RESILIENT LAKE SÄBYSJÖN

A Collaborative Endeavor for Ecosystem Restoration and Community Engagement

AG2809 Project Sustainable Urban Planning – Assessments, Plans, and Processes, KTH

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Abstract

This project evaluates Lake Säbysjön's resilience, an urban wetland in Järfälla municipality, Stockholm, Sweden, against water-related challenges using the green-blue infrastructure. Addressing urgent water resource management needs amidst urbanization, climate-induced events, and local environmental concerns like water pollution and flooding risks. The study delves into understanding cross-boundary collaborative water management strategies that could potentially support the comprehension of interconnected water system dynamics, contribute to the preservation of biodiversity, and enhance community engagement, particularly in aspects such as recreational opportunities.

The methodology underscores resilience analysis as a purposeful approach, requiring a tailored framework aligned with the project's objectives and scale. The main output comprises the knowledge and insights acquired during the research, to lay the groundwork for more comprehensive research in similar ecological landscapes and water-related challenges. Moreover, identifying critical thresholds and proposing strategies relevant to the specific research objectives are the ambitious outputs of this project. By shedding light on these thresholds and suggesting targeted strategies, this study seeks to contribute not only to understanding the dynamic of Säbysjön's ecosystem but also to lay the groundwork for more comprehensive research in similar urbanizing landscapes and water-related challenges.

Sammanfattning

Detta projekt utvärderar Säbysjöns motståndskraft, en urban våtmark i Järfälla kommun, Stockholm, Sverige, mot vattenrelaterade utmaningar genom användning av grönt-blått infrastruktur. Adressering av brådskande behov av vattenresursförvaltning mitt i urbanisering, klimatinducerade händelser och lokala miljöproblem som vattenförorening och översvämningsrisker. Studien fördjupar sig i förståelsen för gränsöverskridande samarbetsstrategier för vattenförvaltning som potentiellt kan stödja förståelsen av sammanlänkade vattensystems dynamik, bidra till bevarandet av biologisk mångfald och förbättra samhällets engagemang, särskilt inom områden som rekreationella möjligheter.

Metodiken betonar bedömningen av motståndskraft som ett ändamålsenligt tillvägagångssätt och kräver en skräddarsydd ram som är anpassad till projektets mål och omfattning. Huvudresultatet omfattar den kunskap och de insikter som erhållits under forskningen för att lägga grunden för mer omfattande forskning i liknande ekologiska landskap och vattenrelaterade utmaningar. Dessutom är identifiering av kritiska tröskelvärden och föreslagna strategier som är relevanta för de specifika forskningsmålen de ambitiösa resultaten av detta projekt. Genom att belysa dessa tröskelvärden och föreslå riktade strategier strävar denna studie efter att bidra inte bara till förståelsen av Säbysjöns ekosystems dynamik, utan också för att lägga grunden för mer omfattande forskning i liknande urbaniserade landskap och vattenrelaterade utmaningar.

Contents

1. Introduction

Water-related challenges have become increasingly urgent, impacting human well-being and environmental sustainability (McGrane, 2016). The rise in urbanization and environmental degradation highlights the critical need to manage and preserve water resources (Zipperer et al., 2020) for urban resilience. Resilience defined as "the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedback" (Walker et al., 2004)is increasingly used as an approach for understanding and navigating the dynamics of social–ecological systems (Folke et al., 2002). Climate change-induced events, such as floods and storms, emphasize the necessity of the adaptive and proactive measures that resilience thinking aims at, to mitigate risks and thereby safeguard communities and ecosystems (Lee et al., 2023).

In Järfälla municipality, North-western Stockholm, Sweden, significant challenges like water pollution, risks of drought and flooding exist surrounding the lake Säbysjön. This is exacerbated by the rapid transformation of Barkarby, in proximity to Säbysjön, into a new city district, which introduces and amplifies pressures on the socio-ecological dynamics. Yet, resilience thinking suggests that such pressures and disturbances might, conversely, create opportunities for innovation and sustainable urban development (Berkes et al., 2008). Prompting the exploration of green-blue infrastructures (GBI) for nature-based solutions (NbS) (Ferreira et al., 2023).

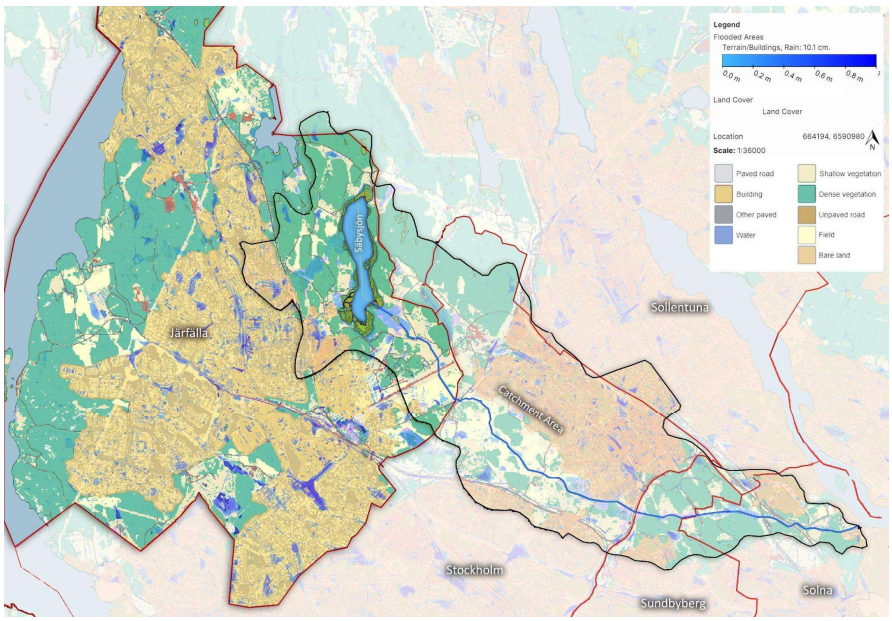
The role of urban wetlands is becoming essential in contemporary urban design and development (Ferreira et al., 2023). Recognizing Säbysjön's robust buffer functions and its role in flood mitigation, the Järfälla comprehensive plan acknowledges the necessity to both preserve the biological and recreational values of Västra Järvafältet nature reserve and open the culvert of Igelbäcken which continue to Edsviken and the north Baltic sea to maintain water quality (Järfälla_kommun, 2014). The ecosystem services of urban wetlands, including flood mitigation, water quality improvement, habitat quality for biodiversity, and public amenities such as recreation, nature education, and aesthetics, are necessary for the well-being of urban inhabitants (Ahn and Schmidt, 2019).

However, despite awareness of its ecosystem services and the existence of some collaborative water management agreements within the Edsviken catchment, the urgency for collaborative management in Järfälla has not kept pace with these growing challenges. This identifies a gap in the current water management assessment, illuminating the need for a deeper understanding of the urban wetland potential in Järfälla.

While these challenges often involve an interconnected water body from upstream to downstream (upstream-downstream conflicts reference), they are frequently discussed and managed solely within administrative boundaries. This project focuses on assessing the resilience of Säbysjön, an urban wetland in Järfälla, recognized as an essential part of a protected nature reserve (Järfälla_kommun, 2014). However, rapid urbanization in the adjacent Barkarby area poses potential future disruptions, such as water pollution or excessive recreational use of wetlands. The project aims to explore cross-boundary collaborative water

management, based on well-established knowledge regarding the necessity of participatory management of natural resources, reflecting both ethical–democratic and pragmatic motivations (e.g. Browning-Aiken et al., 2004), utilizing biophysical boundaries to comprehend the intricate dynamics of interconnected water system (Fig. 1). It seeks to pinpoint critical thresholds identify essential system components and ensure biodiversity enhancement and water security against climate extremes and societal regime shifts in the future.

Recent advances in understanding social processes and adaptive governance are significant in comprehending the complexities of managing ecosystem services (Folke et al., 2005). The project aims to bolster societal resilience and advocate sustainable water management practices, particularly in the context of community-based recreation, aligning with the evolving concepts in social learning, knowledge integration, and adaptive capacity.



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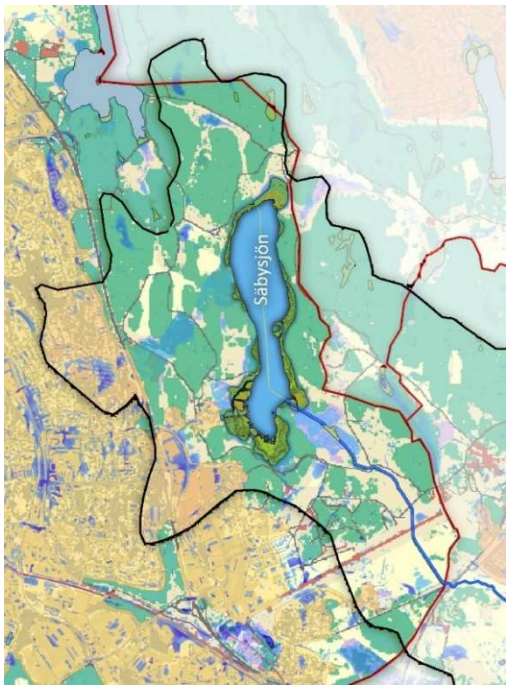

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Fig. 1. (a) Sub-catchment area and (b) Säbysjön location and land cover in Järfälla municipality

The primary aim of this project is to evaluate the resilience of Säbysjön's blue-green infrastructure as a multifaceted solution to address various water-related challenges prevalent in Järfälla (Matthews et al., 2015, Wong and Brown, 2009). Järfälla faces several pressing water-related challenges, including pollution and water security concerns in Säbysjön and the downstream waters. Säbysjön demonstrates robust buffer functions, displaying its ecological potential through its rich biodiversity and water-related social networks that foster collaborative water management initiatives (Ostrom, 1990, Folke et al., 2005). This project aims to further explore these three key potentials and through analysis of the socio-ecological facets within this water network, to contribute to Järfälla's transformation into a water-sensitive municipality in the midst of its ongoing urbanisation (Brown et al., 2009, Fletcher et al., 2015). In this context, a water-sensitive city signifies an urban environment that integrates water management strategies, emphasizing sustainability, efficiency, and resilience in water usage, distribution, and conservation.

This project delineates ecological boundaries, emphasizing the water catchment area, as its primary demarcation. It concentrates on implementing strategies aimed at enhancing resilience within three pivotal aspects: flood mitigation, biodiversity enhancement, and the creation of recreational opportunities. The research is specifically focused on identifying and implementing strategies tailored to enhance resilience in these areas, providing valuable insights to municipal planners and stakeholders engaged in water resource management. Furthermore, the project aims to show the potential of Säbysjön for improving collaboration among diverse stakeholders and municipal entities invested in the sub-catchment area of Säbysjön. By fostering proactive engagement and dialogue, it seeks to encourage effective utilization of the ecosystem's potential among the five interconnected municipalities. Ultimately, the project aims to contribute to a resilience action plan, customizing a framework tailored to Säbysjön's unique characteristics and needs. This approach aims to lay the foundation for an integrated and effective strategy that aligns with the ecosystem's requirements (Berkes et al., 2008, Biggs et al., 2015).

The challenges addressed in this report align with several Sustainable Development Goals (SDGs), including, but not limited to, SDG 6 (Clean Water and Sanitation), where the focus on water quality is fundamental; SDG 11 (Sustainable Cities and Communities), as disaster risk reduction and interconnected wetlands play a role in creating more resilient and sustainable urban areas; and SDG 13 (Climate Action), as the report contributes to the preservation and enhancement of terrestrial ecosystems, aligning with the goals of SDG 15 (Life on Land). SDG 17- “partnership for the goals,” is significantly related to the involvement of stakeholders, including local people and regional institutions, and its fair decision-making process in water management.

Recognizing Säbysjön’s inherent potential to act as a natural buffer against climate change impacts, such as intensified rainfall and flooding, while purifying water through its natural filtration system (Bavor et al., 2001, Greenway, 2004, Kalantari et al., 2021), and fostering biodiversity, this project aims to harness these capacities to mitigate adverse impacts and foster a resilient, sustainable future for Järfälla.

Consequently, to delve deeper into the multifaceted dynamics of Säbysjön's GBI and the complexities of water-related challenges in Järfälla, this study addresses the following research questions:

1. *What factors contribute to Säbysjön's resilience against water-related challenges, focusing on flood mitigation, biodiversity, and outdoor recreation?*
2. *How can collaborative water management strategies across boundaries address interconnected water challenges in Säbysjön, while ensuring biodiversity preservation, climate-resilient water security, and urban outdoor recreational opportunities in Järfälla?*

2. Background

2.1 Definitions of core concepts

Resilience thinking

In proposing a foundational understanding of resilience, Holling (1973) laid the groundwork for what would emerge as 'resilience thinking'. This conceptual framework has increasingly permeated interdisciplinary research, particularly in understanding complex socio-ecological systems (Berkes et al., 2008, Biggs et al., 2015). Resilience thinking focuses on the capacity of systems to endure disturbances while maintaining core functions, the presence of alternative regimes and thresholds, and the ability of a system to adapt or transform in response to change (Walker and Salt, 2012).This form of thinking is pivotal in sustainable development, emphasizing the need for a holistic system perspective that acknowledges the interplay between ecosystem dynamics and human activities (Folke et al., 2002).

The core of resilience thinking lies in its systemic approach. It centralizes the importance of change, the inevitability of disturbances, and the critical thresholds that, if crossed, can lead to alternative system regimes (Berkes, 2000). Accordingly, this approach advocates for adaptive and transformative strategies that go beyond conventional resource management to incorporate an understanding of these dynamics (Walker et al., 2004). In the broader context of sustainable development, this translates to an emphasis on policies and practices that promote the sustainability of socio-ecological systems, ensuring that development meets present needs without compromising the ability of future generations to meet theirs (Brundtland, 1985).

Urban wetlands, watersheds, and collaboration

Urban wetlands play an integral role within the urban landscape, forming vital links within watersheds that contribute to the holistic management of water bodies (Davis et al., 1997). Watersheds, encompassing all land where water converges to a single point at a lower elevation, are critical spatial units for comprehensively managing water-related issues, recognizing the multitude of interacting stakeholders and the interconnected nature of socio-ecological systems (Pahl-Wostl et al., 2008).

The collaborative aspect within this context is paramount, as it addresses the complexity of water management in urbanized landscapes by endorsing inclusive stakeholder engagement

(Ansell and Gash, 2008). Collaborative management, especially in the context of watersheds, acknowledges the diverse influences and impacts across stakeholders, promoting strategies to transcend administrative boundaries and effectively address common concerns like upstream-downstream conflicts (Cosens and Williams, 2012). The 'catchment-based approach', as introduced by Falkenmark (2003), emphasizes the physical boundaries of watersheds to better manage water resources and enhances the practicality of Collaborative Water Management (CWM). This approach is widely acknowledged for fostering societal resilience and advancing sustainable water management practices by enabling a platform that connects stakeholders in watershed and integrates their efforts towards shared water system goals (Pahl-Wostl, 2009).

2.2 The main water challenges in Järfälla and Säbysjön

In Järfälla, like many other regions globally, the impact of climate change poses significant challenges to water resources and environmental sustainability. The municipality is dealing with pressing water-related issues amplified by climate change-induced events, including floods and storms (Järfälla_kommun, 2014). Historically, Säbysjön has experiences the several severe lack of oxygen which were happened in 1900 and 2002, and sometimes changes of human activities such as stop grazing also affected the condition of Säbysjön (JSFK, 2012). These challenges, intertwined with urbanization and environmental degradation, accentuate the urgency to manage and preserve water resources effectively. The consequences of climate change in Järfälla manifest prominently in water-related issues. Rising temperatures result in new weather patterns, leading to more intense and frequent rainfall events as well as heat waves and droughts. Consequently, the region experiences increased instances of flooding, threatening both infrastructure and the safety of communities, but also scarcity of green water (Järfälla_kommun, 2014). Additionally, extreme weather variations disrupt the dynamic of the local ecosystems, leading to heightened risks of water pollution and major ecological shifts.

2.3 Säbysjön catchment and land use history

Säbysjön is a lake in the Västra Järvafältet nature reserve, and it is upstream of Edsviken's catchment area, which connects to the north Baltic Sea at the end (Svensson et al., 2021), Fig 1. The lake is classified as a shallow, about 1.65~2.3m depth, nutrient-rich lake. Västra Järvafältet has been protected as a nature reserve since 1987 and covers 700 hectares, consisting of mixed forest, lake, cultivated landscape, and cultural environment (Länsstyrelsen, 2023). Igelbäcken stream is the only outflow from Säbysjön, and it flows through five municipalities: Järfälla, Sollentuna, Stockholm, Sundbyberg, and Solna, and it has been equipped with a dam that retains the water during spring and early summer (Svensson et al., 2021). Today the catchment area is covered by forest (58%), and especially the meadows (11%), bush, and reed curtain are essential for ecosystem services such as habitats for organisms and storm water purification (Svensson et al., 2021). Previously, the landscape was characterised by agricultural land uses (Bornhall, 2007) , whereas today the remaining meadows and grasslands are kept open by a few small-scale farms hosting grazing cattle and horse keeping facilities and riding schools. These grazing animals are important to keep the grass from growing so that the wetland can pool water (naturpärlor, 2022).

Considering the hydrological and ecological significance of Säbysjön, the existing water governance in the area is multi-dimensional, involving a combination of regulatory measures, collaborative initiatives, and stakeholder participation to manage the lake's resources effectively. The water governance framework integrates municipal and regional policies that emphasize the conservation and sustainable use of water bodies within the catchment area.

The involvement of multiple municipalities in the management of Igelbäcken stream, the lake's sole outflow, necessitates a cooperative management approach. This collaboration is critical for addressing water quality and quantity concerns that impact the entire watershed, which ultimately feeds into the Baltic Sea (Jonsson et al., 2011). The region's water governance also encompasses the EU Water Framework Directive (WFD) principles, aiming to achieve a 'good status' for all waters by a set timeline (Directive, 2000).

Further, local environmental groups and non-governmental organizations often participate in monitoring and conservation efforts, contributing to the practical and community-led aspects of water governance. Partnerships between public, private, and civil society actors help bridge governance gaps and enhance the management of the area's wetland resources (Österblom and Folke, 2013).

3. Methodology

To tackle the multifaceted dimensions of analysing the resilience of Säbysjön's GBI and its role in water management, our methodological approach was designed to be iterative and multidisciplinary. Structured as a series of interconnected phases, our methodology synthesized a range of qualitative and quantitative data to shape a coherent analysis.

Establishing a meaningful connection with Järfälla municipality posed a notable challenge. Given the nature of this research as a university student project, these obstacles in obtaining information were expected but did not impact the depth of insights obtained.

3.1 Literature Review

The foundation of our research was formed by an extensive literature review. This phase entailed a systematic search and synthesis of current academic literature, policy reports, and case studies pertinent to urban water management, resilience thinking, and collaborative approaches. We focused on materials that illustrated the latest advancements in resilience assessment and the use of GBI in urban settings, as well as lessons learned from other municipalities facing similar challenges. Key search terms including "resilience thinking," "urban wetlands," "collaborative water management," and "nature-based solutions" were used to ensure a breadth of sources. The eligibility of sources was appraised based on their relevance, contribution to the body of knowledge on the subject, recency of publication, and the credibility of the authors.

3.2 Case Study Scoping and Site Visits

Simultaneously, a case study scoping was conducted to gain specific insights into the local context. We collated and examined municipal documents from Järfälla, such as strategic plans, environmental assessments, and water management policies. This collection of municipal documentation aimed to offer insights into the present conditions of water bodies and the prevailing challenges faced by this ecosystem, a detailed view of the ambitions and measures considered by local governance for Säbysjön.

Complementary to the documentary analysis, field visits to Säbysjön were made under cloudy and partly rainy weather conditions during October and November 2023 to directly observe the wetland's ecology and stakeholder engagement in-situ. These visits helped us to gain a first-hand understanding and observe biodiversity, ecosystem services. During our field visits, we gathered information from printed pamphlets and brochures available at various information stands provided by the municipality and ecological information card provided by local organisation such as Järvafältets Ornitologiska Klubb across different areas. These informational materials detailed the local vegetation, bird species, insects, and the broader flora and fauna within the catchment area and around the lake (Fig. 2). We documented this information through photographs and note-taking. The site visits facilitated the collection of data on various stakeholders associated with the landscape. Some stakeholders had established premises or provided informational boards, offering valuable insights into their involvement within the ecosystem. This exploration allowed us to delve into the network of societal connections related to the ecosystem. Furthermore, these visits enabled us to examine the reception of initiatives such as the bird tower and other recreational facilities, as well as understand the connectivity between various elements, such as streams to the lake, particularly concerning the movement of fish species.

Fig. 2. Information card provided by local organisation.

For spatial data, we utilized open data sources such as the Lantmäteriet website and SLU.map, which provided geographic information crucial for our analysis, such as high-resolution land cover maps, flood risk assessments, hydrological layouts, and municipalities boundary. Several kinds of maps of water catchment area were collected from multi municipal document such as

Igelväcken local action programm and Edsviken Vattensamverkan. Furthermore, in our quest for GIS data, we collaborated with SLU University, where we were introduced to GIS data sources like storymaps.arcgis.com. These platforms offered an array of GIS data and analytical tools that contributed to our GIS data analyses and the generation of detailed maps. Through these efforts, we enriched our dataset with geospatial information that aided in a more robust analysis of Säbysjön's GBI and its resilience to water-related challenges in Järfälla.

3.3 Framework Development and Data Collection

Progressing from conceptual grounding and contextual familiarity, we ventured into the development of a custom-built analytical framework. To construct a framework that would resonate with the complexity of our case study, we evaluated existing frameworks from the Resilience Alliance (Alliance, 2010), Wayfinder (Wayfinder, 2023), and RESCCUE (Cardoso et al., 2020) projects. By distilling the core principles from these models, we identified and moulded five primary stages central to our analytical framework: 'Describing,' 'Dynamics,' 'Interactions,' 'Governance,' and 'Strategizing' (Fig. 2).

This stage-based framework, visualized in supplementary flowcharts (Fig. 3), guided our data collection and analysis. We created customized worksheets for each stage, designed to parse the gathered data into meaningful categories that relate to each component of our framework. This organization facilitated an exhaustive dissection of data, thereby enabling us to tailor strategies to the specific socio-ecological context of Säbysjön. The site-specific data filled in the worksheets were collected based on the literature described above and website of local organisations.

Each step of the framework informed successive steps, ensuring that insights from one phase enriched the understanding and analysis of the next. This approach allowed for a dynamic and reflexive process that could adjust to emergent themes and findings, critical for resilience thinking which values adaptability and responsiveness to changing conditions.

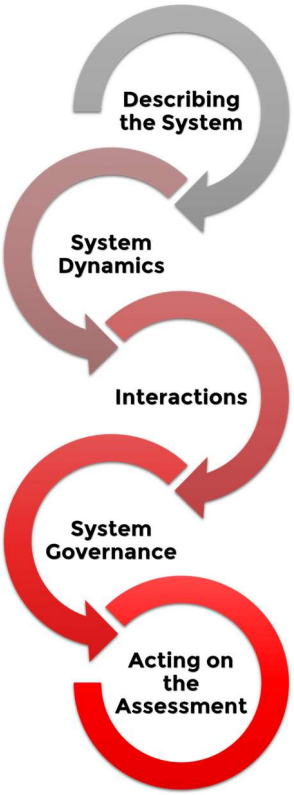


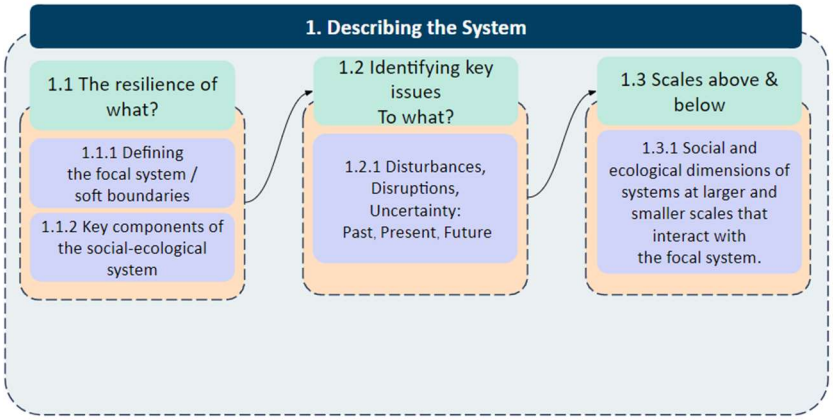
Fig 2. Five steps of defined resilience analysis

4. Resilience Analysis

The following resilience analysis is structured upon a comprehensive workflow designed to thoroughly investigate the social-ecological dynamics and complexities within Säbysjön's GBI (Fig 3). The workflow outlines a systematic process of exploration and analysis, allowing a holistic understanding of the intricate interplay between the social-ecological components vital to Säbysjön's resilience. Each section of this assessment forms a pivotal piece of the puzzle, contributing to our understanding of how this ecosystem functions, copes with disturbances, and thrives in the face of change.

Fig. 3 The flowchart of the framework

4.1 Describing the System



4.1.1 The resilience of what?

Defining the focal system / soft boundaries:

This initial step involves outlining the social-ecological boundaries of the system under review, known as the focal system. These boundaries include both spatial aspects, which is the catchment area (Fig. 4), and temporal elements, considering a time span of 50 years from 1970 to 2050. These boundaries define the limits of the system being examined and provide a clear framework for understanding and evaluating the system's dynamics over this period.

Key components of the social-ecological system:

When exploring the main uses of natural resources within the focal system, several key aspects emerge. This area primarily acts as a reservoir for biodiversity, supporting various species like birds, insects, and different kinds of vegetation. Moreover, it serves as a buffer, where the formal protection as a nature reserves effectively hinders urban exploitation and maintaining ecosystem services.

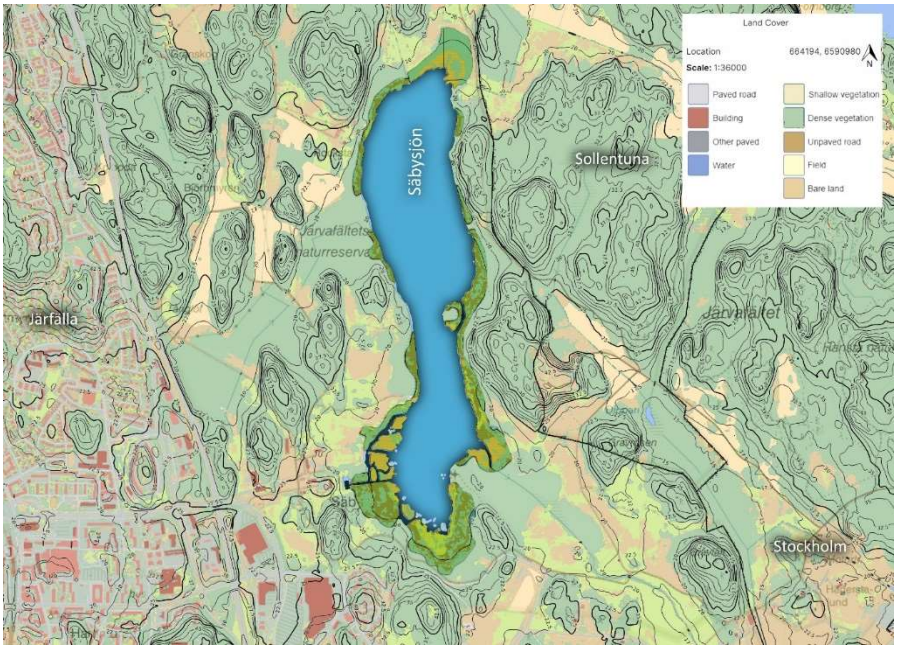


Fig. 4. Landcover map

Considering the indirect benefits derived from the focal system, its socio-ecological complexity presents opportunities for enhanced connectivity among various actors within it, such as environmental groups, local businesses, educational institutions, and residents. This interconnectivity allows for the sharing of resources, knowledge, and strategies, creating a strong network that is vital for adaptive management practices. For instance, local environmental groups collaborating with schools on educational programs can increase awareness and stewardship. Even now, Nature Cafe located in the Säby gård is run by farm and events are facilitated by local bird watching club and so such collaborative networks based on the facilities are instrumental in building not community resilience but also strengthening the local ecological knowledge, particularly in anticipating and responding to potential future disturbances like urban runoff or climate change impacts (Worksheet 1).

Furthermore, its proximity to green spaces amplifies the value of Jakobsberg, as it offers ecological buffers, recreational opportunities, and aesthetic benefits, thus extending its influence beyond the mere provision of direct ecosystem services like water purification and flood mitigation.

Worksheet 1. Direct and indirect uses of key natural resources supplied by the system and the stakeholders that rely on them.

Natural resource users	**Stakeholders**
Direct users	**Inside focal system**
Farmers	Säby gård
Visitors for recreation	Residents in the catchment
Bird watchers	Bird conservation club
Animal owner	Fishing club
Wildlife	Järfälla municipality
Riding Community	Swedish association for nature protection
Järfälla municipality	
Indirect users	**Outside focal system**
Solna municipality	Sollentuna municipality
Sollentuna municipality	Stockholm region
Stockholm region	Scientist, ecologists, research institute
Sundbyberg municipality	

Identifying key stakeholders within the focal system is essential for building a robust governance structure. The municipality holds the critical role of decision-maker and regulatory authority, while various stakeholders (including local conservation groups, fishery clubs, and recreation organizations) drive the sustained engagement and utilitarian activities within the

region. Community-driven initiatives like the Jakobsberg Sport Fishing Club (JSFK) not only promote recreational fishing but also contribute to the lake's monitoring and management, highlighting the importance of integrating local knowledge into broader governance frameworks. Downstream inhabitants, though physically distant from the catchments, influence the water flow dynamics and can be considered stakeholders. The outflow of Säbysjön is critical, and any disruption, such as urban development or construction downstream, could lead to adverse effects like eutrophication, altering the lake's ecosystems. Therefore, maintaining a consistent natural water flow is vital for preserving the integrity of the Säbysjön catchment system.

4.1.2 Identifying key issues. Resilience to what?

Disturbances, Disruptions, Uncertainty

In identifying key issues that have affected the Säbysjön system, we delve into disturbances, disruptions, and uncertainties that have shaped its history and those that currently pose concerns, including potential future disruptions. Pulse disturbances, such as sudden singular events, and press disturbances, which happen continuously, are both considered. These disturbances might involve events like extreme weather conditions such as heavy rain causing flood risks (Fig. 5), pollution incidents, habitat alterations, or human activities that impact the system. This information helps us understand the historical challenges and anticipate potential future disruptions that might affect the Säbysjön system. All these details are documented in worksheet 2, which allows us to systematically record and analyse these disturbances.

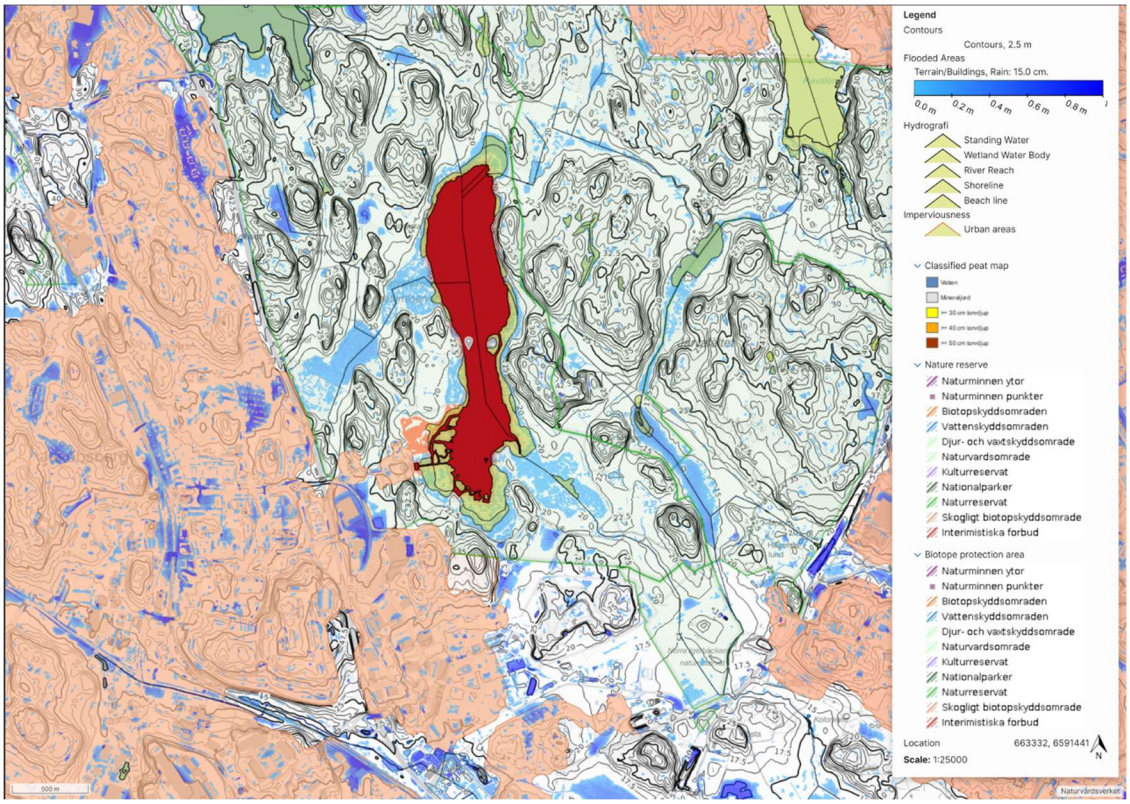


Fig. 5 Map of topography, urban areas, and flood risks

A historical timeline, illustrated in Figure 6, briefly captures the lake's ecological evolution and the confluence of societal influences from the 1900s to the present. This timeline encompasses pivotal changes and issues, depicting the transformation from an agricultural landscape to an urbanized setting, which has introduced new challenges such as increased pollutant load and vegetation overgrowth due to nutrient enrichment.

Worksheet 2. Summary of focal system disturbances and their attributes.

Disturbance (past)	**Pluse or Press**	**Frequency of occurrence**	**Time for recovery between occurrences**	**Components most affected (e.g., soil, markets)**	**Magnitude of impact (minor to severe)**
lack of oxygen (1900-)	press	several decades	several decades	fish, algae	severe
used as military area(1905~1970)	press	65years		soil, vegetation	minor
grazing on the pasture is stopped(1970~)	press	depend on farm	5 years around	birds' breeding /habitats	severe
sharp reduction of fish	press/ pluse?	several in decades	several decades	meadows began to grow, coastal forests became dense, birds decreased	ecosystem of the lake
drought / water shortage	press	often		fish / creatures	
PEFAS pollution	press	often when the water shortage		fish / creatures	severe
Disturbance (present)					
urban construction near the area	press/ pluse?	chronic	unknown	wildlife	minor
water pollution	press	chronic depends on the regulation	unknown	water	severe
waterway construction increase of culvert	press	unknown	until compensation	fish	minor
Future disturbance					
flood	could be pluse	several times in a decade	several weeks for the water to be absorbed into the soil	human	severe
overuse of green area	press	chronic	unknown	wildlife	severe
drought / severe water shortage	press	chronic due to urban infrastructures	unknown	fish/ other water wildlife	severe
grazing stop	press	depends on human activities	until restart	birds	start minor but severe

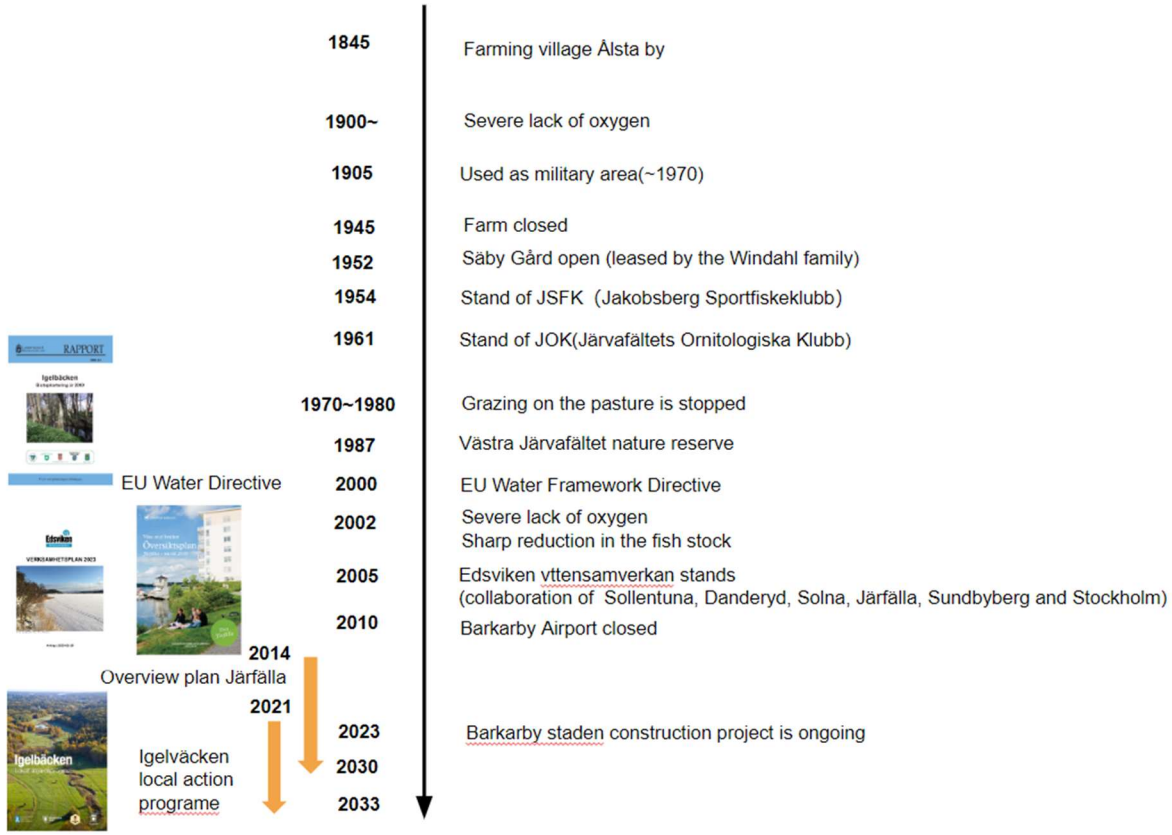


Fig. 6. Timeline

4.1.3 Scales above and below

In Säbysjön, large-scale systems in the ecological dimension are interconnected with smaller-scale systems. Climate conditions such as extreme rainfalls, which might cause flooding over the capacity of the present urban function, are related to both systems. Regarding water management, one of the water-related challenges in Igelbäcken stream, which is the only outflow from the Säbysjön is how to maintain the water level in the river during the dry summer, when parts of the river often dry up.

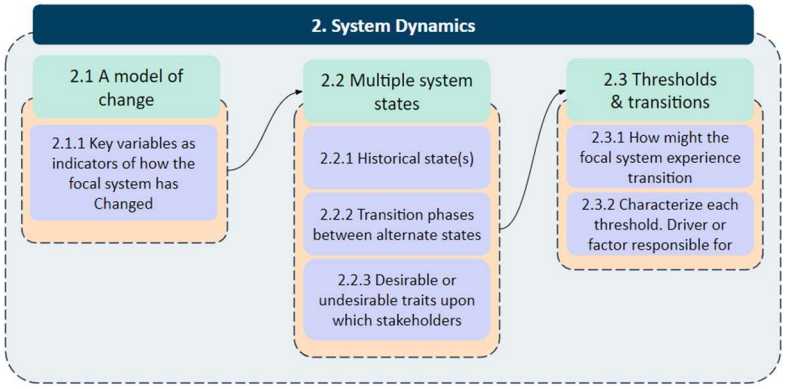
Worksheet 3. Social and ecological dimensions of systems at larger and smaller scales that interact with the focal system.

	Social dimensions that influence the focal system	**Ecological dimensions that influence the focal system**
Larger-scale systems	Nature Reserve regulation Policies for regional biodiversity New trends in outdoor recreation habits such as shifts in use of urban green space during the covid-pandemic	Climate conditions Extreme rainfalls
Focal system		
Smaller-scale systems	Local actions which form the water networks or networks about other uses of the system	Water level in the Igelbäcken stream (ecosystem conditions in the catchment area)

The water shortage affects the ecosystem at the catchment. On the other hand, increased rainwater inflows by extreme rainfall or flooding can lead to water with increased nutrient levels being channelled into streams, so raised pollution levels become another issue related to the ecosystem's presence. When some implementation to minimize the pollutant levels, including planting trees that absorb nutrients throughout the catchment area (Svensson et al., 2021), changes occur at the smaller-river scale (Worksheet 3) .

4.2 System Dynamics

4.2.1 A model of change



Key variables as indicators of how the focal system has changed.

In assessing key variables and indicators of change in the focal system, the size of the open water area becomes relevant, considering Säbysjön's status as a nutrient-rich lake susceptible to vegetation overgrowth. The level of pollutants is a primary concern for the future state of the lake, affecting not only water quality but also the health of the aquatic ecosystem. These variables, coupled with quantitative measures such as alkalinity (typically ranging between 7 to 8.4 pH units) and seasonal fluctuations in oxygen content, provide insights into the lake's current state and trajectory. The low oxygen saturation, particularly under ice in late winter, underscores the sensitivity of the lake's ecology to external and internal disturbances. The plants' oxygen production decreases with reduced light and temperature. Eel, perch, pike, and roach is the typical fish. Fishing is generally prohibited, apart from members of Jakobsberg Sportfiskeklubb (JSFK) that are allowed to fish from ice on the lake. The fishing club has a yearly assignment by the Järfälla municipality to conduct environmental monitoring fishing (JSFK, 2012).

4.2.2 Multiple system states

Historical state(s)

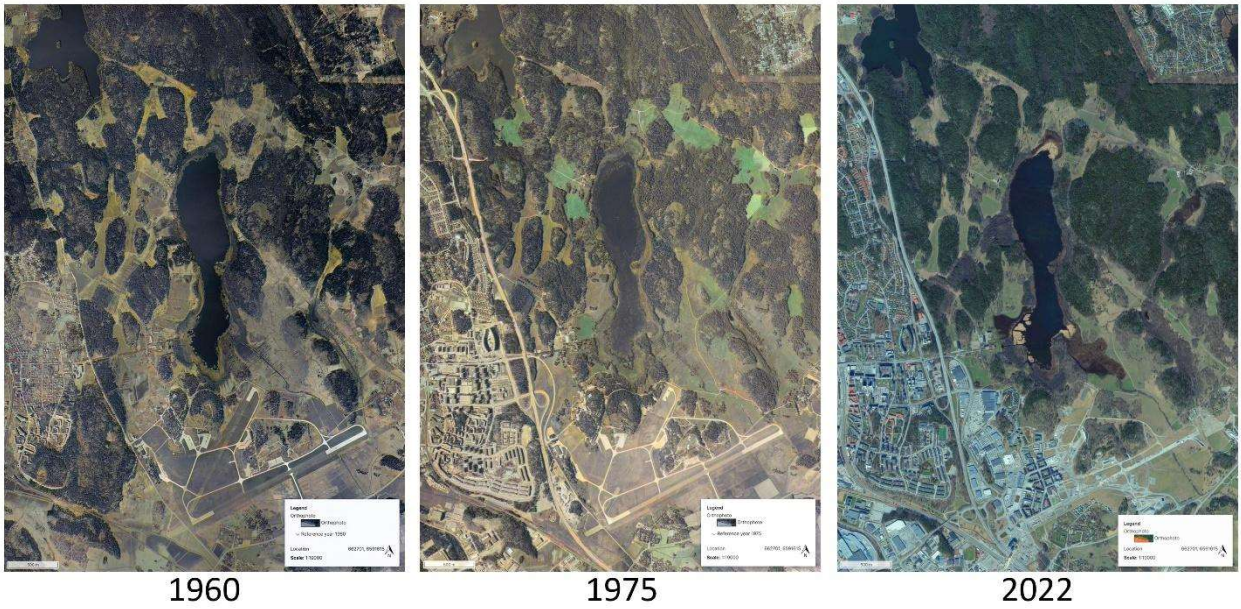


Fig. 7. Historical Orthophotos

The Säbysjön ecosystem has undergone various transitions between multiple system states. For instance, historical agricultural practices led to nutrient-rich runoff entering the lake, which contributed to eutrophication (Håkanson and Bryhn, 2008). This state shifted the lake from clear to a more turbid water state, impacting its biodiversity by favouring certain algae and vegetation that thrive in nutrient-rich conditions while displacing other species. The introduction of measures such as riparian buffer strips and controlled farming practices nearby aimed to reverse this eutrophic state (Prudencio and Null, 2018). However, the degree of reversibility has been challenged by ongoing urbanization pressures, which introduce pollutants and alter land use patterns (Fig. 7). The lake's ecological response to such actions, like the gradual improvement of water clarity, indicates partial reversibility, suggesting a capacity to return to a desired state but with limitations imposed by new urban stressors.

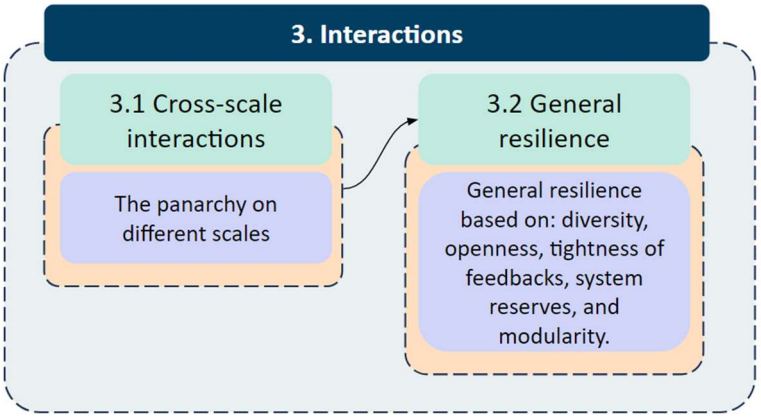
4.2.3 Thresholds & transitions

In the past, Säbysjon has experienced thresholds and regime shifts that happened several times. During the 1970s and 1980s, Säbysjön's shoreline meadows started to become overgrown by vegetation due to the closing of farms and reduction of agricultural activities, resulting in reduction in number of grazing animals. The shoreline forests became denser, and the reeds took over more of the lake, which caused the number of water dependent birds at the lake to decrease (naturpärlor, 2022).

Fig. 8. Säbysjon lake buffer zones.

In addition, during the 1990s, the lake suffered from a severe lack of oxygen on two occasions, and in 2002-03, which led to a sharp reduction in the fish stock.

4.3 Interactions



4.3.1 Cross-scale Interactions

The panarchy on different scales

In the case of Säbysjön, the panarchic interactions are evident when considering the lake's role in the broader Edsviken and Baltic Sea catchment. Beneficial influences from larger-scale systems include conservation policies and regional water management strategies, which help retain essential system configurations. Undesirable influences, like regional climate change impacts causing altered precipitation patterns, can lead to increased runoff and pollution loads from the surrounding urban area. The system's adaptability is illustrated by local interventions, such as constructed wetlands around the lake (Vymazal, 2022), which provide buffer capacity for runoff and improve water quality, showing a local adaptation within the larger regional context. However, this interconnectedness also poses risks; if one of the interconnected urban lakes or streams undergoes a significant negative change, such as a pollution event, it could propagate through and disturb Säbysjön due to their hydrological connectivity, demonstrating the necessity for a coordinated approach across scales.

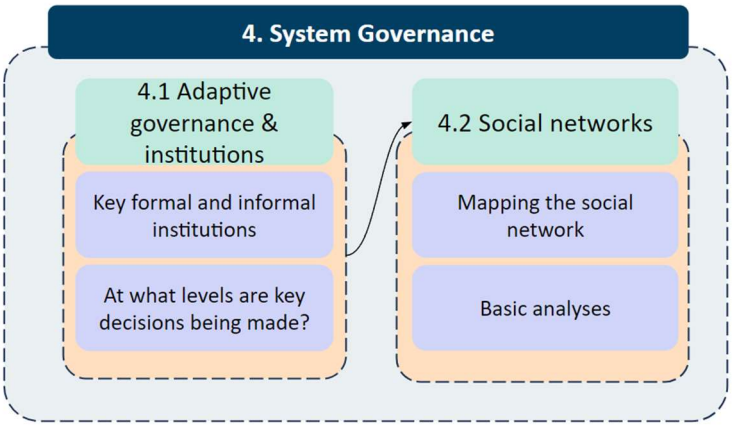
4.3.2 General Resilience

General resilience is based on diversity, openness, tightness of feedback, system reserves, and modularity.

Analysing the general resilience of Säbysjön involves considering attributes such as the diversity of plant and animal species within its boundaries (Rastandeh et al., 2017). Reduced diversity in aquatic vegetation, for example, could limit the lake's capacity to support a broad range of wildlife and might be more susceptible to invasive species domination. Openness in the context of Säbysjön can refer to the inflow and outflow of water, the exchange of species, and the movement of nutrients, which need to be managed to prevent issues such as eutrophication. System reserves, like the abundance of certain fish that control algae populations, are crucial to maintain the balance of the ecosystem. Tight feedback loops, evident

in community-led monitoring and timely response to water quality issues, are vital for quick interventions. Lastly, modularity in Säbysjön's ecology, such as distinct zones of vegetation that provide different ecosystem services, enhances the overall resilience by allowing parts of the system to function independently if other parts are disturbed.

4.4 System Governance



4.4.1 Adaptive Governance & institutions

Adaptive governance in system resilience refers to an environmental management approach that evolves in response to new knowledge and feedback from the social-ecological system (Beall King and Thornton, 2016). It is essential for maintaining the sustainability of complex systems like Säbysjön.

The critical component of this is Adaptive Co-Management, which integrates local experiential knowledge with larger institutional frameworks to bolster resilience (Salizzoni et al., 2020). This process shifts focus from traditional blame narratives to create a solution-oriented dialogue among stakeholders (Ricart and Kirk, 2022). The active participation of stakeholders is pivotal as it allows for real-time adaptation in governance strategies, reflecting the continuous interplay between social needs and ecological realities.

The localizing of governance is a key practice where local knowledge and interactions fuel the adaptive management process. By mapping and understanding stakeholder interactions, such localized governance supports robust decision-making structures that can respond effectively to environmental changes, ensuring the long-term health and resilience of the Säbysjön ecosystem.

4.4.2 Social Networks

Our stakeholder mapping for Säbysjön created a comprehensive social network map, highlighting the intricate web of socio-ecological actors involved in water management and environmental stewardship. Central to this map is Säbysjön Lake, around which various stakeholders (local governments, non-profits, and community members) are strategically positioned to reflect their roles and influence. The visualization of these relationships aids in appreciating the nuances of flood mitigation strategies, biodiversity efforts, and recreational activities.

This mapping not only illustrates formal governance by authorities but also the informal yet significant contributions of grassroots organizations and individuals. Historical practices, such as grazing by animals, are acknowledged as being integral to the system's health, tying together administrative strategies and on-the-ground activities. The map underlines the multiplicity of stakeholders, recognizing that the ecological state of Säbysjön is shaped by a confluence of municipal actions and community engagements (Fig. 9).

By clarifying these connections, the map enhances our understanding of the social capital in the Säbysjön area, providing a layered understanding of the social resilience embedded within phase 4 of our governance assessment. This catchment social landscape shows high potential to accelerate social networking and strengthen catchment social resilience. This social network not only serves as a basis for managing the lake's catchment but also as a catalyst for fostering cross-boundary collaboration essential for the thorough stewardship of Säbysjön's green-blue infrastructure.

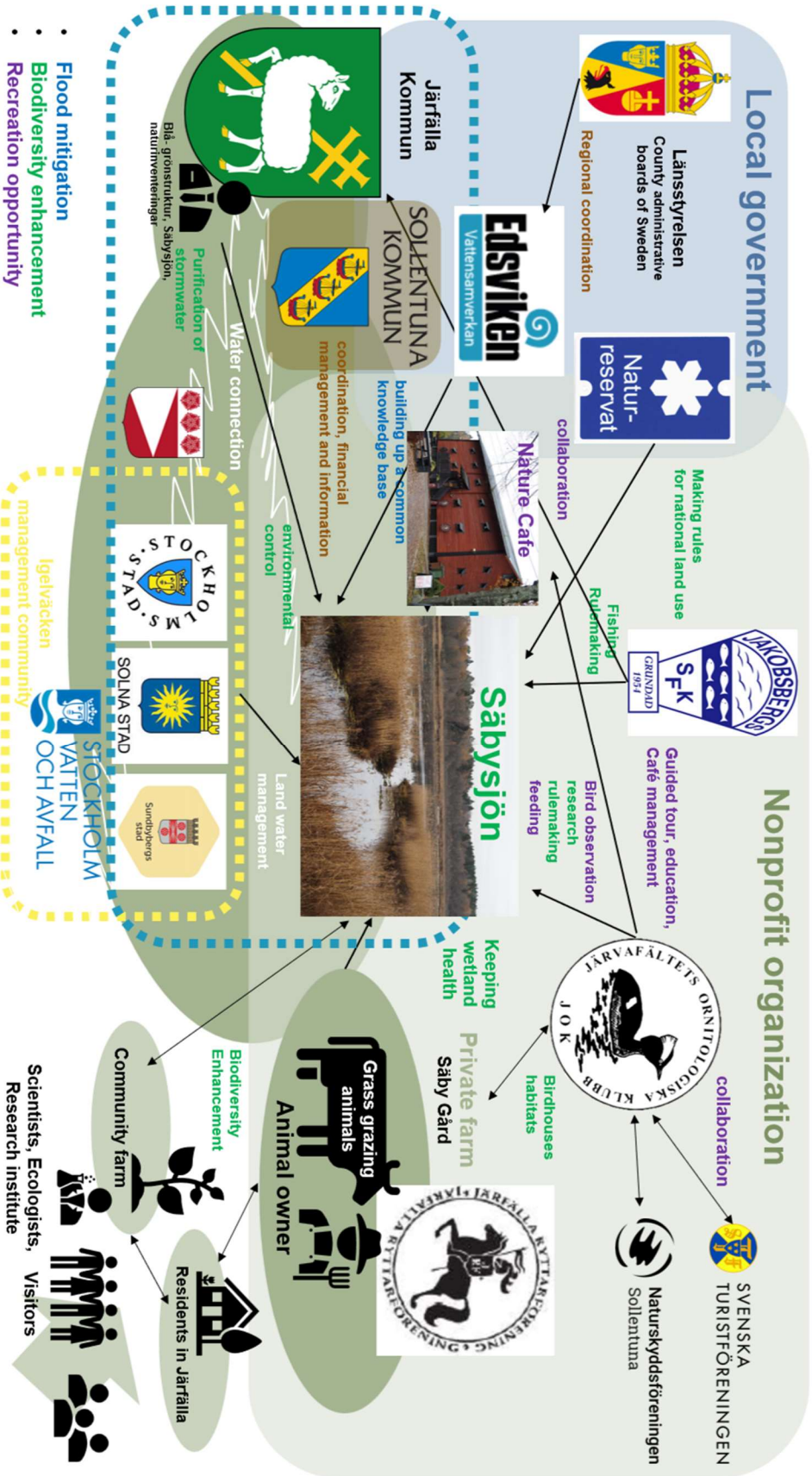
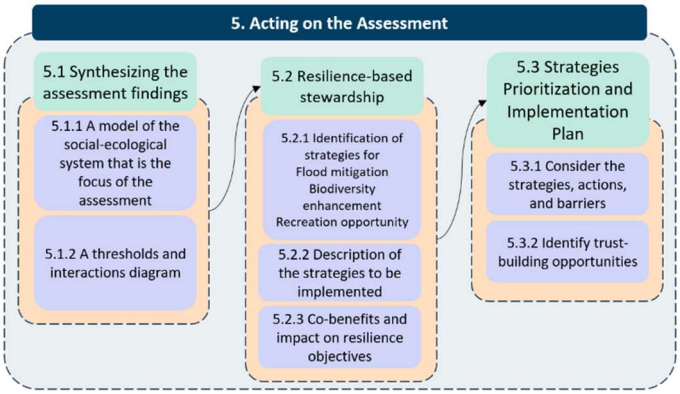


Fig. 9. Mapping the social network and Basic analyses.

4.5 Acting on the Assessment



4.5.1 Synthesizing the Analysis Findings

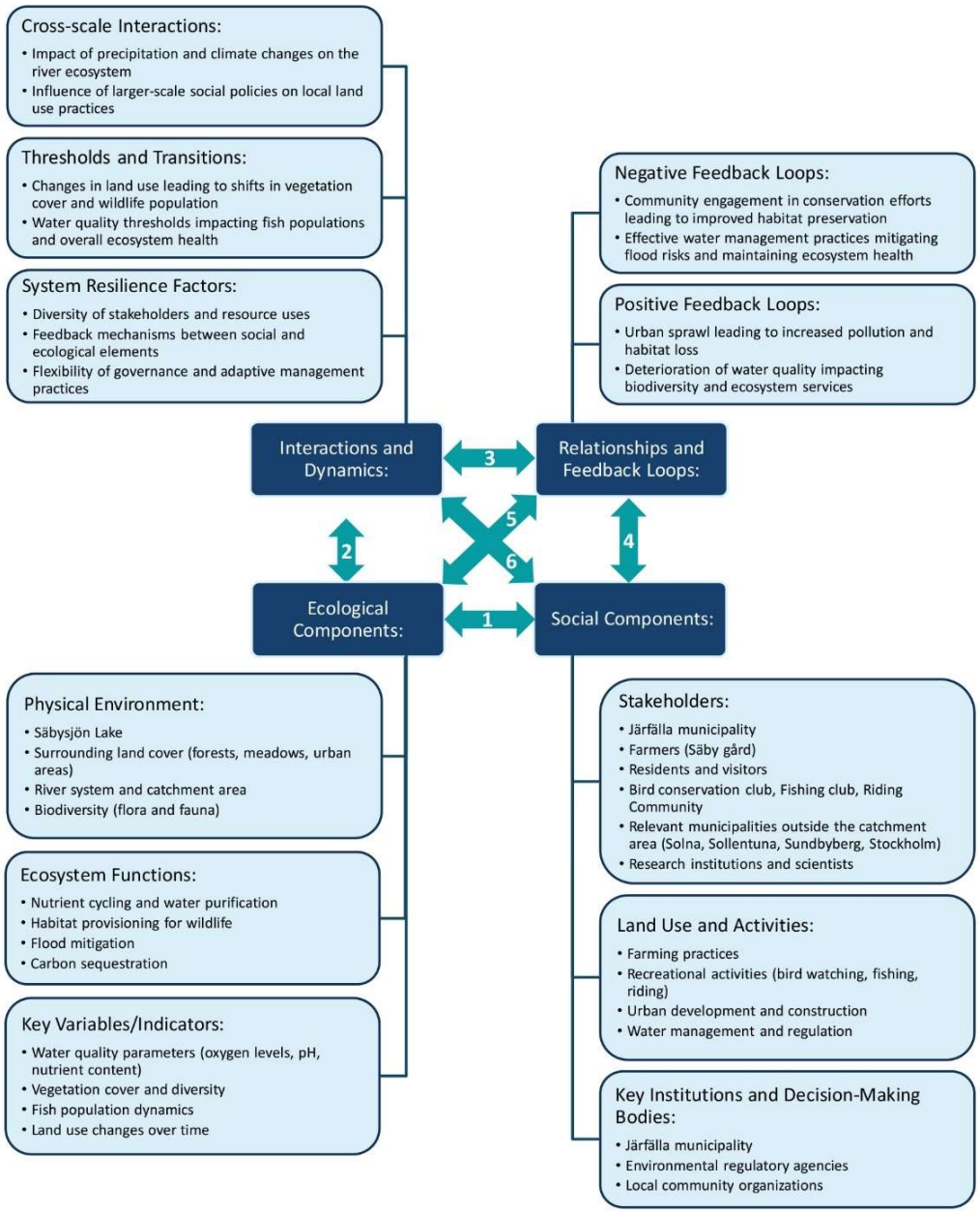


Fig. 10. Conceptual Model of the Säbysjön Social-Ecological System

This conceptual model represents the interconnectedness of various elements within the Säbysjön social-ecological system. It illustrates the relationships, dynamics, and potential thresholds that influence the resilience and sustainability of this system (Fig. 10).
Fig. 11 illustrates some connections between the different components of the conceptual model:

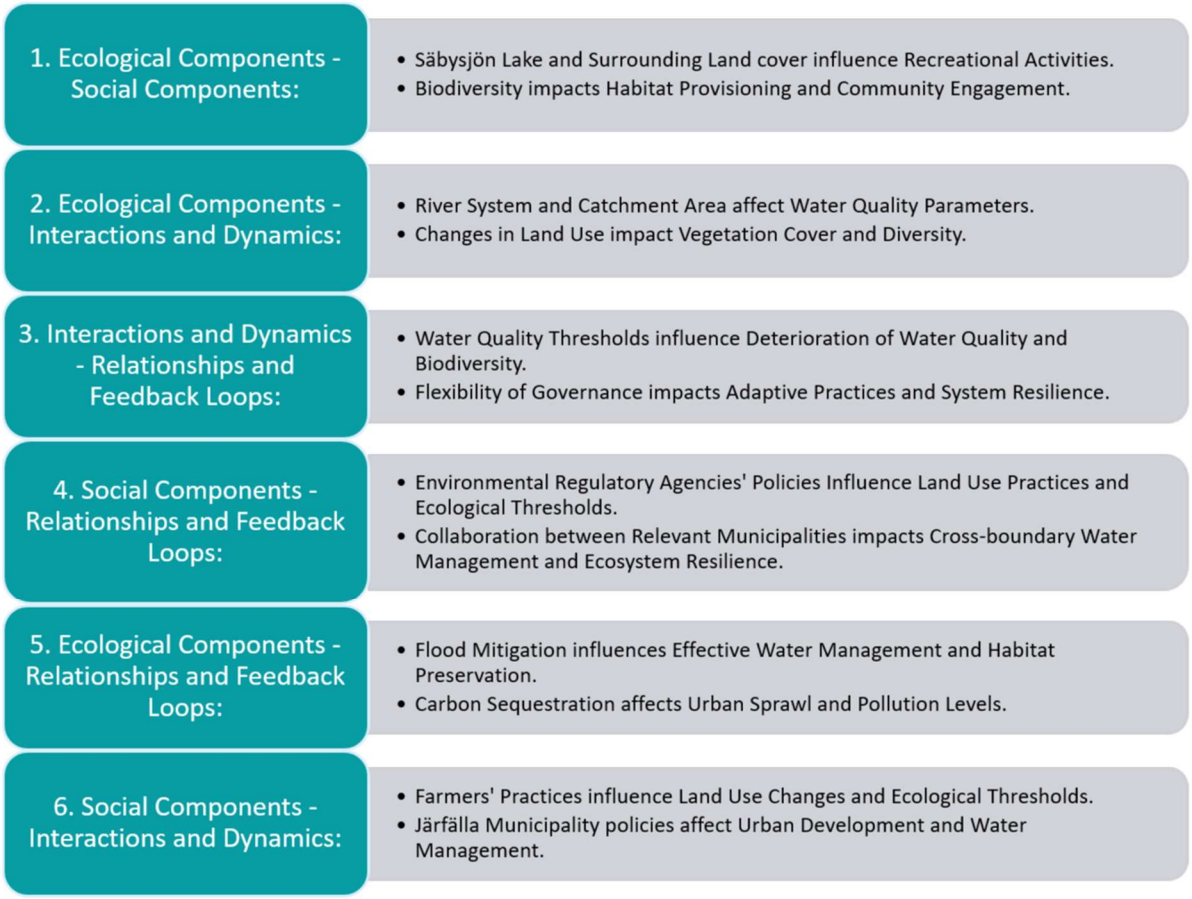


Fig. 11. Connections between components of the Säbysjön Social-Ecological System

4.5.2 Resilience-based Stewardship

In the Resilience-Based Stewardship section, we present a suite of six strategies aimed at bolstering the resilience of Säbysjön's GBI. These strategies, refined through comprehensive analysis and consultation, target critical aspects such as flood mitigation, biodiversity enhancement, and the creation of recreational opportunities within the socio-ecological system. By implementing these strategies, our goal is to instigate a transformative process that not only addresses immediate challenges but also nurtures long-term sustainability. These interventions are designed to leverage the inherent potential of Säbysjön, steering the ecosystem towards resilience amidst ever-evolving environmental dynamics (Fig. 12,13).

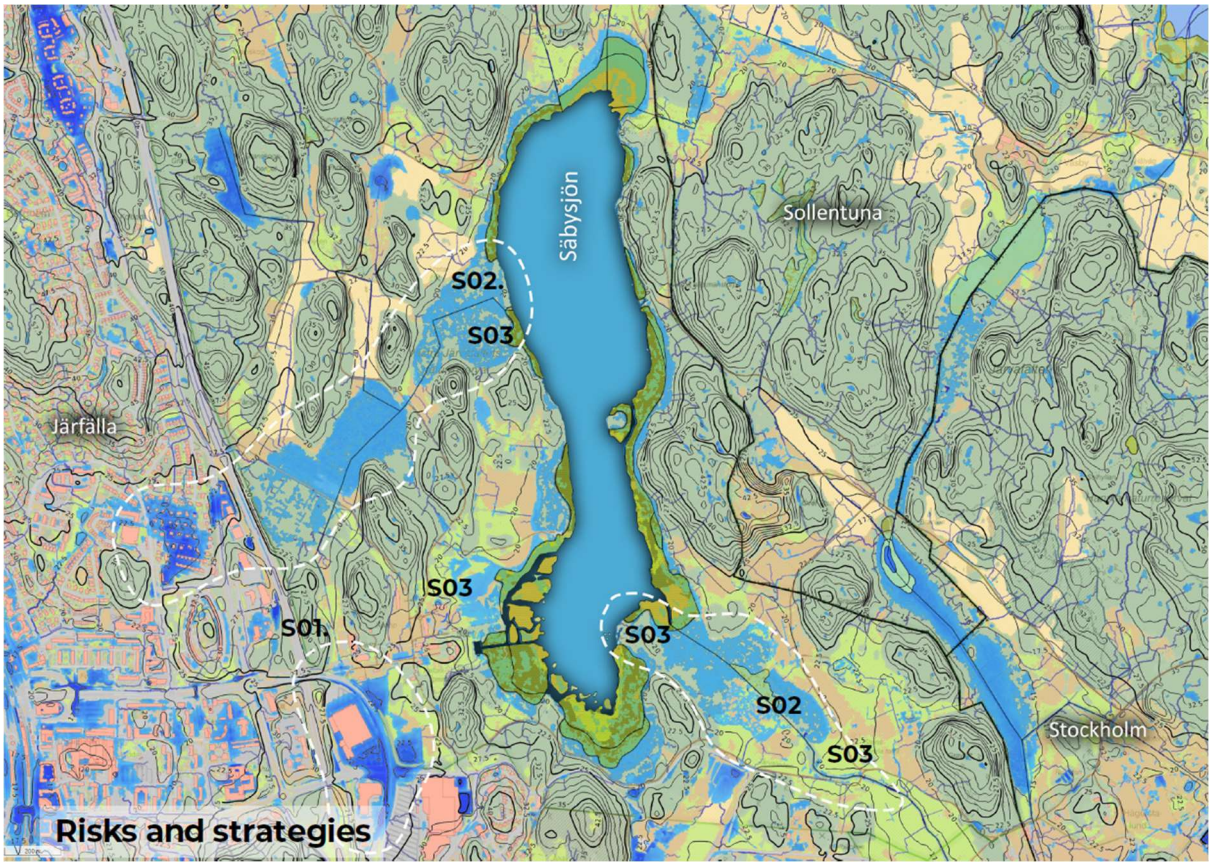


Fig 12. A map that shows a potential zone for more investigation about the strategies

Fig 13. Resilience-based Strategies

S01. Green Infrastructure Development:

Description:

Implementation of green infrastructure measures like constructed wetlands, bioswales, and retention ponds to manage stormwater runoff effectively and enhance biodiversity and recreational spaces.

Measures:

- Bioswales: Utilize vegetated channels along pathways to slow, filter, and infiltrate stormwater, reducing pollutant flow into the lake.
- Retention Ponds: Construct ponds to collect stormwater, allowing natural filtration and reducing the pressure on the drainage system.
- Proper Maintenance: Ensure regular upkeep to retain the effectiveness of green infrastructure.

Co-benefits and Impact:

These measures contribute significantly to flood mitigation, and biodiversity enhancement by providing habitats, and offering recreational spaces for the community, thereby improving social resilience.

S02. Riparian Restoration and Buffer Zones:

Description:

Establishing riparian buffer zones and restoring degraded areas to stabilize banks, prevent erosion, and foster biodiversity and recreational spaces.

Measures:

- Planting Native Vegetation: Introduce diverse native species along the shoreline and streams to support biodiversity and stabilize banks.
- Erosion Control: Implement measures to prevent further degradation and promote habitat recovery.
- Invasive Species Removal: Eliminate invasive species to restore the ecosystem's integrity.
- Keeping healthy meadow: prevent the overgrowth of the shoreline meadow by keeping animal grazing so that it can pool the water and save waterfowl habitats.

Co-benefits and Impact:

Riparian restoration aids in flood control, biodiversity conservation, and provides attractive recreational areas for the community, improving social cohesion and community resilience.

S03. Community-Based Monitoring Programs:

Description:

Engaging the local community in monitoring water quality and ecological health to encourage stewardship and maintain the lake's well-being.

Measures:

- Community Engagement Activities: Organize workshops and citizen science programs to educate and involve locals in monitoring efforts.
- Regular Data Collection: Establish standardized protocols for data collection on water quality indicators and ecological health, ensuring reliability.

Co-benefits and Impact:

Active community involvement facilitates early issue detection, and intervention, and fosters community well-being by increasing understanding and appreciation of the lake's value.

S04. Sustainable Land Use Practices:

Description:

Promoting sustainable agricultural and land management practices within the catchment area to reduce pollution and maintain ecological balance.

Measures:

- Education and Training: Provide training to farmers on sustainable farming practices to minimize soil erosion and chemical runoff.

- Implementation of Best Practices: Encourage the adoption of eco-friendly methods such as agroforestry and crop rotation to preserve soil quality and biodiversity.

Co-benefits and Impact:

Sustainable land use practices contribute to water quality improvement, biodiversity conservation, and long-term resilience by minimizing pollutants entering the lake.

S05. Educational Outreach and Interpretive Programs:

Description:

Conduct educational programs and interpretive activities to raise awareness about the lake's ecosystem and its importance among residents and visitors.

Measures:

- Educational Workshops: Organize workshops, seminars, and nature walks to educate locals and visitors about the lake's ecology and think together management plan using Säbysjön stakeholder map.
- Interactive Signage and Displays: Install informative boards or display at key locations around the lake to convey ecological significance.

Co-benefits and Impact:

Enhancing public knowledge and appreciation of the lake fosters greater support for conservation efforts and encourages responsible use, benefiting both biodiversity and social resilience.

S06. Ecotourism Development:

Description:

Promote sustainable ecotourism initiatives around the lake to offer recreational activities while fostering environmental awareness and conservation.

Measures:

- Developing Nature Trails: Create designated trails for hiking or bird watching, and grazing animal caring, ensuring minimal disturbance to wildlife habitats.
- Visitor Information Centres: Establish visitor centres offering educational resources and promoting responsible ecotourism practices.

Co-benefits and Impact:

Ecotourism encourages economic growth, provides recreational opportunities, and raises conservation awareness while contributing to the lake's resilience.

4.5.3 Strategies Prioritization and Implementation Plan

Prioritizing these strategies, outlining their action plans, identifying potential barriers, and building trust through community engagement and transparent communication are crucial steps toward successful implementation and achieving the resilience objectives for the Säbysjön social-ecological system. Adjustments and continuous evaluation based on stakeholder feedback will be essential for effective execution and long-term sustainability (Table 1).

Table 1. Strategies Prioritization and Implementation Plan

Strategy	Prioritization	Implementation Plan	Barriers	Trust-building Opportunities
S01. Green Infrastructure Development:	• Immediate Implementation: Start with the bioswales along pathways to address immediate stormwater runoff issues. • Phased Approach: Gradually progress to constructing retention ponds to manage larger water volumes.	• Conduct feasibility studies and site assessments • Collaborate with local authorities for necessary permissions. • Secure funding through grants or partnerships. • Engage with local communities for awareness and support.	• Regulatory approvals for land use and construction • Limited initial funding and resource constraints • Community resistance or lack of understanding about green infrastructure benefits.	• Community involvement in planning and decision-making • Transparent communication regarding project goals and benefits • Regular updates and engagement sessions with stakeholders.
S02. Riparian Restoration and Buffer Zones:	• Targeted Restoration: Start with critical areas prone to erosion or habitat loss. • Systematic Expansion: Gradually extend restoration efforts along the lake's edge and streams.	• Conduct ecological assessments to identify priority areas. • Engage local conservation groups for volunteer support. • Collaborate with environmental agencies for technical guidance. • Seek funding through grants or corporate sponsorships.	• Resistance from property owners or land use conflicts. • Availability of native plant species and restoration resources. • Regulatory restrictions on altering natural habitats.	• Community involvement in hands-on restoration activities. • Demonstrating positive ecological outcomes through monitoring. • Acknowledging and respecting local landowners' concerns and priorities.
S03. Community-Based Monitoring Programs:	• Community Engagement: Initiate workshops and awareness programs first. • Gradual Data Collection: Commence regular monitoring after educating locals about indicators.	• Develop educational materials and training modules. • Establish partnerships with educational institutions for expertise. • Create accessible platforms for data sharing and engagement. • Organize community events to celebrate monitoring milestones.	• Low community interest or participation in monitoring activities. • Lack of technical expertise among community members. • Data privacy concerns and skepticism about the program's impact.	• Providing continuous education and skill-building opportunities. • Recognizing and crediting community contributions in reports or publications. • Sharing transparent and understandable data interpretations with the community.
S04. Sustainable Land Use Practices:	• Education and Awareness: Begin with educational campaigns to promote sustainable practices. • Implementation of Pilot Projects: Launch pilot initiatives to showcase successful sustainable land management.	• Develop educational materials on sustainable farming practices. • Collaborate with agricultural extension services for farmer training. • Offer incentives or subsidies for adopting eco-friendly methods. • Create demonstration farms to showcase successful case studies.	• Resistance to traditional farming practices and lack of awareness. • Financial constraints in implementing new techniques or equipment. • Long-term commitment is required for behavior change.	• Providing comprehensive training and support for the transition. • Highlighting success stories and economic benefits of sustainable practices. • Establishing farmer networks for knowledge sharing and mutual support.
S05. Educational Outreach and Interpretive Programs:	• Education Campaigns: Launch informative campaigns in nearby communities. • On-site Interpretation: Install initial interpretive displays near key lake areas.	• Design educational materials and organize interactive workshops. • Collaborate with schools to integrate lake ecology into the curriculum. • Install informative signage at strategic points around the lake. • Host guided tours or nature walks to explain ecosystem dynamics.	• Limited funding for educational materials and installations. • Sustaining interest and participation in educational activities. • Resistance from visitors who may prefer passive recreational experiences.	• Engaging with local schools and community groups for input. • Regularly updating information displays based on community feedback. • Creating engaging and interactive content to captivate visitors' interest.
S06. Ecotourism Development:	• Infrastructure Development: Begin with planning designated nature trails and visitor centers. • Promotional Activities: Promote ecotourism initiatives to attract visitors.	• Design and map nature trails, ensuring minimal impact on habitats. • Establish visitor centers with interactive exhibits and information. • Collaborate with travel agencies for marketing and promotion. • Offer guided eco-tours focusing on the lake's ecology.	• Balancing tourism promotion with conservation efforts. • Ensuring responsible visitor behavior to protect fragile ecosystems. • Initial investments and operational costs for infrastructure and marketing.	• Engaging local businesses and tourism authorities for support. • Highlighting responsible ecotourism guidelines for visitors. • Involving local guides or experts in delivering informative tours.

5. Conclusion and Discussion

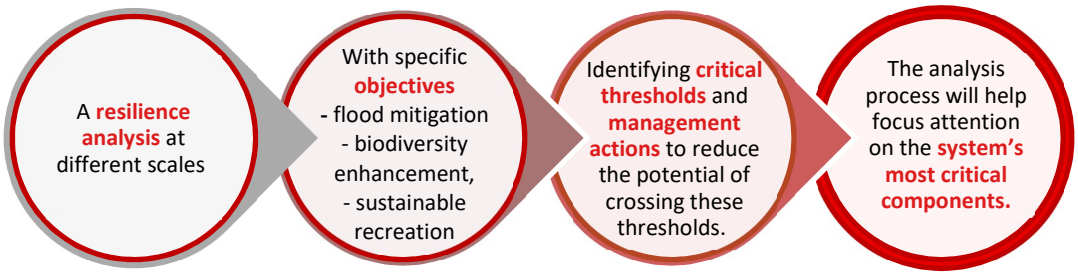


Fig 14. The aim, specific objectives, method, & final output

This research project embarked on a comprehensive journey, employing a resilient analysis methodology to delve into the social-ecological dynamics of the Säbysjön area. With the goal of unearthing strategies to enhance the resilience of this ecosystem against water-related challenges, our inquiry was guided by two research questions (Fig. 14). We set out to identify the contributing factors to Säbysjön's resilience, particularly its capacity for flood mitigation, biodiversity, and outdoor recreation, and to explore collaborative water management methods that forge a harmonized approach to these pressing issues.

Methodological rigor, coupled with a spectrum of data collection efforts, including literature reviews, GIS data analysis, and stakeholder engagement, facilitated understanding of the Säbysjön system. While data management proved to be a complex task, it underscored the necessity for iterative approaches and balance of both ecological and social perspectives in resilience analysis. Notably, a closer alliance with local entities, specifically the Järfälla municipality, emerged as a pivotal factor that could augment the depth and applicability of our findings, by weaving in updated geographic information and stakeholder perspectives.

Through our synthesis of analysis findings, we created a conceptual model that maps out the interconnectivity and dynamics within the Säbysjön social-ecological framework. This model served as a foundation for the development of six strategic interventions tailored to the unique environmental context of Säbysjön. These strategies were meticulously selected to counteract vulnerabilities and lead the system toward a resilient and sustainable future.

Executing these strategies will demand precise planning, stakeholder cooperation, and regular evaluations to ensure they remain aligned with the evolving needs of Säbysjön. The strategies range from green infrastructure deployment to educational outreach, each with a role in fostering systemic health.

In conclusion, the findings and strategies articulated in this project do not only respond to the research questions but also foreground the enduring relevance of adaptability and cross-scale collaborative governance in environmental management. The knowledge and analytical process gained herein acts as a crucial reference point for the ongoing journey towards resilience, not only for Säbysjön but other comparable ecosystems facing similar environmental dilemmas. Our discussion has revealed that, with the right interplay of cross-boundary community involvement and ecological stewardship, resilience becomes a

collaborative conquest, setting the stage for a sustainable conversation between human and nature.

6. References

AHN, C. & SCHMIDT, S. 2019. Designing wetlands as an essential infrastructural element for urban development in the era of climate change. *Sustainability,* 11**,** 1920.

ALLIANCE, R. 2010. Assessing resilience in social-ecological systems: Workbook for practitioners. Version 2.0.: Online: http://www.resalliance.org/3871.php.

ANSELL, C. & GASH, A. 2008. Collaborative governance in theory and practice. *Journal of public administration research and theory,* 18**,** 543-571.

BAVOR, H., DAVIES, C. & SAKADEVAN, K. 2001. Stormwater treatment: do constructed wetlands yield improved pollutant management performance over a detention pond system? *Water science and technology,* 44**,** 565-570.

BEALL KING, A. & THORNTON, M. 2016. Staying the course: Collaborative modeling to support adaptive and resilient water resource governance in the Inland Northwest. *Water,* 8**,** 232.

BERKES, F. 2000. Linking social and ecological systems. Cambridge University Press.

BERKES, F., COLDING, J. & FOLKE, C. 2008. *Navigating social-ecological systems: building resilience for complexity and change*, Cambridge university press.

BIGGS, R., SCHLÜTER, M. & SCHOON, M. L. 2015. Principles for building resilience: sustaining ecosystem services in social-ecological systems.

BORNHALL, I. K. 2007. Ålsta by. Järfälla municipality.

BROWN, R. R., KEATH, N. & WONG, T. H. 2009. Urban water management in cities: historical, current and future regimes. *Water science and technology,* 59**,** 847-855.

BROWNING-AIKEN, A., RICHTER, H., GOODRICH, D., STRAIN, B. & VARADY, R. 2004. Upper San Pedro Basin: fostering collaborative binational watershed management. *International Journal of Water Resources Development,* 20**,** 353-367.

BRUNDTLAND, G. H. 1985. World commission on environment and development. *Environmental policy and law,* 14**,** 26-30.

CARDOSO, M., BRITO, R., PEREIRA, C., DAVID, L. & ALMEIDA, M. 2020. Resilience Assessment Framework RAF—Description and Implementation. *Rescue project*.

COSENS, B. A. & WILLIAMS, M. K. 2012. Resilience and water governance: adaptive governance in the Columbia River basin. *Ecology and Society,* 17.

DAVIS, T. J., BLASCO, D. & CARBONELL, M. 1997. The Ramsar Convention manual: a guide to the Convention on wetlands (Ramsar, Iran, 1971).

DIRECTIVE, E. W. F. 2000. The EU Water Framework Directive—integrated river basin management for Europe. *Official Journal of the European Communities (OJ L 327) on,* 22.

FALKENMARK, M. 2003. Freshwater as shared between society and ecosystems: from divided approaches to integrated challenges. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences,* 358**,** 2037-2049.

FERREIRA, C. S., KAŠANIN-GRUBIN, M., SOLOMUN, M. K., SUSHKOVA, S., MINKINA, T., ZHAO, W. & KALANTARI, Z. 2023. Wetlands as nature-based solutions for water management in different environments. *Current Opinion in Environmental Science & Health***,** 100476.

FLETCHER, T. D., SHUSTER, W., HUNT, W. F., ASHLEY, R., BUTLER, D., ARTHUR, S., TROWSDALE, S., BARRAUD, S., SEMADENI-DAVIES, A. & BERTRAND-KRAJEWSKI, J.-L. 2015. SUDS, LID, BMPs, WSUD and more–The evolution and application of terminology surrounding urban drainage. *Urban water journal,* 12**,** 525-542.

FOLKE, C., CARPENTER, S., ELMQVIST, T., GUNDERSON, L., HOLLING, C. S. & WALKER, B. 2002. Resilience and sustainable development: building adaptive capacity in a world of transformations. *AMBIO: A journal of the human environment,* 31**,** 437-440.

FOLKE, C., HAHN, T., OLSSON, P. & NORBERG, J. 2005. Adaptive governance of social-ecological systems. *Annu. Rev. Environ. Resour.,* 30**,** 441-473.

GREENWAY, M. 2004. Constructed Wetlands for Water Pollution Control-Processes, Parameters and Performance. *Developments in Chemical Engineering and Mineral Processing,* 12**,** 491-504.

HÅKANSON, L. & BRYHN, A. C. 2008. *Eutrophication in the Baltic Sea: Present situation, nutrient transport processes, remedial strategies*, Springer Science & Business Media.

HOLLING, C. S. 1973. Resilience and stability of ecological systems. *Annual review of ecology and systematics,* 4**,** 1-23.

JÄRFÄLLA_KOMMUN 2014. Översiktsplan, Järfälla – nu till 2030. www.jarfalla.se.

JONSSON, A. C., ANDERSSON, L., ALKAN OLSSON, J. & JOHANSSON, M. 2011. Defining goals in participatory water management: merging local visions and expert judgements. *Journal of Environmental Planning and Management,* 54**,** 909-935.

JSFK. 2012. *Säbysjön* [Online]. Available: http://www.jsfk.se/index.php/fiskevatten/sabysjon [Accessed 2023-11].

KALANTARI, Z., SEIFOLLAHI, S., VON PLATEN, H. N., GUSTAFSSON, M., RAHMATI, O. & FERREIRA, C. S. S. 2021. Using landscape connectivity to identify suitable locations for nature-based solutions to reduce flood risk. *Nature-Based Solutions for Flood Mitigation: Environmental and Socio-Economic Aspects.* Springer.

LÄNSSTYRELSEN. 2023. *Västra Järvafältet* [Online]. Available: https://www.lansstyrelsen.se/stockholm/besoksmal/naturreservat/vastra-jarvafaltet.html [Accessed 2023-12].

LEE, H., CALVIN, K., DASGUPTA, D., KRINNER, G., MUKHERJI, A., THORNE, P., TRISOS, C., ROMERO, J., ALDUNCE, P. & BARRETT, K. 2023. Climate change 2023: synthesis report. Contribution of working groups I, II and III to the sixth assessment report of the intergovernmental panel on climate change.

MATTHEWS, T., LO, A. Y. & BYRNE, J. A. 2015. Reconceptualizing green infrastructure for climate change adaptation: Barriers to adoption and drivers for uptake by spatial planners. *Landscape and urban planning,* 138**,** 155-163.

MCGRANE, S. J. 2016. Impacts of urbanisation on hydrological and water quality dynamics, and urban water management: a review. *Hydrological Sciences Journal,* 61**,** 2295-2311.

NATURPÄRLOR, J. 2022. *The bird towers at Säbysjön* [Online]. Available: https://www.naturkartan.se/sv/stockholms-lan/fageltorn-sabysjon [Accessed 2023].

ÖSTERBLOM, H. & FOLKE, C. 2013. Emergence of global adaptive governance for stewardship of regional marine resources. *Ecology and Society,* 18.

OSTROM, E. 1990. *Governing the commons: The evolution of institutions for collective action*, Cambridge university press.

PAHL-WOSTL, C. 2009. A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Global environmental change,* 19**,** 354-365.

PAHL-WOSTL, C., KABAT, P. & MÖLTGEN, J. 2008. Adaptive and integrated water management. *Coping with Complexity and Uncertainty, Berlin und Heidelberg*.

PRUDENCIO, L. & NULL, S. E. 2018. Stormwater management and ecosystem services: A review. *Environmental Research Letters,* 13**,** 033002.

RASTANDEH, A., BROWN, D. K. & PEDERSEN ZARI, M. 2017. Biodiversity conservation in urban environments: A review on the importance of spatial patterning of landscapes. *Proceedings of the Ecocity World Summit, Melbourne, Australia***,** 12-14.

RICART, S. & KIRK, N. 2022. Hydrosocial research for better understanding, managing, and modeling human-nature interactions. *Frontiers in Water,* 4**,** 1025040.

SALIZZONI, E., PEREZ-CAMPANA, R., ALCALDE-RODRIGUEZ, F. & TALAVERA-GARCIA, R. 2020. Local planning practice towards resilience: Insights from the adaptive co-management and design of a mediterranean wetland. *Sustainability,* 12**,** 2900.

SVENSSON, L., TNEL, S., LÜCKE, J. & JUTTERSTRÖM, S. 2021. Igelbäcken – lokalt åtgärdsprogram,MHN/2021:36.

VYMAZAL, J. 2022. The historical development of constructed wetlands for wastewater treatment. *Land,* 11**,** 174.

WALKER, B., HOLLING, C. S., CARPENTER, S. R. & KINZIG, A. 2004. Resilience, adaptability and transformability in social–ecological systems. *Ecology and society,* 9.

WALKER, B. & SALT, D. 2012. *Resilience thinking: sustaining ecosystems and people in a changing world*, Island press.

WAYFINDER. 2023. https://wayfinder.earth/. [Accessed 2023].

WONG, T. H. & BROWN, R. R. 2009. The water sensitive city: principles for practice. *Water science and technology,* 60**,** 673-682.

ZIPPERER, W. C., NORTHROP, R. & ANDREU, M. 2020. Urban development and environmental degradation. *Oxford Research Encyclopedia of Environmental Science.*