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Translation and implementation of nature-based solutions in cities

Experimentation, learning and knowledge production

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Translation and implementation of nature-based solutions in cities

Experimentation, learning and knowledge production

BJÖRN WICKENBERG | IIIIEE | LUND UNIVERSITY



TRANSLATION AND IMPLEMENTATION OF
NATURE-BASED SOLUTIONS IN CITIES

Translation and implementation of nature-based solutions in cities

Experimentation, learning and knowledge production

Björn Wickenberg



LUND
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DOCTORAL DISSERTATION

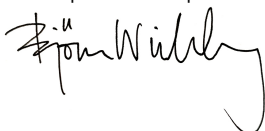
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Abstract As part of current efforts to work towards sustainable development, find solutions to curb greenhouse gas emissions, and adapt cities to the effects of climate change, such as floods and extreme heat, there are high hopes that nature-based solutions (NBS) can support the transformation needed. Based on the knowledge that implementation and governance of urban NBS is still emerging and constrained by various barriers, e.g., regulatory, institutional, political, financial and cognitive, it is important to improve the understanding of processes that can help overcome the barriers to NBS implementation. NBS is an umbrella policy concept for a range of green space governance approaches. It is derived from the policy sphere and, therefore, needs to be translated into scientific knowledge and practical knowledge. This thesis applies an inter- and transdisciplinary research approach, using qualitative methods to investigate how the NBS concept is translated in science and into local implementation in Swedish municipalities. Since research influences knowledge production and implementation in practice by framing and defining NBS, this thesis also seeks to investigate how research interprets and uses the concept, as well as how it addresses implementation. With a dual focus on research and practice, the aim of this thesis is to study in what ways the processes of experimentation, learning, and knowledge production enable and/or constrain the translation and implementation of NBS. NBS is an emerging concept and still subject to definitional efforts on the boundaries between scientific disciplines and science/policy. Most studies on NBS focus on environmental benefits, in spite of a need to consider all dimensions of sustainability, including issues of justice. So far, few NBS frameworks explicitly address implementation. In those that do, stakeholder collaboration and co-production of knowledge are key elements of NBS implementation, which could be further considered in both formal planning and experimentation. Here, targeted strategies towards collaboration and transformative learning can help overcome barriers to implementation and mainstreaming of NBS. However, this requires reflexive governance and cross-boundary interaction among stakeholders, including action-oriented knowledge production and strategic citizen involvement. Thus, it is important to build trust and foster inclusive communication, which warrants increased focus on relational/emotional capacities. Transformative learning requires supportive institutional structures and resources that safeguard the continuity and evaluation of NBS implementation processes and associated learning. Transdisciplinary and collaborative platforms for experimentation, which include both research and practice, have the potential to stimulate and support further learning and knowledge to build transformative capacity and advance NBS implementation, and ultimately, sustainability, in cities.		
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Experimentation, learning and knowledge production

Björn Wickenberg



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MADE IN SWEDEN 

*To Anna,
Astrid, Melker,
and my parents*

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for academic writing that I have appreciated a lot. I would also like to acknowledge the efforts of Naoko and Yuliya, in your capacities as PhD program directors, for ensuring a structured yet flexible framework for PhD studies at the IIIIEE.

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Björn

Lund, April 2022

Abstract

As part of current efforts to work towards sustainable development, find solutions to curb greenhouse gas emissions, and adapt cities to the effects of climate change, such as floods and extreme heat, there are high hopes that nature-based solutions (NBS) can support the transformation needed. Based on the knowledge that implementation and governance of urban NBS is still emerging and constrained by various barriers, e.g., regulatory, institutional, political, financial and cognitive, it is important to improve the understanding of processes that can help overcome the barriers to NBS implementation. NBS is an umbrella policy concept for a range of green space governance approaches. It is derived from the policy sphere and therefore needs to be translated into scientific knowledge and practical knowledge. This thesis applies an inter- and transdisciplinary research approach, using qualitative methods to investigate how the NBS concept is translated in science and into local implementation in Swedish municipalities. Since research influences knowledge production and implementation in practice by framing and defining NBS, this thesis also seeks to investigate how research interprets and uses the concept, as well as how it addresses implementation. With a dual focus on research and practice, the aim of this thesis is to study in what ways the processes of experimentation, learning, and knowledge production enable and/or constrain the translation and implementation of NBS.

NBS is an emerging concept and still subject to definitional efforts on the boundaries between scientific disciplines and science/policy. Most studies on NBS focus on environmental benefits, in spite of a need to consider all dimensions of sustainability, including issues of justice. So far, few NBS frameworks explicitly address implementation. In those that do, stakeholder collaboration and co-production of knowledge are key elements of NBS implementation, which could be further considered in both formal planning and experimentation. Here, targeted strategies towards collaboration and transformative learning can help overcome barriers to implementation and mainstreaming of NBS. However, this requires reflexive governance and cross-boundary interaction among stakeholders, including action-oriented knowledge production and strategic citizen involvement. Thus, it is important to build trust and foster inclusive communication, which warrants increased focus on relational/emotional capacities. Transformative learning requires supportive institutional structures and resources that safeguard the continuity and evaluation of NBS implementation processes and associated learning.

Transdisciplinary and collaborative platforms for experimentation, which include both research and practice, have the potential to stimulate and support further learning and knowledge to build transformative capacity, and advance NBS implementation, and ultimately, sustainability, in cities.

Popular science summary

As a consequence of industrialization and ever-increasing amounts of greenhouse gas emissions released into the atmosphere, global temperatures are rising and causing climate disasters of severe consequences. Wildfires, extreme rains, and rising sea levels are frequently part of everyday life and newspaper headlines and come with high societal costs. Severe flooding has increased during the last decade, and as these words are being written, large parts of Brisbane, Australia, are under water, causing damage to infrastructure and forcing people from their homes. At the same time, the city of Durban, South Africa, has been severely affected by the heaviest rains in over 60 years.

The current environmental and climatic crisis, therefore, urges a transformation of how cities are planned and governed. Cities must adapt and become more resilient to a changing climate. In that endeavor, we need new ideas and approaches for sustainable urban development, which acknowledge planetary boundaries and nature as foundations for civilization. Nature-based solutions (NBS) have the potential to contribute in this direction, but as with any other ideas on sustainable development, it needs to be “translated” into concrete actions.

NBS include blue and green infrastructure, such as trees, urban parks, green roofs, and storm water dams, which can help slow and store water during days of heavy rain, as well as cool temperatures on days of extreme heat. When implemented, NBS can bring multiple benefits; for example, healthier ecosystems, increased biodiversity and human well-being. Many cities have started using NBS, but urban planning is complex and home to challenging goal conflicts that need to be addressed. There are thus many barriers which hamper wider adoption and implementation of NBS. These relate to, for example, knowledge, governance, planning regulations and financial barriers.

As a policy umbrella concept for blue and green infrastructure, NBS has gained significant interest. Researchers from different disciplines are increasingly engaging with the concept to gather evidence on the impacts of NBS, as well as exploring how aspects of innovation, financing and governance can help in scaling up these solutions in cities. But knowledge is still lacking in many areas. In relation to the implementation of NBS, there is a lack of action-oriented knowledge, meaning there is a need to develop knowledge that can be used to support and guide the planning and implementation of NBS.

Acknowledging that NBS can potentially make an important contribution to urban transformation and sustainability, this thesis considers it relevant to improve knowledge about the ways in which the adoption and implementation of NBS can be enabled, and what this requires in terms of new planning and governance approaches. The thesis takes the perspective that successful NBS implementation requires a) translation of the NBS concept into concrete planning actions, and b) capacity to change current norms and practices. More specifically, it seeks to understand in what ways the processes of experimentation, learning, and knowledge production can help build transformative capacity for urban nature-based transformations.

This thesis has been part of three research projects with an interest in how NBS can advance the integration of nature in cities. These involved both researchers and practitioners and ranged from the local context in Sweden to the European level. The Naturvation project involved a database of 1,000 NBS and 18 in-depth case studies in Europe. The Urban Nature project focused on NBS in Sweden, and in particular, the implementation of NBS in Malmö. The City-to-City Learning Lab connected participating municipalities (Eslöv, Höganäs, Kristianstad, Lomma, and Malmö) to work in close cooperation with researchers to understand the barriers to scaling up NBS.

The thesis used qualitative methods for collecting and analyzing data, for example literature reviews, interviews, workshops and study visits. First, it investigated how research interprets and uses the NBS concept, and more specifically, how science addresses and understands NBS implementation. Second, it studied how municipalities experiment with NBS implementation and the constraints and enablers encountered in such processes, with a focus on collaborative experimentation and learning. Third, it provided insights on a case of research-practice collaboration and the challenges and opportunities of transdisciplinary (TD) co-production of knowledge.

The cases of NBS implementation investigated in this thesis point towards the importance of committed individual champions and the strength of collaboration, action and learning to achieve stepwise changes regarding the way cities are planned and developed. Even though, or perhaps just because, it is highly complex and challenging to transform our cities, the idea of testing new solutions and learning from that process to create new insights and knowledge, provides a viable way forward to integrate and scale up NBS. For successful collaboration to implement NBS, it is therefore important to focus on establishing good relations, building trust and engaging in communicative and inclusive approaches.

This thesis has helped shed light on NBS as a comprehensive approach that “mandates”, or pushes forward, cross-boundary and collaborative approaches in research and practice related to urban transformations. The advantage of TD approaches is that these focus on interaction and learning and can bridge different

stakeholders and their knowledge across institutional boundaries and divides, e.g., across project-process, experimentation-formal planning, and science-practice, which is needed to overcome implementation and knowledge gaps related to NBS, and, more broadly, for solving societal challenges.

Thus, the cross-boundary, collaborative, and bridging capacity of TD approaches required for NBS translation and implementation seem to provide keys to unfold the transformative potential of NBS. In other words, the cross-boundary and collaborative qualities of experimentation, learning and knowledge production can generate important learning effects and actionable knowledge for nature-based urban transformations.

List of papers

Paper I

Hanson, H. I., Wickenberg, B., & Olsson, J. A. (2020). Working on the boundaries—How do science use and interpret the nature-based solutions concept?. *Land Use Policy*, 90, 104302.

HH and JAO conceptualized the study. HH, BW and JAO reviewed and analyzed 112 journal articles following a jointly developed analytical framework. HH & JAO were the main responsible for data analysis and article writing with input from BW. All authors reviewed and approved the final version of the manuscript.

Paper II

Wickenberg, B., McCormick, K., & Olsson, J. A. (2021). Advancing the implementation of nature-based solutions in cities: A review of frameworks. *Environmental Science & Policy*, 125, 44-53.

BW conceptualized the study, wrote the manuscript and designed the illustrations. JAO contributed to the method section and KMC contributed to the discussion section. JAO and KMC reviewed earlier drafts of the manuscript and provided supervision. All authors reviewed the final manuscript.

Paper III

Wamsler, C., Wickenberg, B., Hanson, H., Olsson, J. A., Stålhammar, S., Björn, H., Falck, H., Gerell, D., Oskarsson, T., Simonsson, E., Torffvit, F., & Zelmerlöv, F. (2020). Environmental and climate policy integration: Targeted strategies for overcoming barriers to nature-based solutions and climate change adaptation. *Journal of Cleaner Production*, 247, 119154.

The article is based on a collaborative and transdisciplinary research method, which involved all authors in all research steps. CW led the framing and conceptualization of the article and was the main responsible for data analysis and article writing. BW, HH and JAO were the major contributors for finalizing the manuscript. BW and SS were responsible for systematizing the data from the joint workshops. All authors reviewed and approved the final version of the manuscript.

Paper IV

Wickenberg, B., Kiss, B., McCormick, K., and Palgan, Y.V. (2022). Seeds of transformative learning: Investigating past experiences from implementing nature-based solutions. *Frontiers in Sustainable Cities*, 4:835511.

BW was the main responsible for reviewing the literature, writing the article and designing the illustrations. All authors collaboratively contributed to the conceptualization of the study. BK was the main responsible for collecting the data. BK and BW systematized the data and structured the analysis. BK, YVP and KMC reviewed and edited earlier drafts of the manuscript. KMC provided supervision. All authors reviewed the final manuscript.

Paper V

Wickenberg, B. Collaborating for nature-based solutions: Bringing research and practice together. *Environmental Policy* (submitted).

BW was responsible for conceptualization, methodology, data collection and analysis, writing the manuscript, and revision of the article.

Other publications

Kiss, B., Dorst, H., Raven, R., van der Jagt, A., McCormick, K., Wickenberg, B., & Bulkeley, H. Greening infrastructures through urban experimentation: Exploring the politics of nature-based solutions. *Journal of Cleaner Production* (forthcoming).

Basta, C., Kunseler, E., Wamsler, C., van der Jagt, A., Baro, F., Balenciaga, I., ... & Wickenberg, B. (2021). Inclusiveness, Equity, Consistency, and Flexibility as Guiding Criteria for Enabling Transdisciplinary Collaboration: Lessons From a European Project on Nature-Based Solutions and Urban Innovation. *Frontiers in Climate*, 3, 630075. <https://doi.org/10.3389/fclim.2021.630075>

Kiss, B., Wickenberg, B., & McCormick, K. (2021). Urban neighborhoods—the locus of change. What can we learn from the transition story of Augustenborg?. In Persson, B. & Månsson, M. (eds.) *The Eco-city Augustenborg-experiences and lessons learned* (pp. 274-283). Arkus.

Wickenberg, B. (2021). ”Slow down and embrace nature – how to create better cities when the pandemic is over”, in *The Conversation*. Published online April 16, 2021. Available at: <https://theconversation.com/slow-down-and-embrace-nature-how-to-create-better-cities-when-the-pandemic-is-over-155818>

Bush, J., McCormick, K., Oke, C., Kiss, B., Voytenko Palgan, Y. & Wickenberg, B. (2018). Urban forest horizon scanning. Report of the workshop in Lund, Sweden for the Clean Air and Urban Landscapes Hub.

Palm, J., Richter, J. L., Curtis, S., Wickenberg, B., & Schoonover, H. (2018). Article Incubator: building interdisciplinary academic writing skills amongst PhD students. LTHs 10:e Pedagogiska Inspirationskonferens Proceedings.

Preface

This thesis has been written at the International Institute for Industrial Environmental Economics (IIIEE), a research and education institute at Lund University that aims to accelerate the transitions to climate neutral and resource-efficient economies and advance sustainable solutions through inter- and transdisciplinary research and close cooperation with societal stakeholders.

The research has been part of three research projects during the period 2017-2021. First, the project Urban Nature (funded through FORMAS) studied the everyday practice in organizations involved in the implementation of NBS to assess barriers and opportunities in different cultural and socio-economic contexts, mainly focusing on the Swedish context. The project involved researchers from CEC and IIIEE at LU, and various public sector organization representatives in the reference group.

Second, the Naturvation project (funded through Horizon2020) sought to develop an understanding of what NBS can achieve in cities, examine how innovation can be fostered in this domain, and contribute to realizing the potential of NBS for responding to urban sustainability challenges by working with communities and stakeholders. The project involved 14 institutions across Europe in the fields of urban development, geography, innovation studies and economics, including six cities (Barcelona, Győr, Leipzig, Malmö, Newcastle, and Utrecht), which were all convening urban-regional innovation partnerships (URIPs) and which included further local/regional partners and sought to provide local insights on working with NBS.

Lastly, the City-to-City Learning Lab (funded through Mistra Urban Futures) established a learning lab that allowed the participating municipalities (Eslöv, Höganäs, Kristianstad, Lomma, and Malmö) to work in close cooperation with researchers from Lund University (LUCSUS, IIIEE, CEC) for systematic learning from the integration of NBS in urban planning practice, with a focus on stakeholder involvement and governance mechanisms. The project was connected to Mistra Urban Futures Skåne Local Interaction Platform (SKLIP). All the projects have applied inter- and transdisciplinary approaches and shared an interest in understanding how cities can adopt and implement NBS and the enabling and constraining factors associated with such processes.

Prologue

Throughout the last year working from home and coping with the pandemic, I have gone for numerous morning, lunch and evening walks around my neighborhood in the Eastern parts of Lund, Sweden. The area where I live, has three water dams for storing storm water in the event of extreme rains. These help to slow the water instead of overburdening the city's underground water sewage system, which would increase the risk of flooding.

At one of these storm water dams, I first made friends with a beautiful and majestic heron. I've always found big birds impressive. Like other birds in the dam, the heron seems to have found its home here, moving between the three dams depending on the agenda and time of the day.

I once saw the heron catching a fish, like a better version of one of these TV shows about nature, typically portrayed in slow motion and with a deep male voice telling the mysterious ways and wonders of nature, as something distant and disconnected from the human world. Yet, this vivid image of the heron with the fish has stuck with me. Maybe because I observed it, me being bodily present there and then.

Now I'm back at work/home, writing this urban nature experience of mine and reflecting. Had I been an ornithologist, I would likely ascribe meaning to it in a much different way, making use of prior knowledge and a completely different terminological apparatus. Makes me wonder if ornithologists base their knowledge on "pure observations" of the world (birds) based on a positivist ontology. Or, are they more like ethnographers, where the interest in other humans and cultures is but exchanged for that of studying birds, trying to understand what makes them thrive in this world, perhaps even their lives legitimate in their own right?

I often find myself returning back to the image of the fish-catching heron and pondering on the fact that this bird and I depend on the same ecosystem. The heron for habitat and food, I for recreational purposes (like my pandemic-induced walks) and being saved from flooding. These dams were built to store water but they aren't just a water management solution. When it's cold, they freeze over and provide ice-skating facilities during the winter days. And as well as looking visually striking they also provide ecosystems and habitat for animals and wildlife to thrive in.

*We are so separate, the heron and I, and yet connected.*¹

Those reflecting words are inspired by ethnographic writing, which in Narayan's (2012) own writing captures techniques and practices for learning about others through your 'self', and perhaps we should add, learning about yourself through 'the other'. Writing itself is the crafting of material, ideas, and advancing understanding and knowledge; using writing as a form of inquiry and learning. In short, writing as epistemology.

There are similarities between ethnographic writing and writing slow ontology (Ulmer, 2017), and the idea of how writing our local landscapes and bodily reflecting on nature and urban landscapes as part of our writing, can help us engage with place-based and deep reflection about nature and ontology (Tooth & Renshaw, 2009). One example is weather writing to capture the "in-between nature and culture" and the "in-between biology and philosophy" (Neimanis, 2014). Slowness offers an embodied ontological approach, which could be applied to integrate everyday observations into our writing, learning and conveying of ideas (Neimanis, 2014; Ulmer, 2017).

Weather writing provides a practical way to explore the 'world of being'; a world in which nature and culture cannot be ontologically separated. From this viewpoint, nature-based solutions, the phenomenon explored in this thesis, becomes a planning concept and approach that recognizes and materializes the inseparable nature-culture linkages that are key for climate change adaptation, urban resilience and sustainability.

Adopting and implementing nature-based solutions is, in a sense, a way of going back to basics, or perhaps even better, "forward to basics" (Jönsson & Wickenberg, 1992)², to paraphrase a series of educational TV programs about the environment in the early 1990s in Sweden. The current environmental and climatic crisis urges a transformation of how cities are planned and governed, and in that endeavor, we need new ideas and approaches to move forward to basics and acknowledge nature's limits to growth and to stay in line with the planet's own earth-supporting systems. Nature-based solutions have potential to contribute to societal transformations in that direction.

¹ Text in italic is based on Wickenberg, B. (2021) "Slow down and embrace nature – how to create better cities when the pandemic is over", in *The Conversation*. Published online April 16, 2021. Available at: <https://theconversation.com/slow-down-and-embrace-nature-how-to-create-better-cities-when-the-pandemic-is-over-155818>

² The title of the English version of the book was *Forward to Basics*, which also gave name to the six TV programs broadcasted in 1992.

1 Introduction

Leaving one epoch and entering a new is always cumbersome and comes with many challenges. For 10,000 years we have lived in the Holocene, with a relatively stable climate. However, in parallel to industrialization and ever-increasing amounts of carbon dioxide and methane released into the atmosphere, global temperatures are rising and causing a greenhouse effect, which results in a changing climate. Wildfires, extreme rains, a melting polar ice cap and rising sea levels are frequently part of everyday life and newspaper headlines and come with high societal costs.

We currently find ourselves in a new epoch, the Anthropocene, meaning that human activity is causing changes in the climate beyond natural variations. The first IPCC³ assessment report in 1990 stated that “emissions resulting from human activities are substantially increasing the concentration of ... carbon dioxide ... These increases will enhance the greenhouse effect, resulting on average in an additional warming of the Earth’s surface” (IPCC, 1990).

Since then, several assessment reports have been issued and in the latest report, the Sixth Assessment Report Summary for Policymakers (2021), it is stated that “recent changes in the climate are widespread, rapid, and intensifying” (IPCC, 2021). It further states that “it is unequivocal that human influence has warmed the atmosphere, ocean and land”, leading to extreme heat and heavy precipitation affecting every region on Earth, in several ways, most notably as pluvial flooding and wildfires, and these changes will increase with further warming.

The scientific and evidence-based message is clear and in the past decades research and practice have been busy learning how to advance sustainability and mitigate and adapt to climate change. For each decade since the first IPCC report, the world has seen an increasing interest in transformations for sustainability and how to change our lifestyles, innovate and implement solutions that keep us in line with the 1.5-degree Celsius target goal to limit global warming, which was established by the Paris Agreement in 2015. In parallel, fake news, climate change denial and undemocratic political ideas are also proliferating. Knowledge and education have never seemed more salient and necessary.

³ IPCC: The United Nations Intergovernmental Panel on Climate Change responsible for making global assessments of the scientific basis of climate change, its impacts and risks, as well as options for adaptation and mitigation, involving 195 member states of the United Nations.

There is no silver bullet to keeping within the target goal to limit global warming. The global community needs to advance on many fronts in parallel. Production and consumption patterns must change towards more sustainable levels and in line with the planet's own earth-supporting systems. Natural resources must be more wisely and efficiently used, re-used, repurposed and recycled, and more equitably distributed to benefit the well-being of humans. The value of nature and the services it provides to humans, non-humans and nature itself, need to take center-stage as we find new pathways forward in a changing climate.

The need to adapt consumption, production and lifestyle patterns in line with the limits of the Earth's ecosystems has been framed as a transition away from the current unsustainable global economy towards a nature-based economy (EC, 2021). This requires a higher demand for (and supply of) "nature-based" approaches and solutions, for which it is vital that both private and public sector organizations develop visions and policies that demand so, as well as engage in practices that can lead to increased knowledge and experience about nature-based transformations. Equally important is the broader support from and involvement of citizens and local communities (i.e., as consumers, "prosumers", purchasers, taxpayers, managers of green space, holders of knowledge and so forth).

A rapid urbanization on a global scale, meaning that more and more people live and work in cities, motivates a focus on how cities can become more sustainable and take the lead in the transitions that are fundamental to keep us in line with the global warming targets. This poses challenges to urban planning and governance, which need to integrate environmental and climate concerns as well as natural values into the thinking around what a city is (and can be), but also in more physical terms, into the actual built environment and the urban landscape. In other words, how can urban space be used to solve societal sustainability challenges and simultaneously enhance climate change mitigation and adaptation through integrating nature?

These opening paragraphs of this thesis link to my academic background in environmental science and my experience as an urban planning practitioner, and the will and need to learn more about how to solve urban sustainability challenges for the sake of the environment and human well-being of current and future generations, as postulated in the definition of sustainable development more than three decades ago (Brundtland, 1987). With a personal journey spanning from environmental science studies to over a decade of urban planning practice, with experiences from processes of local environmental governance, and now back to research, I have naturally developed an interest in how both research and practice can work towards sustainable urban development. Here, I see an overarching challenge in how to steer towards such a trajectory, i.e., in terms of governance approaches and implementing solutions which contribute to climate change mitigation and adaptation in the broader context of sustainable urban development.

I have also found inspiration in what Donald A. Schön (1984) describes as “the reflective practitioner” in his approach to an epistemology of practice; valuable knowledge can be sought in reflective practice, i.e., knowing and reflecting in action. The three research projects underpinning this thesis have departed from this perspective of research and practice in collaborative reflection to advance knowledge. Moreover, nature-based solutions (NBS), which this thesis studies, is more than just another “green” concept. It is solutions-focused and can be described in terms of a comprehensive and demanding approach for nature-based urban transformations, which is informed by and involves both practical knowledge, for example related to implementation and urban planning processes, and scientific knowledge, for example related to ecology, geography and urban planning and governance. The NBS concept thus goes beyond the principles of ecosystem services and biodiversity; it addresses the societal processes and barriers related to integration of nature in cities. In simple terms, it “mandates” a connection of natural and social sciences *and* practice. If NBS was a hit song, this is the hook.

Consequently, my background, “the reflective practitioner” as an inspiration, and the need to include both practical and scientific knowledge when working with NBS, have motivated the dual focus on research and practice in this thesis. I use NBS as a case to investigate how the translation and implementation of conceptual ideas on urban sustainability are enabled and/or constrained. I am specifically interested in how such processes of translation and implementation are influenced by experimentation, learning and knowledge production.

1.1 Urban challenges

During my time as an urban planning practitioner in Malmö, I experienced what, in retrospect, could be referred to as a “wake-up call”. On 31 August 2014, Arvid came to town. He was not a newborn baby boy; he was a storm that brought the heaviest rains in over 100 years in the history of Malmö (Sörensen & Emilson, 2019). With 120 mm of downpour in six hours, Arvid was considered a “360-years-rain”, meaning that the likelihood is once in 360 years. Even a 100-years rain would cause severe flooding, according to modelled scenarios in the cloudburst plan of the city of Malmö (Malmö municipality, 2017). The sewer systems are not dimensioned to handle these heavy rains, which warrants other alternative urban planning interventions (Hernebring et al, 2015). Arvid represents one of the many observed increases of pluvial (severe) flooding in Northern Europe (IPCC, 2021): extreme weather events as a consequence of climate change, with serious consequences and societal costs.

The flooding effects of the Arvid storm were distributed across the entire city of Malmö. However, in the city district of Söderkulla, where many houses were

severely affected by the flooding, families were not able to move back to their homes for over a year. Arvid thus served as a “wake-up call” for the city regarding flooding, climate adaptation and resilience, and pushed for the development of a cloudburst plan that established long-term targets to prepare the city for pluvial flooding (Malmö municipality, 2017). Interestingly, the two city districts of Augustenborg and Western Harbour (the Bo01 area) were not as severely flooded as a consequence of their open storm water systems and thus were better prepared to handle pluvial rains (Wickenberg et al, 2022).

Arvid is just one of abundant examples of how the climate crisis is hitting cities and humans/non-humans on a global scale. This highlights the lack of urban resilience and preparedness for extreme events, which calls for urban transformations towards sustainable development. In simplified and concrete terms, urban development and densification has led to an increasing share of hard, impermeable surfaces in cities at the expense of blue and green space (figure 1), which has made cities vulnerable to flooding events and urban heat waves. This has, and will continue to have, severe impacts on public health and human well-being, unless we can change the way we think about land-use and how to plan and build our cities.

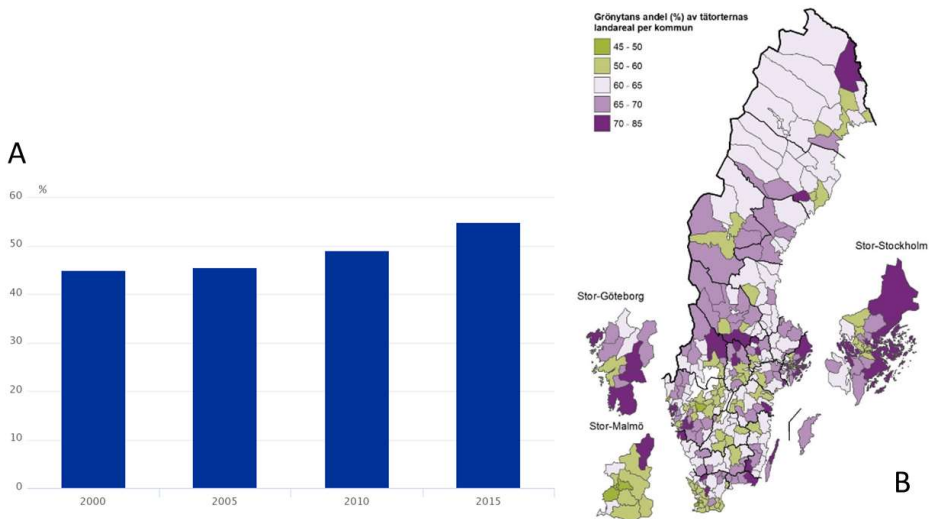


Figure 1: Increased share of hard surfaces in Malmö municipality (2000-2015) at the expense of total green space area. A (left side of the figure): the share of hard surface has increased from approx. 45% to 55% in Malmö between 2000 and 2015 (source: Malmö stads miljöbarometer). B (right side of the figure): the share of green space in Swedish municipalities in 2015, detailing the three major cities of Stockholm, Göteborg and Malmö. Malmö is comparatively poor in terms of share of green space (source: SCB, "Green spaces and green areas in urban centers 2015").

The study of how to solve climate-related challenges in urban contexts does not come without the mention of space. Urban space has for long been subject to struggles, conflicts and contestation related to access to and power over space.

Urban space is increasingly expensive, vested in interests, politicized and contested (Smith, 1996; Lund Hansen, 2006; Mitchell & Staeheli, 2006).

In the field of human and cultural geography, in trying to address the complex character of urban space, critical scholars highlight that urban space is the battlefield of continuous space wars, which is linked to the globalization of commercial property markets (Lund Hansen, 2006) and urban development influenced by neo-liberal political agendas and new urban imperialism (Smith, 1996). Public space takes center-stage when cities and neighborhoods are subject to regeneration, densification and gentrification. Mitchell & Staeheli (2006) describe the city as a “battleground”, where the interests of different stakeholders clash, and different types of contestations unfold as a consequence of the power imbalances involved.

Consequently, modern era wars on urban space, driven by large capital flows on a global-local scale, have resulted in transformation processes which impact citizens in their everyday urban life, not least with regards to the ratio between public and private land, the type of infrastructures our cities are made up of, and the extent to which we can access these, including how. Lund Hansen (2006) further argues that, in the context of urban morphology and processes of transformation, “material boundaries are central elements in space wars”, and “processes of material and social construction and transformation of urban space constitute urban space wars”.

During the last few decades, a new conflict has entered this “battleground”; the struggle between planning based on business-as-usual and transformative planning. Transformative planning adopts systems thinking (Wolfram et al, 2016) to handle the complexity of “wicked problems” (Rittel & Webber, 1973) and adapt our cities to climate change to make them more resilient.

Therefore, there is a need for alternative ideas on how to operationalize urban sustainability, in specific how to curb the current trend of non-resilient urban development, e.g., through adopting the approach of NBS, and work more actively towards the inclusion of blue and green infrastructure, ensure healthy ecosystems, safeguard biodiversity, and increase social cohesion to develop long-term resilience, which is tightly coupled to human well-being and socio-economic sustainability. This is where NBS potentially has something to offer and, consequently, why it is gaining increasing interest in both research and practice. However, from the perspective of sustainable urban development, the NBS concept itself is not really interesting unless it materializes into action. Hence, a core argument of this thesis is that implementation is conditional for the potential of NBS to unfold. Implementation, in turn, requires conceptual ideas around NBS to be translated into more actionable, operational knowledge.

Consequently, conceptual ideas for alternative urban futures, such as NBS, cannot be thought of in isolation, without considering the contested character of urban space and infrastructure, and the challenges associated with urban transformation, especially as regards how to build capacity for translating, integrating and

implementing new sustainability concepts in urban planning and governance. It is here that processes of experimentation and learning are particularly interesting in terms of building such transformative capacity.

In this regard, academic literature has identified specific knowledge gaps which need to be addressed. In the context of implementation of NBS, the most specific ones relate to a lack of action-oriented knowledge for NBS, i.e., the need to develop knowledge that can be used to guide the planning and implementation of NBS (Kabisch et al, 2016; Connop et al, 2016; Raymond et al, 2017; Giordano et al, 2020; Mendes et al, 2020), including in-depth understanding of NBS implementation as a process (Dushkova & Haase, 2020).

From a research perspective, it thus seems relevant to improve knowledge about what the implementation of NBS, as part of necessary but contested solutions towards urban transformation, requires in terms of new governance approaches and strategies to gain ground and become mainstream in cities. This thesis sets out to contribute knowledge in this field. It takes the perspective that successful NBS implementation requires capacity to change current norms and practices (Wolfram, 2016). More specifically, it seeks to understand in what ways processes of experimentation, learning, and knowledge production can help build such transformative capacity for urban nature-based transformations.

1.2 Nature-based solutions

It is in this context of climate change, contested space and a need for urban transformations, that the policy concept of NBS is being promoted as an approach towards planning and urban infrastructure development to better prepare our cities for present and future societal challenges, while simultaneously generating multiple benefits (social, economic, environmental) (EC, 2015; Nesshöver et al, 2017). NBS include green and blue infrastructure, such as trees, green roofs, parks and semi-natural areas, vertical green, community gardens, bioswales and open stormwater systems, and urban forests (Bulkeley & Raven, 2017), which replace or complement grey infrastructure to better capture and store storm water, slow water flows and avoid flooding, but also to provide shadow and protect against urban heat islands. Simultaneously, they could enhance biodiversity, provide habitat for animals, and help improve public health and human well-being (Xie & Bulkeley, 2020). As such, NBS can be viewed as a promising approach with potential to contribute to wider urban transformations and sustainable urban development (van der Jagt et al, 2020).

NBS is an emerging concept (Nesshöver et al, 2017; Dorst et al, 2019) that originates from the policy fields of biodiversity, ecosystem services and nature conservation (Dorst et al, 2019). It is currently being guided and promoted by

various influential policy and research bodies at the international and European level (Davies et al, 2021; Frantzeskaki, 2019; Hanson et al, 2020).

In general terms, NBS are understood as solutions that use the natural properties of ecosystems to limit impacts of climate change, enhance biodiversity and improve environmental quality, while contributing to economic activities and social well-being (EC, 2015; IUCN, 2012). More specifically, the European Commission defines NBS as actions – or living solutions – “inspired by, supported by, or copied from nature”, delivering multiple benefits and strengthening community cohesion (EC, 2015, p.4).

The following table lists some of the key characteristics of the two most cited (Hanson et al, 2020) definitions of NBS (table 1).

Table 1: Key characteristics of the two most used definitions of NBS.

Publication	Key characteristics and rationale of the NBS definition(s)
European commission (2015)	<ul style="list-style-type: none"> Actions – or living solutions - inspired by, supported by, or copied from nature, delivering multiple benefits and strengthening community cohesion Cost-efficient, novel solutions to spur innovation, business opportunities and economic growth Use nature to turn environmental, social and economic challenges into innovation opportunities Stimulate economic growth as well as improving the environment and human well-being Enhancing sustainable urbanization Restoration of degraded ecosystems to secure ecosystem services Develop climate change adaptation and mitigation Improve risk management and resilience
International Union for Conservation of Nature (2012)	<ul style="list-style-type: none"> Interventions that respond to global challenges Cost effective solutions using nature Healthy, restored and well managed ecosystems forms the basis for NBS Sustainable management and conservation of nature Biodiversity benefits Respect communities’ rights over natural resources Can rely on both public and private funding sources

NBS are being promoted as alternative (Eggermont et al, 2015) and complementary (Keesstra et al, 2018) solutions to conventional “grey” technology and infrastructure, as well as “hybrid” blue-green-grey solutions (Cohen-Shacham et al, 2019; van der Jagt et al, 2020). The concept itself, including the terms ‘nature-based’ and ‘solutions’, is signaling two important characteristics of the concept. For a solution to count as an NBS, it should meet the criteria of challenge-orientation (i.e., a desire to provide solutions to societal challenges) and ecosystem process utilization (i.e., the foreseen solutions are based on using ecosystem services) (Albert et al, 2019).

As a broad umbrella policy concept for blue and green infrastructure (Dorst et al, 2019), NBS offer an alternative approach to create greener, more biodiverse and climate adaptive cities while simultaneously generating multiple socio-economic

and environmental benefits and thereby addressing several Sustainable Development Goals (Martín et al, 2020; UN, 2015), in particular goal number 11 on Sustainable cities and communities (Suedel & Oen, 2021). As such, it is a socially relevant concept gaining traction in research and practice.

It is worth noticing that the NBS concept has been described in terms of a boundary concept, which may be more accessible for actors less familiar with ecological and nature-based thinking (Dorst et al, 2019; O’Sullivan et al, 2020). Recent academic work has focused on various concepts promoting sustainable development as boundary objects (Abson et al, 2014; Opdam et al, 2015; Schleyer et al, 2017). Similarly, the term ‘boundary concepts’ has been used to explain sustainability concepts and their ability to make sense to actors across different disciplines and/or sectors (Opdam et al, 2015; Schleyer et al, 2017). A boundary object is a “loose” concept (Allen, 2009:35), includes a set of core ideas, yet leaves room for interpretative flexibility (Jacobs, 1999; Star, 2010); it can support processes of reflection and translation of knowledge between different communities of practice, for example in contexts of collaborative learning (Akkerman & Baker, 2011). Hence, NBS can be seen as a boundary concept with potential to bridge stakeholders and knowledge across disciplinary and sectoral boundaries (De Vreese et al, 2016).

Thus, while NBS is often referred to as a concept, even in the context of this thesis, it should be seen as more than just a concept, understood as a theoretical idea. It can also be described in terms of a comprehensive and demanding approach, reflecting the complexity of planning, designing, implementing, maintaining, and governing sustainability. It includes a variety of solutions (applicable across scales and land use contexts), requires integration in urban planning processes, new and innovative business models, and application of participatory governance involving various stakeholders at different levels. As such, it represents a holistic approach, addressing the why, what, who and how for achieving sustainability through integrating nature in cities. Consequently, it is an approach that implicitly “mandates” transdisciplinary approaches (Nesshöver et al, 2017) in order to be fully operationalized in both research and practice. However, the approach is still lacking clarity in many respects, which is why further development of the concept/approach in and by research and practice is required.

NBS are currently being experimented with on a global scale, especially in urban contexts (Martin et al, 2021; Short et al, 2019; van der Jagt et al, 2019; Raymond et al, 2017; Connop et al, 2016). However, NBS are far from mainstream, and they are not yet adopted and integrated in policy, planning and governance (Connop et al, 2016; Kabisch et al, 2016; Pauleit et al, 2017; Bush & Doyon, 2019). There are many barriers to implementing NBS. In general, the main challenges for NBS and other related concepts (e.g., green infrastructure, ecosystem services, ecosystem-based adaptation) relate to understanding (cognitive barriers), operationalization (e.g., governance and finance barriers), and implementation (e.g., lacking methods

for citizen engagement) (Kremer et al, 2016). Further specific implementation gaps include:

- long-term viability of NBS projects (Kabisch et al, 2016)
- lack of practical and targeted guidance for assessing and balancing the multiple benefits of NBS (Raymond et al, 2017; Giordano et al, 2020)
- lack of concrete planning recommendations (Mendes et al, 2020).

Since the potential societal benefits of NBS are directly dependent on getting these solutions “on the ground”, i.e., successful implementation, it is important to gain knowledge on the various barriers that enable and/or hinder processes of implementation.

In addition to these known implementation gaps, the science-policy-practice gap is also challenging in terms of implementation, i.e., the weak connection of framework(s) to planning and policy problems, including problems of asynchrony (i.e., the timing of scientific input) (Frantzeskaki & Tillie, 2014; Kabisch 2015; Kaczorowska et al, 2016).

How, then, is science engaging with the NBS concept, and how is it contributing knowledge on NBS implementation? This thesis considers scientific engagement with the concept as a process of knowledge production that is relevant for, and runs in parallel to, real-world implementation, which both informs the uptake in practice, but also results from it. This is because research and practice are increasingly interconnected in processes of knowledge production for urban transformations and sustainability.

1.3 An emerging research field

In spite of the fact that NBS has quite recently emerged as a concept in policy and has only been operational in research through research agendas and funding streams over the last five to seven years, the concept has already gained traction in academia.

Currently, a large variety of studies on NBS is proliferating in this field of research. Storm water management, using blue and green infrastructure and green roofs, are the most studied examples of NBS (Parker et al, 2020). Other recent publications within the field concern the role of eco-engineering for disaster risk reduction (McVittie et al, 2018; Faivre et al, 2017), as well as how the provision of social, economic, and environmental benefits from NBS can be seen as part of the re-naturing, regeneration, and greening of cities, in order to adapt to the effects of a changing climate (Yao et al, 2017; Reynolds et al, 2017; Fink 2016). These publications focus on the potential of NBS, such as carbon offsets of urban forests, for disaster risk reduction. Shafraz & Kim (2017) link implementation of NBS to

the walkability of cities. Another interesting but rather underrepresented field of research, with potential added value for NBS research, addresses NBS from a public health perspective by highlighting the benefits to human mental and physical health of being exposed to natural environments (van den Bosch & Depledge, 2015; Pálsdóttir et al, 2018; van den Bosch & Sang, 2017).

Consequently, researchers from different disciplines are increasingly engaging with the concept. There is currently a significant focus on gathering evidence to assess the impacts and efficacy of NBS (Frantzeskaki et al, 2019), as well as exploring how aspects of innovation, financing and governance can help scaling up these solutions in cities (Xie et al, 2020). Specific methods have been suggested for modeling, simulating, monitoring and evaluating the effects of NBS (cf. Marvuglia et al, 2020 effects of green roofs on mortality rates; Kolokotsa et al, 2020 NBS impacts on human health), but the extent of their actual impact on human well-being and urban ecosystems largely remains unknown. This is mostly due to the lack of systemic and overarching methods accounting for the various processes, trade-offs, costs and benefits of NBS implementation. Indeed, critical scholars highlight the unintended side-effects of implementing NBS, such as how increases in property values cause gentrification, and thus how greening interventions may create challenges related to social exclusion, which also raises concerns about distributional environmental justice in cities (Sekulova et al, 2021).

In brief, NBS is a relatively novel and developing research field, for which knowledge in many areas is still largely lacking. In the following, some of the most articulated general knowledge gaps are categorized and described in accordance with my own understanding of the field of NBS research as a result of reviewing the literature:

- **Solutions typology:** defining types of solutions
- **Ontological perspective:** framing or defining what counts as “nature-based”
- **Evidence base:** assessing the efficacy and cost-efficiency of multiple benefits from NBS
- **Method development:** developing assessment methods for improved understanding of the costs and benefits related to the trade-offs between social, economic and environmental aspects
- **Stakeholder engagement:** assessing methods for facilitating and managing stakeholder participation and negotiating various interests
- **Business models:** identifying and innovating viable business models for NBS

Further and more specific identified knowledge gaps around implementing NBS include:

- **Mainstreaming of NBS:** the need to identify factors which enable the integration, implementation and ultimately mainstreaming of NBS in urban planning and development (Wamsler et al, 2017; Dorst et al, 2021)
- **Action-oriented knowledge for NBS:** the need to develop knowledge that can be used to guide the planning and implementation of NBS (Kabisch et al, 2016; Connop et al, 2016; Raymond et al, 2017; Giordano et al, 2020), as well as concrete planning recommendations (Mendes et al, 2020)
- **In-depth understanding of NBS implementation:** the need to narrow the “gaps in the knowledge regarding the different stages of implementation” (Dushkova & Haase, 2020, p.2)

It is primarily the knowledge gaps related to action-oriented knowledge and in-depth understanding of the NBS implementation process that this thesis seeks to contribute towards, through its focus on experimentation, learning and knowledge production for translating and implementing the NBS concept.

1.4 Research objective

The overarching aim of this thesis is:

to study in what ways the processes of experimentation, learning, and knowledge production enable and/or constrain the translation and implementation of NBS.

Based on this aim, and with a firm standing in inter- and transdisciplinary research aimed at producing normative and action-oriented knowledge to advance sustainability, this thesis seeks to answer the following research questions (RQs):

RQ1 - How does research engage with the NBS concept and how is implementation addressed?

RQ2 - How can experimentation enable collaborative processes of NBS implementation and transformative learning?

RQ3 - How can research and practice engage in co-production of knowledge on NBS and what are the associated challenges and opportunities?

To address these questions, this thesis focuses on processes of NBS translation and implementation in urban contexts, as well as the scientific discourse on NBS. From the perspective that both research and practice influence the formation and governance of knowledge on NBS, which is relevant for how these solutions can be

successfully implemented in cities, this thesis approaches NBS implementation in relation to this dialectic relationship between research and practice. It seeks to contribute practical/operational perspectives to the field of NBS research, while also contributing towards urban planning and governance practice by providing knowledge that will support and promote further collaborative efforts towards NBS implementation in cities.

1.5 Overview of the research

This research has been linked to three projects which enabled the investigation of local processes of NBS implementation while simultaneously situating and relating NBS to a broader societal context (mostly European). The large-scale European Naturvation research project, for example, investigated a multitude of perspectives relevant to NBS implementation (e.g., local innovation processes, business models, citizen participation methods), allowing this research to take shape in a wider context of inter- and transdisciplinary research perspectives. In addition, the three projects have included transdisciplinary approaches, involving both researchers and practitioners, to various extents.

These research projects served as platforms to engage in various NBS-related inquiries and for developing and writing the five research papers that this thesis is composed of (table 2). These investigate different aspects related to the translation and implementation of NBS, and span between research and practice (figure 2).

Table 2: Overview of the papers included in the thesis, type of studies and corresponding RQs.

Paper	Author(s)	Title	Study type	Relevant RQ
I	Hanson, H. I., Wickenberg, B., & Olsson, J. A.	Working on the boundaries—How do science use and interpret the nature-based solution concept?	Review	RQ1
II	Wickenberg, B., McCormick, K., & Olsson, J. A.	Advancing the implementation of nature-based solutions in cities: A review of frameworks.	Review	RQ1
III	Wamsler, C., Wickenberg, B., Hanson, H., Olsson, J. A., Stålhammar, S.,... & Zelmerlöv, F.	Environmental and climate policy integration: Targeted strategies for overcoming barriers to nature-based solutions and climate change adaptation.	Participatory/ collaborative case study	RQ2
IV	Wickenberg, B., Kiss, B., McCormick, K., and Voytenko Palgan, Y.	Seeds of transformative learning: Investigating past experiences from implementing nature-based solutions	Case study	RQ2
V	Wickenberg, B.	Collaborating for nature-based solutions: Bringing research and practice together	Reflective case study	RQ 3

To provide an overview, the research process can be described in the following way (figure 2). I first started investigating, through a broad literature review, how science engages with NBS seen as a boundary concept (paper I). Then, through further review and interpretation of the literature, I sought more in-depth perspectives on how the specific process of NBS implementation is addressed in research (paper II). These two reviews formed a basis for an understanding of how the concept and the discourse around its implementation has proliferated in the academic literature. At this point of the research it was interesting to explore how practice engages with NBS, more specifically what enables and/or constrains implementation, and what could be learnt about operational perspectives through investigating various cases. These empirical studies investigated both processes more closely related to the formal planning process in five Swedish municipalities (paper III), and processes of project-based innovation and experimentation with NBS implementation in the city of Malmö, Sweden (paper IV). The insights from both research and practice (papers I-IV) then provided a basis for developing the thesis framework around the role of experimentation, learning and knowledge production for translating and implementing NBS. The findings from papers I-IV and the thesis framework served as a basis for reflecting on a case of research-practice collaboration on NBS, through participatory observations within one of the research projects (paper V).

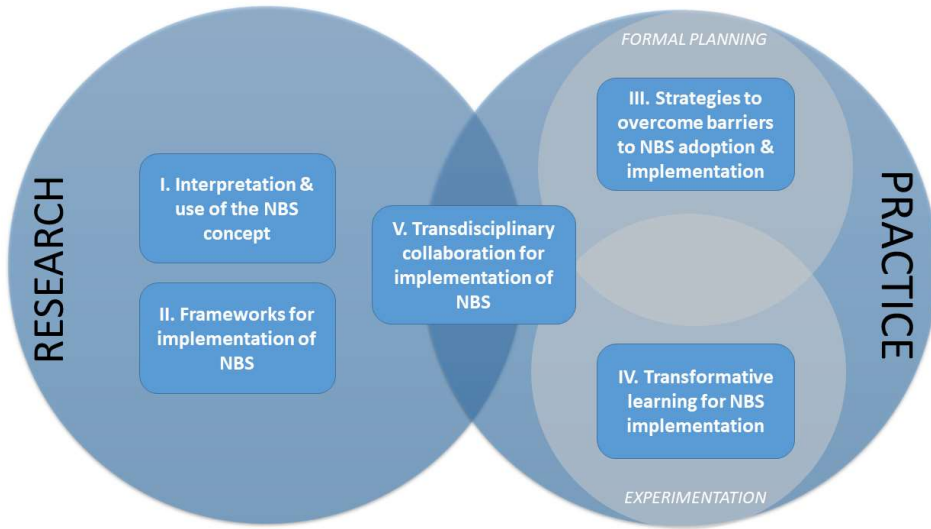


Figure 2: Overview of papers and their focus in relation to study context, i.e., research and practice, the latter including both formal planning and experimentation.

1.6 Scope

This research sits within the broader field of interdisciplinary, urban transformations research, and urban studies related to urban sustainable development and climate change mitigation and adaptation.

In this thesis, NBS presents a case to shed light on the more generic, universal and challenging process of translating sustainability concepts into practice. Hence, for the reader with an interest in the broader perspective of urban sustainability transformations, and the importance of governance and related strategies to build transformative capacity for change, this research can contribute relevant knowledge perspectives beyond the specific field of NBS.

This thesis is interested in various levels of strategic governance that influence how NBS is translated and implemented. It has a dual focus; on implementation and governance processes related to practice in the Swedish urban planning context, and on the role of research in generating knowledge on NBS and their implementation (cf. figure 2). More specifically, this thesis is interested in the role of experimentation and learning to unlock the transformative potential of NBS.

It primarily aims to contribute action-oriented perspectives to the academic discourse and add to the growing knowledge base on NBS. It also hopes to

contribute perspectives on collaborative and transdisciplinary research approaches that could potentially narrow the research-practice divide; thereby addressing the need for weaving of societal needs and academic knowledge on NBS and sustainability transformations. Finally, this thesis seeks to contribute perspectives on how to build capacity for nature-based urban transformations in practice.

With the selected action-oriented and normative research focus on NBS translation and implementation, with a specific focus on experimentation, learning and knowledge production at the intersection of research and practice, this research is therefore limited in scope, and hence:

- only indirectly assesses NBS policy processes, as policies materialize and link to implementation
- analyzes *processes* of NBS and does not engage with types, designs or functions of specific NBS interventions
- investigates NBS from a meso/macro rather than micro perspective, e.g., what individual citizens can do in their own backyards
- centers on urban contexts
- focuses on the global North context, though recognizing the need for global South perspectives in urban research, as highlighted by De Satgé & Watson (2018)
- maintains a practice-oriented perspective and does not expand on ontologies referring to what 'nature' is/is not⁴

⁴ Suggested readings in this domain include, e.g., Osaka et al (2021) for a critical review on the framing of what is "natural" as imbued with socio-political meanings and thus having implications for the selection of specific types of infrastructural interventions; Barua (2021) for a wider ontology of infrastructure; Fremaux (2019) for a critique of the post-modern, "hybridist" world-view, in which nature can be reduced and re-produced, and thus the idea of nature as a separate entity being rejected; Woroniecki et al (2020) for how uncritical framing of nature conditions the potential for social transformation; West et al (2020) who contribute critical scholarship on how relational approaches can foster holistic accounts of human-nature connectedness and contribute to a paradigm shift in sustainability science.

1.7 Thesis outline

The introductory chapter is followed by chapter 2, which describes the overarching thesis framework and key themes for investigating the translation and implementation of the NBS concept. Chapter 3 positions this thesis in relation to ontological and epistemological traditions, as well as in relation to fields of research and research approaches relevant to the thesis. It also presents the methods for data collection and data analysis, and provides a brief account of the research design. Chapter 4 presents the key findings based on the papers that contribute towards this thesis. Chapter 5 introduces the key message of the thesis, presents three challenging imperatives for actionable knowledge that crystalized through this research, and then moves on to discuss the key themes of the thesis framework which were investigated in this thesis. This is followed by recommendations for research and practice, contributions of the research, and methodological reflections. Finally, chapter 6 presents the main conclusions of this thesis.

2 Framework and background

This chapter introduces the framework and conceptual background of the thesis. The framework aims to describe key aspects of urban transformation and more specifically governing nature-based urban transformations, which this thesis explores, as well their relation to each other. The chapter starts with broadly sketching out the framework and introducing its components (2.1). Thereafter the wider context of governing sustainable urban transformation is explained (2.2). The following sections describe the concepts of translation and implementation, and introduce the framework (2.3), and further details the strategic governance activities included in the framework (2.4).

2.1 Overview of the framework

The framework is based on three layers. The first layer represents the broader context of sustainable urban transformation and governing nature-based urban transformations (illustrated as a frame). The second layer represents the cyclic and iterative process of translating and implementing NBS (visualized as a spiral). The third layer represents strategic activities that are part of and influence the translation and implementation of NBS, and which are investigated in this thesis: experimentation, learning, and knowledge production (figure 3).

The framework is underpinned by the perspective that sustainable urban transformations can be defined as dynamic processes of change in/of urban systems, which are largely determined by multiple local factors that interact and result in action/experimentation, learning and knowledge on how to change a system towards sustainability.

While translation within research primarily involves various disciplines engaging with the new concept, e.g., through framing and defining it, translation of NBS in practice manifests in various implementation processes. These include innovating and experimenting with NBS, and the associated learning and knowledge production from that. In the framework, experimentation and learning are seen as strategic governance activities, which are connected through feedback mechanisms to various processes of knowledge production. Learning and knowledge are thus “fed forward” into processes of knowledge governance in both research and

practice. To put it more simply: we test, we learn, and we generate scientific and practical knowledge which is increasingly interwoven in processes of governing urban transformations.

2.2 Governing sustainable urban transformation

Urban development is characterized by various interactions between multiple socio-technical and social-ecological systems (Wolfram & Frantzeskaki, 2016). Nature-based urban transformation can be understood through both types of systems, since it often includes green ecosystem-based solutions (ecological) in combination with already established grey infrastructure systems (technical), interacting with social systems. Thus, to capture NBS from a broader, systems perspective, it would be adequate to use a terminology that combines all three aspects, i.e., socio-ecological-technical systems (cf. van der Jagt et al, 2020).

Cities and urban actors are increasingly seen as agents of change, taking a leading and intermediary role in governing urban transformations towards sustainability (Betsill & Bulkeley 2003; Hodson & Marvin, 2012; Hölscher & Frantzeskaki, 2021), often referred to as sustainability transformations, or transitions. While transformation captures both the process and the outcome, and is more widely used across different fields, transition mostly refers to the change achieved, the results achieved (Wolfram et al, 2016). Transformation has the character of a boundary concept spanning across various disciplines (Chappin & Ligtvoet, 2014), i.e., it allows a broader dialog across research fields. This interdisciplinary perspective fits well with this thesis and motivates why transformation is adopted as the preferred terminology to describe the societal processes of change.⁵

Sustainability transformations in cities are defined by their dependence on the local governance context in which they take place. The literature suggests a set of key factors being relevant; a mix of spatio-temporal factors, actors/agency, governance, policy and planning (McCormick et al, 2013), as well as capacity, experimentation, politics, power and foresight (Wolfram et al, 2016).

Research within the broader field of transition studies and literature on climate and sustainability governance experiments has highlighted the interrelation between governance, experimentation and learning (cf. Bos et al, 2013; Bulkeley & Castán Broto, 2013; Neij & Heiskanen, 2021). In that context, NBS governance and experimentation can be seen as related to the structural and strategic conditions for envisioning, testing, learning and governing urban transformations by means of new

⁵ It could also be argued that the shift from technologically-based to nature-based transformation requires such large-scale changes in societies, that the use of the broader transformation term is motivated.

governance approaches and implementing new types of solutions “outside” the incumbent planning regime (Loorbach, 2010).

However, it should be noted that in the study context of this thesis, i.e., Sweden, the governance and implementation of NBS often takes place at the intersection of formal planning (the “line”) and experimentation (cf. Vogel et al, 2020), initiated from within the regime to solve challenges (cf. Dignum et al, 2020). This has been described by Geels (2007) as the reconfiguration pathway; niches initiated in the prevalent regime with a potential to provoke cumulative change in the regime architecture.

2.3 Translating and implementing nature-based solutions

In a similar vein as Fadeeva (2005), this thesis explores processes of translation and implementation of NBS by investigating how experimentation, learning and knowledge production either enable or constrain these processes. Here, the collaborative and boundary nature of NBS being translated, spans across research and practice.

If urban transformation is needed to achieve more sustainable cities, an important part of such transformations can be ascribed to activities or processes of translation (Frantzeskaki, 2019; Boyer, 2015; Fadeeva, 2005; Nevens et al, 2008; Beery et al, 2016), i.e., an idea or concept related to sustainable development (SD) must be translated and implemented into practice within specific fields or sectors, e.g., urban planning. In more concrete terms, translation of sustainability relates to, for example, participatory processes of envisioning sustainable futures (Nevens et al, 2008), localizing the Sustainable Development Goals (SDGs) (Zinkernagel et al, 2018; Croese et al, 2020), alternatively, translating the NBS concept into local policy, planning and implementation (Frantzeskaki, 2019), which was one of the objectives of the six Urban Regional Innovation Partnerships in the European research project, Naturvation, underpinning this thesis (cf. paper V). These types of partnerships, or networks, allow for actors to re-interpret reality and engage in processes of meaning construction (Fadeeva, 2005), as well as working with innovations and experimentation to implement the shifts towards sustainability.

While these types of translation processes allow actors to more freely re-imagine and innovate sustainable futures, they are simultaneously characterized by a high degree of uncertainty and unpredictability. In other words, translation and implementation is not a straightforward and linear process. It can be described as a “messy”, complex, and ongoing process that involves different levels of governance, various stakeholders and their values, experiences and knowledge.

In the context of urban planning and governance, the translation process is furthermore constrained by conflicting planning goals and the need to consider trade-offs between environmental, economic and social values (Campbell, 1996) and, respectively, how these are affected by the introduction of new sustainability concepts.

Translation is thus connected to processes of change and how new ideas/concepts give input to a process of questioning current practices within a given field or sector, or across these, for example when diverse actors come together to interpret the meaning of, and work towards, the SDGs in a place-specific context. Fadeeva (2005) explores translation of SD in the field of tourism by investigating the role of cross-sectoral networks and critical factors affecting the collaborative process of translating ideas of SD into practice. Fadeeva (2005, pp. 176-177) leans on translation theory, institutional theory and actor-network theory to explain translation as a “process of movements of ideas”, which is constrained and/or enabled by contextual factors, e.g., agency, resources at hand, and different capacities and motivations at individual and organizational levels.

In short, acts of translation of sustainability must balance between, on the one hand, conforming (or not) to institutionalized rules and beliefs of strong systems and maintaining the legitimacy of actions (e.g., planning regulations and norms) (Fadeeva, 2005), and on the other hand, critically examining the effectiveness of established practices in leveraging sustainability, and, creatively and innovatively, coming up with alternative ideas and solutions. In other words, reformulate and redefine current practices by translating novel and potentially transformative concepts into practice, even though the landscape is complex to navigate and surrounded by uncertainty.

It is against the backdrop of translation of sustainability that the overarching framework (figure 3) of this thesis has been developed. Translation is thus seen as directly influential for the implementation of the concept. These two are inextricably interlinked in the operationalization of the NBS concept; they represent two sides of the same coin.

By flipping this coin and turning to implementation, this research sees implementation of NBS as part of the wider local governance context. Implementation has been defined the following way (paper II): as context-specific actions and processes (Frantzeskaki, 2019) that deliberately seek to respond to identified societal challenges (Albert et al, 2019), and are constrained or enabled by a number of conditions in that context. Such conditions include (but are not limited to) actors, networks, agency, knowledge, learning, institutions, legislation, power relations, policies, governance structure, and resources (van der Jagt et al, 2019). In the urban NBS context, implementation is typically linked to the urban planning and policy process (Raymond et al, 2017). However, implementation is not limited to the mere operational execution of formal policies/strategies/plans, but characterized

by being a complex chain of reciprocal interactions (Pressman & Wildavsky, 1984) and working in iterative cycles (Albert et al, 2020) based on a logic of plan-do-check-act (Wickenberg et al, 2021).

To gain wider knowledge about how processes of NBS translation and implementation are governed, this thesis argues that it is relevant to study implementation in both experimentation projects and formal planning processes (in the “line”). While these forms of governing and implementing NBS differ in many ways, both involve experimenting with new approaches and solutions for integrating nature and can thus be considered broadly as experimentation (cf. section 2.2 on the reconfiguration pathway).

In summary, the thesis framework provides a conceptual lens to capture the governing of nature-based urban transformations through activities of translation and implementation of NBS. These strategic governance activities – experimentation, learning and knowledge production – take place *within* and at the boundary *between* research and practice, which illustrates the increasingly interdependent, and sometimes “blurred”, roles of research and practice engaging in knowledge production related to sustainability and urban transformation.

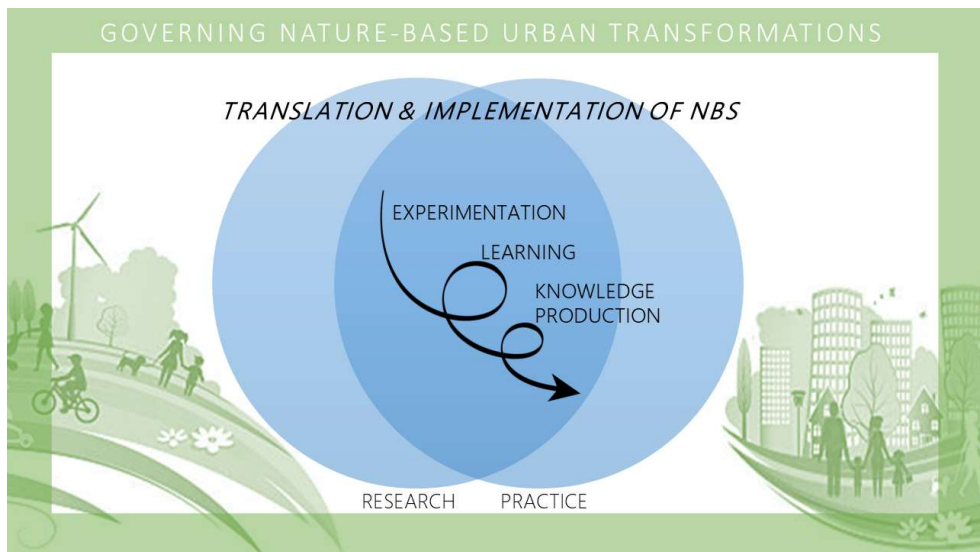


Figure 3: Thesis framework. In the broader context of governance of nature-based urban transformation, ongoing and cyclic processes of translation and implementation of NBS take place, which are enabled and/or constrained by experimentation, learning and knowledge production in research and practice. These are interconnected, strategic activities for governing sustainable urban transformations (illustrated by the spiral).

2.4 Strategic governance activities

Although visualizing experimentation, learning and knowledge production in this framework as integral to the same continuous process of strategically governing translation and implementation of NBS (figure 3), this thesis acknowledges the difference between the three. While experimentation and learning work as more direct forms of engaging with translation and implementation, knowledge production can be seen as a parallel process, generating both scientific (conceptual) knowledge and practical (operational) knowledge. Scientific knowledge (e.g., frameworks, definitions) informs further implementation, while practical knowledge informs research (e.g., research based on empirics). This represents the research-practice dialectics involved in processes of experimentation, learning and knowledge production for governing the translation and implementation of NBS. The following three sub-sections explain each one of these strategic governance activities in more detail.

2.4.1 Experimentation

Urban governance increasingly requires more flexible and adaptive governance arrangements that accommodate for citizen participation, community interests, and blending of local and scientific knowledge, while simultaneously handling the complexity and uncertainty inherent in urban landscapes (Dietz et al, 2003, Folke et al, 2005; Heiskanen et al, 2015; Buijs et al, 2016; Pahl-Wostl, 2007). To address some of these issues, van der Jagt et al (2021) investigate the potential of reflexive governance for sustainable and just cities and highlight how various power dynamics steer such processes. Indeed, while urban greening initiatives have traditionally been run by the government, over the years this form of governance has been increasingly complemented by more innovative governance arrangements, such as collaborative and network governance (Khan, 2013), as well as various forms of experimentation (Hildén et al, 2017). In that context, experimentation and reflexivity has become ever-more important in making such governance arrangements more learning-oriented.

Evidence suggests that the governing of cities towards sustainability is increasingly being conducted and shaped through practices of experimentation (Hildén et al, 2017; Fuenfschilling et al, 2019). Evans and Karvonen (2014, p.415) explain the purpose of urban laboratories and experimentation:

“...to create a space apart from the norm and by bounding space, urban laboratories not only territorialize carbon emissions at a small, manageable scale but also inscribe a privileged space of innovation. Thus, urban laboratories offer a sub-local space to implement government approaches to climate-change mitigation and adaptation but

achieve this through spatial differentiation that has both positive and negative implications.”

The authors point out that while experimentation seeks to test sustainable solutions, it has also implications for the interplay between knowledge production and local governance. While urban space is used to experiment and monitor changes, the underpinning intention is to find viable solutions, learn, and produce new knowledge to inform policy. However, there is risk that this new knowledge is “controlled” by the few, not engaging with the larger social context and citizen perceptions, or not adequately conveyed. This means that experimentation demands formal and deliberate structures for disseminating and communicating the knowledge gained. As the authors argue, “The success of certain cities and failure of others in addressing climate change will be determined in large part by their ability to harness flows of knowledge for their particular contexts, successfully translating empirical findings into reality...” (Evans & Karvonen, 2014, p.427).

In the context of this thesis, experimentation is thus considered as the provision of space and resources to challenge existing planning and governance practices related to implementation of NBS in cities. Experimentation enables the testing of future configurations and learning forwards from that (cf. Kemp et al, 1998). Thus, experimenting with NBS in cities is a way of connecting the present with the future and “provides a means by which diverse actors seek to navigate and make sense of the present whilst also giving concrete form to particular visions of the future” (Bulkeley et al, 2019, p.318).

The forms of urban experimentation with innovations (e.g., urban living labs, real-world laboratories, testbeds) (Mahmoud et al, 2021; Bulkeley et al, 2019; Menny et al, 2018; Voytenko et al, 2016) are often represented by real-life demonstration projects undertaken collectively by diverse urban actors with active user engagement to advance learning, improve acceptance of the innovations (Voytenko et al, 2016) and enhance the transformative potential of these innovations (Menny et al, 2018).

Experimenting with NBS can also be associated with the paradigm shift in urban planning, from traditional forms of modernist planning to a post-modern contemporary planning (Rydin, 2007), or the “transformative turn” (UT, 2021), in which new planning approaches, instruments and multi-actor institutions are gaining grounds to address urban challenges as they are being tested through various forms of niche experimentation and new governance models aimed at transformation towards sustainability (Hölscher & Frantzeskaki, 2021).

Transformative planning and governance involve clashes between niche practices and established planning regimes (i.e., institutions, rules, routines) and furthermore focuses on actor agency, disruptive initiatives, reflexivity, and social learning (Peris & Bosch, 2020). Part of these clashes can be attributed to urban planning and the

dual role it has in both enabling and constraining transformative governance and experimentation (Peris & Bosch, 2020; cf. Geels, 2007; Dignum et al, 2021). These clashes often occur at the intersection between experimentation and formal planning, when multiple actors and agendas interact, and, consequently, render important opportunities for learning.

2.4.2 Learning

In this thesis, improved understanding of how learning is enabled or constrained in processes of NBS implementation is seen as important for realizing the potential of NBS and their co-benefits; in particular, the transformative character of learning, i.e., how transformative learning can contribute to processes of change in which actors learn how to see and do things differently (Sterling, 2011).

A defining feature of governance and experimentation relates to its learning processes and effects. In addressing urban transitions, Loorbach (2010) refers to reflexive activities for learning related to policies, actions and societal change. Cities provide opportunities for a close interaction among multiple stakeholders and exchange of different types of knowledge, which impact both the scale and opportunities for experimentation and associated learning processes. In other words, urban contexts hold capacity for learning and knowledge production (Campbell, 2009), and increasingly so through real-life demonstrations, e.g., urban living labs (Voytenko et al, 2016; Bulkeley et al, 2019).

Learning relates to knowledge production processes, in turn shaped by cultural and socio-political conditions, which may take the form of institutionalized rules (Jasanoff, 1998; van Kerkhoff & Pilbeam, 2017). In other words, learning is bound by context, social institutions, rules and norms. Scholarship on knowledge governance examines knowledge-based processes and the complex science-practice relation (van Kerkhoff, 2014), including the formal/informal rules and institutional arrangements that shape how we engage in knowledge processes, e.g., through knowledge sharing or co-production. Through the research projects and case studies underpinning this thesis, it has been possible to investigate the role of reflexivity and social learning in knowledge-based processes in the context of NBS implementation. However, rather than analyzing the institutions shaping such processes, the focus is on the activities, experiences and practices within processes of NBS experimentation – as an already institutionalized knowledge production process – which could bring learning that leads to changes in the planning and governance regimes, i.e., so called *transformative learning* (TL).

While there is a growing body of literature on NBS governance and experimentation (Frantzeskaki, 2019; Dignum et al, 2020; Coenen et al, 2020), current research pays less attention to the ways in which experimenting with, and governing, NBS relate to TL (Wolfram, 2016; Boström et al, 2018; Neij & Heiskanen, 2021), i.e., the role

of learning in and for processes of nature-based urban transformation. Learning embedded in local processes, or “localized learning processes” (van Mierlo & Beers, 2018; Grillitsch & Rekers, 2016), has indeed received little attention in research on NBS implementation (cf. Dignum et al, 2020; van der Jagt et al, 2019; Kiss et al, 2021).

TL as a term originates from the field of adult education, with the most cited work authored by Mezirow (1991). He refers to TL as “learning [that] is understood as the process of using prior interpretation to construe a new or revised interpretation of the meaning of one’s experience in order to guide future action” (Mezirow, 1996:162).

Since NBS experimentation is typically embedded in a wider governance context, the assessment of TL can also be related to what is termed “governance learning” (Neij & Heiskanen, 2021), in particular the potential learning from experiments to gain experience for transformative action. TL is based on critical reflection and experimenting with new meanings, including through taking action, to achieve both individual and societal transformation (Bennet & Howlett, 1992).

The concept of TL for sustainability (Boström et al, 2018) includes institutional structures, social practices and conflict perspectives, and is central for understanding processes driving change. It is characterized by being process-oriented, interactional, long term and sometimes cumbersome (Boström et al, 2018). TL relates to social learning, which centers around collective and systemic learning on how to govern urban transformations (Johannessen & Mostert, 2020; Johannessen & Wamsler, 2017), and organizational change, with a focus on participatory processes and social and community transformation (Mezirow & Taylor, 2009). Such learning is also contextualized, or localized, for example, within the safe spaces of experimentation projects, i.e., geographically embedded in place-specific networks and institutions (Dignum et al, 2020).

TL theory (e.g. Mezirow, 1978) refers to first, second and third order learning. First order learning is understood as the reproduction of knowledge to improve action, i.e., *doing things better* (conformative learning) (Sterling, 2011:22-25). Second order learning involves critical reflection, not only on the action but also on the subject of action, i.e., *doing better things* (reformative learning). Third order learning, or transformative learning, is subject to deep reflection on worldviews and established orders that can disrupt established paradigms and open up for change, which can lead to *seeing and doing things differently*. This can result in a “deep structural shift ... of actions” (Morrell & O’Connor, 2002: xvii). It may, however, be difficult to single out exact demarcations between first, second and third order learning.

In the context of this thesis and its focus on NBS translation and implementation, this translates into inquiries around the type of actions, practices or perspectives that have the potential to enable the type of learning that opens up for change. Thus, this

this thesis is interested in identifying potentially important learning instances and activities in cases of NBS implementation (paper IV), geared towards the transformation of NBS governance. This thesis includes learning as an essential element of such deliberate fundamental shifts (O'Brien, 2012), and thus TL as connected to the transformative potential of NBS (cf. Palomo et al, 2021; Frantzeskaki, 2019; Hölscher & Frantzeskaki, 2021).

2.4.3 Knowledge production

Processes of NBS experimentation and implementation in practice render not only critical learning, but also practical knowledge (operational knowledge) and scientific knowledge (conceptual knowledge). Increasingly, this knowledge is produced in transdisciplinary settings at the intersection of research and practice, which include various stakeholders, and where different types of perceptions and knowledge perspectives interact and result in learning and knowledge (Pohl & Hadorn, 2008; Perry & Atherton, 2017).

In transition management research, which is interested in transformations of socio-technical systems (Loorbach, 2007; Pahl-Wostl, 2007), calls have been made for the need for interdisciplinary (ID) and transdisciplinary (TD) research and new modes of knowledge production (Gibbons et al, 1994). In essence, such claims are targeting a need to move from so called Mode 1 to a new Mode 2 knowledge production (Pahl-Wostl, 2007), which entails a move from “discipline-based knowledge production within academic institutions toward a ... knowledge production which is interdisciplinary, cross-boundary, and includes scientists, engineers, designers, policy makers, NGOs and other stakeholders”. Research related to NBS has made similar calls for TD approaches (cf. Nesshöver et al, 2017).

Since this thesis sees experimentation and learning processes as closely linked to knowledge and its production (figure 3), I will first explain how the thesis understands knowledge. Thereafter, I will return to the subject of knowledge production.

Theoretical knowledge (*theoria*) can be distinguished from practical knowledge (*praxis*), i.e., knowing and doing. These two forms of knowledge are different but intrinsically interconnected and relevant for understanding, operationalizing, and implementing NBS. Lundgren (1996, pp.139-141) distinguishes between four different forms of knowledge: *facts*, *understanding*, *practice*, and *experience* (my translation). This thesis adopts these broad categories of understanding knowledge in relation to the governance processes in which different actors across sectors and disciplines translate and implement NBS, i.e., define, understand, frame, conceptualize, and/or operationalize NBS.

Facts relate to information and data that has been validated, e.g., facts related to how specific NBS perform in a given context, ideally assessed and validated through

several studies. *Understanding* is primarily a qualitative type of knowledge, the way we theoretically comprehend and give meaning to facts and data (“what is”) (Lundgren, 1996). The use of definitions and concepts for an operational understanding of how biophysical and socio-economic system components are interrelated could serve as an example of *understanding*, which furthermore serves as an important basis for communication. Some sustainability scholars (cf. Abson et al, 2014) refer to this as systems knowledge; insights from different disciplines and our ability to connect the disciplinary dots into a wider, systems perspective. *Practice* is knowing how to change the current situation; by which means of instruments, tools and practices we can achieve change and the actual knowledge, ability, to do so (“how to get there”) (Lundgren, 1996). Abson et al (2014) refer to this as transformative knowledge, which from an NBS perspective would refer to knowing how to achieve a systemic change to meet societal challenges. The last type of knowledge Lundgren (1996, pp.139-141) speaks of is *experience*, a “tacit” knowledge that builds on insights gained from processes of interactions and behavior in different societal contexts. The latter involves value-laden, or normative, judgements, i.e., what we want the social-ecological system to look like, the preferred situation based on visionary and value-based goals (“what ought to be”).

Addressing urban sustainability transformations requires the capacity to integrate and manage different types of knowledge, e.g., in relation to housing, transport, energy and waste, economic, social, green and blue infrastructure (Perry & Atherton, 2017). Perry & Atherton (2017, p.2) point to the potential role of engaged research-practice relationships in catalyzing such urban transformations and suggest that “co-production is one pathway to develop spaces for learning and cross-institutional reflection between academia and policy”. Co-production of knowledge is seen as necessary when dealing with complex life-world problems such as, for example, environmental deterioration (Pohl & Hadorn, 2008). The purpose of TD co-production of knowledge is then to adjust knowledge production to real and pressing societal problems; the goal is to provide descriptive, normative and practice-oriented knowledge.

However, to understand diverse perspectives of problems and engage in co-production of knowledge is challenging. The knowledge of different participants needs to be recognized based on respect, openness and deliberation (Pohl et al, 2010). This is the very basis of a fruitful collaborative knowledge production process. Specific disciplines and social actors should not be privileged to the detriment of what other disciplines and social actors can contribute. Perry & Atherton (2017) and Pohl & Hadorn (2008) suggest similar stepwise approaches for the process of implementing co-production in practice. First, to grasp the complexity and develop a shared critique and understanding of contemporary urban situations based on a diversity of life-world and scientific perceptions of the problems. Secondly, to link abstract and case-specific knowledge to explore options. Thirdly,

to co-develop knowledge and test actions that promote what is perceived to be the common good.

This thesis has included investigation of different cases of TD co-production of knowledge (cf. paper III, IV and V). The research itself has also taken shape within research contexts which included TD knowledge co-production (section 1.5). On that basis, this thesis seeks to contribute understanding of how co-production of knowledge can enable and/or constrain the translation and implementation of NBS.

3 Methodology

3.1 Research foundations

3.1.1 Ontological and epistemological position

The choice of methodological and analytical approach can be contextualized within the larger context of philosophy; the ontological and epistemological standpoints of the researcher, and “taking sides in the philosophy of social science” (Rosenberg, 2012:24). Ontology refers to worldviews and how we perceive the nature of social reality; what there is to be known. It is like a system of belief and regards how we study and understand reality by use of a set of concepts or theories, or even methods. Epistemology refers to the nature of knowledge, responding to what knowledge is and how it is produced (Brinkmann & Kvale, 2015). Throughout the modern history of science, different ontologies have been framed within different philosophical traditions.

Does ontology and epistemology matter? Ontologies and epistemologies have an impact on social reality. Seen through the lens of (post)post-modern philosophers, Callinicos & Schott (2006) and their resources of critique, as well as Dant (2003) and critical social theory, ontology matters because it influences major influential societal structures, systems and associated practices (e.g., neo-liberal capitalism as a social order) and sets boundaries for normative thinking. The concept of ‘emancipatory aspiration’ is described as the need for critical review of those social structures by means of self-reflection and questioning to enhance enlightenment and emancipation and, ultimately, emancipatory action can lead to transcendence of such social orders (e.g., applicable to social orders that underpin the unsustainable societal patterns of current development). If failing to acknowledge how different scientific traditions and ideas about the life-world and knowledge about it – and what counts as credible and legitimate knowledge and, not least, who is in power of producing it – have been, and still are, part of dominating and maintaining socio-political and economic structures that control land use and natural resources, we are also failing to understand part of the problem, i.e., the ontological and epistemological underpinnings causing environmental deterioration and climate change. In a relativist and constructivist vein, scholars point to how dominant understandings of nature have been politically-scientifically produced (partly in the

spirit of universalistic positivism) (Jasanoff, 2010) and have failed to incorporate the plurality and heterogeneity of worldviews and local dimensions of knowledge (Martello & Jasanoff, 2004).

A general statement about methods grounded in positivism would posit that knowledge is derived from objective and falsifiable facts that are quantitatively measurable (Chalmers, 1999) and applies methods following specific, strict rules and predetermined steps (Brinkmann & Kvale, 2015). In a positivist view, the research object can be separated from the research subject. A similar account of qualitative approaches based in ontologies that have been framed as reactions to positivism, i.e., post-positivist ontologies, such as hermeneutics and phenomenology or other post-modern scholarly thoughts, would instead emphasize the relevance of subjectivity, experience, and meaning interpretation to understand social reality (Brinkmann & Kvale, 2015). Consequently, such positions refrain from the object-subject dichotomy and the idea that the research object can be separated from the research subject. On the contrary, subjective elements are often seen as part of understanding and producing knowledge in qualitative research.

In describing a post-modern epistemology in which knowledge is seen as a social construction that rests on contextual and conversational foundations, Kvale (1994:7) makes the following statement regarding the validity of knowledge:

“A move from knowledge as correspondence with an objective reality to knowledge as a social construction of reality involves a change in emphasis from observation of, to a conversation and interaction with, a social world. Truth is constituted through a dialogue; valid knowledge claims emerge as conflicting interpretations and action possibilities are discussed and negotiated among the members of a community.”

Although leaving the reader with a clear image of the post-modern epistemological turn in social science, it could be claimed that this perspective echoes a knowledge context largely dictated by the researcher. It is therefore important to ask ourselves: what constitutes a knowledge community, and who are the members of such a community? Conversations can take place within a singular discipline (intra-disciplinary), or between several disciplines (inter-disciplinary), alternatively stretching beyond scientific disciplines and involving other societal actors (transdisciplinary). I will soon return to this perspective (section 3.1.2.).

This thesis is grounded in the qualitative research tradition, with an interest in exploring and investigating societal phenomena and processes, primarily through inquiries around the “how”. It takes interest in how social processes and mechanisms, as well as agency and experiences of different actors, are contributing to the construction of meaning, the production of knowledge, and action in society.

As such, the thesis adopts a constructivist and interpretative research approach. Knowledge and learning are here understood as products of relations, contexts and narratives. In following Mantzavinos’ (2012) description of “meaningful action”

(Ricoeur, 1994), but taking a more simplified and interpretivist approach, human actions are understood as meaningful events, which can be observed and interpreted in their context to unveil their underlying motives, intentions, reasons or rationales.

In the context of this thesis, the interpretative approach is operationalized through assessing various stakeholders' knowledge and experiences of how NBS is experimented with, practiced, and made sense of, to interpret and understand how NBS translation and implementation is enabled and/or constrained.

3.1.2 Urban transformation research

This research sits within the broader fields and approaches of interdisciplinary and transdisciplinary sustainability studies and urban transformation research.

“Urban transformation research forms an emergent interdisciplinary field with open boundaries that combines complex system studies and urban studies. It explores patterns and dynamics of change linking cities and diverse socio-technical and socio-ecological systems across levels and scales, and develops new forms of interventions to foster their sustainability” (Wolfram et al, 2016:18).

Wolfram and Frantzeskaki (2016) mention four research epistemologies by which a variety of drivers of knowledge production and systemic change towards sustainable urban futures can be studied: i) transforming urban metabolisms and political ecologies; ii) configuring urban innovation systems for green economies; iii) building adaptive urban communities and ecosystems; and iv) empowering urban grassroots niches and social innovation. The authors furthermore suggest that the interrelations between these epistemologies should be studied to understand what is driving systemic change in urban areas.⁶

These epistemologies help situate the research in this thesis within the broader field of urban transformation, especially the part of the research that focuses on NBS in practice, which relates mostly to the first and third epistemologies above, i.e., the use of nature and natural elements in the making of new infrastructure (transforming urban metabolism), and how these infrastructures contribute towards adaptive urban communities.

This thesis furthermore draws on urban transformation research and three perspectives which underpin this thesis' understanding of what defines sustainability transformations: *system change* (i.e., new system configurations, testbeds, local innovation systems, contested sites of implementation); *urban change* (i.e., new urban structure and processes, system dynamics focus); and

⁶ It is interesting to note that these epistemologies can also be reflected in the very approach of NBS; more specifically, changing urban metabolisms and building adaptive communities through green (nature-based) technologies and social innovation.

urban/system interactions (i.e., urban change and system reconfiguration as mutually dependent processes across scales and levels) (Wolfram et al, 2016).

3.1.3 Interdisciplinary and transdisciplinary research approach

This thesis is focused towards the production of normative, applied science, i.e., the applicability of knowledge in society is central. It primarily seeks to contribute practical over theoretical knowledge perspectives, while simultaneously acknowledging that a pluralistic knowledge society is needed to identify solutions that move societies towards sustainability, i.e., it acknowledges the importance of mixing theoretical, practical and local knowledge across disciplines, sectors and communities. Therefore, it is deemed useful to turn to TD research, which is characterized by transgressing boundaries between research and practice, as well as working across scientific disciplinary boundaries (Hansson & Polk, 2018; Pohl & Hadorn, 2008).

In an NBS context, for example, expert knowledge about the functioning of specific ecosystems or species is as important as knowledge about human well-being and public health, as well as more philosophical knowledge perspectives on human-nature relations that concern how we as humans relate to nature, what it means to us, and how this affects our actions. This points to the need for combining insights from various disciplines through adopting interdisciplinary (ID) research approaches.

Equally important for NBS implementation is the inclusion of tacit, layman's knowledge, especially from the perspective that NBS is a universal concept that needs to be adapted to specific local contexts (Connop et al, 2016) and where local knowledge and experiences may turn out crucial for successful implementation. But also from the perspective that inclusive and participatory governance approaches may play an important role for broader public acceptance of NBS. This points to the need for TD research approaches which include various types of societal stakeholders, e.g., urban planners, civil society groups, residents, communities, and their knowledge. Transdisciplinarity is thus an interesting approach for widening the scope for learning and knowledge production, to enrich the scientific knowledge base on processes that underpin NBS implementation, and potentially also to narrow the research-practice gap.

This thesis adopts the “bricoleur” approach (Denzin, 1994),⁷ meaning that the researcher applies concepts irrespective of their disciplinary origin as long as they

⁷ In what is referred to as the blurred genres phase in philosophy of science, the researcher developed as a ‘bricoleur’; one who borrows relevant concepts and theories from different disciplines, which fits the inter- & transdisciplinary action- and practice-oriented research focus which underpins this thesis.

are found useful to advance a certain body of knowledge. For example, transformative learning theory (paper IV) originates from the field of adult education (cf. Mezirow, 1991) and is helpful to describe learning processes related to sustainability transformation processes in society. Another example is boundary work theory (papers I & V), with its origins in sociology, to discuss, e.g., problems related to demarcation within science and between science and non-science (cf. Gieryn, 1983), which is a useful probe when investigating translation and knowledge production in science, and at the interface of science and practice.

For ID sustainability-related research as a relatively general field of research, and as a cross-disciplinary basis for researchers from different scientific disciplines interested in systems thinking and urban systems, it is natural that cross-boundary concepts are applied. Any single discipline does not suffice to account for describing and understanding the complex social-ecological-technical systems that cities and societies represent. To my understanding, it is hence the explicit and intentional role of ID research to apply a broad range of theoretical and conceptual/analytical constructs to cross-fertilize different fields of knowledge, to advance understanding and identify solutions in the quest for more sustainable societies.

The term ID is sometimes interchangeably used with TD, or multi- or cross-disciplinary, which demonstrates the multiple ways of interpreting what these terms actually mean. This thesis adopts the view that transdisciplinarity has one fundamentally different and defining characteristic than the others, namely the active involvement and participation of other than academic stakeholders in the research process (Pohl, 2011; Vogel et al, 2020) because their experience and/or knowledge is valuable and key for the definition of specific problems and identification of their solutions. However, as noted by Sakao & Brambila-Macias (2018), TD research can either transcend disciplines, so called T1 research, and/or transcend academia so called T2 research. In other words, due to different interpretations of the term, research may sometimes be referred to as TD without necessarily involving non-academic participants, or that these are only marginally involved, e.g., as participants being interviewed.

This TD spectrum is partly related to methodological difficulties, such as the identification of the “right” stakeholders to involve, defining what meaningful involvement entails, e.g., by applying the criteria of mutual learning, and designing research processes accordingly (Kirby, 2019). However, it can also be explained through the broader challenge for sustainability research, namely that “tradition, reputation, and incentives do not require or even encourage stakeholder engagement in solution-oriented sustainability research” (Wiek et al, 2015, p.26).

TD research is a rather novel approach in the history of science. Tracing its ontological underpinnings is not an easy task. Transdisciplinarity has been compared to generalist practice and philosophy in that it, as epistemology and ontology do, seeks to see ‘the whole’, as opposed to a strict reductionist ontology

(Lynch et al, 2020). According to Lynch et al (2020), generalism and transdisciplinarity align in their “broad scope, relational processes, complex knowledge management, humble attitude to knowing, and real-world outcome focus”.

With a considerable focus on knowledge co-production, and how it can draw on and integrate different types of knowledge to be applied to real-world challenges that go beyond “siloed” or fragmented approaches, TD research could perhaps be primarily understood as epistemological rather than ontological. Or an ontology heavily underpinned by its epistemological principles. It may in fact, in managing complex knowledge settings, draw on several ontologies from different scholarly traditions within both natural and social sciences.

Thus, what unifies TD approaches is their focus on knowledge integration, i.e., their viewpoint that the combination of different types of knowledge is necessary in order to produce socially relevant, credible and legitimate knowledge for solving societal challenges (Hansson & Polk, 2018). Hence, it is less interested in a priori knowledge about the nature of social reality but rather seeks posteriori knowledge acquired from experiences, observations and interpretations, i.e., knowledge derived from the real world, to be applied to the same.

The TD research emphasis on action-oriented knowledge, co-produced by various social actors, rests on both pragmatic and constructivist foundations. However, differences between epistemological traditions may pose barriers to inclusive forms of integrating and governing knowledge in real-world settings of environmental governance. Obermeister (2017) proposes the concept of ‘geographies of knowledge’ in which the conflict between “the universalizing drive of positivist epistemology and the localism of relativist and constructivist epistemologies” impede the integration of non-scientific knowledge (e.g., local and tacit knowledge). ‘Geographies of knowledge’ and its resulting barriers and how to overcome these in pursuit of TD and actionable knowledge, will be further addressed (cf. section 5.2).

3.1.4 Research design

The research design is best described by using a metaphor I heard through a former colleague, who described a certain project management process as a “cinnamon bun”, which also resembles the planning and execution of this research in iterative cycles, back and forth. This is also reflected in hermeneutics and the iterative circles of interpretation and understanding of the empirical material (cf. 3.2.2.2) to reach a point of saturation, and more importantly, to gain a deeper understanding of the topic being studied.

To fulfil the objective of this research and respond to the research questions, this thesis has included qualitative literature reviews (papers I & II) and different types of case studies (papers III, IV & V). These studies have been performed in the

methodological domain of interpretative research and participatory research, respectively.

The research has taken place within the frames of three different research projects (Urban nature, Naturvation, City-to-City learning lab), interested in how NBS are enabled and constrained in urban contexts. These research projects have, to various degrees, included inter- and transdisciplinary methods and involved stakeholders other than researchers.

Each individual study of this thesis has applied analytical concepts or theoretical constructs related to the thesis framework and conceptual background (section 2), both for framing and analysis purposes. The table below provides an overview of the papers, their methods and analytical/conceptual frames, and the specific aims of each paper (table 3).

Table 3: Overview of papers, their methods, analytical/conceptual frameworks, and study aims.

Nr	Paper	Method	Analytical/ conceptual framework	Aim(s) of study
I	Working on the boundaries—How do science use and interpret the nature-based solution concept?	Qualitative review; structured and interpretative analysis	Boundary work	To study the scientific use and interpretation of the NBS concept
II	Advancing the implementation of nature-based solutions in cities: A review of frameworks.	Qualitative review; content analysis & hermeneutic interpretation	<i>Inductive, conceptualizes implementation</i>	To 1) investigate how NBS frameworks address implementation, and 2) identify the key elements and conditions for enabling the implementation process
III	Environmental and climate policy integration: Targeted strategies for overcoming barriers to nature-based solutions and climate change adaptation.	Transdisciplinary learning lab; applied participatory analysis	Environmental policy integration; mainstreaming strategies	To explore how NBS are integrated into urban planning and governance practice
IV	Seeds of transformative learning: Investigating past experiences from implementing nature-based solutions	Qualitative; interpretative case study	Transformative learning analytical frame: visionary ideas & strategies, stakeholder participation and institutional arrangements	To investigate how transformative learning is enabled and/or constrained in the processes of NBS implementation
V	Collaborating for nature-based solutions: Bringing research and practice together	Qualitative embedded research; participant observation, 'network compass' analysis	Boundary work; transdisciplinary co-production of knowledge	To reflect on the challenges and potentials of transdisciplinary collaboration and knowledge co-production

3.2 Research methods

3.2.1 Methods for data collection

This thesis has applied qualitative methods for data collection.

The literature reviews (papers I & II) used bibliographic databases (Web of science and Scopus) and specific search terms to retrieve peer-reviewed scientific publications for the analysis. Certain screening and selection criteria were used to ensure the final sample/set of articles for further coding and analysis.

The case studies include the following methods for collection of primary data: semi-structured interviews, presentations and workshops, videos, mobile labs and site visits. Interviews and presentations and workshops were recorded and transcribed. Field notes were used to complement the interviews.

In addition, grey literature and various policy documents were used as secondary data, for example to provide background material and overviews of the study cases and their contexts.

3.2.2 Methods for data analysis

Methods for data analysis concerns selection of a method(s) which is aligning with, and grounded in, the ontological and epistemological perspective(s) that the researcher holds. It includes the concrete work of analysis, and selection of certain protocols, tools, software or constructs to perform the analysis.

This thesis applies qualitative methods to analyze the data/empirical material. These include qualitative content analysis, qualitative interpretation, applied participatory analysis, and participant observation.

3.2.2.1 *Qualitative content analysis*

Qualitative content analysis is a method for systematically interpreting and describing the meaning of qualitative material (Schreier, 2014). It is technically performed by coding the material, either deductively and following established coding categories (coding frame), or inductively by extracting themes, ideas, narratives, and/or elements present in the empirical material and in coherence with the aim and research question(s).

The analytical process in paper II builds on qualitative content analysis (Schreier, 2014) and inductive reasoning (Brinkmann & Kvale, 2015), and will be used to exemplify this type of analytical process. First, a coding protocol was developed to code the characteristics of the studied frameworks. Second, the articles were clustered in accordance with the four main phases of the urban planning cycle:

strategic planning, implementing, maintaining, and evaluating. For each phase, a corresponding clustering category was developed and defined. The four clusters served to identify and define the targeted foci of the frameworks and select those addressing implementation. After clustering, seven articles remained for in-depth analysis. Third, central “carrying” themes, or narratives, were inductively identified, extracted and interpreted. This was done by working in iterative circles of interpretation and moving between the parts (or system components) and the structure (or system), to identify common themes across the empirical material, as well as specific accounts, which were interpreted as relevant and meaningful in relation to the aim of the study.

3.2.2.2 *Qualitative interpretation and hermeneutics*

Papers II and IV are grounded in the qualitative interpretation tradition. The choice of method for interpreting the data in paper II is inspired by hermeneutics and interpreting meaning. Gadamer (1960) introduced the hermeneutic circle for which two principles are important. The first revolves around the relation between the meanings of system components and the larger system; we move between these two levels in iterative steps in the interpretation process. The second principle refers to the relation between preconception and comprehension. Our own knowledge and experiences interact with the knowledge of others when interpreting new meanings and perspectives within a given discourse (Bergström & Boréus, 2012). Throughout the analysis, the two principles “perform” in the interpretation process, where knowledge within the observer and the observed unite in new knowledge horizons (Alvesson & Sköldberg, 2008).

Including pre-understanding as an interpretation-enhancer and horizon-expander in qualitative research and knowledge production (Alvesson & Sandberg, 2022) requires transparency about the pre-understanding. Paper II therefore provided an explanation of the authors’ own experiences and pre-understanding. In my case, my preconceptions are based on my own professional experience within the field of urban planning and governance, and on knowledge/experiences acquired through the research projects. In this sense, and leaning on the traveler metaphor forwarded by Brinkmann & Kvale (2015:58), one could perceive “the... [interpretation of material] ... and analysis as intertwined phases of knowledge construction”, in which the preconceptions and values of the researcher have impact on the knowledge constructed and produced. Knowledge, in this context, is therefore inter-relational and inter-subjective (Brinkmann & Kvale, 2015).

Gadamer and Ricoeur and other modern/post-modern scholars who were inspired by the hermeneutical tradition of the humanities, which originated from exegetic studies that sought to interpret and understand the Bible and other literary texts, further developed the hermeneutic tradition to include not only texts in the stricter sense, but all kinds of representations of texts, including interviews, discourses and actions. While Gadamer introduced the central ideas around prejudices

(preconceptions) and context for understanding, Ricoeur placed ‘meaningful action’ at the forefront of hermeneutic interpretation and analysis (Brinkmann & Kvale, 2015; Ricoeur, 1994). From a conceptual perspective, hermeneutics highlight knowledge as something produced, relational, conversational, contextual, linguistic, narrative and pragmatic.

Following 20th century philosophers like Heidegger, Wittgenstein and Dewey, knowledge is not to be studied as an isolated, abstract and disembodied phenomenon, but rather to be understood by its contextual relation to human beings as active, experienced and knowing agents. A fundamental ontological issue that underpins this view on knowledge is thus “what is the mode of being of the entity who understands?” (Ricoeur, 1994). Hermeneutics thus takes a more constructivist, pragmatic, epistemological perspective, as opposed to positivist and realist conceptions of knowledge as objective and possible to extract. It believes that new knowledge is continuously constructed through iterative cycles of conversation with, and subjective interpretation of, ‘texts’ (as narratives and/or actions) by others.

3.2.2.3 Applied participatory analysis and transdisciplinary learning lab

Paper III is based on applied participatory analysis (Burns, 2007; Glassman & Erdem, 2014) in the context of a transdisciplinary learning lab established and run in 2018 based on the participating municipalities’ own needs and desire for increased knowledge exchange. The lab involved five Swedish municipalities and three research institutes, and the participants jointly engaged in all phases of the research process. The aim was to explore, compare and learn from the integration of nature-based approaches for CCA into municipalities’ daily planning and governance practices. The data was collected through a series of joint workshops and field visits, participatory observations, group discussions, interviews and videos. For the analysis of data, a jointly developed framework for policy integration/mainstreaming was applied.

3.2.2.4 Participant observation and embedded research

The method used in paper V is inspired by participant observation (Spradley, 2016), which has been described as interactionism, with pragmatist emphasis on practice (Rock, 1979), and involves, e.g., spending time working with people to understand their actions in a specific context (Laurier, 2010). In the vein of ethnographic research, I took the position of the "embedded researcher" who takes active part in the project process (a local innovation partnership on NBS), while simultaneously making observations from within the process (Mattor et al, 2014), with a focus on components, key themes and challenges of transdisciplinary collaboration encountered throughout the duration of the observed process.

3.2.3 Ethical considerations

The data collected in papers III and IV did not include any sensitive personal data as defined by the EU General Data Protection Regulation (GDPR), or cause harm or burden to the research participants following the Swedish Ethical Review Act (2003:460). All research participants provided informed consent to participate in the research/study. The research projects have been carried out in accordance with current ethical guidelines provided at LU to ensure that all collection, processing and handling of data has not violated any ethical guidelines and has followed good research practice.

There could be risks related to the sharing of information, knowledge and experiences from the part of the participating practitioners. Research participants share personal opinions and experiences about the working reality within public administration organizations, which is often subject to contesting perspectives and existing power relations within the organizations. On the other hand, these are political organizations and societal institutions, subject to the principles of openness and equal treatment, which means it is important that these organizations can be critically examined in the interest of the common good.

The TD research project (City-to-City learning lab) was based on the method of applied participatory analysis, in which the participants were part of planning the research (needs/aims, questions and methods) and jointly producing and disseminating the research outputs and results. This could present potential problems as the practitioners, as co-authors of scientific journal article(s), appear with their names and affiliations, and the studied city cases appear in the material. It would thus be possible for anyone with bad intentions to backtrack who said what, even if quotes were anonymized and did not include any personal identity markers. This had to be considered when selecting quotes, to ensure that any information sharing was not potentially causing any burden or harm to the research participants. In addition, all the research participants took part in joint analysis workshops to discuss the results before revising, finalizing and publishing them.

Consequently, even in these types of research cases where “grey zones” might potentially evolve, the handling of data could become sensitive and thus require ethical considerations and discussions to avoid causing any harm or risk to the participants, especially when managing, storing, as well as publishing, the data. This is certainly something to carefully consider and discuss in TD projects, since these depend on collaboration and trust between researchers and practitioners.

Another potential type of ethical risk related to research involving practitioners and societal stakeholders is associated to “research fatigue” as a consequence of many research projects being carried out. I cannot assume, only hope, that research participants find it interesting to be part of conversations close to their professional competences and areas of expertise, and value having access to research platforms for knowledge exchange and learning purposes.

4 Key findings

4.1 Paper I

4.1.1 Objective and framing

This paper departs from the perspective that various green concepts have emerged in the last decades to operationalize the idea of sustainable development and are used in order to describe and communicate the interdependence between nature and society. Such concepts include, for example, urban green space (Jim & Chen, 2003), ecosystem services (MEA, 2005), ecosystem-based adaptation (CBD, 2009), and green infrastructure (Benedict & McMahon, 2006). The latest addition to the “green concept family” is nature-based solutions (Cohen-Shacham et al, 2016). From the perspective that policy and science influence the framing and operationalization of green concepts (Opdam et al, 2013), which play an important role in framing the form and content of sustainable green space governance (Erixon et al, 2013; Hansen et al, 2015; Wilkinson et al, 2013), the aim of this paper was to analyze how science interprets, frames and uses the NBS concept. We leaned on the concept of boundary objects (Star, 2010; Star & Griesemer, 1989), and applied the use, core ideas and granularities of NBS as analytical categories to explore the fragmenting and cohesive powers of the NBS concept in science.

This paper is grounded in the theoretical perspective of boundary work (Gieryn, 1983), which is useful for exploring instances in which boundaries between fields of knowledge or practice overlap, and where certain concepts are defined, contested or shifted. In this study we were specifically interested in understanding how the NBS concept is working on the boundaries of scientific disciplines.

The study is based on a structured, qualitative review (Hart, 1998; Ridley, 2012) of 112 peer-reviewed scientific publications using the NBS term.

4.1.2 Results

The first publication that includes the term NBS is from 2014, but most of the publications are from 2017 or later, which indicates the novelty of the concept and that NBS is an emerging field of research. The selected publications demonstrate diversity in terms of scientific journals and author affiliations (i.e., also including

organizations other than academic), but also regarding the type of NBS studied, at what scales, and land-use contexts considered, even though more than half of the publications consider urban contexts. Close to half of the publications were funded by the European Commission (EC), notably through the EU's 7th Framework Program. Furthermore, the EC is the most used reference for defining the concept, which most studies do explicitly (58%).

The review revealed a geographic bias towards the European context (46% of the publications), whereas 17% were geographically independent, i.e., conceptual papers and universal frameworks with a focus on different frameworks and typologies for evaluating and implementing NBS. Furthermore, most studies address at least one sustainability goal; flood mitigation and, respectively, functional ecosystems and biodiversity conservation being the most commonly addressed.

Empirical and modelling (and/or empirical modelling) studies are the most common types of studies. Regarding co-benefits and stakeholder involvement (two characteristics of the NBS concept), the publications typically focus on environmental benefits; few studies consider ecological/social/economic benefits combined, or involve stakeholders in the research approach.

The integration of the concept varies greatly across the publications. Most publications demonstrate a low level of integrating it (59%), usually focusing on ES or GI as the main concept, using NBS merely as a “buzzword”. Around one third of the publications integrate it to a medium level, typically using NBS as a complementary concept. Only 16 publications (14%) show a high level of conceptual integration, i.e., explicitly defining the concept, embedding the concept throughout the whole article, and exploring the concept in relation to other concepts (ES, GI), typically using all three, i.e., NBS, GI and ES.

4.1.3 Conclusions

Regarding the fragmenting and cohesive powers of the concept in terms of granularities, i.e., the tensions in the use and interpretation of the concept, three overlapping granularities were identified: temporal (the time it takes for the concept to enter science), ontological (the interpretation of what the concept means), and epistemological (how the concept is operationalized into science). With regard to temporal granularity, the uptake of the concept is clearly influenced by the EU research agenda with implications regarding who engages with the concept. On the other hand, the concept has proliferated into various research fields, indicating scientific diversification. Regarding ontological/epistemological granularities, the uptake of the concept is biased towards natural sciences. On the other hand, it has also been able to attract new research fields, such as health and environmental psychology. For ontological granularity, the interpretation of the concept is

connected to other related concepts (e.g., ES, GI), which facilitate the uptake and use of the concept. On the other hand, in many of the publications the NBS concept is operationally empty or biased towards a specific context.

A major contribution that the concept has brought to the “green concept family” is the idea of using nature to solve challenges. The openness regarding the variety of possible solutions addressed, and sustainability goals targeted, indicate that the concept is relatively easy to grasp and operationalize for science; two ingredients that characterize boundary objects (Jacobs, 1999).

This paper concludes that the NBS concept is used as an umbrella concept for other related green concepts and has a strong presence in research in the European urban context. It is derived from environmental and climate change policy agendas, resulting in a number of research and innovation programs, notably within the EU, and as such, is potentially influential for urban development contexts and local agendas for green space. In other words, a green concept spanning scientific disciplines and subject to ongoing definitional (i.e., translational) efforts, as well as working on the boundaries between policy, science and practice.

Based on the findings of how the NBS concept is interpreted and used in research publications, three future development pathways are suggested for the concept:

- Broader & deeper – it becomes its own, independent, concept with impact on real-world implementation of NBS
- Biased – it will have minor impact compared to other related concepts (ES/GI/EbA)
- Buzzword – it will have no impact, and is likely to be replaced by another concept

4.2 Paper II

4.2.1 Objective and framing

This paper departs from the view that scientific frameworks are part of steering scientific discourses and knowledge production (Entman, 1993; Opdam et al, 2013). Furthermore, delineation of frameworks relates to articulation of the focus and boundaries (van der Jagt et al, 2019), e.g., to the relation between NBS and other associated concepts. Frameworks thus play a significant role in the process of understanding but also guiding implementation of the concept. Frameworks can open up and allow for interpretative space and inclusion of diverse knowledge perspectives, which has been called for in the discourse on NBS. On the other hand, too narrow knowledge and research interests could act in the opposite manner.

On this basis, it is important to understand how NBS frameworks, in their capacity as knowledge steering devices which inform the implementation of NBS, are framed to address and overcome implementation barriers. This paper presents an in-depth analysis of implementation-oriented frameworks for NBS in peer-reviewed articles. The aim of this paper was to i) understand how frameworks for NBS address implementation, and ii) synthesize and present key elements and conditions required for enabling the implementation process.

The paper is based on a review of scientific publications which included frameworks for NBS (n=36). These were clustered according to the four main phases of the urban planning cycle (planning-implementing-maintaining-evaluating), which yielded seven publications/frameworks explicitly addressing implementation, which were subject to further analysis.

The paper used qualitative content analysis (Schreier, 2014) to identify central, “carrying”, ideas and elements present in the frameworks. It took an inductive approach (Schwandt, 2007) and used the hermeneutic circle (Gadamer, 1960) to interpret and understand the content and role of NBS implementation as framed in the studied frameworks, as well as more in-depth interpretation of their content (Stevenson, 2000). These “carrying” ideas were further elaborated as main elements and steps of the NBS implementation process.

4.2.2 Results

Even though NBS is a relatively novel field of research, a wide variety of frameworks for NBS has been developed. The types of frameworks range from, e.g., analytical, assessment and theoretical to conceptual frameworks. The review finds that, so far, few frameworks address the NBS implementation process. Only seven

of the 36 frameworks on NBS explicitly address and include concrete ideas, clear concepts and/or empirical data related to implementation.

All studied frameworks highlight the importance of co-design, co-creation, co-implementing for overcoming barriers related to knowledge, financing, and land ownership. The principle, or idea, of collaboration to advance knowledge is thus emphasized as one of the prerequisites for generating actionable knowledge required for the implementation of NBS.

The most prominently featured elements, although not unanimously depicted/framed across the different frameworks, were extracted and categorized under two broader analytical categories and framed as key elements. These include collaboration and co-creation of knowledge, the latter with a set of three sub-elements (steps): analysis of options and benefits, identification of key policies and actors, and exploration of financial options. Furthermore, each implementation process must be adapted to the local context, embedded in the wider planning and governance structure, and include broad stakeholder involvement.

4.2.3 Conclusions

This paper concludes that few frameworks address NBS implementation, which aligns with scholarly claims about a lack of action-oriented frameworks (Connop et al, 2016) and a lack of knowledge regarding the different stages of implementation (Dushkova and Haase, 2020). Continued investigation and conceptualization of the NBS implementation process is thus called for, for instance in terms of exploring more practical considerations around collaboration (e.g., which stakeholders to involve, when in the process, and what type of knowledge to target). Decisions regarding the type of collaboration, its objective and timing in the process, are important in that they affect how each collaboration partnership will be able to engage in what Albert et al (2019) refer to as joint problem formulation and understanding challenges. In other words, decisions that are relevant for ensuring cross-boundary understanding of how NBS can be applied to create multiple benefits across ecological, social, and economic domains.

This paper suggests that collaboration and co-creation of knowledge are key elements in the NBS implementation process, and are vital for shared and enhanced understanding of challenges, opportunities, and potential synergies of implementing NBS, and for building capacity at the local level for implementing and governing NBS. Here, it is also critical that each local collaboration effort defines the initial rationale for NBS implementation, the key actors to involve, and the role of formal planning/planners in order to ensure planning efficiency (Zingraff-Hamed et al, 2021) and socially inclusive planning and equity (Albert et al, 2020).

The paper argues that the integration of the NBS concept (i.e., translation) would benefit from being situated in relation to the iterative cycles of the urban planning

cycle (planning-implementation-maintenance-evaluation), to better comprehend at what scales of urban planning the integration and implementation of NBS is feasible, as well as to move beyond conceptual towards operational, action-oriented understanding. In addition, representations of such operational knowledge, e.g., frameworks, should address the process and target the “how”, i.e., the process of stakeholder collaboration and how to enable and facilitate it. Such considerations, a) are decisive for the type of knowledge included in the process of NBS implementation, and b) therefore address issues of power imbalances, inclusion and democracy.

Finally, the paper also raises concerns over a one-sided focus in research on experimentation to promote the transformation needed. It is suggested that future frameworks should account for both experimentation and formal planning to further develop operational knowledge perspectives and improve the knowledge base on how to advance implementation (figure 4).

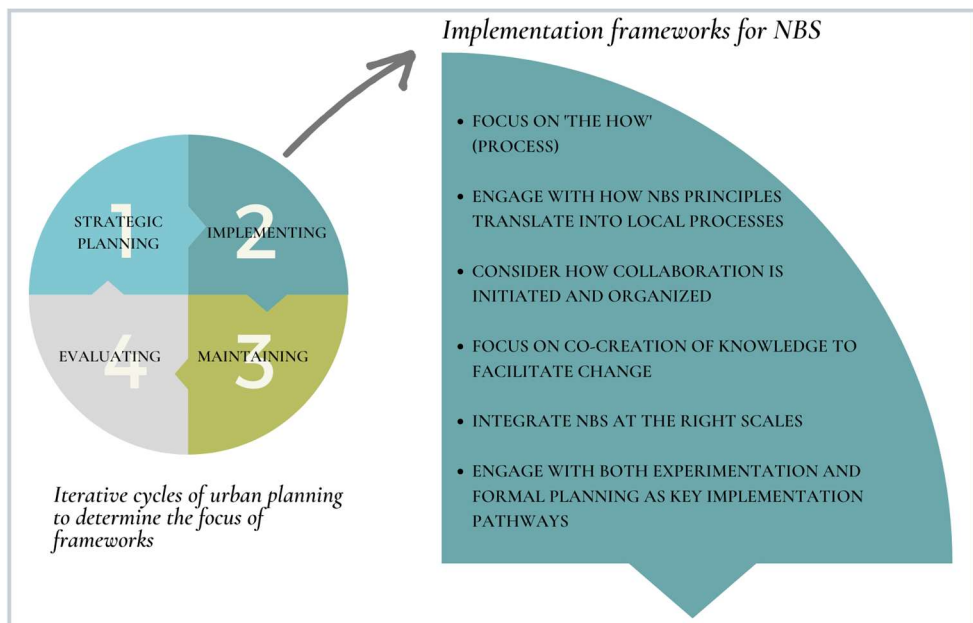


Figure 4: Applying a perspective of urban planning as cyclic and iterative may help to move beyond conceptual towards operational understanding of NBS and to establish key elements and necessary conditions for implementation processes thus overcoming some of the knowledge gaps (e.g., lack of action-oriented frameworks) and build capacity for NBS implementation.

4.3 Paper III

4.3.1 Objective and framing

The point of departure of this paper was based on the perspective that sustainable urban development requires improved understanding of how NBS for climate change adaptation (CCA) are managed and mainstreamed, or integrated, into urban planning and governance (Hansen et al, 2015; Luederitz et al, 2015; Nordin et al, 2017). Such work has to take place at the municipal level, where international and national legislation and policies are translated into practice (Beery et al, 2016). Furthermore, nature-based planning and governance is challenging in that it requires transdisciplinary approaches (Nesshöver et al, 2017), and a focus on the political, administrative and institutional aspects of urban planning which are largely lacking in the NBS concept (Beery et al, 2016; Kabisch et al, 2016). As such, NBS have not yet been integrated in existing policy and governance processes (Connop et al, 2016; Pauleit et al, 2017). Since knowledge about governance processes with potential to support nature-based planning and adaptation through involvement of internal/external stakeholders is scarce (Brink et al, 2016; Wamsler et al, 2017), the objective of this article was to assess the role of governance strategies to overcome barriers for NBS integration in planning practices in municipalities in Scania (Southern Sweden).

This paper is based on applied participatory analysis (Burns, 2007; Glassman & Erdem, 2014) in the context of a transdisciplinary learning lab established and run in 2018 based on the participating municipalities' own needs and desire for increased knowledge exchange. The lab involved five Swedish municipalities and three research institutes, and with the participants jointly engaged in all phases of the research process.⁸ The aim was to explore, compare and learn from the integration of nature-based approaches for CCA into municipalities' daily planning and governance practices. The data was collected through a series of joint workshops and field visits, participatory observations, group discussions, interviews and videos. For the analysis of data, a jointly developed framework for policy integration/mainstreaming was applied.

4.3.2 Results

The results revealed that five main strategies are used by municipal staff and individual champions to tap into existing potentials and to overcome barriers to the integration of NBS in daily planning practices.

⁸ However, the writing of this article was led by the researchers, but all lab members were involved in discussing the analysis, and in the revision and finalization of the manuscript.

Targeted stakeholder collaboration is characterized by the targeted involvement of the private sector, academia and/or other local authorities to support single activities and increase policy support for NBS. This strategy typically involved external stakeholders to provide expert assessments or advice on, e.g., climate impacts or ecosystem services. While generally suffering from siloed work, municipal staff have, relatively, a considerable amount of maneuver space, increasing external funding and collaboration opportunities which facilitate the involvement of external stakeholders for advice or specific assessments, or to expand the knowledge base.

Strategic citizen involvement is characterized by engagement with a diversity of strategic and communicative activities aimed at increasing public awareness and avoiding contestation, e.g., planning walks, planning games, digital dialog, strategic use of media, public surveys, informal workshops, and continuous dialog with citizen groups. While there is a general lack of resources for comprehensive citizen involvement, NBS and CCA interest is growing among staff who are trained/educated in these topics.

Alteration of internal cooperation structures is characterized by changes to internal cooperation, working structures and capacities that aim to ensure the integration of NBS/CCA based on an internal paradigm shift; from silos towards more cross-sectoral work. In some of the municipalities this strategy was considered to be key to achieving change, and as directly linked to science-policy integration. The strategy is realized through, e.g., improving informal networking and communication, and pooling of financial and human resources (knowledge and various budgets), but also through intersectoral working groups and site visits for learning purposes. Some of the related barriers that this responds to include complex administrative and financial organizational structures, relevant knowledge/capacities for NBS/CCA dispersed throughout the municipal organization and not coordinated (i.e., sub-optimization), and lack of monitoring of NBS considerations (from start to end), and hence, missed opportunities for learning within the municipal organization. The latter is often further exacerbated by high staff turnover.

Outsourcing is a type of multiplying strategy, i.e., when municipalities offer information and advice to other (external) stakeholders, thus enabling and supporting them to implement NBS/CCA. While political and legal lock-ins hinder cooperation (especially related to the strong legal/financial/organizational division between private and public land/property), this strategy is realized through e.g., providing NBS guidelines and incentives for private property owners to take action.

Concealed science-policy integration is characterized by systematic science-policy integration aiming to mainstream NBS/CCA into informal/formal planning regulations and/or mechanisms/tools through creating momentum and putting pressure on both staff and policymakers to give due consideration to NBS/CCA in their daily planning practice. This can be seen as a response to the current lack of

planning frameworks and tools, or even a vision, for NBS mainstreaming/integration. When applied, often dependent on individual champions and increased expert knowledge on NBS/CCA, this strategy leads to incremental transformation of the policy landscape, e.g., manifested in development of policies, plans, tools, and checklists for detailed planning.

4.3.3 Conclusions

This paper revealed numerous barriers to the integration and mainstreaming of NBS in Swedish municipalities, and how municipal staff apply various targeted strategies to overcome them. In addition, three cross-cutting themes emerged from the results. These relate to: i) the role of individual champions as change agents; ii) the increasing focus on relational approaches to better address NBS and their integration in planning and governance; and iii) as a consequence, the need to support the development of cognitive/emotional capacities to foster trust, inclusive communication and social learning, which requires changes to the current regulatory and policy landscape (figure 5).

The results show that although there is much talk of NBS as an important pathway towards sustainability, it has not translated into adequate support for municipalities, e.g., through increased financial and human resources, or capacity for personal development and systematic mainstreaming.

In addition, the learning lab methodology provided insights about the role of knowledge co-production and research-practice collaboration for advancing understanding of NBS, i.e., through facilitating the exchange of experiences and building a common knowledge base across municipalities and across the research-practice divide, and through developing more relational capacities.

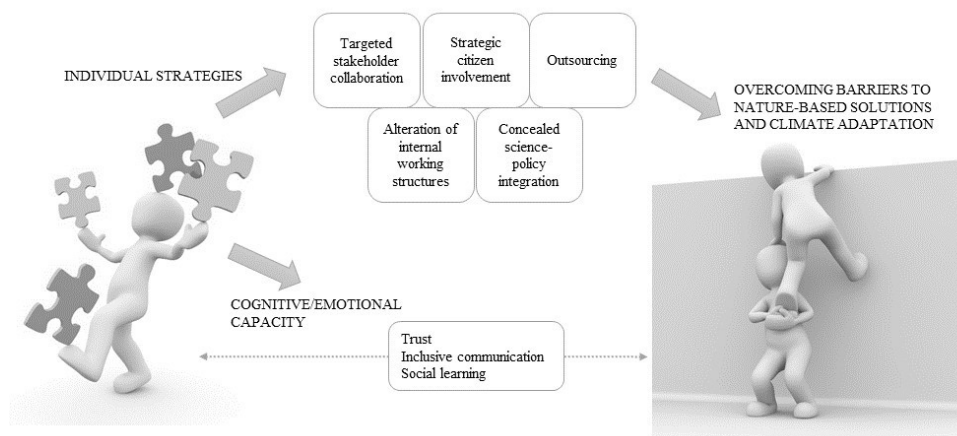


Figure 5: Different individual governance strategies to overcome barriers to NBS implementation and climate adaptation, which requires cognitive/emotional capacity for building trust, inclusive communication and social learning.

4.4 Paper IV

4.4.1 Objective and framing

Paper IV claims that research has not sufficiently addressed the role and potential of learning processes for the implementation and integration of NBS, specifically how transformative learning (TL) can spur radical shifts and unfold the transformative potential of NBS (Palomo et al, 2021). To analyze learning in processes of NBS implementation, this paper draws on urban transformation and sustainability literature and the emerging research on governing and experimenting with NBS in cities. Its central research question is: *How is transformative learning enabled and/or constrained in the processes of NBS implementation?*

This paper employs case study research design and explores past experiences from two cases of NBS implementation in Malmö, Sweden: the EcoCity Augustenborg and the BiodiverCity projects.

The data was collected as part of the research project NATURVATION.⁹ Primary data was collected through site visits and a mobile lab (Marvin et al, 2018) and 20 semi-structured interviews (Bryman, 2016), while secondary data was derived from academic and grey literature (e.g., Bowen, 2009).

4.4.2 Results

The analysis of visionary ideas and strategies, stakeholder participation, and institutional arrangements showed that the combination of interaction, committed people and organizations, and place – especially in terms of stakeholders' prior learning experiences and readiness for TL – continue to be of key importance for TL. Change agents and leaders are essential for fostering learning within the frame of innovative experiments and governance. However, for broader collective learning an active learning community is needed, in this study comprised of engaged network partners and citizens who capitalized on the learning opportunities and implemented, as well as maintained, new ideas and solutions.

The selection of sites for NBS experimentation was likely path-dependent, i.e., depended on prior municipal decisions. This can influence the opportunities for learning; areas previously exposed to sustainability projects might have better stakeholder engagement and citizen involvement and therefore be more advanced in terms of readiness, or capacity, for TL. At no surprise, NBS often lack citizen

⁹ NATURVATION (Nature-based Urban Innovation) was an EU-funded research project (2017-2021, GA#730243) involving 14 institutions across Europe. It investigated the potential of NBS in responding to urban sustainability challenges (<https://naturvation.eu/home>).

participation in new developments. On the other hand, these may provide important spaces for learning about more technical, ecological and economic aspects of NBS, e.g., quality, ecosystem function, maintenance and costs.

By analyzing the two NBS cases, specific enablers and constraints were identified and framed as ‘seeds of transformative learning’. These included change agents, citizen engagement, co-production of knowledge, maintenance perspective, and site selection. The table below summarizes in what ways these unfolded in the two cases.

Table 4: Seeds of transformative learning for NBS implementation identified in the two cases of NBS (the open storm water system in the EcoCity Augustenborg and the seashore green roof in the BiodiverCity project).

Change agents	<p>“early learners” are important for understanding knowledge gaps and learning needs</p> <p>action-oriented and committed individuals who drive transformation through experimentation which fosters reflexivity and learning</p>
Citizen engagement	<p>key for inclusive governance, enabling collective/social learning</p> <p>enables inclusion of local/tacit knowledge, which provides important learning input to collaborative processes</p>
Co-production of knowledge	<p>intensive collaboration and interaction on NBS across stakeholders and boundaries to foster iterative processes of knowledge exchange and mutual learning</p>
Maintenance perspective	<p>holistic planning perspective, which includes day-to-day maintenance practices as part of the full planning cycle, counters short-term thinking</p> <p>fosters organizational learning beyond end-of-project</p> <p>enables an evaluation of NBS which includes true costs and benefits of NBS</p>
Site selection	<p>path-dependency impacts selection of sites for experimentation</p> <p>risk of trade-off between capitalizing on prior learning opportunities and distributional justice and empowerment</p>

4.4.3 Conclusions

From a learning perspective, the main insight from the two cases is that NBS implementation aimed at urban transformation can be seen as acting on three levels which concur with first, second and third order learning. While experimentation projects that deliberately address societal changes and test new NBS seem to, by nature, go beyond conformative learning, i.e., simply reproducing knowledge to improve things, they are struggling to move from second to third order learning, i.e., from reformative to transformative learning. As regards interaction between committed individuals and stakeholders engaging in collaborative learning and knowledge production, the experimentation projects demonstrated their participatory, integrative and reflexive capacity that led to *doing better things*.

However, their power in terms of generating radical shifts and wider mainstreaming of NBS in urban planning and governance is less clear, in spite of successfully implemented NBS projects.

The two cases (and their wider project contexts) indicated that the city of Malmö has been gradually incorporating NBS into the urban environment during recent decades. Here, experimentation has been an important pathway for providing valuable spaces for learning, which have resulted in seeds of TL. These learning seeds include interdisciplinary and cross-boundary collaboration, action-oriented knowledge production, and citizen involvement, which seem important to enable TL for NBS implementation in urban areas. Moreover, in line with the literature on TL, interactivity and reflexivity are suggested to be key guiding principles for such learning-oriented governance.

Through highlighting the importance of evaluation, continuity and relational capacities for TL in the two cases, we concluded that these comprise institutional supportive structures, including innovative funding, which are fundamental prerequisites for establishing spaces/platforms for continuous and transformative learning.

All these aspects combined were synthesized into key enabling institutional structures and factors for TL (figure 6), which could be more systematically and strategically applied in future NBS implementation to unfold the transformative potential of NBS and to help mainstream NBS for climate mitigation and adaptation.

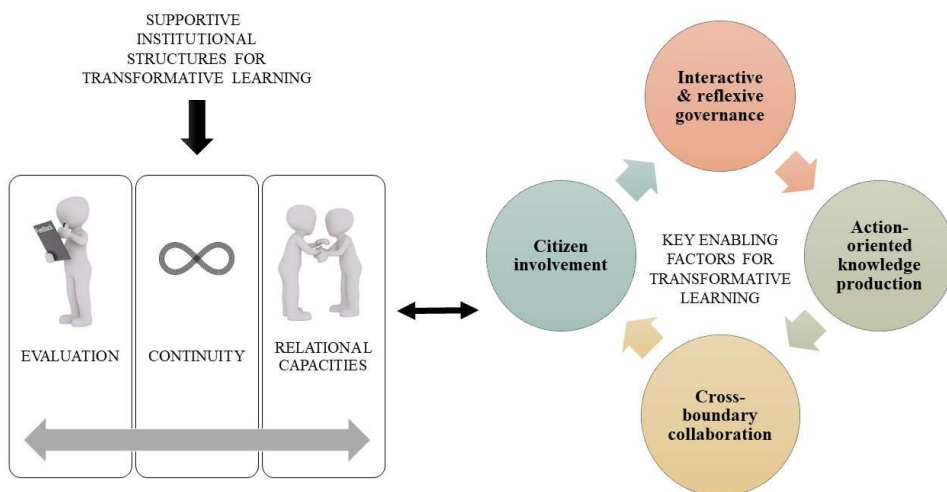


Figure 6: Key enabling factors, or seeds, and supporting structures for transformative learning which could be integrated in future implementation of NBS for continuous and systemic learning for nature-based urban transformations.

4.5 Paper V

4.5.1 Objective and framing

This paper aims to reflect on the process of transdisciplinary (TD) research-practice collaboration for NBS, and its associated potentials and challenges. The point of departure is that NBS is a relatively novel concept and real-world application has only started to proliferate, prompting the relevance of reflecting on this type of collaborative process and learning forwards from that, for future TD efforts in the field of NBS.

This paper analyzes one of the local urban-regional innovation partnerships (URIPs) within the Naturvation research project, which included urban planning practitioners, researchers, and public and private organizations/companies, and had the objective of understanding what NBS can achieve in cities and how to advance their implementation by collaborating with local stakeholders.

It draws on two streams of literature to frame these reflections: a) transdisciplinary (TD) research (e.g., Pohl & Hadorn, 2008), to reflect on the collaborative process of research and practice engaging in learning and knowledge co-production; and b) literature on boundary work/objects/concepts (Gieryn, 1983; Abson et al, 2014; Opdam et al, 2015), to capture the boundary-spanning nature of NBS as the policy concept that underpins the collaboration process, both in terms of boundary objects (the URIP platform) and boundary concepts (NBS).

This paper adopts a qualitative research approach and uses participant observation (Spradley, 2016) as methodological inspiration. In the vein of ethnographic studies, I take the position of the "embedded researcher" who takes part in the process while simultaneously making observations from within the process (Mattor et al, 2014). My own observations and grey literature were used to map the process, which then served as a basis for analysis and reflection. 'The network compass' by Schneider et al (2021) was used to identify and map 'fields of action' and associated potentials and challenges.

4.5.2 Results

The URIP process can be described through four main fields of action, each one including sub-actions/activities: joint problem understanding and building relations, visioning and creation of roadmap, targeted collaboration, and vertical/cross-URIP learning. Each field of action could be related to different opportunities and challenges related to the TD collaboration process, for example, challenges around building relations, related to creating trust, clarifying actor roles and ensuring inclusiveness. In other words, setting the scene for the TD process.

When developing a joint understanding of the problem, it was easy to relate challenges to self-experienced problems and impacts from climate change due to recent flooding events in the city. However, internal organizational structures (municipal and project-related) were more difficult to define and address. Another challenge consisted of defining the novel NBS concept in relation to other similar concepts already established in urban planning.

As for the visioning and creation of a roadmap, a ‘window of opportunity’ was envisioned for testing the NBS concept on two new developments. This process, including the creation of a roadmap with different steps forward, was owned entirely by the municipality. Here, a challenge was how to include the other URIP participants in the process. This was partly solved by engaging them in continued innovation and knowledge production tied to the selected thematic priorities in the roadmap, e.g., around mapping and assessing ecosystem services and NBS. This phase in the project was characterized by targeted collaboration, i.e., collaboration in smaller clusters, which led to more tangible output and activities focused on innovating/testing, learning, and knowledge production. Here, an additional stakeholder was identified as key for the continued process so was thus included. In the last phase, vertical learning and knowledge exchange took place across the six URIPs, e.g., workshops and study visits. Here, challenges related to process ownership, facilitation skills, setting and communicating clear objectives, especially in relation to learning.

A general challenge could be related to process ownership and the high expectations on clear communication and management which follow from that, highlighting that communicative capacity is essential, especially considering the (already) high degree of complexity and uncertainty involved in processes of urban planning and development.

4.5.3 Conclusions

The URIP served as a platform for exchange of knowledge and experiences between public and private organization stakeholders and researchers. It provided a “safe space” to explore NBS and its potential application, challenge existing planning norms and routines, and, through an innovative planning tool, integrate NBS into the complex process of urban planning and development. However, this last part of the process became less clear due to Covid-19, which resulted in a loss of momentum and put a halt to planned activities and potential societal impact. It also impeded a proper closure of the project with individual and collective self-reflection on the generated impacts, which is important for learning purposes in TD processes (cf. Pohl et al, 2017).

The key conclusions from this article are that research-practice collaborations require new competences; soft skills are hard to measure but vital; blurred and flexible roles calls for continuous reflection; and, education and hiring for transformation can pave way for building transformative capacity.

The paper suggests that the following aspects of TD collaboration need further attention to bring research and practice closer in future collaborations on NBS:

- Building relations for TD collaboration through trust, good communication, and flexibility requires relational capacities and communicative skills.
- Learning needs to be explicitly acknowledged as a central component for co-producing transformative knowledge, and as such, deserves due consideration and continuous joint reflection throughout the whole collaboration process.
- Specific skills and methods for facilitating and managing the process of TD co-production of knowledge are required; they should be considered an area of expertise and not taken for granted.

5 Concluding discussion

In the context of urban nature-based transformations, this thesis has been particularly interested in the role of experimentation, learning and knowledge production for enabling the translation and implementation of NBS. An overarching objective and three RQs were formulated along these key investigation themes (section 1.4). To explore these, this thesis has reviewed and analyzed the scientific interpretation, use and framing of the NBS concept to understand in what way research influences, or informs, the uptake and implementation of the NBS concept (papers I & II). It has also investigated the role of individual governance strategies for integrating and mainstreaming NBS in ordinary planning processes (paper III), and the role of collaborative governance strategies and experimentation with NBS for transformative learning (paper IV). Finally, based on one of the research projects, a concrete case of a local partnership for NBS implementation has been used to reflect about the challenges and opportunities related to research-practice collaboration for implementing NBS (paper V).

I start this chapter by presenting a key principle for urban transformations, which serves as a key message of this thesis (5.1). Based on that, and since transdisciplinary learning and knowledge production point to a challenging future for research and practice, I present three imperatives towards enhancing actionable knowledge (5.2). With these knowledge needs in mind, I return back to the thesis framework and discuss the enabling strategies for NBS translation and implementation that this thesis has investigated (5.3), and then move on to summarize my recommendations for research and practice (5.4). Finally, I present the contributions of this research (5.5), and then discuss limitations of the research and methodological reflections (5.6).

5.1 Cross-boundary collaboration – a key principle for urban transformations

This thesis indicates that experimentation and learning can act as enabling strategies for translation and implementation of NBS. These are closely related and converge around transformative learning to change knowledge perspectives and promote actions for integrating nature in cities. In other words, *collaborative*

experimentation and transformative learning leads to seeing and doing things differently.

A theme which cuts across the key enabling factors for translating and implementing NBS identified in this thesis, i.e., across collaborative experimentation, transformative learning and co-production of knowledge, is the principle of cross-boundary collaboration, which seems to be one main driver behind increased learning effects and generation of integrated, actionable knowledge for implementing NBS. In other words, in processes of translation and implementation of NBS, *cross-boundary collaboration is an underlying principle that drives and builds transformative capacity for nature-based urban transformations*. This aligns with, and further details, what is referred to as the potential to bridge stakeholders and knowledge across disciplinary and sectoral boundaries (De Vreese et al, 2016).

In conclusion, the boundary quality of the NBS approach resides in transdisciplinary processes, collaborative experimentation, transformative learning and co-production of knowledge; concrete translation activities that bridge stakeholders and diverse types of knowledge, which can translate into shared understanding, learning and knowledge for NBS implementation.

Thus, what can be described as the genius strategy behind the construction of the NBS policy umbrella concept relates to what has been articulated earlier; it represents an approach that addresses the need for action in both research and practice through requirements around the integration of practical, tacit and scientific knowledge. It forces new ways of thinking, or at least re-thinking, what a sustainable city is – and can be – but also addresses the process of how to achieve it, and with what knowledge. This is why NBS is more than a concept. NBS presents a smart strategy to revitalize the discourse and praxis around sustainable urban development and transformation, which is highly warranted to speed up the efforts towards reaching climate targets.

While this is the potential “magic” residing in the NBS concept, scholars have warned against a concept that is too loosely and vaguely defined and not understood in the context of existing similar concepts (e.g., ecosystem services, green infrastructure) (Nesshöver et al, 2017), both for risking opportunities of generating deeper knowledge on how to improve natural resources management, and for failing to make use of the concept’s potentially communicative and cohesive powers across different knowledge communities.

Since NBS are still just emerging in cities, and we have only started to gather knowledge and seeds of transformative learning for nature-based transformations, there is considerable room for further NBS development in research and practice.

5.2 Imperatives for actionable knowledge

This thesis argues that rather than trying to solve sustainability challenges in theory and expecting such knowledge will automatically be applied in practice, research and practice will increasingly need (and be required to) co-produce knowledge. This entails a shift in the role of research and practice and consequently a need for new methods and approaches aimed to solve real and pressing problems through collaboration between research, practice and other stakeholders and through the combination of various types of knowledge.

In acknowledging that TD co-production of knowledge is a challenging task, a set of three challenges, framed as *action imperatives* which have implications for research and practice, has been identified. These imperatives relate to the different types of knowledge needed to build transformative capacity for nature-based urban transformation, including the production of actionable knowledge to advance NBS implementation. They include cognitive knowledge needs (facts and understanding), normative knowledge needs (experiences and values), and practical knowledge needs (actions and learning) (cf. 2.4.3), which are called for when governing nature-based urban transformations (figure 7). All of these knowledge needs must be addressed to build transformative capacity for solving societal challenges. Here, both research and practice are needed since they contribute valuable, yet different knowledge.

In this thesis, the investigation of NBS translation and implementation in research and practice served as a case to understand that these knowledge needs and transformative capacity are interrelated and necessary to successfully implement and govern nature-based urban transformations. This prompts the following imperatives, which call for action for knowledge:

The cognitive/reflexive imperative (“*knowing*”) refers to the necessary task of each discipline/sector to embrace the complexity of social-ecological-technical systems and reflect on the individual contribution to systemic knowledge. It responds to the demand for inter- and transdisciplinarity and the need to diversify and increase the knowledge base on NBS.

The normative/value-based imperative (“*saying*”) refers to in the ways in which knowledge within each discipline/sector responds to societal challenges and sustainability goals. This requires shifts of normative knowledge frames, and acknowledgement of normative diversity and plurality of knowledge perspectives. The challenge here is to shift from an individual (disciplinary/sectoral) to a collaborative (inter-/transdisciplinary) focus, without abandoning any expertise or experience, and even though approaching this complexity includes uncertainty. This imperative responds to the need to overcome silos and fragmentation barriers.

The practical/collaborative imperative (“doing”) refers to the integration of practical, tacit and scientific knowledge and how to engage with other disciplines and stakeholders, e.g., through experimentation and learning processes. This requires action-focus, relational approaches and communicative skills for collaborative and participatory processes. In addition, end beneficiaries/non-beneficiaries and target audiences must be considered. This imperative responds to the need to include various stakeholders and diverse types of knowledge and also create broader acceptance for nature-based urban transformations.

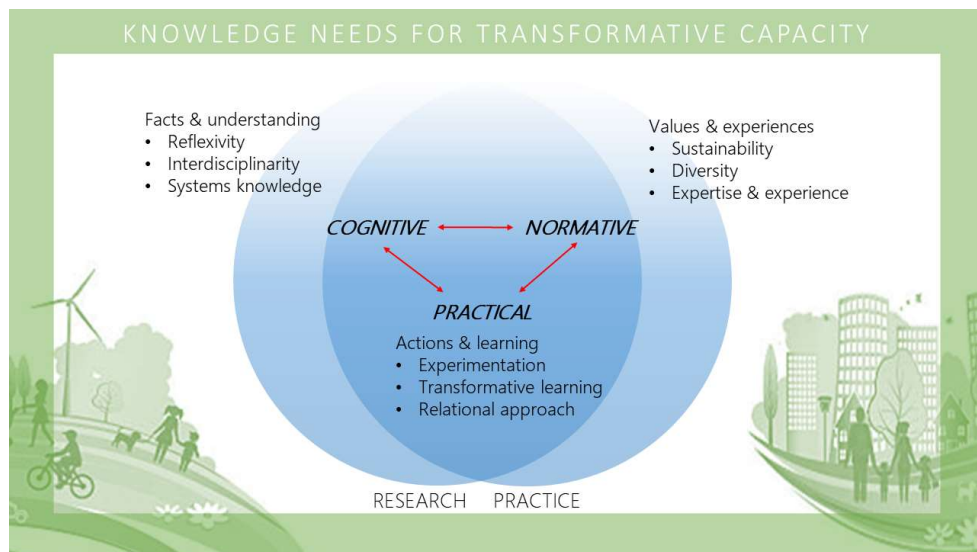


Figure 7: Action imperatives for research and practice. The imperatives represent the different types of knowledge which are interrelated and needed to enhance transformative capacity for nature-based urban transformations.

5.3 Key enablers for translating and implementing NBS

Along the overarching aim of this thesis – *to study in what ways the processes of experimentation, learning, and knowledge production enable and/or constrain the translation and implementation of NBS* – this section elaborates on the thesis framework, more specifically, how these governance strategies express transformative qualities, or characteristics, i.e., as collaborative experimentation, transformative learning and co-production of knowledge. These constitute key enabling strategies for translating, implementing and governing NBS.

This thesis suggests that the combined application of key enabling governance strategies, cross-boundary collaboration (as a key principle), and diverse knowledge perspectives, are important to drive the wheels of translating NBS into local

implementation and, more broadly, for building capacity for governing nature-based urban transformations (figure 8).

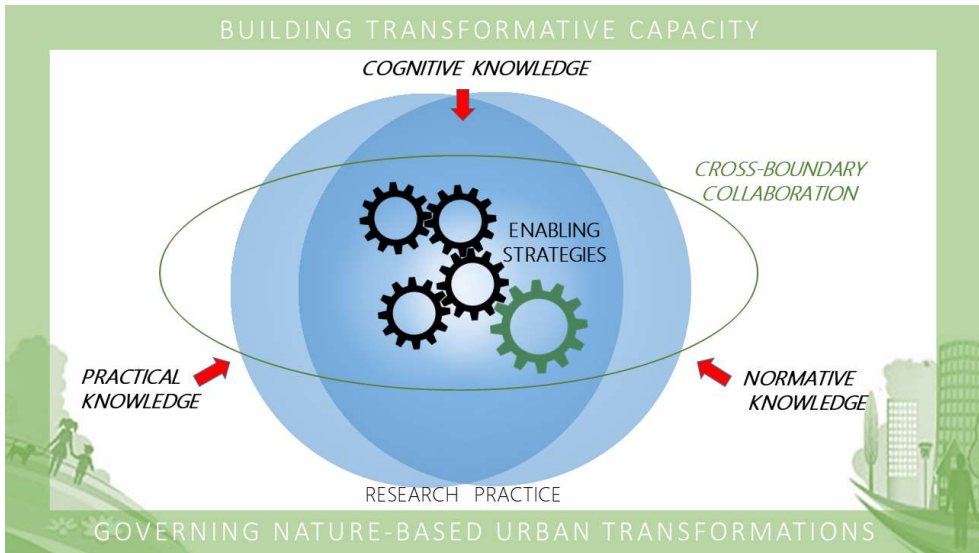


Figure 8: Elaborated thesis framework. Key enabling strategies, cross-boundary collaboration and diverse knowledge perspectives contribute towards research and practice, building transformative capacity for governing nature-based urban transformations.

This thesis has presented a framework around the translation and implementation of NBS which includes three strategic governance activities, or strategies: experimentation, learning and knowledge production. These strategies are interconnected in processes of governing and implementing urban NBS, which this thesis has investigated. These investigations have shed light on a key principle for governing nature-based urban transformations: cross-boundary collaboration (5.1). This key principle must be acknowledged and considered for successful NBS translation and implementation. This thesis furthermore argues, through the formulation of action imperatives, that cross-boundary collaboration for transformation requires the combination of cognitive, normative and practical knowledge (5.2). In other words, these are knowledge needs that must be addressed to develop actionable knowledge and build transformative capacity in research and practice. To enable such capacity building, governance strategies play an important role, i.e., the experimenting and associated (re)learning and knowledge development contribute towards building capacity for urban transformations.

Consequently, while NBS is a promising approach, it still needs to be translated and implemented for its transformative potential to unfold. The question, then, is how

experimentation, learning and knowledge production, seen as governance strategies, enable and/or constrain the translation and implementation of NBS.

Collaborative experimentation

This thesis has investigated how different experimentation strategies have been applied to enable the implementation of NBS. Here, it is possible to discern between individual and collaborative governance strategies, as well as challenges related to scalability and competencies.

Individual strategies result as a consequence of few resources and competencies available in municipalities (especially smaller ones), which makes change agents (individual champions) deploy targeted strategies to pool resources for enabling NBS implementation, e.g., through targeted stakeholder collaboration, strategic citizen involvement and alteration of internal cooperation strategies (paper III). This is possible through the relatively high degree of freedom, or maneuver space, for individual planners in Swedish municipalities, possibly linked to the strong municipal planning monopoly in Sweden.

As regards collaborative governance strategies, the two cases of NBS implementation in Malmö (paper IV), indicate that these experimentation projects enabled cross-boundary stakeholder interaction and provided valuable spaces for committed people and networks to engage in visionary, yet practically focused, processes and joint learning on how to integrate NBS in the built environment. However, even for collaborative experimentation strategies, individual change agents were influential for how these experimentation projects could evolve and lead to successful implementation of NBS.

What is interesting about both of these examples of individual and collaborative strategies for experimenting with NBS, is that their common denominator is to strive for *collaborative experimentation*; the strategic pooling of resources, stakeholders and knowledge to drive change. Together is stronger.

Through studying NBS, it has also become clear that there are two main pathways which are both potentially important for advancing the translation and implementation of the NBS concept, namely through applying strategic experimentation in both experimentation projects *and* formal planning processes, in individual innovation projects and in “the line”. This aligns with similar conclusions by Vogel et al (2020) and Geels’ (2007) ideas around the reconfiguration pathway. This may especially be the case in the Swedish context, where municipalities have a leading role in implementing and experimenting with sustainability concepts.

A challenge is that experimentation and implementation of NBS often seem to be treated as piecemeal approaches, limited in scope, which stands in contrast to the need for mainstreaming (Wamsler et al, 2020) and adopting solutions at landscape level (cf. Albert et al, 2019), thus creating networks of NBS for real impact and to achieve targets on adaptation and resilience. This clashes with a planning reality in

which land is developed and regenerated at smaller scales (often through detailed planning), and furthermore constrained by a sectoral approach to planning, in which each sector (transport, green space, housing, etc.) is sub-optimized at the expense of achieving synergies and systemic effects across sectors and connecting economic, social and ecological sustainability challenges. In this piecemeal and “siloe” (and reductionist) reality resides a fundamental challenge.

Therefore, this thesis argues that there are risks related to a one-sided focus on experimentation for implementation of NBS. It is suggested that future practice, research and framework development should account for both of these processes as relevant pathways, or platforms, in order to further develop operational knowledge perspectives and improve the knowledge base on how to advance the translation and implementation of NBS. A challenge here is how to bridge these two implementation pathways for synergistic learning effects and knowledge production. This is an area which warrants further research.

Finally, collaborative and reflexive governance models based on interaction and production of actionable knowledge, requires an increased focus on the type of skills, competencies and capacities needed for managing urban transformations (papers III, IV & V). This thesis concurs with, e.g., Frantzeskaki et al (2021) and Oliver et al (2021) on the need for additional resources for developing relational, cognitive/emotional capacities and facilitation skills. The ability to build trust and communication to enhance interaction and reflexivity in nature-based experimentation (and governance), and benefit from the learning and knowledge associated with such processes, is an important part of building transformative capacity for NBS (cf. Wolfram et al, 2019).

Transformative learning

The two cases of NBS experimentation investigated from the perspective of learning (paper IV) indicated opportunities for *transformative learning* (TL). The identified drivers of learning were therefore framed as “seeds of TL”, which suggests that there is a basis for TL to build on. However, these seeds need to be more systematically and strategically integrated and applied in planning and experimentation for the potential of TL to unfold and for achieving more deep-seated shifts in planning and governance in order to mainstream NBS.

There is emerging evidence that cities with experience in climate governance have developed transformative capacity (cf. Fitzgerald & Lenhart, 2016), i.e., “learned [how] to learn” (Neij & Heiskanen, 2021, p.13). However, the main challenge for Malmö and other cities is perhaps related to the establishment of TL as a key strategic component of NBS implementation and sustainable urban development. To fully capitalize on the accumulated seeds of TL, in Malmö and elsewhere, long-term strategies for TL, and more permanent organizational/institutional structures to support it, may be needed.

This points to the need to acknowledge learning as a key factor and creating conditions for it through learning-oriented organizational/institutional structures. To speed up sustainability transformations, more strategic and structured establishment and use of TL platforms are needed. Here, van der Jagt et al's (2019) NBS case study, which includes learning alliances on two levels/tiers, integrated in the design of the NBS project structure, provides a good example of how to create such conditions for reflexivity and learning. Indeed, this type of deliberate establishment of specific learning alliances at different levels as a key part of experimentation projects – as deliberate learning organizations – could allow for continuous and more structured and systemic learning processes.

Paper IV indicated that long-term commitment in terms of leadership, participating actors, and 'stable' funding leads to continuity in the process, which seems favorable in terms of generating continuous learning, but also for more practical aspects, such as facilitating hand-over of tasks and functions in the project and enabling incremental improvements, because it guarantees the presence of stakeholders – and their knowledge, skills and capacities – over time. Hence, continuity allows for a more systemic learning approach needed for TL, even though this is challenging to ensure in a reality of short-term politics and an increasingly mobile labor force.

In relation to institutional structures for TL, this thesis raises a few concerns. First, experimentation and learning-by-doing (Connop et al, 2016; Frantzeskaki, 2022) can provide a viable way for integrating NBS and generating learning through interactive, innovative and reflexive governance. However, the "projectification of experiments" (Torrens & von Wirth, 2021) leads to discontinuity, which puts organizational and social learning at risk: once a project has ended, another project starts, and hence, the potential of evaluation and associated learning is underestimated. Thus, continuity in terms of learning spaces, stakeholders and resources, i.e., the provision of long-term supporting conditions and structures for TL, is an important factor to avoid disruptive learning. Second, systematic evaluation of impacts and learning lessons, i.e., both outcomes and process, was largely lacking in the analyzed projects (paper IV). It could therefore be argued that learning from experimentation has, so far, been too slow considering the urgent need for transformation. Here, it could be useful to focus on the potential (and further development) of incremental change within existing regimes, which has been suggested to be more radical, i.e., transformative, than radical change within niche innovation (Dignum et al, 2020).

Urban planning remains a central domain to develop transformative capacity (Wolfram et al, 2019) based on its potential for cross-sector, multi-scalar and place-based action to resolve urban challenges by means of comprehensive and holistic systems approaches. However, both experimentation and formal planning as pathways for TL are not void of challenges; multiple barriers towards participatory, decentralized and reflexive governance and organizational TL must be addressed to increase capacity for learning. On that basis, a complementary pathway is

suggested: to continue the current practice of engaging in “evolutionary transition” (Wihlborg et al, 2019) seen in the BiodiverCity project, which combined new and traditional approaches, i.e., engaged in parallel with both experimentation and formal planning for implementing NBS (cf. Wickenberg et al, 2021). This learning pathway could render continued production of valuable seeds of TL to be strategically used when developing more structured and systemic approaches towards learning for nature-based urban transformations.

To summarize, learning needs to be more actively integrated in governance structures and approaches to build transformative capacity for unfolding the transformative potential of NBS. This requires increased focus on transformation as an ongoing cognitive/reflexive, normative/value-based, practical/collaborative, and emotional/relational process (figure 7). This in turn requires new competencies and more resources in practice. It also requires further research on learning as an active ingredient in, and driver of, processes of sustainable transformation.

The findings in paper IV indicate that fostering interactions between societal actors and institutions is key for learning and building collaborative capacity for implementing and governing new forms of urban infrastructure (such as NBS), or in other words, the ability to focus beyond technical solutions and acknowledge the transformative potential of stakeholder involvement and problem-focused interactions and associated learning processes (cf. Wolfram et al, 2019). Hence, collaborative, networked, and reflexive governance approaches for implementing and governing NBS need to be scaled up.

Co-production of knowledge

NBS research is a relatively new field and, as such, one line of the research in this field focuses on the conceptual understanding and framing of NBS, e.g., how the concept is defined and relates to other similar concepts, and how they come to matter in large-scale social-ecological (cf. Albert et al, 2019) or socio-technical systems (cf. Dorst et al, 2021; Mitić-Radulović & Lalović, 2021). Another research trend focuses on the type of solutions, their environmental impacts and delivery, and efficacy of multiple benefits (Hanson et al, 2020), predominantly discussing environmental functions and qualities from the perspective of broader societal challenges to be alleviated, such as climate mitigation and adaptation, resilience, functioning ecosystems, and biodiversity. Along these lines, recent research predominantly focuses on assessing the impacts and effectiveness of NBS in delivering co-benefits for cities (Frantzeskaki et al, 2019; Chausson et al, 2020). Thus, on the whole, research has mainly been concerned with the conceptualization and impacts of NBS with a focus on urban environments, along with the delivery and efficacy of multiple benefits, rather than its operationalization, implementation and management (Wickenberg et al, 2021).

One of the findings in this thesis is that NBS is an emergent concept, working on the boundaries between different disciplines and thus creating scientific inertia

(Hanson et al, 2020). From a Foucauldian perspective, this scientific inertia can be seen as a power struggle, where several disciplines claim to define the ‘truth’ and where discourses include contestation regarding how to conceptualize – or translate – NBS. This thesis is not excluded. One possible explanation for this is that different ontological traditions underpin the different research disciplines involved in translation of NBS.

The need to gather evidence to build the knowledge base on NBS has been highlighted in the European research and policy agendas on NBS. Being aware of neo-liberal positivist underpinnings of the notion of evidence-based knowledge, research should critically ask what type(s) of knowledge is needed to build this knowledge base. A key question concerns the applicability of such evidence-based knowledge. Thus, what is perceived as relevant knowledge to advance NBS? Do we need more knowledge about nature functionality, and/or do we need more knowledge about human agency and collaborative capacity for societal transformation? Alternatively, do we need more critical discourses around the contested nature of urban infrastructure and the power imbalances involved in prevalent social orders which impact urban planning and transformations? To conclude, it is relevant to ask what knowledge is required to reach the end goals and visions associated with the NBS policy agenda, including how that knowledge can be made relevant to broader society.

While researchers engage in conceptual, empirical, and operational knowledge production on NBS, this is paralleled by similar processes of knowledge production in practice, alternatively in transdisciplinary contexts (papers III & V). By returning to the categorization of different NBS frameworks (paper II) and the four broad iterative and cyclic phases of urban planning (design/planning, implementation, maintenance, evaluation), these can be used to distinguish the types of knowledge these phases are broadly oriented towards. Design/planning aims for high-level conceptual understanding, e.g., on how NBS relate to other planning concepts and how NBS can be integrated at landscape level. Implementation aims for operational/practical understanding, e.g., through experimenting and learning how to integrate NBS “on the ground”, either as experimentation projects or through processes of formal planning. Maintenance aims for “managerial” understanding, e.g., on how to manage NBS as a resource over time and change management practices accordingly. The evaluation phase aims to monitor and follow-up NBS interventions to develop empirical data and understanding of how NBS, both as a physical measure and as a planning and governance approach, performs, e.g., in terms of environmental, social, economic benefits.

A pluralistic knowledge perspective acknowledges the need for all these types of knowledge for advancing NBS implementation. However, for increased learning effects, it is important that cognitive, normative and practical forms of knowledge are interconnected and seen as equally contributing, and thus need to be fed back into the planning and policy cycle for further integration and overall transformative

learning for sustainability. However, challenges still remain in practice on how to systematically capture and make use of the learning and knowledge, e.g., from experimentation (cf. Vogel et al, 2020). This is related to the conflict inherent in the difference between the logics of change of “the line” (focused towards routines, keeping budgets, and solving problems within the organization) and “the project(s)” (experimentation-oriented projects which seek to create space outside the routines and structures to achieve change).¹⁰ Here, the extent of TD *co-production of knowledge* between research and practice could increase, to make better use of the various skills and capacities needed for transformation (Frantzeskaki, 2022).

This thesis concludes that there is a need for further development of frameworks for NBS, and sustainable urban transformations more broadly, which acknowledges the current challenges of translating conceptual knowledge and focus on how to facilitate processes for governing transformations (cf. Frantzeskaki, 2022), e.g., through developing action-oriented frameworks for NBS, including how cross-boundary and collaborative learning and knowledge co-production can be further developed and integrated as key elements of such implementation processes (paper II).

Knowledge production in research and practice are parallel processes but intertwined, highlighting the (partially) blurred boundaries between theoretical knowledge (*theoria*), and practical knowledge (*praxis*), i.e., the knowing and the doing. The four shades of knowledge, i.e., facts, understanding, practice, and experience (Lundgren, 1996), are different but intrinsically interconnected and relevant for understanding, operationalizing, and implementing NBS, especially in the context of sustainable development that is characterized by problem-solving in highly complex and uncertain socio-ecological-technical systems. This tendency of fusing theory and practice has been seen in the context of this research, in the projects and in the investigated cases of translation and implementation of NBS. This highlights the boundary character of NBS. The open and broad concept leaves room for interpretative flexibility, while simultaneously blurring the boundaries between research and practice and resulting in translation challenges, and, to quote a famous movie, with the risk of leaving research and practice lost in translation.

A central issue for co-production of knowledge is to move from theory to action, from critique to the development of alternative futures. Acknowledging the diversity of perspectives is critical in mutual learning processes; “intense exchange requires a deeper knowledge of one another’s positions and a flexible attitude with regard to one’s own position” (Pohl & Hadorn, 2008, p.116). The process hence needs to

¹⁰ “Oseglade vatten? – då behövs expeditioner!” [“Unnavigated waters? – then you need expeditions!”] Available at: <https://reglab.se/wp-content/uploads/2018/12/Holmberg-2019-Oseglade-vatten-d%C3%A5-beh%C3%B6vs-expeditioner-1.pdf> [Accessed on 26 Jan 2022]

include deliberate self-reflection, both from individual participants and jointly on the impact of the research project (Pohl et al, 2017).

Co-production of knowledge across boundaries requires skills in facilitating collective learning processes (paper V). Facilitation is needed to enable both knowledge exchange and reflexivity, and to manage conflicts (Pohl et al, 2010). Furthermore, it is also necessary to develop context-specific approaches in which stakeholders can build trust (Westin et al, 2014) and enable infrastructures that support training, facilitation and the creation of ‘safe’ spaces to promote trust and legitimacy (Palmer et al, 2020).

There are no silver bullets for solving complex sustainability problems. This thesis has pointed towards the need for pluralistic knowledge perspectives, systemic understanding of, and for, societal change, and therefore the need for increased interaction across disciplinary and sectoral boundaries. Here, key enabling strategies can be applied to continue learning and co-produce actionable knowledge and, ultimately, build capacity for nature-based urban transformations.

5.4 Recommendations

An ambition of this thesis is that the combined focus on research and practice helps to shed light on how research and practice can further strengthen cross-boundary collaboration to build the knowledge base and advance NBS implementation. Therefore, this section summarizes and lists recommendations for research and practice.

5.4.1 Recommendations for research

The main recommendations for research based on this thesis are summarized here in these key points:

- It is important to gather evidence and build the knowledge base on local implementation of NBS for continued framework development, e.g., through further case studies investigating in what ways NBS can be translated, and comparative studies seeking to synthesize learnings across studies and research outputs.
- To move beyond conceptual towards operational knowledge on NBS, frameworks on NBS implementation should include a stronger focus on how to govern the implementation process, e.g., in terms of facilitation of collaboration and co-production of knowledge.

- Processes of both formal planning and experimentation should be considered as important pathways for implementation of NBS and therefore included in future frameworks on NBS.
- More research is needed to better understand how cognitive/emotional capacities and relational approaches can support building relations and trust in processes of NBS implementation.
- Further investigation of how TL can enhance NBS implementation could be structured around the principles of cross-boundary collaboration, action-oriented knowledge production, interactivity and reflexivity.
- TD research demands a new role for research, which stands in a good position to support practice, e.g., with methodological, analytical/reflexive, and communicative skills in TD processes.

5.4.2 Recommendations for practice

The main recommendations for practice based on this thesis are summarized here in these key points:

- Implementation is a key stepping-stone for integrating and potentially mainstreaming NBS; it requires transfer of learning and knowledge between experimentation projects and formal planning.
- For successful implementation, NBS must be integrated at the right scales in relation to the planning cycle and the wider local context of governance, e.g., by joint mapping of the planning process to get a shared understanding of the barriers towards implementation.
- TL can be enabled through methods/approaches that include cross-boundary collaboration, action-oriented knowledge production, interactivity and reflexivity.
- To make better use of the TL potential of NBS implementation, it is key to provide long-term institutional/organizational structures for TL that support continuity, evaluation of both process and outcome, and strengthen relational capacities.
- Reflexivity, communication and facilitation skills are key competencies required in urban planning practice to develop further collaborative and transformative capacity for nature-based transformations.

- Integrating and implementing NBS and applying TD approaches is challenging in terms of time and resources, and thus need further financial, institutional/structural support, as well as supporting policies and visions.

5.5 Research contributions

5.5.1 Conceptual contribution

In this thesis, operational understanding is argued to be largely left outside the academic discourse and thought of as a process owned by local stakeholders and experts, as an aspect mainly for practitioners to define. This has been highlighted by other scholars as a gap of action-oriented knowledge on NBS (Dushkova & Haase, 2020; Connop et al, 2016). In addition, Woroniecki et al (2020) argue that it is unclear how NBS can bring about change as little is yet known about the processes that underpin their design and implementation. It is in this space that this thesis has contributed perspectives.

Throughout the process of understanding how research addresses NBS and its implementation, while in parallel following and investigating real-world implementation, this research has engaged in what could be framed as “translating back to research” and contributing relevant perspectives on some of the elements and steps of the implementation process. I call this contribution *conceptualization of implementation*, or the conceptualization of operational knowledge, which aims to move the NBS discourse beyond conceptual towards operational understanding.

To advance operational knowledge, this thesis has argued for the relevance of adopting a process perspective to improve understanding of how transformative learning and co-production of actionable knowledge can be generated through stakeholder interaction and collaborative and reflexive governance strategies for implementing NBS. This research thus acknowledges implementation as a key stepping-stone for NBS integration and potential mainstreaming, not merely as a final stage of planning and design left hanging in the air, unworthy of attention and deeper investigation.

5.5.2 Empirical contribution

The empirical contribution of this research mostly relates to how (parts of) the research has been undertaken, i.e., engaging in processes of research-practice collaboration and joint learning and knowledge production. In more specific terms, this thesis (partially) applied TD research approaches through various activities of testing and developing forms of collaborative learning and knowledge production.

These included joint workshops, site visits, analysis and reflection in the City-to-City learning lab; joint learning workshops across the local partnerships (URIPs) in the Naturvation project, e.g., testing a beta version of a NBS business model puzzle. These research activities have contributed towards testing and developing methodological approaches which are mutually beneficial to both research and practice, thereby addressing the need for the weaving of societal needs with conceptual knowledge on NBS and transformations in research, and then operationalizing these into structured processes of collaborative visioning, investigation, learning and knowledge production.

5.5.3 Practical contribution

This research has highlighted the need for relational approaches and cognitive/emotional capacities for building relations and trust in the processes of NBS implementation, especially since the latter seem to depend on the success of collaborative efforts. It has furthermore highlighted the importance of these skills and capacities as key competencies to continue learning and develop further transformative capacity in urban planning practice. This directly links to the demand for reflexive and collaborative governance approaches to enhance participation and increased social/transformational learning for nature-based urban transformations.

Some contributions to practice overlap with the empirical contributions, i.e., link to how this research has engaged with practitioners, and vice versa, for facilitating exchange of different types of knowledge and co-producing actionable knowledge (5.5.2). Here, I believe research stands in a good position to support practice with methodological and analytical/reflection skills and writing and communication skills (cf. Frantzeskaki, 2022).

To some extent this research has also contributed to practice through outreach activities related to the research projects, in other words related to how we as researchers work with societal impact and outreach to make the knowledge societally relevant. Along this research such activities have included, e.g., two seminars on the green and dense city, which attracted researchers, practitioners and decision-makers (the Urban Nature project), an online seminar on TD in practice, which included both researchers and practitioners (the Mistra Urban Futures SKLIP platform), and the making of short films with urban practitioners sharing their experiences (the City-to-City Learning Lab) with multiple uses, e.g., in a massive online open course (MOOC) on NBS – an educational training program for anyone, free of charge, with thousands of participants, including urban practitioners, from various countries worldwide.

An additional aspiration of this thesis is to contribute perspectives on how to narrow the research-practice gap. It does so through highlighting the roles of research and practice in jointly developing NBS as a TD field through increasingly adopting and

applying approaches for collaborative learning and knowledge production. While moving in that direction is a challenging task, this thesis has also framed three imperatives for actionable knowledge to promote broader shifts towards NBS in cities (5.2).

Lastly, this research has contributed indirectly to practice through providing prescriptive and normative research perspectives to elevate practical/operational considerations in NBS research. Additionally, it has highlighted the importance of TD approaches and collaboration between research and practice, with potential to translate into practice and future governance of nature-based urban transformations.

5.6 Reflections on the research

5.6.1 Limitations

The research in this thesis is in parts undertaken through case studies limited to the Swedish planning and experimentation context. I am highly aware that other local contexts may present other challenges based on contextual differences in relation to NBS implementation (e.g., planning norms, regulations, national legislative and planning frameworks, resources at hand). Therefore, this thesis acknowledges the tension between the production of generalizable knowledge and the context-sensitivity of urban experiments (Evans & Karvonen, 2014). Along ideas on knowledge consolidation within processes of urban transformation and co-production of knowledge (Frantzeskaki & Kabisch, 2016), there is, however, a value in contributing to the “systematic production of exemplars” (Flyvbjerg, 2006), to add to the growing knowledge base within NBS related research. Hence, the aim is not direct transfer of place-specific details but rather to learn horizontally about enabling and/or constraining factors and conditions for NBS. The case-based results presented in this thesis, may thus be relevant for research and practice relating to cities of a similar type in terms of scale, conditionality and context (Caniglia et al, 2017) and material and social parameters (Tabory & Ramaswami, 2020). In other words, this study is relevant and general enough to inform NBS implementation in comparable socio-political urban contexts. This has also been evident when comparing insights from various European cases in the Naturvation project.

This research is normative; it aims to elevate discussions and provide prescriptive action-oriented perspectives on how to advance implementation of NBS in cities. Here, my professional background and experiences in urban planning and governance has been both a challenge and an opportunity. Sympathetic to the real-world challenges of urban planning and governance towards sustainability, based on first-hand experiences of how “messy” and complex these processes are, I would argue that I am in a position to allow normative statements that regard where we (as

researchers and urban practitioners) ought to go to improve efforts towards sustainability.

However, conflicting societal goals and planning challenges are difficult to handle, and it remains important to balance the social, environmental and economic trade-offs when implementing NBS. This research has not provided in-depth knowledge on any of these three domains; rather, it has shed light on the processes of cross-boundary, collaborative learning and knowledge production as a prerequisite for the understanding and possible handling of such trade-offs. Hence, this research recognizes any practical and scientific knowledge that would contribute further understanding of the trade-offs involved in NBS implementation and how to balance and handle these.

5.6.2 Methods

Throughout this research there have been methodological struggles related to being a researching practitioner and handling possible biases. It has not always been easy to know which leg to stand on, and which logic to use: that of the urban planning and governance practitioner, or that of the emerging researcher in me?

Considering myself a reflective practitioner, I have been in a good position to sympathize with and understand the challenges around NBS implementation that I have been investigating. However, it has sometimes been a little difficult to know exactly how to avoid bias and adequately make use of and include my earlier experiences and knowledge from urban planning and governance in the research process. There is no evident methodological platform in established standards of academia for the type of practicing scholar I consider myself to be. Here, I found the words of Alvesson & Sandberg (2022) useful, around legitimate inclusion of pre-conceptions as horizon-expander as part of interpretative research, as long as the researcher is transparent of those pre-understandings. I have hence tried to provide descriptions of my pre-comprehension of key concepts being investigated, e.g., municipal governance and implementation, and specific aspects related to the cyclical character of urban planning (mainly addressed in paper II).

I also found the PhD course on TD co-production of knowledge provided by Mistra Urban Futures and Chalmers University highly valuable for learning about applied TD research and its challenges. The level of TD can vary. For example, some parts of this thesis have not engaged other than academic stakeholders, and thus not fully applied a TD approach.

Along the way, and with support from other scholars, I have found ways to combine the qualitative interpretative research approach with the experiential knowledge I carry in my backpack. Early on, my experiences certainly helped me appreciate the contribution and relevance of the research projects I was part of, and later to ground

and position my own research, e.g., in relation to transdisciplinarity, collaborative research processes, and urban sustainability and transformations research.

Qualitative research based on interpretation and inductive reasoning (Brinkmann & Kvale, 2015) unavoidably include subjectivity, which is sometimes subject to scholarly criticism. However, from a post-modern constructionist perspective, all conceptualizations and interpretations of social phenomena include elements of subjectivity through the use of language and the researchers' preconceptions when constructing meaning and understanding social reality, which, I would argue, is the case for most knowledge production in research today. Hence, it is important to emphasize that interpretations and conceptualizations in this type of research are not aimed at claiming undisputable absolute truths, but rather to, in the vein of improved understanding and continuous learning, welcome further scholarly scrutiny and contribute to further engagement, debate and development of the discourse on NBS.

5.6.3 Research framework

The thesis framework lends itself to some critical self-reflection. The construction of a framework around translation and implementation with focus on experimentation, learning and knowledge production, per definition, represents a tiny fraction of the complexity involved in the processes it seeks to capture. This means that the analysis is thus limited to a selection of identified key aspects (in the framework), which concur with my individual research interests, in turn affected by prior experiences in the field. There are certainly further relevant aspects, and streams of research, which relate to this area of research and can contribute relevant knowledge, e.g., around organizational leadership and management, change management, behavioral change, political science and governance, and knowledge on citizen contestation and participation processes. Thus, it is important to emphasize that the purpose of this research has been to contribute normative and action-oriented knowledge perspectives related to NBS implementation and discuss how policy concepts for sustainability can be translated and turned into action. From that perspective, the framework has been useful to analyze enablers and drivers of such processes.

Primarily, I see the thesis framework as an analytical tool: it helps conceptualize how a set of selected aspects around implementation relate, and how they affect each other. It has helped to situate and discuss the findings of individual papers in a wider analytical context. However, while an individual framework is limited, for me as a researching practitioner it feels more relevant to continue TD discussions on the key aspects that this thesis has highlighted, e.g., whether conceptualization of implementation is meaningful; if cross-boundary collaboration and transformative learning can help to overcome many of the identified implementation barriers for NBS; and whether wider adoption of TD approaches in research and practice add value for NBS implementation. What perspectives might be missing, and how do

these aspects stand in relation to other NBS research, and in relation to urban transformations research? I hope that my modest contribution will generate continued discussions in this domain.

I could have included a larger focus on policy processes in the framework, e.g., how different levels of policy interact and how that in turn influences translation and implementation of NBS in research and practice. At earlier stages of this research, the policy sphere was included, but later excluded for a more targeted focus on what I have been able to actually investigate. Future frameworks could thus investigate the interactions and feedback mechanisms between all the three spheres (policy, research and practice) resulting from implementation of a policy concept. It would be interesting to see, for example, how the relatively early efforts on NBS implementation in cities generate new knowledge and how this is fed back and affects policy development at various levels.

Yet another reflective remark concerns the possible inclusion of the politics of NBS; the tensions, power asymmetries, vested interests and conflict perspectives related to contested urban space and infrastructure, which I have experienced in practice but only indirectly addressed in this thesis. This is partly due to limitations and scope of the research (and the topic has furthermore been covered in a parallel study in which I have been involved). However, reflecting on my working experiences, these have always centered on processes of experimentation, formal planning, environmental policy integration, collaboration, silos and departmental fragmentation, and handling various goal conflicts. These *are* the very expressions of the tensions and contestations, i.e., the politics, involved in processes of translating and implementing sustainability. What is even more interesting, then, is to better understand the potential processes to overcome these barriers. This research has highlighted some relevant aspects to do so, even if further research and practice is needed.

5.6.4 Research approach

This research has intentionally focused on both research and practice, i.e., does not provide in-depth knowledge in any of these domains, but instead investigates how both are engaging in, and influencing, NBS implementation. This has been a useful approach when seeking to understand the reciprocal and sometimes “sticky” relations and blurred boundaries between science, policy, and practice involved in processes of translation of sustainability.

This research has also focused on inquiries around the “how”, i.e., adopted a process-focus. As a reflecting practitioner, this focus partly resulted from reviewing the NBS literature and identifying a general lack of operational perspectives. This could be explained through the novelty of the concept and that uptake in practice is still only emerging, and the basis for research therefore relatively limited. However,

it could also indicate that operational focus and urban planning perspectives are in fact underrepresented in NBS research, and therefore deserve more attention.

There might be limitations regarding some of the research perspectives presented in this thesis. I am certain that other related strands of research, e.g., land use and landscape planning, ecology, and systems analysis, as well as further insights from practice, can fill some of these gaps. On the one hand, such limitations may be attributed to the limited time span of a doctoral dissertation. On the other hand, it has been the deliberate intent to keep a broad perspective, holding both worlds alive. Throughout the PhD, I believed that this is where my research can contribute the most: as an intermediary (or translator!) feeding the discourse at the intersection between the two. The inclusion of practical perspectives as part of my research approach, can therefore be seen as a response to the often-reported silo-thinking and disciplinary divides. I therefore hope that this thesis makes a small contribution – even beyond the topic of NBS – to create understanding of how the research-practice gap related to urban transformations can be narrowed.

Here, however, I see some challenges. While academic discussions, and related forums, typically require long time spans and work in indirect ways (i.e., far from practice), the research-practice interaction through TD projects often provides more direct and two-way communication around problems, needs, and inquiries relevant to practice. In a way, this reality leads to parallel discussions in research and practice, and somewhere between. From a TD perspective, it would have been beneficial for both research and practice to increasingly establish and use common learning platforms for continuous communication, knowledge exchange, and knowledge co-production, with a close connection to the problems we seek to solve.

With that said, I am aware much more needs to be accomplished to change the current situation and thus narrow the research-practice gap. Scientific communication cultures and standards of academic publication and outreach must change. At the same time, urban planning and governance need to “open up” to a broader set of stakeholders and challenge departmental and sectoral silos. In addition, TD work is time-consuming and thus challenging in terms of resources that are already scarce. Understanding diverse stakeholder perspectives and engaging in TD co-production of knowledge *is* challenging. It requires mutual interest in collaboration, learning and building transformative capacity, and requires adequate skills and capacities for facilitating and managing such processes.

At the same time, in spite of these challenges, my experience is also that collaborative partnerships are continuously established (at least as projects), not seldom coinciding with those individual champions that this research has witnessed. This research strongly supports any efforts to further develop and extend such cross-boundary and collaborative undertakings between universities, cities and urban public and private organizations. These are real drivers of strategic governance for transformation and needed for developing more sustainable cities.

Regarding the increased focus on collaborative forms of governance, experimentation, learning and knowledge production, Rydin (2007, p.54) argues that “consensus is potentially inherent in the act of communication between stakeholders”. This highlights cognitive, relational and communicative skills as key components of successful TD research and practice. I concur with Rydin; however, I am not sure that consensus should always be seen as the final goal. In reality, it may be even more productive with capacity to handle diverging views, and methods/approaches to balance these, to generate important cross-boundary learning and new knowledge for advancing sustainable solutions.

In my view, however, this is not sufficiently highlighted in academic research and education. Students and future researchers will likely need to be better equipped to meet increased demands for facilitating and managing processes of knowledge co-production and balancing diverging knowledge perspectives. I believe Pohl (2011, p.618) was resoundingly right in his statement: “The future of knowledge production will see more inter- and transdisciplinarity.”

6 Main conclusions

This chapter finally presents the main conclusions of this thesis; a thesis which seeks to contribute knowledge and understanding on how to enable and advance NBS, and more broadly, how to build capacity for urban transformations. The conclusions align with the statement that cross-boundary collaboration is a key principle for successful translation and implementation of NBS and for building transformative capacity for nature-based urban transformations (5.1).

The main conclusions of this thesis and its associated research are summarized here in these key points:

- NBS is more than a concept; it is a smart strategy and approach to revitalize the discourse and praxis around sustainable urban development and transformation.
- The boundary quality of the NBS approach fosters transdisciplinarity, collaborative experimentation, transformative learning and co-production of knowledge, which enable the translation and implementation of NBS.
- Transformative learning is a key component of change and driver of knowledge production, and should therefore be acknowledged, and more seriously considered, as a catalyst for urban nature-based transformations.
- Collaborative and reflexive governance, as well as relational approaches, are important to generate transformative learning and actionable knowledge for NBS implementation.
- Transdisciplinary research is an approach that requires communicative skills and relational capacities for facilitating and managing collaborative learning and knowledge production processes, which include deliberate and continuous reflection on learning.
- Building capacity for nature-based urban transformations requires the combination of cognitive, normative and practical knowledge, i.e., systemic understanding, value-based and diverse understanding, and action-oriented collaboration and learning across disciplinary and sectoral boundaries.

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Epilogue

Now, what about the heron?

For some time I hadn't been able to spot the heron, as if it was trying to tell me something. So, on that day of practicing slow ontology and reflecting on human-nature interrelations, I headed for the most nearby storm water dam in my neighborhood. Just as I arrived, believe or not, in its most majestic appearance, the heron came in from the skies and landed, like an airplane, only meters away from me. A contemplative smile on my face, it's back, I thought.

Leaning on Ricoeur's idea of the 'hermeneutic self', but expanding it beyond human beings to encompass human-nature relations; we are inseparable, the heron and I, and perhaps the heron is only another self of me?

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The area where I live, has three water dams for storing storm water in the event of extreme rains to avoid risks of flooding. This type of nature-based solutions are gaining interest as a concept for climate change adaptation in cities. However, to unlock their potential for urban sustainability, conceptual ideas must translate into action. Integrating nature in cities can potentially bring multiple benefits, but requires collaboration, learning and

knowledge production across disciplines and sectors.

At the boundaries between research and practice, this thesis explores the translation and implementation of nature-based solutions with a focus on experimentation, learning and knowledge production. It seeks to advance knowledge about implementation processes that enable nature-based urban transformations and sustainability.