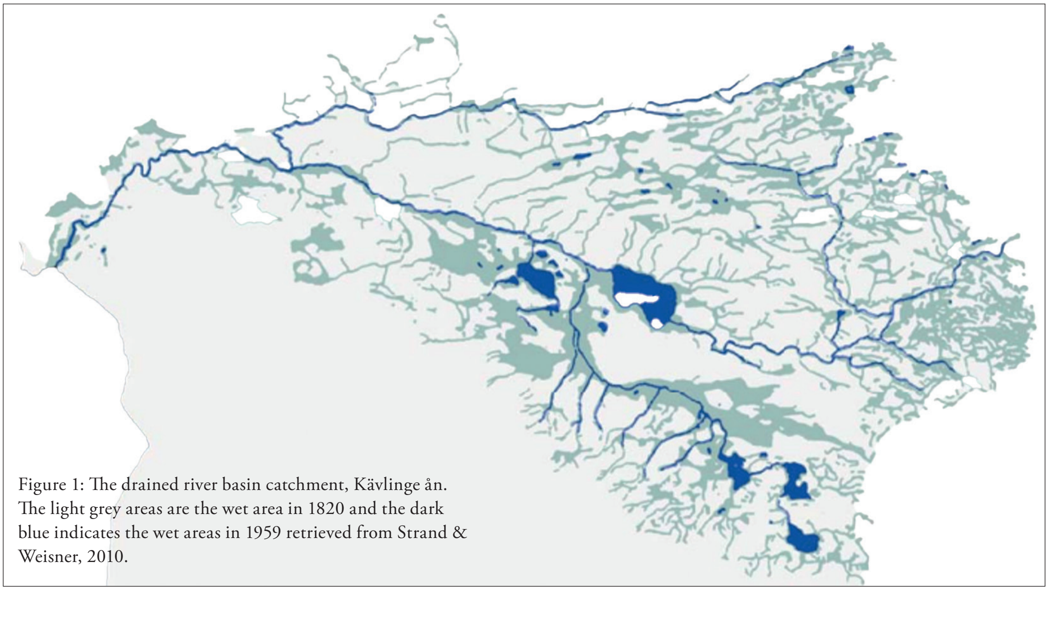

Figure 1: The drained river basin catchment, Kävlinge ån. The light grey areas are the wet area in 1820 and the dark blue indicates the wet areas in 1959 retrieved from Strand & Weisner, 2010.

sediment accumulation and plant uptake realised by these processes: nitrification, denitrification, NH_3 volatilization, plant and microbial uptake, and mineralization (Vymazel, 2007). But because wetland areas are diminished, the nutrient retention capacity has become very limited. Skåne has an agricultural dominated landscape with high nutrient loads, nitrogen and phosphorus, from agricultural practices. So high nutrient loads combined with limited nutrient retention capacity lead to nitrogen and phosphorus ending up in the surrounding surface waters that run into the Baltic Sea causing eutrophication (Arheimer et al., 2004; Verhoeven, 2014).

The first efforts to combat this eutrophication started as early as 1985 with a policy to restore and implement wetlands. Implementation of wetlands refers to a constructed wetland (CW). A constructed wetland is a technical environmental measure that is an excavated 'environmental dam' usually with a permanent water surface. This policy from 1985 forms the basis of constructed wetland initiatives and big government efforts in Sweden (Hansson et al., 2012). Constructed wetlands are proposed as a cost-effective environmental measure to reduce nutrient loads and increase biodiversity. The policy from 1985 was followed by a variety of policies, initiatives and funding projects from the government supporting wetlands. Approximately 2000 constructed wetlands have been implemented in Skåne (Land et al., 2016).

Each wetland is unique and operates in its own way. The complex internal processes are not precisely known and vary from wetland to wetland (Vymazel, 2007). Measuring nutrient retention capacity or biodiversity increase for an individual CW is costly and complex due to the different results in each wetland. Data on performance of a constructed wetland project from a nutrient and biodiversity perspective is often not available (Graversgaard et al., 2021). Due to the limited information available on the internal processes and the uniqueness of each wetland, the exact benefit of a CW is not exactly known through testing. It is only estimated through the use of models. Moreover, the government has supported big effort projects with moderate successes where initial project goals in hectares of implemented CW were not reached (Arheimer & Pers, 2017). Therefore, effectiveness and success of these constructed wetland projects are still debated (Arheimer & Pers, 2017). Interestingly enough, after more than 30 years, constructed wetlands are still being proposed and implemented in Skåne as cost-effective environmental measures. Constructed wetlands as environmental measures are continuously developing through experiences and an increasing body of research. That raises the question about the trajectory of the constructed wetlands in Skåne since its emergence and how it could look like in the future.

The objective of this case study is to explore the interactions and influences on the more than 30 years relevance of the CW in this area. Understanding the developmental trajectory can support predicting potential future trends of CW in Skåne. In a broader sense, understanding different interactions and influencing factors on this embedded environmental measure, could support the long-lasting use and implementation of other environmental measures.

Methodology

A case study on the 30 year's development of constructed wetlands in Skåne was conducted as master thesis research (Witte, 2024). The case study used the conceptual framework Technological Transitions in Multi-Level Perspective from Geels, 2002 to review the developmental trajectory of constructed wetlands in Skåne since the first projects in the early 1990s. Data collection for the case study consisted of literature, interviews with landowners and stakeholders, and field observations. The data was collected in 2023. Constructed wetlands in Skåne have been partially reported at vattenatlas.se, predominantly for the Kävlinge and Höje river catchments. An initial broad inventory of constructed wetlands in Skåne was reviewed for context-building and determining the constructed wetlands included in the case study, see figure 2.

A total of 18 constructed wetlands were included in the case study, 15 were observed in the field and 9 interviews with a landowner or manager were conducted for 10 constructed wetlands. A further 10 qualitative interviews were conducted with governmental stakeholders, organisations and researchers.

Thematic analysis was used for analysing and structuring the collected data. The analysed data is


Figure 2: One of the constructed wetlands in Skåne, included in the study.

aimed to suggest interactions and trends of constructed wetlands in Skåne. These suggested interactions and trends have been subjected to context-analysis, as part of triangulation, to increase the credibility and validity of the research findings.

Results

Three terms have been used to describe and report the constructed wetland projects: environmental dam, wetland and irrigation dam. The purpose of the constructed wetland influences the design of the CW with enhancing characteristics that benefit processes for the main purpose. In practice the terms wetland and environmental dam are used interchangeably. Their main purpose is either nutrient retention or biodiversity but it is generally assumed that a constructed wetland benefits both purposes. An irrigation dam differs from the previous types of CW as its purpose is to facilitate irrigation of crops so creating a higher water volume within the dam, for example with deeper bottom width and steeper slopes.

Many of the constructed wetlands in Skåne were implemented in the Kävlinge and Höje river catchments. Kävlinge river catchment reported nearly 200 constructed wetlands. Besides the total amount of implemented constructed wetlands, these catchments have also been 'early-implementors' referring to the early involvement in constructed wetlands and generating local-specific knowledge. The first constructed wetlands emerged in 1991 with upscaling from 1991-1996. The 'early-implementors' are coincidentally neighbouring catchments located in South-Western Skåne in close proximity to Lund University. Most CW in South-Western Skåne are small sized wetlands, circa 1 hectare. The implementation of larger-sized wetlands increases over time.

The aspects related to CW projects included in this research are: technology, stakeholders and policies, presented in sub-chapters below. The development has also been considered in a broader perspective through climate.

Technology

The design of the constructed wetland besides the purpose are limited by the landscape, shaped by landowners' ideas and decision-makers perspectives using policies. Some technological characteristics and trends of the CW are clear. Since 2003, projects with multiple connected wetlands in a system showed up instead of single wetland projects. This change illustrated the preference of using variance in the constructed wetland design to support the nutrient retention and biodiversity objective. Initially, a small island providing habitat for wader birds in the middle of the CW occurred. A period without these small islands within the CW occurred, interviewees pointed out policy restrictions. The bird islands have reoccurred with a reduced height design to support naturality of the landscape.

Blending in constructed wetlands with the natural landscape was applied to more design characteristics than the small islands. The first CWs have been compared to 'craters' by a few interviewees. Over time, the bottom topographies of the CW have developed from being dominated by flat, shallow areas with a deeper part, to varying bottom depths with deeper and shallower areas. The slopes of constructed wetlands changed from steep to more gradual creating a variance in the ecosystem benefitting biodiversity and naturality of the structure. The development towards natural and environmental structures is supported by the accumulating knowledge and experiences of consultants and governance stakeholders.

Stakeholders

The main stakeholders involved in CW projects are listed below:

- Landowners: decide about CW projects on their land, often economically driven, other objectives include wanting to support nature, increase hunting possibilities, while irrigation has been sparked since the 2018 drought
- Consultants: several experienced established companies with own expertise and perspectives, usually run the project from start to finish and can provide a contact person for the funding and licensing.
- Municipalities: local authorities include CW as part of their landscape planning, run projects, fund projects and apply for funding of projects.
- Water councils: association for all stakeholders of water in a river basin catchment. Aimed to increase collaboration for higher implementation of environmental measures, with initial focus on nutrient retention.
- The County administrative board: the regional government body that administrates the funding (projects costs & annual maintenance support) and permits for CW projects. Does also plan and implement CW projects.

Landowners were unanimously pointed out as key stakeholder for constructed wetlands. Land to implement constructed wetlands is essential and because of the strong decisive rights they have over the land, landowners are key. That means that only if a landowner approves a constructed wetland can it be implemented. In Skåne, landowners contact and are contacted by the government. The interviewed landowners had, in general, a positive attitude to the collaboration with other stakeholders but voiced a potential mismatches in practical reality and theoretical ideas. To illustrate, three landowners pointed out that the timing and guidelines for maintenance activities is not aligned with weather circumstances. They explained that when accumulated sediments are taken out of the CW, they lay on the side for a period of time. The purpose is to dry and test, if needed, before spreading it out on the fields. Meanwhile, it can start raining and all the nutrients leak back into the system. The landowners with a lot of land have higher flexibility, and also in CW projects early adopters.

All interviewed governmental stakeholders believe in strong cooperation with landowners' ideas on the constructed wetlands. As previously portrayed, constructed wetlands emerged slowly and increased over time. This coincides with the slow development and expansion of stakeholder networks and trust-building surrounding CW projects. The connections built up from projects 30 years ago remain the foundation of current and future projects. The early networks build up in Skåne came from the first big governmental funding initiatives. These aimed to start collaborations within river basin catchments, through water councils, to implement environmental measure such as constructed wetlands. One illustrative example is the Kävlinge river project which ran in several stages between 1995-2011. The efforts to establish water councils has supported the CW projects. The stakeholders connections are maintained through some activities such as dialogue meetings.

The participation and effort for CW projects varies between the municipalities and water councils. Engagement and interest was sparked early and has been high locally in the areas surrounding Lund but emerged later in other areas of Skåne. The recreational benefit of CW has become an additional objective over time for local authorities. Recently, also water retention and flooding have been included in their objectives.

Policies

In 1964, Naturvårdslagen (Nature Conservation act) 18c§ required that drainage activities must be authorized. Before that, drainage of the landscape could be done without any regulation. Naturvårdslagen was expanded in 1991 to the option of prohibiting land drainage § 18 c. Law (1991:641). The first policy targeting construction of wetlands in Skåne emerged in 1989, 'Nya inslag i anslaget' (New elements in appropriation) starting funding and incentives for

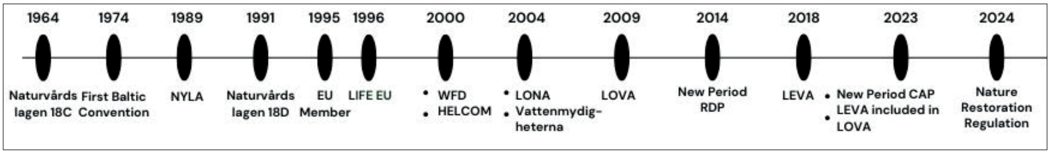

Figure 3: Non-linear timeline that visualizes policies and governmental changes that impacted the developmental trajectory of constructed wetlands in Skåne.

stakeholder collaboration. The monetary funding was minimal and co-funding played an important role. See figure 3 for a timeline visualization of the policies.

Sweden joining the European Union in 1995, marked the beginning of a reform by adding a government layer. Funding and policies at EU level trickle down in the region. Major funding from EU for constructed wetlands is part of the 5-year program Common Agricultural Policy (CAP), previously Rural development Programs (RDP). Other EU funding for environmental measures, such as constructed wetlands, can be obtained through EU LIFE projects.

The Helsinki Convention (HELCOM) was signed in 1974, putting eutrophication of the Baltic Sea on the agenda. In 2000, the Water Framework Directive (WFD), legislation on water quality and quantity from the European Union was proposed. The renewed HELCOM was ratified in the same year. Both are strong incentives for regional and local authorities to implement nutrient reducing measures. A new institution, water district authorities were founded in Sweden in 2004 as part of the implementation of the WFD.

The national LONA and LOVA funding programs have been, and still are, important and main funding for CW projects in Skåne. These were most often singled out as interviewee's most important funding. The first was LONA in 2004 which stands for: Lokala naturvårdssatsningen (Local nature Conservation Programme). One of the specific mentioned objectives is funding for "thriving wetlands" and thus directly connected to wetlands. The grant paid to the county administrative board comes from Naturvårdsverket (Swedish Environmental Protection Agency) (Eriksson et al., 2021). After LONA, LOVA, Lokala åtgärder för bättre havs- och vattenmiljö (local measures for a better sea and water environment) started in 2009. This funding focusses on locally supported water management measures, managed by municipalities and non-profit organizations. In the period 2018-2023 a funding program LEVA, Lokalt engagemang för vatten (Local commitment to water) targeted setting up new infrastructure for water measure implementation. This supported the introduction of new collaboration networks among stakeholders, LEVA is continued as funding within LOVA.

Additionally, after the master thesis period:

- The Nature Restoration Regulation has been adopted by the European Union in 2024 and is scheduled to be implemented on national level in 2026. This legislation will push incentives even more towards natural restoration solutions in wetlands. These are often more natural fitting with the landscape characteristics and usually cheaper. This will lower the incentive and interest for funding to construct wetlands which are considered robust technical solutions and less cost-effective.

Climate

Climate has become relevant in landowners decision-making after a massive drought hit Skåne in 2018 during the beginning of the growing season. It sparked a shift in the focus of landowners towards water availability needs for agricultural production creating a higher interest for irrigation dams, another type of constructed wetland. Besides these droughts causing water shortages, water excesses due to floods and periods with high water levels increasingly occur, such as during the fieldwork conducted in the end of 2023. Floods are part of the natural landscape and have increased risk due the drained landscape and increasingly intense wet periods. The potential of temporary wetlands for flood reduction and increasing buffer capacity, mainly to protect urban areas, is more recent and being explored but has not been embedded yet compared to other uses of CW.

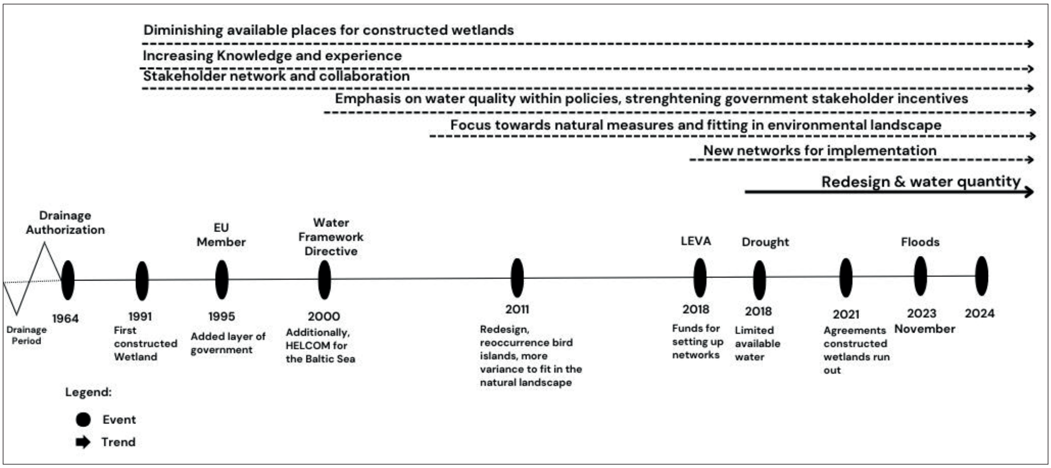

Figure 4: Overview of the events and trends of the constructed wetland developments in Skåne

The trajectory of the constructed wetlands in Skåne is comprised in figure 4.

Discussion

During the research period other points shaping the development of CW projects were stumbled upon. After such a long period of implementing an environmental measure unforeseen hurdles, that need to be addressed can arise. At the same time, there are on-going trends that potentially shape the use and implementation of the CW. Suggestions for consideration for both hurdles and future shaping are included in the list below.

• CW is the opposite of drainage meaning that it creates water retention which leads to potential losses of agricultural production. Drainage has been the norm for generations, therefore it can feel counter-intuitive for a landowner and can be met with some doubt or resistance and should be minded. The potential effect of a CW on neighbouring properties and surrounding areas are often highly considered in the design and project as a whole.

• There are many CW in the upcoming years that have completed their 'life-cycle' after 15-30 years and vegetation growth will close the water surface. In the upcoming years the retirement of the early implemented CWs needs to be dealt with because accumulated sediments can start leaking nutrients increasing eutrophication.

• Constructed wetland agreements with monetary support between landowner and government are usually for a period of 20-30 years. After this period, the landowner is not allowed to close the wetland but does not have an obligation to maintain it. This could cause potential nutrient leaking. Several CW agreements are already out-aged but this will only increase in the near future. As if now, there is no guideline and direction for the constructed wetlands that have out-aged these agreements. It is important to start working towards solutions to avoid countering the function and effect of the CW.

• There is competition between constructed wetlands for biodiversity and nutrient retention and irrigation dams for the available areas of land. The funding for these measure differs in favour of the constructed wetlands.

• Available areas for CW projects are diminishing, the low-hanging fruits have already been picked since already more than 2000 projects were implemented in Skåne. The highly productive soils in these areas make agricultural purposes prioritized over CW.

• The development and implementation of CW is also connected to the efforts of strong pioneers or comes down to extreme efforts of single people which is difficult to pinpoint. The early implementors of CW were in close proximity of the Lund University. This could indicate, although not decisive from this research, that the proximity of the university and thus academics has a causal relation to the early implementors both in the water councils and consultant establishment.

• At international and national level, food security as part of preparedness for crises and war has received more attention. Aiming to increase reliance on own national food production, this means that environmental measure such as CW will have to compete with areas for food production, despite CW commonly being implemented on the least productive areas.

Conclusion

The emergence of constructed wetlands (CW) over 30 years ago has been concentrated in the Kävlinge and Höje river catchment, the early-implementors. The slow building and strengthening of a stakeholder networks through water councils has significantly benefitted the widespread implementation of CW in the whole of Skåne. This has also led to the accumulation of experience and knowledge over time. WFD and HELCOM have incentivized governmental stakeholders for CW implementation targeting eutrophication. The initial objectives for CW have been expanded with recreational values and since 2018 water quantity management. The 2018 early spring drought has sparked a focus from landowners towards irrigation purposes of constructed wetlands. It will become more difficult to find suitable areas for new CW due to potential competition with irrigation dams and many additional CW are already using those areas. Since the 2010s a trend towards more natural design that fit within the landscape emerged. This increasingly gained support and will be especially relevant in the upcoming years due to the New EU Restoration Law. Ultimately, it started out with a few constructed wetland 'craters' in 1990s that turned into many constructed wetlands that have become more natural and adaptive for even more purposes.

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