The potential for transformative adaptation

Collaborative spaces and collective value development in local climate adaptation

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Abstract

The need for climate action, adaptation and transformation in order to address the consequences and vulnerabilities of human-induced climate change and biodiversity loss has never been more critical. Current approaches to adaptation often revolve around technical responses to changing climate parameters. These approaches are vital, but climate adaptation also requires holistic and integral approaches to adaptation that require changes in the mindset, beliefs, values, norms and practices of people and organisations. Addressing these internal dimensions could provide deep leverage points for change and are a crucial part of transformative adaptation strategies. Aiming to understand the potential for advancing transformative adaptation strategies, I study the interaction and collaboration between relevant adaptation actors in two arenas: (1) climate service co-production processes and (2) blue-green infrastructure (BGI) planning processes. This thesis discusses how to address interests and values in adaptation, the role of collective values in adaptation, and the potential of holistic approaches to adaptation. It has combined co-production workshop methods with analysing collaborative adaptation efforts in actual planning contexts. The two perspectives highlight the importance of providing physical and collaborative spaces for negotiations between actors' values and interests and have proposed concrete ways of doing so. These spaces are particularly vital in actual planning processes. I have also emphasised the importance of conceptualising the internal dimensions of transformation in ways that resonate with people working in technical adaptation contexts. The actors in BGI development processes generally represent values associated with their professional mandates, responsibilities and objectives in local adaptation work. However, they can also develop collective value sets across sector interests. The main contribution of this thesis to the transformative adaptation literature is how it empirically shows the potential for collective value development and the opportunities in material urban infrastructures to implement new ways of thinking and working on local adaptation.

Samandrag

Behovet for klimaomstilling, -tilpassing og -handling for å kunne handtere konsekvensane av menneskeskapte klimaendringar og tap av biologisk mangfald har aldri vore større. Dette prosjektet utforskar korleis heilskaplege klimatilpassingstiltak og løysingar kan påverke klimaomstilling og samfunnsendring, samt handtere klimasårbarheit på lang sikt. I dag dreier klimatilpassing seg ofte om å finne tekniske og konkrete løysingar på kriser og risiko. Nokre løysingar vil krevje større endringar knytt til indre menneskelege dimensjonar som tankesett, tru, verdiar, normer, og verdssyn. Å ta omsyn til slike indre dimensjonar kan påverke endringsprosessar sterkt og er difor ein viktig del av klimaomstillings- og tilpassingsstrategiar. Med mål om å forstå potensialet for å fremje tilpassingsstrategiar som kan skape klimaomstilling og samfunnsendring, studerer eg samspel og samarbeid mellom aktørar på to klimatilpassingsarenaer, (1) samproduksjonsprosessar for klimakunnskap og (2) planleggingsprosessar for blå-grøn infrastruktur. Avhandlinga diskuterer korleis ein kan handtere interesser og verdiar, rolla til kollektive verdiar, samt potensialet heilskaplege klimatilpassingstilnærmingar kan skape. Eg analyserer både samproduksjonsmetodar i eit workshop-format og samhandling mellom aktørar i faktiske planleggingskontekstar. Dei to perspektiva viser kor viktig det er å skape både konkrete og mentale rom for samarbeid og forhandling mellom aktørar med ulike verdiar og interesser. Avhandlinga føreslår konkrete metodar for å skape slike rom, og legg vekt på kor viktig det er å beskrive indre dimensjonar på måtar som gir mening for menneska som arbeider i tekniske tilpassingskontekstar. Aktørane innan klimatilpassing i arealplanlegging representerer ofte verdiar knytt til yrkesfaglege ansvar, mandat og mål. Samtidig kan dei og utvikle kollektive verdisett på tvers av sektorinteresser. Denne avhandlinga sitt hovudbidrag til klimaomstilling- og klimatilpassingslitteraturen er korleis den empirisk viser potensialet for kollektiv verdiutvikling, samt mogelegheitene i fysisk urban infrastruktur som kan gi rom for å implementere nye måtar å tenke og arbeide med lokal tilpassing på.

List of papers

Kvamsås, H., Neby, S., Haarstad, H., Stiller-Reeve, M., & Schrage, J. (2021). Using collaborative hackathons to co-produce knowledge on local climate adaptation governance. *Current Research in Environmental Sustainability*, *3*, 100023. https://doi.org/https://doi.org/10.1016/j.crsust.2020.100023 (Kvamsås 30%)

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Contents

1. Introduction

In February 2022, the Sixth IPCC Assessment Report (WGII) stated that the need for climate action, adaptation and transformation has never been more critical in order to address the consequences and vulnerabilities of human-induced climate change and biodiversity loss (IPCC, 2022). Climate adaptation is increasingly embedded in policy and planning globally, but its implementation remains slow and needs scaling up in order to manage future climate risks (UNEP, 2021). Since humanity is collectively not adapting well to the climate it is changing, the need for climate action and strategies that enable societal change is increasingly evident (O'Brien, 2021). Based on understanding climate adaptation as a decisive part of necessary societal transformation processes (O'Brien, 2021), I investigate the potential of transformative climate adaptation in municipal area planning and how to advance actionable transformative adaptation strategies.

The need to understand transformative climate adaptation is rooted in the urgency to minimise the risk of maladaptation and climate change vulnerability (IPCC, 2022; O'Brien, 2021). It is equally crucial to promote adaptation measures that could help people envision and develop a just, equitable and sustainable future for all humans and other actors (O'Brien, 2021). Current approaches to adaptation often revolve around technical responses to changing climate parameters such as temperature change and precipitation patterns through improved water management, better infrastructure and new regulations (O'Brien & Selboe, 2015). These approaches are vital, but framing climate change as a technical problem has not generated action close to the rate, scale or depth that is needed to address its consequences (O'Brien, 2021; O'Brien & Selboe, 2015; Wamsler et al., 2021).

Implementing adaptation also requires human action that demands changes in the mindset, beliefs, values, norms and practices of people and organisations (Heifetz et al., 2009; O'Brien & Selboe, 2015). Addressing such internal dimensions of change can be aligned with an integral and holistic approach to climate change, viewing it as a human problem intrinsically linked to other global crises concerning health issues, poverty and biodiversity loss (Seddon et al., 2021; Wamsler et al., 2021). Addressing these internal dimensions could also provide deep leverage points for change (Wamsler et al., 2021) and is thus crucial for transformative adaptation strategies.

The concept of transformation is gradually becoming institutionalised in the vocabulary of scientific and policy communities that work to address the consequences, vulnerabilities and risks of climate change. Understanding adaptation as transformation could promote strategies that challenge established values, organisations and power structures (Pelling, 2011). However, there is still a broad range of understandings regarding the conceptual basis of transformation (Ajulo et al., 2020; Feola, 2015; Moore et al., 2021) and there is a need to ground concepts of transformation in empirical examples (Lonsdale et al., 2015). Also, research on the internal dimensions that affect transformation often focuses on private individuals or settings, while occupational groups and work-related contexts receive little attention (Wamsler et al., 2021). Aiming to contribute to these knowledge gaps, I empirically study municipal climate adaptation planning and blue-green infrastructure development in Norway, focusing on the interaction and collaboration between relevant adaptation actors.

Specifically, I investigate the interaction and collaboration between relevant adaptation actors in two arenas: (1) climate service co-production processes and (2) blue-green infrastructure planning processes. (1) The transformative adaptation potential of the co-production of local climate data connects to it being a participatory and collaborative approach, involving more actors and, therefore, more perspectives, values and interests in the data production process. It can therefore allow the development of new perspectives from actors who traditionally do not collaborate (Trainer et al., 2016). Climate services can be very technical and tangible forms of climate knowledge presented in models, calculations and figures. They also involve addressing different understandings, needs, communications and negotiations when developing, applying and implementing climate knowledge in municipal area planning (Hewitt et al., 2017). This makes it a suitable arena for studying the interaction and collaboration the relevant adaptation actors.

The co-production of climate science can encompass practices and understandings ranging from the deliberate collaboration to achieve a common goal to the acknowledgement of how science and society continuously shape each other (Bremer & Meisch, 2017). Both perspectives are relevant to this thesis: the first as a concrete research method and the second as a philosophical foundation. Building on previous climate service projects at NORCE, I have been part of a research team that has been developing a method and space to co-produce local climate knowledge. The events called *Klimathon* were hackathon-like workshops on adaptation in municipal area planning for practitioners and decision-makers from local, regional and national institutions, as well as researchers from natural and social climate sciences. Hackathons are a collaborative problem-solving workshop format. The Klimathons were arranged annually from 2018 to 2020 and were designed to address the different understandings, needs and negotiations between the relevant actors when developing and implementing local climate knowledge in municipal area planning. The first paper of the thesis (paper 1) reflects on the Klimathon co-production method and results.

The overarching Klimathon research theme concerning adaptation in municipal area planning resulted in the idea of (2) investigating municipal blue-green infrastructure planning from a stormwater management perspective. Stormwater management is currently shifting from building traditional grey stormwater infrastructure to ambitious plans for implementing holistic nature-based solutions such as blue-green infrastructure (BGI), aimed at addressing the growing social, technological and environmental complexity and uncertainty (Franco-Torres et al., 2020). Thus, the transformative adaptation potential of BGI planning connects to providing multiple co-benefits for a range of actors and its requirement for holistic stormwater management, planning and thinking (Alves et al., 2019; Frantzeskaki et al., 2019; Kvamsås, 2021; Raymond et al., 2017). Co-benefits constitute the additional positive effects and values that are achieved from a specific mitigation or adaptation measure (Sharifi, 2021).

While co-benefits and multifunctionality concepts represent holistic arguments for implementing blue-green infrastructure and promoting stormwater as an urban resource, they also represent the increasingly visible conflicting interests and values in stormwater governance (Finewood et al., 2019; Meerow, 2020). Holistic approaches to stormwater management are about resolving multiple issues simultaneously (Schuch et al., 2017), just like holistic approaches to adaptation involve solving multiple entangled global crises (Wamsler et al., 2021). Thus, understanding the co-benefits and holistic approaches to blue-green infrastructure development could help the development and implementation of holistic strategies for climate adaptation, which is regarded as critical for achieving further societal transformation (O'Brien & Selboe, 2015).

Three thesis papers (papers 2, 3 and 4) provide insight into municipal stormwater management and BGI planning in two Norwegian municipalities, Bergen and Tromsø, using qualitative research methods such as observations, interviews, document analyses and mapping BGI in urban landscapes. Bergen and Tromsø are two small to medium-sized cities in a European context in which human action will increasingly result in stormwater problems and the need for adaptation due to climate change and heavier precipitation combined with urban densification policies (Flores et al., 2021; Hanssen-Bauer et al., 2017; Hovik et al., 2015; Koning et al., 2020; Nyseth, 2011). The two cities have developed specific sector plans for alternative stormwater management, enabling different municipal sectors, professions and people to discuss, negotiate and collaborate on stormwater planning in new ways, thereby making this another suitable arena for studying the interaction and collaboration between the relevant adaptation actors.

1.1. Research questions

This thesis aims to understand the transformative adaptation concept (Ajulo et al., 2020; Feola, 2015; Moore et al., 2021) and ground it in empirical examples (Lonsdale et al., 2015). Few studies have reported on the implementation of transformative adaptation (Fedele et al., 2019). I would assert that there is a need to understand transformative adaptation strategies and have formulated three research questions framed within one broad overarching research question:

- *How can an understanding of adaptation as transformation be developed into actionable transformative adaptation strategies in local planning?*

Since transformative adaptation strategies require integral and holistic approaches that require changes in the mindset, beliefs, values, norms and practices of organisations and people (Heifetz et al., 2009; O'Brien, 2021; O'Brien & Selboe, 2015), I then ask:

1. *How can municipal and private sector actors address the many interests and values in local climate adaptation planning?*

The internal aspects of transformational climate action, such as values, could provide deep leverage points for change and require further knowledge development (Rosenberg, 2021; Wamsler, 2020). Also, research on the internal elements that affect transformation in occupational groups and work-related contexts requires greater focus (Wamsler et al., 2021). I therefore ask:

2. *How can the co-benefits of BGI highlight the role of collective values in adaptation?*

Acknowledging and addressing these internal dimensions of change processes while challenging the structural elements concerning multiple entangled global crises are part of the emerging holistic and integral approaches to transformative climate adaptation (Wamsler et al., 2021). Requiring more knowledge about holistic approaches to adaptation, I ask:

3. *How can the holistic stormwater planning ideal help actors understand actionable transformative adaptation strategies?*

1.2. Summary of papers

My research has resulted in four academic papers: The first paper is about the Klimathons and the co-production of local climate knowledge. The other three papers cover the alternative stormwater management and blue-green infrastructure (BGI) planning and implementation in two Norwegian municipalities, Bergen and Tromsø.

Paper 1 Using collaborative hackathons to co-produce knowledge on local climate adaptation governance

This paper discusses how collaborative climate hackathons can co-produce local adaptation knowledge and what the Klimathon co-production method reveals about local climate governance. While climate adaptation knowledge is advancing, adaptation is neither inevitable nor automatic, even where adaptive capacity is presumably high. Furthermore, while the co-production of knowledge is growing in popularity in social and climate sciences, there is little empirical evidence about the process of stakeholder involvement and co-production in the development of municipal adaptation strategies. The adaptation decision-making space is filled with voices from multiple sectors and disciplines. Thus, climate change adaptation requires collaborative and co-production efforts, employed in this context through two collaborative climate hackathons called *Klimathons*. The Klimathons attracted 73 and 98 participants, respectively, in Bergen, Norway in 2018 and 2019. The participants were practitioners and decision-makers from local, regional and national institutions and researchers from natural and social climate sciences. Their collaborative group work revolved around the challenges and solutions of local adaptation planning and uncovered how a diversity of key actors understand local adaptation work in Norway. The Klimathon interventions revealed significant disagreements and a divergent understanding of relevant laws, regulations and responsibilities between practitioners working in the same governance system. Though cross-sectorial interaction does not dissolve these divergences, they allow actors to renegotiate the boundaries between divergent knowledge communities. In conclusion, the Klimathons helped the actors to navigate the complexity of local climate adaptation by shifting the focus to how different actors make sense of and work on adaptation and showing the intertwining and interdependence of the potential drivers of adaptation.

Paper 2: Addressing the adaptive challenges of alternative stormwater planning

This paper investigates the adaptive planning challenges that emerge when shifting stormwater management from traditional grey underground solutions to planning alternative blue-green infrastructure above-ground and how municipalities can address these challenges. While the existing stormwater management literature investigates a range of technical, institutional and financial barriers to alternative stormwater implementation, this paper discusses how the shift requires a deeper understanding of holistic and flexible approaches to stormwater management, including the understanding of adaptive elements such as values, worldviews, mindset, interests, norms, beliefs, practices and approaches to change. The paper investigates the planning process of two new municipal sector plans for stormwater management in Bergen and Tromsø. In this context, the paper investigates adaptive challenges such as norms, practices, uncertainty and new ways of collaborating across sectors in alternative stormwater planning in Norway. The studied planning processes exemplify how the need to make stormwater measures legally binding in municipal planning processes changes work practices in the municipal water sector. A novelty of the paper is that it shows how water departments take leadership of formal planning processes and adopt the planning department´s language and working methods. Furthermore, the paper reveals that the studied municipalities promote cross-sectoral collaborative approaches that create space for professional negotiation and mediation and invite a deeper understanding of the interests and views of other actors. The paper concludes that such approaches could contribute to more holistic and flexible planning approaches, ensuring long-term sustainable stormwater management.

Paper 3: Co-benefits and conflicts in alternative stormwater planning: Blue versus green infrastructure?

Blue-green infrastructure (BGI) is often promoted for its co-benefits and multifunctionality. However, these infrastructures are repeatedly planned, implemented and researched almost entirely based on the goals of stormwater management. Thus, more knowledge is required about how co-benefits are perceived and actioned by planning actors. By investigating co-benefits from a value perspective, this paper will contribute to the ongoing debates on how stormwater planning actors address the potential co-benefits and conflicts in BGI planning and implementation. The data are derived from policy document analyses and interviews with municipal and private sector planning actors in Bergen and Tromsø, Norway. The paper argues that municipal water actors are motivated to implement BGI beyond stormwater management goals and approach co-benefits and holistic stormwater management as an ideal in stormwater planning. However, the tensions and conflicts between the co-benefits become more evident in actual implementation of BGI. The paper finds that since holistic implementation of BGI tends to be initiated by municipal water actors, the stormwater management objectives dominate BGI implementation. Finally, the paper concludes that even though blue and green values and interests often conflict in the implementation of BGI, a blue-green value set based on the potential synergies from co-benefits is being developed in urban stormwater planning. To demand more space for the green elements in BGI, actors representing green values may need to take increasingly active and leading roles in BGI development processes.

Paper 4 Understanding holistic blue-green infrastructure implementation and mainstreaming

This paper seeks to understand how to define an ideal of holistic stormwater management, how implementation of BGI practices in Bergen correspond with this holistic ideal, and how this correspondence between holistic practices and ideals could highlight the potential for further implementation and mainstreaming of BGI. In the literature on blue-green infrastructure (BGI), there is an assumption that holistic stormwater management is decisive for sustainable implementation and mainstreaming of BGI. However, there are few explanations of what *holistic* means in this context. Based on empirical examples from Bergen, this paper provides new insights into ideals of holistic stormwater management and how actual BGI practices correspond with such ideals. The paper defines holistic stormwater management as an approach whereby actors simultaneously aim to solve multiple stormwater problems, include co-benefits that secure the green BGI elements and urban living qualities, and require policy and implementation processes that integrate multiple relevant actors and values and interests. The Bergen example indicates a substantial generational development of new blue-green value in the field of stormwater management. This provides a significant potential for further holistic stormwater management development. Furthermore, BGI measures that are closer to the holistic ideal seem to require more complex planning and building processes and require the integration of more actors and knowledge communities. Examining where the BGI measures in Bergen have been implemented, these examples show how new urban spaces, such as empty rooftop spaces and new development areas, can provide the necessary physical and collaborative space for implementing and potentially mainstreaming holistic BGI solutions.

Figure 1

Knowledge gaps and new knowledge in the papers

Knowledge gaps:

Paper 1: While the co-production of knowledge is growing in popularity, we need to understand how to co-produce local climate knowledge.	**Paper 2:** The shift from traditional to alternative stormwater management requires new ways of thinking, working and collaborating. We need to understand these new challenges/opportunities.	**Paper 3:** Co-benefits can increase implementation of adaptation and BGI. We need to understand how actors approach co-benefits in urban adaptation planning.	**Paper 4:** When holistic stormwater management is a prerequisite for implementation of BGI, we need to understand what the holistic concept entails in the literature and in practice.

New knowledge:

Paper 1: There are disagreements and divergent understanding of laws, regulations, and responsibility between practitioners. The Klimathon allowed negotiating the boundaries between relevant knowledge communities.	**Paper 2:** Municipal water departments take leading roles in planning and change their language and working methods. Could promote cross-sectoral collaboration and create space for the negotiation between professional interests.	**Paper 3:** Blue-green value sets based on potential synergies from co-benefits are being developed in urban stormwater planning. The leading actors and their value sets affect the final implementation of BGI.	**Paper 4:** The holistic BGI concept entails solving multiple problems simultaneously, including green co-benefits, and integrating all relevant actors in policy and planning. Implementation requires blue-green value development and physical and collaborative space.

2. Theoretical approaches

2.1. Defining transformative adaptation strategies

On a theoretical level, this thesis investigates the concept of transformational and transformative adaptation. This section will explore the theoretical understanding of the concept and elaborate how it relates to collaborative efforts, values, interests and holistic approaches to adaptation. There has been a huge growth in focus on adaptation related to transformation as a crucial response to climate change (Ajulo et al., 2020; Moore et al., 2021). The concept of transformation generally describes adaptation beyond the limits of incremental adaptation, promoting how transformation could provide adaptive possibilities for organisations and individuals, either forced or actively chosen (Pelling et al., 2015). In a world unable to avoid the severe consequences of climate change, adaptation efforts associated with societal transformations are crucial (O'Brien & Sygna, 2013). While the transformational adaptation concept can serve as an umbrella term for adaptation related to societal transformation, transformative adaptation can refer to the actions leading, or intending to lead, to transformation (Lonsdale et al., 2015). In this thesis, I am interested in what happens in adaptation planning processes that offer a potential for transformative climate action.

The concept of transformation can include reactive changes resulting from societal collapse or the active promotion of the capacity to change systems and societies (Feola, 2015). Understanding adaptation as transformation could promote measures that challenge established values, organisations and power structures (Pelling, 2011); transformative adaptation requires new ways of governing, planning and collaborating (Glaas et al., 2022). Thus, understanding transformative adaptation as something that requires human action that requires changes in the mindset, beliefs, values, norms and practices of people and organisations (Heifetz et al., 2009; O'Brien & Selboe, 2015; Wamsler et al., 2021) is crucial to my understanding of transformative adaptation strategies in this thesis.

Effective climate adaptation could reduce risk and vulnerability, develop resilient social systems, improve the environment, increase economic resources and enhance governance and institutions (Owen, 2020; Wolf et al., 2022). Importantly, adaptation constitute responses to changing conditions that can be active or reactive and unconscious or deliberate (O'Brien & Selboe, 2015). For decades, climate adaptation has been a contested policy concept due to fears about adaptation efforts potentially undermining mitigation efforts (Schipper & Burton, 2009). However, there is a growing consensus regarding the importance of linking mitigation, adaptation and sustainable development strategies and promoting the potential co-benefits between them (Burch et al., 2014; Sharifi, 2021; Shaw et al., 2014; Wolf et al., 2022). Thus, exploring approaches to adaptation that downplay the division between adaptation and mitigation policies could be crucial to identifying transformative adaptation strategies and measures that promote societal change (O'Brien & Selboe, 2015).

The overall understanding of the practicability and the potential outcomes of transformative adaptation remains fragmented (Ajulo et al., 2020), and what Moore et al. (2021) describe as a "transformational turn" in the climate literature has not yet resulted in shared definitions. Regarding potential definitions, Moore et al. (2021) and Fazey et al. (2018) suggest that transformations have three key dimensions: depth (the intensity or quality of the change), breadth (the distribution of change) and speed (the time frame through which change occurs). In this regard, Patterson et al. (2017) emphasise the fundamental changes in the structural, functional, relational and cognitive aspects of socio-technical-ecological systems that result in new patterns of interactions and outcomes. Knowledge of how to achieve the anticipated sustainable and transformed future is also needed.

From a social-ecological systems perspective, Fedele et al. (2019) characterise transformative adaptation as restructuring, path shifting, innovative, multiscale, system wide and persistent. These elements also touch upon the depth, breadth and speed of transformative climate action. Thus, there are several elements and perspectives to take into account when attempting to understand the concept of transformative adaptation and explore climate adaptation as transformational (Fedele et al., 2019). Yet, according to the same paper, very few studies of climate change adaptation have reported on the implementation of transformative adaptation measures (Fedele et al., 2019). Without concrete examples, the mentioned transformative qualities can be somewhat elusive. Understanding what these fundamental changes could entail in practice in adaptation processes is part of the scope of this thesis.

O'Brien and Sygna (2013) define transformation as physical and/or qualitative changes in form, structure or meaning-making. They assert that it is not always clear what will be transformed, nor why, how, in whose interest, or with what consequences transformation occurs. Most definitions of transformational adaptation refer to how it addresses the fundamental aspects of a system, often including elements of power and justice (Lonsdale et al., 2015). However, many transformative responses to climate change ignore the role of politics and power in perpetuating business as usual (O'Brien, 2017). Focusing on questions about whose interests are sustained by transformative adaptation highlights the importance of understanding the root causes of vulnerability (Ajulo et al., 2020; Pelling, 2011).

Pelling (2011) argues that as climate change progresses and mitigation policies fail, the potential for dangerous climate change impacts increases. He further contends that adaptation should be a political tool that is equal to mitigation and is therefore utilised beyond coping with crises. In this regard, he argues for making the human processes that drive anthropogenic climate change more visible. The re-politicisation of climate change could be crucial for envisioning, enacting and realising alternative futures. Yet, re-politicisation can be difficult to achieve when dominant paradigms associated with capitalism and market economies downplay the role of human and political agency in change processes (O'Brien, 2017).

Based on these theoretical perspectives on transformation, I assert that transformative adaptation strategies must include actions that result in, or intend to result in, transformation (Fedele et al., 2020; Lonsdale et al., 2015). A definition of transformative adaptation must acknowledge the potential for human agency that stems from internal human dimensions and encourage deliberate climate action without forgetting structural and political powers, obstacles and opportunities (O'Brien & Selboe, 2015; Pelling et al., 2015). Importantly, such deliberate adaptation and transformation actions and intentions could also have unintended consequences (Hukkinen, 2008). As stated in the introduction, the world needs climate adaptation measures that can help us envision and develop a just, equitable and sustainable future for all humans and other actors (O'Brien, 2021). Such focus could provide opportunities to create transformative adaptation strategies that acknowledge human agency and collaborative efforts. Understanding how such visions connect to the reality of adaptation is also crucial.

According to Shi and Moser (2021), transformative adaptation to climate impacts will require coherent, cohesive and collective responses across locations, societal sectors and scales of governance. The following section will investigate the role that collaboration and interaction between actors could play in transformative adaptation planning.

2.2. Collaboration and interaction

Defining transformative adaptation strategies to include actions that result in, or intend to lead, to transformation (Lonsdale et al., 2015) engenders questions about what actions are appropriate. To facilitate transformative adaptation, Fedele et al. (2019) point to the importance of finding key actors that can help spread new practices and create safe spaces in which to question the current dominant values, power structures and knowledge systems. Participatory approaches and collaboration among multiple stakeholders, such as researchers, communities, practitioners and policymakers, are crucial in this respect (Fedele et al., 2019). Moore et al. (2021) refer to policy and governance factors as the most common drivers of and barriers to transformation, and refer to policymakers as the most identified group of actors, particularly when understanding transformation as a deliberate process. Patterson et al. (2017) further explain how governance and politics are key to understanding and analysing transformations towards sustainability. However, despite receiving growing attention in recent years, the governance of transformation and political aspects remain under-developed in the literature on global sustainability (Patterson et al., 2017).

In this thesis, I have (in collaboration with others) investigated the participatory approach of collaborative climate hackathons in a municipal climate governance context (Kvamsås et al., 2021). I have also examined the interaction and collaboration between actors in stormwater planning in Norwegian municipalities (Kvamsås, 2021).

These studies reflect on the potential for human agency in co-production and collaborative processes in climate governance contexts.

Approaching transformative adaptation as something that has the potential for active and deliberate change highlights the fundamental role of agency in transformation processes (Feola, 2015; Nelson, 2009; O'Brien, 2021; Pelling, 2011; Pelling et al., 2015). Such an approach also lays the foundation for scientists to actively engage in climate change action (Feola, 2015; Haarstad et al., 2018). Scoones et al. (2020) call approaches that foster human agency, values and capacities *enabling approaches* for transformation. They highlight the importance of recognising the potential for collective action and addressing power asymmetries. Nevertheless, they question the ability of these enabling approaches to consider significant structural and political obstacles to societal transformation. However challenging, the potential for collective action in climate governance contexts can be investigated using methods of co-production.

This thesis has investigated co-production efforts in collaborative climate hackathons called *Klimathons*. These specific efforts originated in previous climate service projects (Kolstad et al., 2019; Kvamsås, 2021). Climate services are an emerging field and involve transforming climate science into information products and support for decision-makers, enabling society to better manage the risks and opportunities arising from climate change (Bremer & Meisch, 2017; Hewitt et al., 2017). Planning for climate adaptation is one of the most complex and intricate challenges faced by urban areas and municipalities (Anguelovski et al., 2014). Co-production approaches are fundamentally participatory and collaborative and can allow the development of new perspectives from actors who traditionally do not work together (Trainer et al., 2016).

Co-production approaches generally include more non-scientific actors and aim to democratise knowledge production processes. However, they often struggle with asymmetrical power relationships, empowerment and societal transformation (Funtowicz & Ravetz, 1993; Turnhout et al., 2020). Turnhout et al. (2020) show how dynamics of depoliticisation in co-production could reinforce rather than mitigate the existing unequal power relations, which also could prevent societal transformation.

Acknowledging and challenging existing power hierarchies between research and other knowledge and engaging the broader political context of research projects are crucial to avoiding such pitfalls. Re-politicising co-production is thus crucial for realising its transformative potential (Turnhout et al., 2020). In other words, co-production can generate actionable knowledge and offer a deeper understanding between actors without automatically transforming norms or structures within science and society (Jagannathan et al., 2020).

Addressing the conflicting values, interests and different understandings of climate change is also crucial for re-politicising climate adaptation and addressing the root causes of risk and vulnerability (O'Brien & Selboe, 2015; Pelling, 2011). Agreeing with this argument, this thesis also emphasise the potential of addressing the synergising values and interests in transformative adaptation efforts.

2.3. Values, interests and understandings of climate adaptation

Promoting transformative adaptation strategies that could help envision and develop a just, equitable and sustainable future for all humans and other actors requires that the values and interests in the climate adaptation work are addressed (O'Brien, 2021). According to O'Brien (2021), there are no value-neutral responses to climate change, and certain climate actions will have adverse outcomes for some actors and positive effects for others. It is therefore crucial to make the values and intentions behind transformative adaptation visible and transparent. Wamsler et al. (2021) assert that there is an urgent need for a more integral understanding of transformation that links internal and external approaches to change. Internal dimensions connect to values, beliefs, worldviews, paradigms and associated internal capacities. These aspects can provide deep leverage points for change as they can address the root causes of vulnerability associated with the entangled crises concerning climate change, poverty, racism, elitism and injustice (Wamsler et al., 2021).

According to Rosenberg (2021), values can be defined as what people deem to matter. For example, sustainability could be aligned with specific values such as dignity, equality, safety and harmony for people and nature. The role of values in transformation processes is increasingly gaining interest both within and outside academia (Rosenberg, 2021). Values can be conceptualised in many ways. For example, seeing values as something that individuals hold is different from understanding values as socially constructed discursive practices. A socially constructed value perspective sees values as being formed collectively rather than individually, making collective values potentially different from what people deem to matter individually (Rosenberg, 2021). These two value perspectives place values within and outside the mind without addressing the intrinsic relationship between the two realms. Conceptualising values as material-discursive practices could amend such dualisms, acknowledging the entanglement between the “inner” and “outer” dimensions of sustainability (Rosenberg, 2021).

The collective value perspective is vital when exploring climate adaptation and transformation in municipal planning processes, as actors are generally represented by their professional disciplines in this field. Wamsler et al. (2021) show how research on the connection between internal and external focus is on private and individual settings in contrast to occupational groups and work-related contexts. Dilling et al. (2017) reflect on how the collective climate action of cities can be tied to political ideologies, interests, environmental values and risk perceptions. O’Brien and Sygna (2013) outline three interacting spheres of transformation (personal, political, practical) to explain the dynamics of transformation processes. This is one way of showing how individual and collective values can be a foundation for climate action, connecting the personal to the political and practical spheres.

According to Patterson et al. (2017), incommensurable value sets can be the foundation for the different judgments about problem boundaries and perceptions of change processes. Patterson et al. (2017) further emphasise the potential for resistance to change when transformation causes deeply manifested norms and values to be questioned. The processes and implications of these disruptive changes are barely understood (Patterson et al., 2017). Thus, addressing contested values and multiple narratives of change are crucial parts of pathways to sustainability. Even though values are hard to change and can be a barrier to transformation, they can also be powerful mechanisms of transformative change that could contribute to new perspectives and paradigms (Rosenberg, 2021). This combination promotes an understanding of values as material-discursive practices with the potential to change over time, rapidly or slowly, and within people and communities (Rosenberg, 2021).

In this thesis, discussing the role of values in transformational adaptation processes is relevant to understand the different interests and objectives in municipal adaptation planning and alternative stormwater management. Both values and interests are part of what O'Brien and Selboe (2015) call *adaptive elements* when defining climate change as an adaptive challenge. They argue that climate adaptation is a social, cultural, political and human process. Recognising our collective capacity to shape global environmental and societal conditions, and redefining climate adaptation to include broader and deeper transformations, nurtures the need to address conflicting values, interests, understandings and approaches to change (O'Brien & Selboe, 2015). Thus, understanding how adaptive elements influence adaptation is critical to understanding the potential for societal transformation (O'Brien & Selboe, 2015).

This adaptive challenge theory builds on organisational leadership literature from Heifetz et al. (2009). The concept of adaptive challenges originally had no direct connection to climate adaptation and could also apply to other organisational or societal change contexts. Heifetz et al. (2009) separate challenges into technical problems and adaptive challenges and promote adaptive leadership as a strategy for transformative change. Expertise, (current) knowledge, innovation, political will and resources can solve technical problems. Adaptive challenges, on the other hand, are generally less specific, less linear, and more uncomfortable to deal with as they can cause anxiety, conflict and a sense of disequilibrium (O'Brien & Selboe, 2015). Solving adaptive challenges is demanding and involves trying new ways of working, tolerating losses and gaining new capacities. Adaptive leadership concerns how to lead people through such processes (Heifetz et al., 2009).

As emphasised in the introduction, many current approaches to adaptation revolve around technical responses to changing climate parameters such as temperature change and precipitation patterns through improved water management, improved infrastructure and new regulations. These approaches are vital, and most challenges comprise a combination of technical and adaptive elements. However, problems arise when people attempt to solve adaptive challenges using technical responses only (Heifetz et al., 2009). Addressing the internal dimensions of climate adaptation, such as values, is aligned with integral and holistic approaches to climate change, viewing it as a human problem intrinsically linked to other global crises concerning health, poverty and nature (Wamsler et al., 2021). The following section will investigate how holistic approaches to adaptation relate to the transformative adaptation ideas.

2.4. Holistic approaches to adaptation

Acknowledging and addressing the internal dimensions of change processes while challenging the structural elements concerning multiple entangled global crises are part of the emerging holistic and integral approaches to transformative climate adaptation (Wamsler et al., 2021). In this thesis, I argue that blue-green infrastructure (BGI) planning is an appropriate arena in which to study the potential for transformative approaches to climate adaptation. The argument is based on precisely understanding holistic adaptation processes that aim to solve multiple problems at once and include the internal and external dimensions of change processes. Solving the twin crises of climate change and biodiversity loss using nature-based solutions such as BGI is gaining popularity (Seddon et al., 2021). International bodies such as the European Commission, the Intergovernmental Panel on Biodiversity and Ecosystem Services (IPBES) and the Intergovernmental Panel on Climate Change (IPCC) have recognised BGI approaches as being crucial nature-based adaptation and resiliency solutions in urban areas (de Macedo et al., 2021).

Material urban (storm-)water infrastructure is a crucial part of the structural and external dimensions of BGI development. Urban drainage is an ancient field with a primary focus on conveying water away from urban areas, and dates back to at least 3000 BC (Fletcher et al., 2015). Three separate urban water infrastructure systems still service many cities: water supply, sewerage and stormwater drainage (Brown et al., 2013). The urban drainage infrastructure and related literature are currently evolving towards holistic approaches that focus on BGI multifunctionality and co-benefits (Fletcher et al., 2015). In the last decade, there has been a shift from conventional underground stormwater management to above-ground stormwater management

(Alves et al., 2019; Brears, 2018; Flores et al., 2021; Ghofrani et al., 2020; Hansen et al., 2019; Meerow, 2020; Wihlborg et al., 2019). This shift is described as part of a new urban water paradigm that addresses growing social, technological, and environmental complexity and uncertainty (Franco-Torres et al., 2020).

One way of understanding holistic stormwater management and BGI focuses on protecting whole hydrologic cycles and aquatic ecosystems (Brears, 2018). BGI is now one of the most common nature-based solutions for stormwater management in urban areas. It comprises interconnected natural elements such as rivers, streams, canals, ponds, wetlands, water reservoirs, and designed landscape elements such as rain gardens, bioswales and green roofs (Liao, 2019; Oral et al., 2020). BGI changes the physical urban landscape by moving the stormwater infrastructure from underground to above-ground solutions. This material change affects how planning actors think, work, plan and collaborate on solving stormwater problems in urban areas (Bohman et al., 2020).

BGI contributes to transforming stormwater management into an interdisciplinary professional field comprising engineers, landscape architects and urban planners (Meilvang, 2019). Although perceptions of, interest in and goals for blue-green strategies vary across professional sectors and actors, Meilvang (2019) describes a new willingness to focus on shared ideas and visions of urban rainwater management that can result in greener cities and added urban value. A common feature of the holistic stormwater management concept is attempting to simultaneously solve a range of problems associated with urban densification, climate change, increasing risk of flooding and drought, water security and decline in environmental quality (Schuch et al., 2017). This entails integrating multiple actors, values, interests and professional approaches.

BGI development from a stormwater management perspective involve a range of actors. In this thesis, I mainly focus on the actions, experiences, values and interests of the human actors in local adaptation and BGI planning processes. Many actors use ecosystem service frameworks to examine the value of urban ecosystem-based approaches and consider potential synergies and trade-offs (Raymond et al., 2017). Ecosystem service frameworks generally emphasise nature's contributions to people and should include the multiple values associated with other worldviews on human-nature relations and knowledge systems in environmental decision-making (Raymond et al., 2017). Respecting the many ways that people ascribe meaning to and value nature is crucial when working with transformative approaches to a sustainable future (Pascual et al., 2017).

The focus on multiple BGI functions and co-benefits is crucial for understanding stormwater management and planning as a holistic adaptation approach. BGI provides multiple social, ecological and technical benefits beyond flooding and stormwater problems, such as water savings, energy savings, mitigating urban heat islands, improving air quality, conserving biodiversity, carbon sequestration, reducing crime and improving public health and well-being (Alves et al., 2019; Meerow, 2020; Raymond et al., 2017). When BGI is promoted as being vital for solving the climate change and biodiversity loss crises, biodiversity protection becomes one of the most significant co-benefits of BGI. Besides flood mitigation and functional ecosystems, biodiversity conservation is one of the most targeted sustainability goals in the current nature-based BGI literature (Hanson et al., 2020). Green roofs and inter-connected nature reserves in urban areas are examples of BGI that provide habitat for wildlife and ensure biodiversity (Frantzeskaki et al., 2019; Ghofrani et al., 2020). A green infrastructure is crucial for biodiversity conservation because it can provide areas of varying biodiversity in urbanised landscapes.

Green infrastructure can further create ecological connections between different habitat areas and translate ideas about the importance of wildlife habitat areas into a language that is understood by planning actors and decision-makers (Garmendia et al., 2016). Importantly, the value of a piece of land to biodiversity depends on finding a species-and-place-specific balance between habitat area, quality and connectivity. Not all green spaces are suitable as breeding habitats for all species (Garmendia et al., 2016). BGI solutions generally promote and include green infrastructure elements. However, some solutions associated with BGI mainly concern water management goals and might not even include vegetation (e.g. permeable pavements, blue roofs) (Liu et al., 2019; Matsler et al., 2021; Sowińska-Świerkosz & Garcia, 2022). If BGI development is to be holistic, the green BGI elements associated with how people approach and value (urban) nature must be included.

3. Methods and research design

3.1. How can transformative adaptation be studied?

The social sciences are increasingly called upon to engage with how multiple actors address climate and energy challenges. This requires reflections on what core social science competencies, epistemological toolboxes and critical sensibilities are productive (Haarstad et al., 2018). Working with climate change and transformation, research communities in the natural and social sciences study and develop projections, climate models and plans for adaptation and mitigation measures for an uncertain and potentially unsafe future. As Wangel et al. (2013) emphasise, sustainable development is fundamentally about the future, in the sense of exploring what a sustainable future might look like and understanding how present actions such as decision-making and urban planning could relate to such a future. Aiming to understand the potential for transformative adaptation in local area planning, I study the interaction and collaboration between actors in contemporary planning processes that result in such an unknown future. The research could benefit from qualitative research methods that provide data on people's perceptions, interests, motivations, values and actions in local planning contexts.

According to the tradition of Western secular thought, the future does not yet exist but is something that becomes (Wangel et al., 2013). Thus, the future only exists as a product of our personal and social imagination and lies outside the scope of objective observation. However, path dependency can create a "logic of practice" that could explain why some alternative actions seem more (or less) appropriate than others and why it could be difficult to change the course of societal development (Wangel et al., 2013). Believing in the power of human agency and its dependence on values, beliefs and worldviews acknowledge that all individuals and groups have the capacity to shift systems and cultures (O'Brien, 2021). This study investigates how actors work on changing urban landscapes, knowledge and collaboration processes in areas dominated by structural elements and path dependencies connected to extensive (material and institutional) infrastructures. Studying potentially transformative adaptation processes may require actively engaging in processes heading into the future (such as in the co-production work), often with the intention of influencing the results of the transformation process. This will have implications for the role of social scientists in climate action processes.

Haarstad et al. (2018) propose three modes of productive social science engagement with climate and energy challenges: producing and situating actionable knowledge, critically reframing discourses, and connecting actors and processes. These modes of engagement contrast with roles such as being a mediator between the natural sciences and society, being an uncritical co-producer who overlooks power structures and biases, and being highly critical in ways that prevent actual engagement and solutions. Instead, the three modes can open up spaces for social scientists to critically assess and participate in sustainability transformations (Haarstad et al., 2018). This understanding of social science engagement with climate action lays the foundation for the methodological and empirical work of this thesis.

3.2. Studying climate adaptation in municipal area planning

3.2.1. Selecting the research arenas

The University of Bergen and NORCE Norwegian Research Centre (UniResearch until 2018) funded this research project, starting in 2017. Three climate service projects (HordaKlim, HordaPlan and R3: Relevant, reliable and robust local-scale climate projections for Norway) lay the foundation for the project. These projects facilitated my participation in the research team that developed the three co-production events called *Klimathons*. Thus, my research started by focusing on the co-production of local climate knowledge. The methodological and thematic choices of the Klimathons depended on the development and collaboration process between multiple research and planning actors over time. Based on the co-production experiences and research focus, I wanted to create a research project that explored local climate adaptation related to municipal area planning.

Corresponding to the current literature on transformative adaptation that promotes the addressing of conflicting values, interests, understandings and approaches to change (O'Brien & Selboe, 2015), I wanted to provide new insights into identifying and addressing such elements based on empirical investigations. The climate knowledge co-production in the Klimathon addresses challenges regarding how relevant actors (researchers and practitioners) represent different interests, values, needs and understandings of the world in local adaptation work (Kvamsås et al., 2021). Based on the argument that there is a need for transformative approaches to adaptation that make societal change possible (O'Brien, 2021), I also wanted to investigate related arenas that offered the potential for adopting such transformative approaches. I found such an arena in alternative stormwater planning because of its potential for providing multiple benefits for multiple actors and its requirement for holistic planning and thinking (Alves et al., 2019).

This led me to investigate municipal blue-green infrastructure planning from a stormwater management perspective in Bergen and Tromsø municipalities. In this part of the project I used a case study research approach (Yin, 2009), applying qualitative methods including observation, interviews, document analysis, field trips and mapping the implementation of BGI in urban landscapes.

3.2.2. Deciding the research locations

As the NORCE climate service projects were focused on municipalities in the Vestland county (Hordaland county until 2020) in western Norway, this was a natural geographical starting point for my research project. Also, in a co-production project development workshop in which Bergen municipality participated, the city demonstrated a strong focus on alternative stormwater management and BGI development. As the first municipality in Norway, Bergen was at the starting point for a planning process that developed a municipal sector plan for stormwater management in 2017. Understanding that this planning process could be a potential research arena, I contacted the Bergen municipal water department to check whether there were any opportunities for collaboration. In an introductory meeting in January 2018, the municipal water department invited me to observe the planning process of the current stormwater sector plan by participating in meetings and being given access to the relevant planning process documents.

When I started investigating the status of alternative stormwater planning in Bergen and Norway, I discovered that Tromsø municipality in northern Norway had also started making a municipal sector plan for stormwater management. Believing that the experiences from two similar planning processes could complement and enrich collective data material on Norwegian stormwater adaptation and BGI planning, I contacted Tromsø municipality about studying its stormwater planning process. Even though Tromsø is a long way from the Norwegian west coast region, I considered their combined experiences would make a suitable case. The two cities are relatively large in a Norwegian context (though small to medium cities in a European/international context) and share the national adaptation policy context. The data on the Tromsø planning process were mainly produced during a two-week field trip to Tromsø in October 2019.

3.3. Co-production of local climate knowledge

3.3.1. Understanding co-production

Providing appropriate research data is often associated with terms such as *data collection* or *data gathering*. According to Aase and Fossåskaret (2007), data are not a finished product ready to be collected by a skilled field worker. They argue that actions and statements must be conceptualised in order to become data and that such conceptualisation makes the data produced rather than collected by scientists. Adding to the argument of scientific data as something that is produced, knowledge co-production is growing in popularity in social sciences, particularly in climate change research (Bremer & Meisch, 2017). Co-production of scientific knowledge can encompass practices and understandings ranging from the deliberate collaborations to achieve common goals to the acknowledgement of how science and society shape each other (Bremer & Meisch, 2017). Co-production approaches emphasise how scientific knowledge is co-produced in the interactions between the multiple actors involved in the research process (Bremer & Meisch, 2017).

Bremer and Meisch (2017) describe how co-production recognises climate challenges as being too complex for science to find solutions alone. They outline two main understandings of co-production. The first understanding regards co-production as a deliberate collaboration between specific actors to achieve a common goal, i.e. a normative understanding associated with researchers such as Ostrom (1996) and Lemos (2015). They focus on how different actors together should co-produce practical and usable knowledge. Lemos and Morehouse (2005) claim that many scholars are becoming increasingly interested in research approaches in which the division between science and policy is blurred, and usable knowledge should be co-produced in everyday interaction between scientists, policymakers, and the public. Ostrom (1996) argues that co-production is a process in which individuals who do not belong to the same organisation contribute to producing goods or services.

The second understanding of co-production examines how science and society constantly shape each other in unexpected and unintended ways (Bremer & Meisch, 2017). This understanding is more descriptive and is associated with the work of researchers such as Jasanoff (2010), Latour (1998) and Wynne (2010), using the co-production concept to analyse and describe the occurrence of co-production of various settings, knowledge, social orders and power relationships (Bremer & Meisch, 2017). Co-production approaches often aim to democratise knowledge production processes by expanding peer communities to include more non-academic actors. Such democratisation processes could replace a "culture of truth" associated with pure science with a "research culture" in which science and society come together to ask questions and seek shared solutions (Latour, 1998). Jasanoff (2010) also argues that the co-production framework directs attention to the necessary political work for bringing about an actionable consensus on scientific facts.

Such descriptive understandings highlight how social order is inevitably produced through new knowledge and technologies being accepted as facts by the public and supporting institutions (Dannevig, 2015). Both perspectives are relevant to this thesis: the first as a concrete research method for the Klimathons and the second as a philosophical foundation for the entire thesis.

3.3.2. Collaborative climate hackathons – Klimathon

Starting in the spring of 2017, I was part of a research team of natural and social scientists and partners from regional public authorities who have organised three collaborative climate hackathons called *Klimathon*. The first Klimathon was organised as a workshop in the Hordaklim project based on experiences from the HordaKlim, HordaPlan and R3 projects concerning challenges regarding co-production as a research method in the existing projects (Kolstad et al., 2019). The challenges involved the lack of sufficient funding for actual co-production work, lack of competence in dialogue facilitation, as well as the diverging expectations of researchers and municipal partners concerning the needs and outcomes of the projects (Kolstad et al., 2019). Paper 1 describes the Klimathon as a potential space for the relevant actors to renegotiate the boundaries between these divergent knowledge communities (Kvamsås et al., 2021).

In early winter 2018, the first Klimathon attracted 73 participants in Bergen. The Klimathon participants were from municipalities, counties and research institutions all over Norway, though most of them were from the west coast and northern Norway. The participants comprised practitioners and decision-makers from local, regional and national institutions and researchers from natural and social climate sciences (Kvamsås et al., 2021). The following year, we repeated the event with 98 participants and in 2020, we held a Klimathon comprising around 60 participants, which took place online due to the COVID-19 pandemic (Stiller-Reeve, 2021). Paper 1 in this thesis comprises the detailed findings and methodological choices and actions of the two first Klimathons as a co-production method.

The method for co-producing actionable climate adaptation knowledge in the Klimathons was modelled after the hackathon concept (Briscoe & Mulligan, 2014). In a hackathon, people aim to solve pre-defined problems within a limited time frame (generally 24–48 hours) through intensive and often interdisciplinary group collaboration. The term *hackathon* is derived from two words: 1) hack/hacking and 2) marathon, and was first used in 1999 for software development events (Briscoe & Mulligan, 2014). Crucial elements of hackathons are autonomy and creativity in the problem-solving process (Pogačar & Žižek, 2016). Traditional hackathons are often formed as competitions where the participants can win prizes, get funding for their ideas and expand their contact networks. The Klimathons instead focused on collaboration and finding shared solutions.

The hackathon method is also spreading to other fields, such as urban planning. Since the early 2010s, people have organised social hackathons, urban hackathons and green hackathons (Pogačar & Žižek, 2016). Hackathons are also often associated with

Urban Living Lab approaches that aim to overcome the tensions between bottom-up and top-down governance initiatives that promote socio-technical innovation processes (Baccarne et al., 2014).

The Klimathons were facilitated by a systematic process methodology informed by the problem-oriented and collaborative ethos of traditional hackathons. We aimed to achieve a broad representation of participants – geographical, disciplinary and sectoral – for the discussions during the climate hackathon events (Kvamsås et al., 2021). The potential democratisation of knowledge creation processes in co-production increases the relevance of ethical considerations concerning asymmetrical relationships and the power to define research questions (Funtowicz & Ravetz, 1993). In the Klimathons, we tried to negate this by being transparent in the organisation process by involving practitioners in the planning committee and asking them to comment on the final report before publication (Kvamsås et al., 2021). Respecting and including all voices in a research process might not require equal input and effort from all actors in the process. However, in this regard, there is potential for continuous method improvements, including further democratisation of the interpretation and analysis phases. As previously discussed, I support the way in which Turnhout et al. (2020) connect co-production efforts with transformation only when challenging existing and inherent unequal power relations.

3.3.3. Analysing the co-produced data

Returning to the argument that actions and statements must be conceptualised to become data (Aase & Fossåskaret, 2007), researchers' categorisation and interpretation of information and knowledge are crucial parts of data production and co-production processes. Concepts and categories are crucial analytical tools in the qualitative-oriented research tradition. Researchers can create meaning and insights when the concepts and categories can be connected to the (co-)produced observations and statements (Aase & Fossåskaret, 2007).

The Klimathons allowed the methodology to incorporate a representation of a realistic context. The collaborative climate hackathons were qualitative experiments in a realistic but not real setting. The actors, sectors and knowledge representation substituted the formal roles of decision-making processes, and the participants were encouraged to draw on their real-life experiences (Kvamsås et al., 2021). The co-produced data material provided extensive reflections on how the participants, with all their varied professional experience in climate work, perceived solutions to local adaptation challenges (Kvamsås et al., 2021).

Analysing the co-produced data material from the Klimathons was challenging for different reasons. The Klimathon organisers, mainly academic researchers, had the main say when selecting and defining the project, working method, location, groups, and, as far as possible, the hackathon participants. The researchers also made most of the decisions regarding how the data from the Klimathons were conceptualised, categorised, analysed and presented. The other participants were given a few opportunities to review and provide input to the written reports presenting the results and policy recommendations from the hackathon. Nevertheless, the traditional academic researchers had the main say in the analysis and academic paper writing processes. Acknowledging the power hierarchies and imbalances and striving to represent the different forms of expertise in the process have a bearing for the results. The concrete analysis processes from the Klimathon work are thoroughly described and discussed in paper 1.

3.4. Case methodology

To study alternative stormwater management in Bergen and Tromsø, I used a case study research approach (Yin, 2009). Case methodology is generally the preferred method when researching a contemporary phenomenon in a real-life context in which the researcher has little control over the events and when the research questions start with *how* or *why* (Yin, 2009), which are all relevant aspects of this study. The case's qualitative methods involved observation, interviews, document analysis, field trips and mapping of the implemented BGI measures in Bergen. In Tromsø, the research methods comprised qualitative interviews, field trips and document analysis.

According to the Yin (2009) definition of a case study, this research approach involved investigating a contemporary phenomenon within its real-life context, acknowledging that the boundaries between the phenomenon and its context are unclear. Flyvbjerg (2010) emphasises how social sciences generally do not produce context-independent theory and that case studies are well suited to producing the context-dependent knowledge that social sciences can provide. Gerring (2004) defines a case study as the intensive study of a single unit to understand a larger class of (similar) units. Gerring (2004) describes a unit of analysis as a spatially bounded phenomenon, like a nation-state, revolution, political party, election or person, observed at a single point in time or over a limited time frame. Similarly, according to Yin (2009), a case can refer to an event, entity, individual or unit of analysis. Based on this, I define my case and unit of analysis as the process of BGI planning and implementation in Norway, represented by planning and implementation processes in Bergen and Tromsø. In other words, I do not consider these as two different cases but as part of the same case.

In order to understand the potential for transformative adaptation and investigate the actors' interests, values and understandings of adaptation planning, I initially started by researching one stormwater planning process in Bergen. Adding the investigation of a similar planning process in Tromsø and presenting the empirical experiences of these two different (and not directly connected) places as one case may challenge the idea of the unit of analysis as being spatially bounded. However, the world is entangled, interconnected and interdependent (Ward, 2010). Thus, the idea behind exploring similar planning processes in two locations is to provide richer and more extensive data material to support the findings on municipal adaptation planning.

Studying a phenomenon that happens in two different places raises questions about how the different experiences relate to and inform each other. Social sciences have a long history of working on various aspects of comparative research (Ward, 2010). Studying processes in two separate locations might quickly result in comparing the two locations and their respective experiences. Bergen and Tromsø share a national adaptation policy but have specific local climatic, geographical, cultural, individual and institutional conditions that affect the two studied stormwater planning processes differently. Comparing the two municipalities directly and analysing their similarities or differences in detail (Ward, 2010) has not been the goal of this study. Instead, the goal has been to allow the different planning process experiences in their respective local contexts to inform the data material on Norwegian stormwater planning, making it more nuanced.

Case study research approaches can be exploratory, descriptive and explanatory in nature (Yin, 2013). This case study relates to all three aspects, aiming to investigate, describe and explain the potential for advancing the implementation of a transformative adaptation strategy in municipal area planning. The explanatory role might be the most challenging. According to Yin (2013), this means documenting and interpreting a set of outcomes and then trying to explain how these outcomes came about. As for generalising the findings in this study, I use analytical generalisation and thus generalise the results to broader theoretical propositions, not to populations or universes (Yin, 2009). My case does not represent a sample (representing statistical generalisation) and the goal is to expand and generalise theories. The following sections will go into more detail on the multiple methods of data production.

3.4.1. Observation methods

The observation method was crucial to studying alternative stormwater management planning in Bergen. As a research method, observations can provide a contextual understanding of complex social phenomena such as a climate adaptation planning process (Aase & Fosslåskaret, 2007). The observation method can also provide information about people's actions and relationships without the inclusion of outspoken statements (Thagaard, 2009). Thus, observation can offer an in-depth understanding of the interests and actors involved in complex planning processes. The primary purpose of the observation method used in Bergen was to gain broad first-hand information on the actors, interests and context of implementation of BGI. Combining observation methods with, for example, qualitative interviews can also help obtain knowledge about a phenomenon from different perspectives, including information the researcher does not ask for directly (Thagaard, 2009). The field observations started at a planning forum event in Vestland/Hordaland county in 2017, in which alternative stormwater management was a central issue.

The sector plan field observations started with an introductory meeting with the Bergen municipal water department in January 2018. Then, from February 2018, I observed the Bergen planning process for the municipal sector plan for stormwater management by participating in the local working group meetings, reference group meetings with different municipal departments, external information meetings, professional seminars, as well as information workshops with municipal professionals and private sector consultants. My observations involved sitting in, listening and taking notes at meetings, while not disturbing the process. Importantly, I also obtained information from informal field conversations before and after these meetings. Bergen City Council approved the sector plan in September 2019, and the last information workshop I attended was held in December 2019.

Being invited in and enjoying the hospitality and goodwill of the municipal employees who worked on the stormwater sector plan made me reflect on my role as a researcher in an observation context. On a personal level, I was new in Bergen in 2017 and was not personally familiar with the local municipal environment. The invitation to observe the stormwater planning process was from an open and welcoming municipal water department interested in knowledge development and research. The fact that I represented a familiar local research environment at NORCE and the University of Bergen was probably part of the warm welcome. At first, I was slightly concerned about how some of the municipal actors referred to my research as a potential evaluation of the planning process, as I had no intention of delivering such an evaluation. However, as time passed and we got to know each other better, I grew less concerned. These notions resemble the reflections in the co-production section on building trust and understanding between researchers and participants (or co-researchers) in any research setting.

I took personal field notes at all the observed meetings. I also had access to all official minutes from the meetings in the Bergen planning process, thanks to a structured project leader who courteously shared information about the process. This was particularly helpful as I was on parental leave from December 2018 to July 2019 and did not observe the planning process directly during this time. Public minutes from city council meetings were also crucial sources for understanding the planning processes. See Table 1 for a list of observation points.

Table 1

List of observation points

Observation at meetings and workshops in Bergen
2017:
1. Planning forum in Vestland/Hordaland county
2018:
2. Introductory meeting – Department of Water and Sewerage, Bergen municipality
3. Information meeting – Municipal sector plan for stormwater management, Bergen municipality
4. Workshop – Department of Water and Sewerage, Bergen municipality and the Norwegian Natural Perils Pool
5. Project group meeting – Municipal sector plan for stormwater management
6. Project group meeting – Municipal sector plan for stormwater management
7. Reference group meeting -–Municipal sector plan for stormwater management
2019:
8. Project group meeting – Municipal sector plan for stormwater management
9. Meeting about zoning plans – Bergen municipality and private consultants
10. Information workshop about the municipal sector plan for stormwater management for departments in Bergen municipality
11. Information workshop about the municipal sector plan for stormwater management for private consultants in the Bergen area
2021:
12. Meeting about implementation of BGI – Department of Water and Sewerage, Department of Urban Environment, Bergen municipality

3.4.2. Qualitative interviews

As qualitative interviews can provide knowledge about detailed experiences, opinions and self-understanding (Kvale & Brinkmann, 2009), this was a key method for studying the actors' interests, values and understandings of alternative stormwater planning in Bergen and Tromsø. The purpose of the interview method in this project was to provide in-depth knowledge of the practical experiences of the multiple actors involved in the BGI planning and implementation, as well as their background, knowledge, position and interest concerning alternative stormwater planning.

From September 2019 to August 2020, I conducted six interviews with municipal actors in Bergen about the municipal stormwater sector plan. I invited the municipal actors based on their involvement in the ongoing planning processes and their general knowledge of and role in urban planning and stormwater management.

From September 2020 to September 2021, I conducted six interviews with private sector actors about blue-green development and implementation in Bergen. The private sector actors in Bergen were recruited based on their participation in the municipal information workshop about the stormwater sector plan and from systematic online searches of local actors and projects in BGI construction, planning and landscaping.

In Bergen, the municipal actors were more accessible than the private sector actors, probably because of my observation work in the municipality. My observations gave me a useful overview of the relevant municipal actors, and everyone I asked agreed to be interviewed. Recruiting the private sector actors was a more demanding process due to a lack of information and no initial contact. This required considerable effort on my part to identify the relevant actors. It was also the case that several efforts to contact private sector actors were unsuccessful, and I do not know why.

In Tromsø, I conducted six interviews with municipal and private sector actors in October 2019 and one follow-up interview in June 2020 about the Tromsø sector plan. The municipal and private sector actors in Tromsø were recruited based on their involvement in and knowledge of the stormwater sector plan process. The Tromsø sector plan project leader was a critical resource in identifying and contacting the other relevant actors in Tromsø. See Appendix 1 for interview guides (in Norwegian).

The interviews were generally face-to-face, but out of 19 interviews, five were group interviews with two participants present, as well as the author. The group interviews took place when it was more convenient to talk to two people from the same company/department and when the invited actors asked to bring a colleague to the interview. Up to winter 2019/2020, I met with all the actors in person in their workplace. After the outbreak of COVID-19 in 2020, the remaining interviews were mainly conducted online or on the phone. The online interviews were generally successful, but the information I would get from meeting people in their workplace disappeared. This information could be particularly crucial when the interviewee's workplace is not an office but a construction or landscape site.

This research project has been approved by the Norwegian Centre for Research Data (NSD). Before the interviews, all actors received and approved an e-mail with information about the project, data protection and gave their informed consent. The interviews were recorded and transcribed. The interview data have been presented in three different research papers with references to an anonymised list of relevant professions and municipalities. See Table 2 for a list of interviews.

Table 2

List of interviews

Interviews with municipal and private sector planning actors in Bergen **2019:** 1. Interview – Department of Water and Sewerage 2. Interview – Department of Urban Environment 3. Interview – Department of Planning and Building 4. Interview – Department of Planning and Building, GIS 5. Interview – Department of Planning and Building **2020:** 6. Group interview – Department of Urban Environment 7. Interview - Private consultant, construction entrepreneur 8. Group interview – Private consultant, planning firm 9. Interview – Private consultant, planning firm 10. Interview – Private consultant, engineering, and planning firm 11. Group interview – Private consultant, landscape gardening entrepreneur **2021:** 12. Interview – Private consultant, landscape gardening entrepreneur
Interviews with municipal and private sector planning actors in Tromsø **2019:** 13. Interview – Department of Water and Sewerage 14. Group interview – Department of Urban Environment: Park and Recreation 15. Interview – Department of Planning and Building 16. Interview – Department of Water and Sewerage 17. Interview – Private consultant, advisor water and sewerage 18. Group interview – Private consultants, engineering, and planning firm **2020:** 19. Follow-up interview – Department of Water and Sewerage

3.4.3. Document analysis

Analysing documents has a long tradition in qualitative research and comprises the systematic analysis of written (or audio-visual) depictions (Thagaard, 2009), for example, policy documents. While the observation methods and the qualitative interviews can provide knowledge about stormwater planning processes and their actors, this document analysis provides knowledge about the results of the planning process and the actors' interactions. The two documents analysed in this thesis are the Bergen Municipal sector plan for stormwater management from 2019–2029 (BergenKDP, 2019) and the Tromsø Municipal sector plan for stormwater management from 2019–2032 (TromsøKDP, 2020), both Norwegian policy documents. The document analysis aimed to overview the concrete political intentions, requirements and strategies that affect implementation of BGI in current policy documents. Specifically, I sought to understand how stormwater planning actors address priorities, synergies and trade-offs regarding BGI co-benefits and conflicts in planning and implementation.

The analysis started with a thorough examination of the two policy documents in order to identify their main themes. I then created a table and collected all references to co-benefits/multiple benefits/multifunctionality from the two documents. The potential conflicts were then categorised to analyse their role in the policy documents. This categorisation helped me to understand which co-benefits and potential conflicts the two plans emphasised. The exercise also demonstrated how the co-benefits and conflicts are associated with specific parts of the plan like the visions, the goals and the proposed solutions, which further can represent concrete implementation phases. Paper 3 presents the document analysis and the results.

3.4.4. Mapping the implementation of BGI in Bergen

To understand the potential for blue-green infrastructure (BGI) implementation and mainstreaming in Bergen in paper 4, I provided an overview of the implemented BGI measures. In June 2021, I started mapping the status of BGI implementation in Bergen using information from the conducted observations and interviews, secondary literature, policy documents, municipal and private sector actors' websites, media, as well as physical observation/investigation. BGI measures are often prestigious and costly and are therefore promoted in the media and on project websites. However, I am aware that I have not managed to capture all the projects and measures in Bergen because of a lack of complete information and access.

The presented overview in paper 4 is limited to BGI measures mainly constructed for stormwater management purposes. This means that many non-constructed blue and green areas and areas such as natural rivers and parks built for other purposes have been excluded. Since BGI is an area of development in Bergen, several of the measures mentioned in my data material are so new they are currently in the planning and construction phase. I chose to include selected measures in the construction phase as they are also crucial for future mainstreaming opportunities. Being aware of certain limitations, I believe that such mapping can provide relevant data for discussing the connections between holistic planning and BGI implementation and mainstreaming. In November 2021, I also had a meeting with the Bergen municipal water department and the municipal environmental department in order to quality check the achieved implementation status of BGI in Bergen.

Even though this mapping was a method for understanding the status of the Bergen BGI implementation (exemplified in paper 4), I conducted a similar exercise in Tromsø. During my two-week field trip to Tromsø in October 2019, I visited and photographed the relevant BGI sites in order to comprehend the physical landscape and context of the BGI measures.

3.4.5. Analysing the interview and observation data

From the observation methods, qualitative interviews, document analysis, field trips and mapping of the status of implementation of BGI, I was left with extensive qualitative data on alternative stormwater planning and implementation in Bergen and Tromsø. The many engaged and knowledgeable professionals who were willing to share and develop their knowledge of stormwater management were a crucial part of the entire data production process in Bergen and Tromsø. The data were processed, analysed and developed continuously throughout the project and often determined the direction of the project.

All interviews were recorded and transcribed by the author. Listening to the interviews and transcribing them was the first step to getting an overview of the material and starting the interpretation process (Braun & Clarke, 2006). My observations at meetings and workshops resulted in extensive personal field notes. The second step of analysis was to systematise the text material into thematic categories. This approach to analysis is aligned with methods of thematic analysis that can help organise and describe qualitative data material in rich detail and help identify, analyse and report patterns and themes in qualitative data sets (Braun & Clarke, 2006). Aase and Fossåskaret (2007) emphasise the difficulty of categorising and how careful researcher must be when claiming to understand the intended meanings of observations and statements.

The interviews were structured and provided two sets of basic categories. The first set of categories relates to the planning processes of the sector plans and the BGI implementation processes, including the pre-planning phase, planning phase, measure designing phase, implementation phase and the maintenance phase. The second set of categories concerned cross-cutting themes such as knowledge/experience, motivations, professional goals/ideals, challenges/opportunities in the BGI work, working methods, BGI development over time, as well as local conditions for implementation of BGI. Reflecting on what constitutes relevant themes and categories in qualitative research analysis (Braun & Clarke, 2006), the themes concerning the co-benefits and conflicts in the implementation phase became prominent in the material.

3.5. Bergen and Tromsø as research locations

In this project, I selected the research locations of rainy coastal Bergen and freezing arctic Tromsø because they were the first municipalities in Norway to develop dedicated municipal sector plans for stormwater management. In the two cities, the municipal water departments have been leading actors in incorporating stormwater management into municipal planning processes. Developing dedicated municipal sector plans for stormwater management has been crucial for their stormwater planning strategies. This demonstrates that Bergen and Tromsø, have committed actors and substantial interest in the stormwater management shift from underground grey solutions to above-ground BGI and incorporating stormwater issues into municipal planning processes.

Such a shift can provide new opportunities for sustainable urban areas (Haase et al., 2017; Lund, 2018). However, it will also require new forms of collaboration by multiple actors and sectors, creating potential conflicts of interest and new planning challenges (Kati & Jari, 2016; Lund, 2018). Based on this, the stormwater management shift requires new ways of thinking, working, collaborating and a deeper understanding of holistic and flexible approaches to stormwater management (Alexandre, 2018; Bohman et al., 2020; Kvamsås, 2021). Studying BGI planning and development in Bergen and Tromsø could highlight conflicting and synergising interests and understandings of stormwater planning processes and the role of holistic planning ideals in adaptation planning.

Bergen is a port city on the west coast of Norway with a strong identity as Europe's rainiest city (Bremer et al., 2020). Bergen has a mild climate, with an average temperature of around 0 °C in the winter (Klimaservicesenter, 2021a). Bergen was founded in 1017 and has long been an administrative and trading centre in Norway and Europe (Bremer et al., 2020). Bergen municipality comprises eight districts, and a car-based urban sprawl development has previously been the norm. Presently, Bergen municipality is focusing on new urban densification strategies (Koning et al., 2020). Such densification strategies create stormwater problems and requirements for alternative stormwater measures, like in many other parts of the world (Rosenberger et al., 2021).

Located far north of the polar circle, Tromsø represents the most extensive urban structure in a rural region with an extremely low population density (Nyseth, 2011). The climate in the Troms region is characterised by relatively mild temperatures and heavy precipitation at the coast, while the inland have low annual precipitation and low temperatures during the winter (Klimaservicesenter, 2021b). Tromsø was founded in 1794 and has developed from a small-scale trading and industrial coastal town to the regional capital of northern Norway. Tromsø city centre on the main Tromsø island is small, but the urban sprawl has resulted in a scattered urban pattern (Nyseth, 2011), including on the mainland and on Kvaløya island.

Densification and massive house building projects in central areas, involving filling in sea areas, are prominent strategies in current local urban development plans (TromsøKPA, 2021).

For both Bergen and Tromsø, climate change will result in the need for adaptation due to heavier precipitation and increased problems with stormwater. There is also the risk of increasing landslides, flooding, sea level rises and storm surges (Hanssen-Bauer et al., 2017). As future climate change increasingly exposes Norwegian municipalities to more intense precipitation, the municipal water sector is a crucial actor in local climate change adaptation (Hovik et al., 2015). The two municipalities are illustrative examples of cities that are working purposefully to promote BGI in planning as solutions for stormwater management, while also illuminating the challenges concerning slow BGI implementation and mainstreaming. Their experiences of how actors interact and collaborate on BGI and stormwater management issues could be relevant for other cities, particularly those in the early stages of BGI development.

With populations of 265,470 inhabitants (Bergen) and 77.399 inhabitants (Tromsø) in 2021 (SSB, 2021a, 2021b), Bergen and Tromsø are small to medium-sized cities in a European context and smaller than the many large cities that BGI research often centred around (Flores et al., 2021). This could make the BGI experiences from the Bergen and Tromsø governance contexts relevant to many cities and towns worldwide.

Bergen and Tromsø are also two locations with particular needs for local adaptations and solutions when implementing alternative blue-green stormwater measures due to their specific climatic conditions. As previously stated, Bergen is famous for its rainy climate and there are numerous reports of stormwater incidents and urban flooding every year. Tromsø faces challenges related to ice, snow and freezing of the new blue-green solutions. Their experiences will be directly relevant to cities and towns with similar climatic conditions. Many available BGI products have been developed and tested in drier areas such as central and eastern Norway. The examples from Bergen and Tromsø could also be relevant to cities and towns that need to adapt BGI measures developed for other locations (often more central and larger cities) to local climatic and political conditions.

Figure 2

Map of Bergen and Tromsø, Norway

Source: Map created using Google My Maps in google.no/maps

4. Main findings: Developing transformative adaptation strategies

In this thesis, I have investigated the potential for transformative adaptation, grounding my research in empirics from municipal adaptation work. I studied (1) co-production processes of local climate knowledge and (2) blue-green infrastructure planning processes as arenas for potential transformative approaches to adaptation. The research has focused on the interaction and collaboration between relevant planning actors. Climate adaptation implementation generally remains slow (UNEP, 2021) and few studies have reported on the implementation of transformative adaptation measures (Fedele et al., 2019). I therefore started the thesis by asking the overarching research question: *How can an understanding of adaptation as transformation be developed into actionable transformative adaptation strategies in local planning?*

To answer this question, I have used methods of co-production and qualitative methods, including interviews, observation, document analysis and mapping of implementation of BGI in urban landscapes to provide relevant data, all outlined in section 3. Section 2 explored the theoretical understandings of transformative adaptation and elaborated on how it relates to crucial elements such as collaborative efforts, values, interests and holistic approaches to adaptation. The four papers of the thesis answer specific aspects of the research questions, laying the foundation to draw overall conclusions. Thus, this section will first discuss the research findings by answering the three sub-questions before concluding.

4.1. Addressing interests and values

Based on arguments that transformative adaptation strategies should reflect and promote human agency for collective climate action (Scoones et al., 2020), and that human agency is affected by values and interests (Heifetz et al., 2009; O'Brien, 2021; O'Brien & Selboe, 2015), the first sub-question is: *How can municipal and private sector actors address the many interests and values in local climate adaptation planning?*

I argue that municipal and private sector actors can address the multiple interests and values in planning by providing physical and collaborative spaces for negotiations between the relevant adaptation actors. Paper 1 shows how collaborative climate hackathons (such as the Klimathons) can allow actors to renegotiate the boundaries between divergent knowledge communities. However, although such co-production approaches could solve challenges regarding knowledge silos and cross-sectoral collaboration issues, they do not automatically ensure climate action or adaptation (transformative or other) outside the workshop format.

Thus, I assert that it is crucial that such spaces also exist in actual planning processes. Paper 2 shows how municipal planning processes that require formal cross-sectoral collaboration could provide collaborative spaces for negotiations between different sectoral and professional interests. Also, actual progress requires some actors to take an active leadership role in the planning processes. Thus, transformative adaptation strategies must balance the need to incorporate multiple interests and actors with requirements for active leadership in adaptation planning processes, which could move change processes forward.

My findings are aligned with Wamsler et al. (2021) who assert that there is an urgent need for a more integral transformation understanding that links internal (e.g. mindset, beliefs, values, norms and practices) and external (e.g. improved infrastructure, new regulations, technological innovation) dimensions of change. I argue that one way to bridge these elements is to conceptualise internal dimensions in ways that resonates with actors who work in technical and concrete adaptation contexts in which values are not the main focus. This thesis is based on a broad definition of values, acknowledging how material and discursive elements are entangled and discussing values and interests in technical professional settings.

Specifically, I show how professional objectives can represent multiple values and interests in BGI adaptation planning. For example, I have argued that municipal water actors generally represent a set of collective blue values, promoting the goals and interests of holistic water management. Municipal urban environment actors commonly represent a set of collective green values concerning biodiversity protection and recreation objectives. These values also seem to merge into a new blue-green value set based on potential synergies from co-benefits and holistic BGI planning. The reflections concerning what professional groups value collectively could make the value concept more tangible in an environment dominated by technical approaches.

4.2. Collective values in adaptation

Acknowledging that the internal aspects of transformation, such as values, need further knowledge development and that such dimensions, also collectively, could provide deep leverage points for change (Rosenberg, 2021; Wamsler, 2020), the second sub-question is: *How can the co-benefits of BGI highlight the role of collective values in adaptation?*

In answering this question, my research has shown that BGI co-benefits can help highlight how collective values and interests can develop and unfold across sectors and professional disciplines in adaptation planning. Based on papers 2, 3 and 4, I argue that the multiple co-benefits concept could play a role in developing blue-green value sets. These three papers provide an account of municipal water actors taking leading roles in planning processes, adopting the language and formal working methods of municipal planning actors, and developing BGI plans and measures beyond the goals of stormwater management. My data show the individual and institutional will to establish holistic BGI solutions in locations in which local climatic conditions do not favour the green elements of BGI. I therefore argue that municipal water actors are motivated to implement BGI beyond stormwater management goals and approach co-benefits and holistic stormwater management as an ideal in stormwater planning.

Since research on the internal dimensions that affect transformation is often focused on private individuals or settings (Wamsler et al., 2021), I have analysed climate adaptation settings in which the actors are represented by their professional role, mandate and identity. The data provide little to no information about the values, interests or choices the actors make as individuals outside their professional settings. As values can be powerful mechanisms of transformative change, potentially contributing to new perspectives and paradigms (Rosenberg, 2021), I find that cross-sectoral collaboration and collective value development in professional adaptation settings could play a significant role in transformative adaptation. This thesis shows how professional adaptation actors find it advantageous to identify common interests and agree on shared solutions in BGI development. This will also often ensure support for their individual professional interests in their adaptation planning work.

4.3. The holistic stormwater planning ideal

Recognising and addressing the internal dimensions of societal change processes while challenging the structural elements concerning multiple entangled global crises are part of the emerging holistic and integral approaches to transformative climate adaptation (O'Brien, 2021; Wamsler et al., 2021). With this in mind, the third and final research sub-question is: *How can the holistic stormwater planning ideal help actors understand actionable transformative adaptation strategies?*

I argue that the holistic stormwater planning ideal can help actors understand holistic approaches to adaptation because it shows the potential to bridge different goals, strategies and interests. However, it can also hide conflicts between objectives and interests that could affect the final implementation of BGI measures, particularly the vulnerability of green elements in the BGI implementation phases.

In paper 4, I define holistic stormwater management ideals as approaches in which actors simultaneously aim to solve several stormwater problems, include co-benefits that secure the green BGI elements and urban living qualities, and require policy and implementation processes that integrate multiple relevant actors, values and interests. I find that the implemented BGI measures correspond to this holistic ideal in varying ways. This study has shown how BGI measures that are closer to the holistic ideal seem to require more complex planning and building processes and require the integration of more actors and knowledge communities. In papers 2 and 3, I connect municipal urban environment actors to a set of collective green values concerning biodiversity protection and green measures improving urban living quality. These actors generally do not have leading roles in the BGI development processes relating to stormwater, which could be part of the problem. Green elements are particularly vulnerable if none of the planning actors state their case.

I have also found that new urban spaces, such as empty rooftops and new development areas, can provide the necessary physical and collaborative space for implementing and potentially mainstreaming holistic BGI solutions. This thesis is based on the idea that BGI development can have a transformative adaptation potential due to the focus on holistic co-benefits. Material urban (storm-)water infrastructure is a crucial part of the structural and external dimensions of BGI development, and much of this development is still very similar to the existing stormwater infrastructure. While the transformative aspects and potential are present in the way actors think, work and approach BGI planning in new ways and not in whether BGI should replace grey infrastructure completely, a significant transformation in material infrastructure should also be expected at some point. One of the most transformative aspects in this matter could be starting to value and prioritise green BGI elements beyond what serves human interests in the current ecosystem service framework mindset.

4.4. Final research insights: Developing transformative adaptation strategies

At the outset of this thesis, I asked: *How can an understanding of adaptation as transformation be developed into actionable transformative adaptation strategies in local planning?*

The main contribution of this thesis to the transformative adaptation literature is how it empirically shows the potential for collective value development and the opportunities in material urban infrastructures to implement new ways of thinking and working on local adaptation. I have discussed the importance of providing physical and collaborative spaces for negotiations between actors' values and interests and have proposed concrete ways of doing so. These spaces are particularly vital in actual planning processes. I have also emphasised the importance of conceptualising the internal dimensions of transformation (O'Brien, 2021; Wamsler et al., 2021) in ways that resonate with people working in technical adaptation contexts. The actors in BGI development processes generally represent values associated with their professional mandates, responsibilities and objectives in local adaptation work. They can also develop collective value sets across sector interests, such as the blue-green values described in papers 3 and 4.

Starting this thesis by arguing that (1) co-production and (2) BGI planning processes represent arenas with a transformative adaptation potential requires some final reflections on what constitutes transformation. First, I will argue that these two arenas could allow the envisioning and development of a just, equitable and sustainable future for all humans and other actors (O'Brien, 2021). This kind of focus could provide different adaptation strategies than approaches that mainly aim to avoid maladaptation and vulnerabilities. Many processes of knowledge co-production and BGI planning share idealistic goals and visions regarding involving and benefitting multiple actors, voices, interests and values when responding to climate challenges. Second, I assert that the two arenas are appropriate for re-politicising adaptation and challenging the dominating interests in adaptation processes (Ajulo et al., 2020; O'Brien, 2021; Pelling, 2011). As shown, another commonality between co-production and BGI planning is the struggle of balancing the interests and values in actual implementation. Transformative adaptation strategies will continuously require reflections and efforts concerning power hierarchies and leading actors who impact implementation in local adaptation planning processes.

Finally, defining transformation as physical and/or qualitative changes in form, structure, or meaning-making (O'Brien & Sygna, 2013), I will keep arguing that the two arenas have the potential for transformative adaptation. Actionable transformative adaptation strategies will involve solving many complex and entangled challenges simultaneously. The previously discussed holistic adaptation planning ideals and working methods represent a qualitatively different approach to adaptation that could connect internal elements such as values and external factors such as regulations or material infrastructures.

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Appendix

Intervjuguide 1 – KDP-prosess for overvatn, kommunal aktør

- **Kan du fortelje litt om eigen bakgrunn, erfaring, og kompetanse på VA, overvasshandtering og klimatilpassing?**
  - Utdanning? Tidlegare arbeidserfaring?
  - Kvifor jobbar du med dette fagfeltet

- **Når/korleis blei du involvert i arbeidet med KDPen for overvatn?**
  - Kva har di rolle/oppgåver i arbeidet med KDPen vore?

- **Kan du fortelje litt om starten på planprosessen for KDPen for overvatn i kommunen?**
  - Korleis oppstod ideen? (kom ideen frå adm. eller pol. nivå, eller anna?)
  - Kven og korleis starta prosessen?
  - Del av eksisterande strategi/mål i kommunen?

- **Kva kompetanse/fagbakgrunn har ein trengt i arbeidet med planen?**
  - Korleis har fagkompetansen vore samansett i arbeidsprosessen?
  - Er det kompetanse du/de har følt mangla?

- **Korleis har det vore å jobbe med KDPen for overvatn?**
  - Er det noko som har vore utfordrande i prosessen med planarbeidet?
  - Er det noko som har overraska deg i prosessen?

- **Korleis tenkte ein når ein inviterte fleire avdelingar/aktørar inn i prosessen?**
  - Kva aktørar er invitert med i prosessen?
  - Korleis skjedde ev. inkluderinga av fleire aktørar?
  - Når skjedde det? (formelt/uformelt, med/utan politiske vedtak)
  - Har det vore aktuelt å ousource noko av arbeidet til privat aktør?

- **Korleis har det tverretatlege samarbeidet fungert?**
  - Kven har utført sjølve arbeidet med planen?
  - Ressursar til rådigheit? Budsjett, stillingar?

- **Korleis har kommunikasjon med og innspel frå politisk nivå vore?**
  - Er det bestemte politikarar som har vore involverte i prosessen?
  - Har det vore interesse for planen frå politisk side?
  - Har ein hatt behov for eit politisk mandat? Har ein ev. hatt dette i ryggen?
  - Har du opplevd at planen har hatt politisk prioritet i kommunen?
  - Har ein aktivt involvert politisk nivå i planprosessen?

- **Kva ressursar har ein hatt i arbeidet med KDP for overvatn?**
  - Har ein sett til andre kommunedelplanar for inspirasjon i arbeidsprosessen?
  - Andre viktige dokument, inspirasjonskjelder?

- **Kva er det viktigaste ein ønsker å oppnå med KDPen for overvann i kommunen?**

- **Har du refleksjonar rundt korleis KDPen for overvatn kan legge føringar for kva tiltak som vert brukt for å handtere overvatn i kommunen?**
  - Kan KDP for overvatn vektlegge t.d. tradisjonelle eller alternative løysingar for handtering av overvatn?

- **Ein har fokus på blå-grøn faktor, opne løysingar og blå-grøn infrastruktur –**
  - Kva er den største utfordringa med å innføre desse tiltaka?
  - Kva er fordelane med å innføre desse tiltaka?

- **Veit du om kommunen har hatt spesielle kriser/hendingar knytt til overvatn?**

- **Status for kommunedelplanen - kor legg planen seg i planhierarkiet?**

- **Privat vs. kommunalt eigarskap til overvassinfrastrukturen? Refleksjonar?**

- **Korleis vil de bruke KDPen i dagleg arbeid vidare i di avdeling?**

- **Iflg. Planprogrammet er klimatilpassing sentralt i arbeidet med KDPen for overvatn – kva er klimatilpassing for deg?**

- **Har omgrepet klimatilpassing vore sentralt i arbeidet med KDP for overvatn?**

- **Klimafaktor og klimapåslag vert nemnt, kva datagrunnlag for klimapåslag vert brukt?**
  - Hadde du/de høyrt om eller brukt Klimaprofilane eller data frå Norsk Klimaservicesenter?

- **Noko du ønsker å ta opp som du tenker eg har gløymt å spørje om?**

Intervjuguide 2 – arbeid med blå-grøn infrastruktur, privat aktør

- **Kan du fortelje litt om arbeidet i di bedrift og din eigen bakgrunn, kompetanse og arbeidskvardag?**
  - Utdanning og eventuelt tidlegare arbeidserfaring?
  - Kva prosjekt jobbar du med?

- **Har di bedrift prosjekt der overvatn, klimatilpassing eller blå-grøn infrastruktur er hovudfokus?**
  - Kva er utfordringane rundt å jobbe med overvatn i dykkar prosjekt?
  - Om det er fokus på blå-grøn infrastruktur i eit prosjekt, kva er fordeler med å innføre blå-grøne tiltak i dykkar prosjekt?

- **Korleis jobbar di bedrift med overvasshandtering og blå-grøne løysingar?**
  - Kva typar overvasstiltak blir brukt i di bedrift sine prosjekt?
  - Kva er grunnlaget for å velje dei løysingane som blir brukt?

- **Har du tankar om korleis arbeid med overvatn i planlegging har utvikla seg gjennom dei åra du har jobba med planlegging?**

- **Kan du fortelje litt om korleis di bedrift får oppdrag, ev. kva oppdragsgjevarar som er spesielt viktige?**
  - Kor stor/viktig samarbeidspartner er kommunen?
  - Korleis fungerer samarbeidet?
  - Er det nokon byggherrar som er spesielt interesserte i blå-grønt?

- **Kjenner du til Kommunedelplanen for overvatn i kommunen din?**

- **Har du ev. tankar om kva rolle Kommunedelplanen for overvann eventuelt vil spele i di bedrift sitt videre arbeid med klima- og overvassplanlegging?**
  - Tankar om korleis ein ev. kan/vil bruke den framover?
  - Er slike planer nyttige for di bedrift? Ev. korleis?
  - Er det andre planer/retningslinjer/rettleiarar som er spesielt relevante/nyttige?

- **Er klimaendringar og klimatilpassing ein sentral faktor i arbeidet dykkar?**
  - klimafaktor/klimamodell og klimapåslag i arbeidet, kva datagrunnlag for klimapåslag vert ev. brukt?
  - Hadde du høyrt om eller brukt Klimaprofilane eller data frå Norsk Klimaservicesenter? Andre?

- **Noko du ønsker å ta opp som du tenker eg har gløymt å spørje om?**

Paper 1

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Using collaborative hackathons to coproduce knowledge on local climate adaptation governance

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ABSTRACT

While coproduction of knowledge is growing in popularity in social sciences, and especially climate change research, we still need to better understand *how* to coproduce climate knowledge. In this paper, we explore how collaborative climate hackathons coproduce local adaptation knowledge, and what this method reveals about local climate governance. The data derives from two collaborative climate hackathons, called Klimathons, that attracted 73 and 98 participants in Bergen, Norway. The participants were practitioners and decision-makers from local, regional, and national institutions as well as researchers from natural and social climate sciences. The collaborative group work revolved around the challenges and solutions of local adaptation planning and uncovered how a diversity of key actors understand the local adaptation work in Norway. These interventions revealed that there are significant disagreements and divergent understanding of relevant laws, regulations and responsibility between practitioners working within the same governance system. Though the cross-sectorial interaction does not dissolve these divergences, they allow actors to renegotiate boundaries between divergent knowledge communities. The Klimathons helped us navigate the complexity of local climate adaptation by shifting the focus to how different actors make sense of and work on adaptation and showing the intertwining and interdependence of potential drivers for adaptation.

1. Introduction

Knowledge of the challenges, needs, and opportunities for climate adaptation has advanced significantly in recent years (Di Giulio et al., 2019; Dilling et al., 2017; Ekstrom and Moser, 2014; O'Brien, 2017; Reckien et al., 2015). Research has for example elucidated the likely contributing factors to adaptive capacity and communities' potential for adaptation (Berrang-Ford et al., 2014). However, adaptation is neither inevitable nor automatic, even where adaptive capacity is presumably high, as in Norway (Berrang-Ford et al., 2014; Burch, 2010; O'Brien et al., 2004), and there is little empirical evidence on the process of stakeholder involvement and coproduction in the development of municipal adaptation strategies (Wamsler, 2017).

Previously, much research on climate adaptation governance has revolved around how existing systems can be instrumentally fine-tuned and adjusted, rather than understanding how the interplay between the organization of knowledge and the development of support for such organization within governance can be nurtured (Termeer et al., 2013). Accordingly, we need to explore empirically how municipalities and related actors navigate the politics of adaptation and formulate responses to climate risk (Dilling et al., 2017). This decision-making space is filled with voices from many sectors and disciplines, providing an opportunity to test new forms of dialogue. Thus, climate change adaptation requires collaborative and coproductive efforts. For our purposes, collaborative climate hackathons can improve climate governance by providing a new mode of knowledge coproduction in climate adaptation, and allowing the development of new perspectives from actors that traditionally do not work together (Trainer et al., 2016).

In this paper, we ask, firstly, how collaborative climate hackathons coproduce local adaptation knowledge, and secondly, what this coproduction method reveals about local climate governance. Based on a semi-structured hackathon method employed in a Norwegian context, the results offer insights into how practitioners and decision-makers make sense of the challenges and solutions in local climate adaptation planning. The qualitative data analyzed in this paper comes from two knowledge coproduction events framed as collaborative climate hackathons, organized to foster deliberate cross-sectoral and interdisciplinary collaboration and create insights into challenges for local climate adaptation governance.

The paper proceeds as follows. Section 2 reviews literature on how coproduction and collaborative climate hackathons are helpful for exploring local climate adaptation governance in the Norwegian context. Section 3 outlines the methods of our collaborative climate hackathon process.

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Section 4 describes the findings from the Klimathons, and section 5 discusses and concludes what the climate hackathons reveal about local climate adaptation governance.

2. Understanding coproduction and governance of local climate adaptation

2.1. Coproduction of local adaptation knowledge – Collaborative climate hackathons

A wide range of factors and conditions shape climate adaptation and governance at the local level. Arguably, researchers can engage with this complexity and contribute to adaptive agency through coproduction of knowledge (Berkes, 2009; Lemos and Morehouse, 2005; Wall et al., 2017). Coproduction acknowledges how data and scientific knowledge is created through the interactions between the many different actors involved in a research process (Bremer and Meisch, 2017; Jasanoff, 2010). Instead of creating theoretical models of the relationships between abstract factors, coproduction focuses on practitioners' experiences and interpretations of challenges. Coproduction has been particularly relevant where the division between science and policy is blurred, increasing the need for interaction between scientists, policymakers, and the public (Lemos and Morehouse, 2005).

In this context, coproduction can be understood as a deliberate collaboration between actors to achieve a common goal (Lemos, 2015; Lemos and Morehouse, 2005; Ostrom, 1996). This resonates well with the intentions and ideas behind the collaborative climate hackathons in this study, bringing together actors with differing perspectives, values, and foci.

The word hackathon consists of the two words *hacking* and *marathon,* and has traditionally been associated with coding and software development (Briscoe and Mulligan, 2015). Hackathons have also been used to address a variety of societal issues, including urban development, health education, and homelessness (Aungst et al., 2019; Baccarne et al., 2014; Linnell et al., 2014; Pogačar and Žižek, 2016). While classic hackathons emphasize technical “hacking” approaches, they have also facilitated community-based learning and interdisciplinary or intersectoral collaboration (Duncombe et al., 2018; Lara and Lockwood, 2016). Therefore, this form of knowledge coproduction can provide an “institutional trigger” (Armitage et al., 2011) that allows learning across disciplinary or institutional boundaries, builds trust, and strengthens relationships between actors over time (Bremer and Meisch, 2017).

In a hackathon, participants from different fields, competencies and specialties gather to work collaboratively, often over 24 to 48 hours, to develop new solutions to a pre-defined problem. Both creativity and autonomy in the problem-solving process are crucial elements of the hackathon method (Pogačar and Žižek, 2016). Traditional hackathons have often been arranged as competitions where the participants can win prices or funding for their ideas, and achieve prestige and contact networks (Pogačar and Žižek, 2016). Arranging a hackathon for the scientific purpose of gathering data needs adjusting and systematic preparations. How we did this, is outlined in detail in section 3.

2.2. Factors influencing local adaptation governance

To understand the outcomes from the Klimathons, it is useful to review what research already tells us about what enables or hinders local climate adaptation governance.

Climate adaptation governance refers to the ways in which public, private, and civil society actors and institutions articulate goals, exercise influence and authority, and manage planning and implementation processes. While successful mitigation and adaptation require measures taken by international and national actors, many initiatives and solutions are designed and implemented at the local level (Anguelovski and Carmin, 2011). Over the past decade, research has identified a diverse range of barriers and drivers of local climate adaptation (Biesbroek et al., 2015; Eisenack et al., 2014; Moser and Ekstrom, 2010). Ample research highlights how a range of organizational, technical, resource, or institutional conditions affect adaptation governance (Lawrence et al., 2015; Reckien et al., 2015; Simonet and Leseur, 2019).

The two first Klimathons focused on finding solutions to local adaptation challenges. In this study we develop an analytical framework to understand the value of collaborative hackathons in developing knowledge of local adaptation governance. Based on current climate adaptation literature, we will discuss how knowledge, political leadership, and institutional factors affect and potentially drive local adaptation and governance processes.

First, *the role of knowledge* is important in existing adaptation literature. Scientific climate knowledge is emphasized as key to understanding the potential impacts of climate change and developing adaptive strategies (Adger, 2007). Even though the growing body of scientific knowledge does not itself lead to growing consistency in societal attention, political commitment, or state interventions (Vink et al., 2013), knowledge connects climate adaptation and local political agendas, influencing priorities and anchoring decisions. For example is reducing the impact of a natural hazard contingent on recognizing knowledge gaps in adaptation processes, and coproduction has increasingly been perceived as a way to increase local adaptive capacity (Dannevig et al., 2013).

In this context, a range of research institutions, companies, and local authorities have contributed to the production of climate services, which are relevant forms of knowledge to inform decisions and policymakers on local adaptation needs (Hewitt et al., 2017). Effective engagement between actors who use, produce and even coproduce new knowledge is seen as an essential element of any climate service (Hewitt et al., 2017; Kolstad et al., 2019). Thus, interactions between governance actors could even drive effective climate governance, provided that climate information meets practical needs and that new knowledge is integrated into existing knowledge and decision contexts (Lemos, 2015). In such settings, coproduction may create forceful epistemic communities or networks that have increased capacity for climate action.

Second, *the role of political leadership* is frequently identified as necessary to implement adaptation successfully (Anguelovski et al., 2014; Dilling et al., 2017). Leadership can be critical at different stages of an adaptation process, but perhaps most important in initiating the process and sustaining momentum over time. Such formal as well as informal leadership relates to the ability to identify and agree on adaptation goals along with ways to achieve them (Moser and Ekstrom, 2010). Leadership can come from any position in the governance hierarchy, but top-level leadership from a supervisor, mayor or other elected official is commonly seen as critical to get adaptation on the political agenda. Further, where there is political leadership, funding follows (Moser et al., 2019).

In a local governance context, political leadership includes the distribution of ownership and support for administrative processes. In practice, political leadership is exercised by local stakeholders initiating and supporting changes in legislation, policy documents, and has been identified as a key resource for urban climate change adaptation (Ekstrom and Moser, 2014; Uittenbroek et al., 2013). As such, a combination of leadership, local government support, and stakeholder buy-in has been proven necessary to implement adaptation measures (Anguelovski et al., 2014; Dilling et al., 2017).

Third, *institutional* factors are recognized as important elements in enabling, constraining, and shaping climate adaptation (Birkmann et al., 2014; Patterson et al., 2019). These relate to factors such as organizational development, regulatory environments, access to technological innovation, public awareness and opportunity for outreach, capacity for monitoring, and financial support. Given the breadth and complexity of institutional factors, research remains inconclusive about which are important and their influence on adaptation, decision-making, and performance (Oberlack, 2017). According to Berrang-Ford et al. (2014), institutional capacity is the strongest predictor of national adaptation policies and action. At the local level, this is apparent in institutions' capacity for internal and external communication, cohesion, and motivation (Dannevig et al., 2013). Local areas are where abstract policy goals “hit the ground”, and where conflicts and contradictions must be resolved. Of course, this does not mean that all solutions are distinctly local – “local” climate governance is involved in many cross-scalar interactions (Haarstad, 2014). However, it remains crucial to integrate the effects of institutional factors to understand solutions of local adaptation work. Effective governance is a cross-sectoral and multilevel endeavor and coordination between actors and institutions remains a key challenge (Cashmore and Wejs, 2014; Lodge and Wegrich, 2014).

2.3. Local adaptation and governance in the Norwegian context

It is useful to give an overview of climate adaptation in the Norwegian context since both Klimathons took place in Norway. Norwegian municipalities vary greatly in their geographical features, organizational resources, and societal needs. According to Westskog et al. (2017), Norwegian national and sectoral governmental authorities and policies do not sufficiently recognize these significant variations.

During the last decade, local adaptation work in Norway has developed from a situation characterized by municipal confusion about how to adapt to climate change, to gradually improving local adaptation knowledge (Orderud and Naustdalslid, 2020). A common explanation for confusion and failure to implement effective climate adaptation in Norway is the lack of coordination between municipal departments and with regional and national stakeholders (Amundsen et al., 2010; Neby, 2019; Westskog et al., 2017).

In Norway, the national authorities are responsible for facilitating and overseeing compliance with national requirements, guidelines, and intentions by municipalities. The Planning and Building Act requires Norwegian municipalities to be formally responsible for planning and implementing measures that safeguard the municipality and the residents, including handling the impacts of climate change (Westskog et al., 2017). The municipalities are also required by the Civil Protection Act to develop overall risk and vulnerability analysis's (RVAs) that incorporate climate change and to prepare and develop adequate measures for responding to potential climate events (Westskog et al., 2017).

Although, the national level in Norway controls and guides the municipalities' work on climate change, the municipalities have a significant degree of freedom when designing their policies, including climate adaptation policies (Westskog et al., 2017). Research has shown that Norwegian municipalities also implement adaptation policies that are not initiated at the national level, and this often depends on the efforts of individuals within the municipal organization, municipal size, and the use of external expertise (Dannevig et al., 2012).

3. Methods: Coproducing actionable climate knowledge

3.1. Hybrid climate hackathons

The two collaborative climate hackathons were held in Bergen, Norway, and engaged Norwegian practitioners and researchers. The first Klimathon in 2018 (K1) came from the experiences of a set of multidisciplinary projects that entailed collaborations between research communities and practitioners in municipalities, counties, and government agencies over years. As we recount elsewhere (Kolstad et al., 2019), we discovered early in the working process that cross-sectoral collaboration is more challenging than is often assumed. K1 was devised to improve the collaboration and knowledge exchange between institutions, practitioners, and governance levels, which we had observed to be lacking in previous project work. An overarching motivation behind organizing the climate hackathons was precisely to overcome the barriers of a lack of cooperation and coordination between governing actors, administrative levels, and scientific communities.

The second Klimathon in 2019 (K2) built on this initial effort to develop a more engaging collaborative process, drawing more explicitly on actors' problem-solving skills. Both Klimathons were facilitated by a systematic process methodology informed by the problem-oriented and collaborative ethos of traditional hackathons.

We aimed for a broad representation of participants – geographical, disciplinary, and sectoral – for the discussions during the climate hackathon events. Because the main research theme was adaptation in municipal planning, the main target group was municipal planners. An important aspect of the Klimathons was to allow for the methodology to incorporate a representation of a realistic context. The representation of the most relevant actors working within the Norwegian adaptation field in each group, framed the hackathons as a qualitative experiment in a realistic – but not real – setting. Actor, sector, and knowledge representation substituted the formal roles of decision-making processes, and the participants were encouraged to draw on their real-life experiences.

Creativity and autonomy in the problem-solving process are crucial elements of the hackathon method (Pogačar and Žižek, 2016). Therefore, at K1, we asked the participants to discuss openly and present a decision-making process for municipal climate adaptation work where they met all the current challenges in that process. For our purposes, the hackathon method was adjusted to achieve certain research objectives; for example, there was no focus on competition (Briscoe and Mulligan, 2015), but rather on cooperation, learning, information sharing, and communication within and across the working groups. To achieve a broad range of experiences, the organizers composed the groups and assignments strategically, which challenged the autonomy elements of the original hackathon format. The discussion process for K2 was also deliberately structured to accommodate efficiency and focus, an approach not common in classic hackathons.

Even though coproduction approaches are intended to democratize knowledge creation processes through better inclusion of nonscientific actors (Funtowicz and Ravetz, 1993), potential ethical problems are still involved, for example, asymmetrical relationships and the power to define the questions. We tried to negate this by being as transparent as possible in the organization process (e.g., by involving practitioners in the planning committee), and inviting comments on the final reports before publication.

3.2. Structuring the hackathon work process

At the Klimathon events, 12 (2018) and 10 (2019) interdisciplinary and intersectoral groups collaborated intensively over two days, discussing and designing practical and strategic solutions to the challenges of planning and implementing climate adaptation at the local level (See Table 1 for an overview of participant backgrounds and Fig. 1 for photos from the events). The wide variety of backgrounds of group participants reflected a complex reality in the decision-making processes of municipal planning and climate change adaptation. This allowed the participants to exchange experiences and discuss the different perspectives. The collaborative hackathon events provided a specific arena for understanding others' daily realities through collaboration and dialogue across research environments, practices of policymaking, and levels of public administration.

When preparing for K1, we challenged the groups to work toward improved decision-making processes and present a theoretical decision-making process for local climate adaptation planning. The tasks at K1 required the participants to design solutions to improve the decision-making processes around climate adaptation and to facilitate climate adaptation work for planners, especially in smaller municipalities. The motivation behind this was to provide actionable scientific climate knowledge for decision-making that would make Norwegian municipalities and communities better equipped and competent to manage future climate change. This format proved to be challenging, and most of the groups focused mainly on the formulation of challenges and solutions

Table 1
Participants in Klimathons 2018 and 2019.

Participant background	K1 2018	K2 2019
Municipalities in Hordaland	*11*	*14*
Municipalities outside Hordaland	*14*	*16*
Regional County Council/Regional Governor	*18*	*15*
University/Research Organization	*18*	*30*
National Government Agency	*6*	*12*
Planning Consultancy	*2*	*8*
Private Sector	*4*	*3*
Total	**73**	**98**

Fig. 1. Klimathon I and II. Photos from the Klimathon group work and presentations.

in the planning processes and less on presenting a theoretical decision-making process. All the groups presented their solutions in a plenary session on the second day of the event.

The methodology and tasks of K1 were revised and improved for K2. An expressed goal for K2 was for the participants to align perspectives across the different participant types and to develop shared perspectives among the participants. From discussing one common task about adaptation in area planning at K1, we developed four distinct tasks for K2. The themes of the four tasks were (1) water-related issues; (2) nature, agriculture, and cultural heritage; (3) organizational and institutional processes; and (4) climate vulnerability and emergency preparedness. The tasks asked the participants to develop innovations, such as new policies, governance solutions, or products that would draw on the expertise of the group, and to agree on a short-term plan for their respective institutions to progress the idea.

At K1, the group discussions were not formally structured. The only means of keeping the discussions on track was an assigned (but informal) group leader in each group. At K2, the group discussions were structured pedagogically as pyramid discussions, a dialogue method to give all participants time to speak while pushing the discussions forward (Hampel and Heckmann, 2005; Jordan, 1990).

At K2, the participants were asked to create a mind-map showing the range of knowledge, processes, and actors that were pertinent to their case. This allowed participants to ground their assigned task in their own contexts and experiences. The mind-map allowed them to connect different elements and helped them to identify recurrent issues. Each group then had to identify one or two leverage points for change, that is, elements that occupied a crucial position on their map and required the participants to agree on a limited set of issues to be prioritized. Continuing, the groups were required to develop innovations, such as new policies, governance solutions, or products, that would draw on the expertise of the group and address identified issues. Finally, the participants had to agree on a short-term plan to carry the idea through in their respective institutions. Deliberation and discussions are at the core of this process, and as organizers, we expended considerable effort on streamlining the process. All the groups presented their solutions in a plenary poster session the second day of the event, where also local politicians were invited.

3.3. Analyzing data from the two climate hackathons

The two Klimathon events coproduced a rich data set. From K1, we coproduced 12 digital group presentations on solutions to local adaptation challenges, individual notes of reflection about the working process from all 12 group leaders, and evaluations from the K1 participants. From K2, we coproduced 10 group posters with mind-maps of their adaptation strategies (See Fig. 2 for examples), reflective notes from 10 group leaders, evaluations from the participants, and designated field notes from one social science researcher.

Analyzing the qualitative data from K1, we systematically summarized the group discussions in an extensive table containing three categories related to the decision-making process for adaptation: 1) challenges,

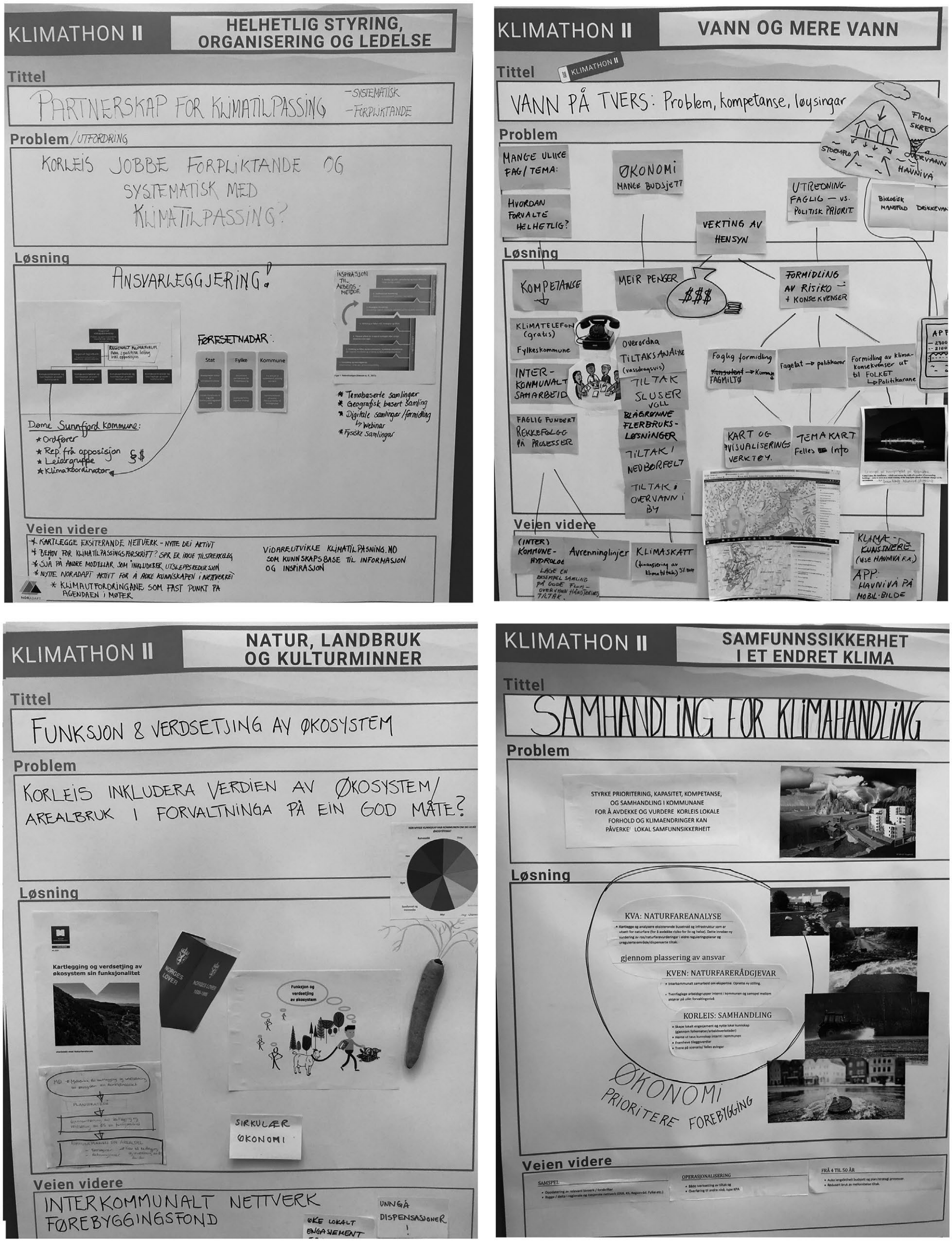

Fig. 2. Klimathon II posters. A selection of posters from K2 showing the group presentation solutions. Titles: "Climate adaptation partnerships," "Water crossing borders," "Valuing ecosystem services," and "Climate action collaboration."

2) solutions, and 3) the way forward. Producing this table of categories required a systematic analysis of the themes and solutions presented. After getting an overview of the data, we placed the different themes from the presentations into the three categories. We then counted how many times the groups presented each of the identified themes to get an impression of which themes were most important to the groups. Importantly, though some thematic challenges were discussed more than others (like knowledge or political will), the solutions were intertwined and often came from other themes (like resources for competence building or cross-sectoral collaboration).

Analyzing the data from K2, we held a dedicated workshop to examine the 10 posters, drawing important connections between themes, challenges, solutions, and drivers of adaptation from each group. This material was supplemented by detailed field notes from the group discussions from one social researcher with the role of an observer at the event. For both K1 and K2, we made written reports that summarized and synthesized the workshop, assignments, methods, and results from the workshops. This collective process of analyzing the data in practice consisted of three steps. First, as a preparation, all involved researchers had the chance to familiarize themselves with the existing material. Second, we collectively assessed each main item of the data – particularly the poster presentations – while opening for deliberation on interpretations and taking notes. Third, we grouped the data based on thematic distinctions and made a loose, collectively agreed prioritization to signal what themes were considered more important than others. This approach resembles the method 'collective qualitative analysis' as described by Eggebø (2019), but differs in the sense that our data were already "filtered" and semi-processed through the coproduction processes of K2.

These reports are openly available (in Norwegian) and serve as a documentation of both the Klimathon process and the rudimentary findings (Kvamsås and Stiller-Reeve, 2018; Neby, 2020). Together, this material provided extensive reflections on how the participants, with all their varied professional experience of climate work, perceive solutions to local adaptation challenges.

Finally, it is important to note that – as any qualitative work – the processing of the material gathered from the Klimathons relied on an interpretative approach. We emphasized to identify themes that were reflected across groups. In practice, this involves a process of condensation and abstraction by us as researchers. This interpretation was also a process of deliberation between the authors of this paper. This condensation, abstraction and deliberation thus builds on the analytical and methodological competencies of each participating researcher, but it is important to note that deliberation also entails assessing claims, interpretations with a critical perspective as much simply reviewing the data. The group of researchers represent interdisciplinary approaches to climate change adaptation, spanning both social and natural sciences. Interdisciplinarity is a characteristic of adaptation challenges, which we thus attempted to "match" by working across academic specialties.

4. Findings

This section presents findings and reflections concerning how the Klimathon participants made sense of the practical work of climate adaptation, focusing on the roles of knowledge, political leadership, and institutions.

4.1. Understanding solutions to climate knowledge challenges in municipal planning

At K1, the most discussed topics concerned the quality and quantity of climate knowledge and the need for competencies to facilitate local climate adaptation. A lack of general climate knowledge among the governance actors and gaps in the scientific climate knowledge were identified as challenges. It was acknowledged that although the actors that contribute to local adaptation governance may have such knowledge, it is often not accessible or systematized in a manner relevant to local planners or decision-makers. Although the discussions reflected subjective experiences of lacking knowledge and relevant climate data, not all actors reported similar needs. Indeed, many of the researchers found this somewhat surprising, as they expressed satisfaction with their access to several sources of systematized information. This may indicate that some actors do not know where to find relevant information or how to process it, rather than an actual absence of knowledge and data. Crucially, mapping local information and knowledge needs and conditions was also underlined by practitioners as a way to develop more contextual and relevant knowledge support.

A majority of the groups at K1 promoted professional training and formal certification in the municipalities as solutions to these challenges. They focused on the importance of securing professional training for both administrators and politicians, for example, to increase legal competence in the municipalities and build local competence. Specifically, they suggested more guidance and advice from researchers, as well as from regional and national authorities such as the county council, the county governor, or the National Environmental Agency. Some held that improved visualization of data and contextual knowledge of climate effects would facilitate the local absorption of knowledge. One specific suggestion was that municipalities could "borrow a visiting researcher" to aid the integration of climate knowledge into their governance processes (this was tested by a municipality in northern Norway the following year).

At K2, the need for further knowledge and competences in climate adaptation work also emerged as a key topic. However, this time, we saw examples of how participants developed proposals to facilitate knowledge exchange. After two days of discussions, an emerging emphasis seemed to be the awareness that knowledge is created in a particular context, rather than simply transferred from its possessors, like the researchers or state agencies. They suggested new arenas, platforms, and methods for gathering and presenting data. In addition, they tended to link knowledge generation to political decision-making processes by suggesting mechanisms for embedding political decisions in contextualized knowledge and making specific political actors responsible for local climate adaptation work.

For instance, one group at K2 proposed changes to the local–regional governance structure to improve the commitment and systematization of local climate decision-making. The members suggested establishing a "Regional Climate Forum" involving administrators and politicians – including opposition politicians. The forum would institutionalize responsibility for climate action, and it was planned how this would fit within the existing system of governance. It was emphasized that this solution relied on existing active and engaged networks because several informal networks with similar purposes have already been established. Interestingly, the participants at K2 – drawing on challenges from their regular work – were more interested in integrating and institutionalizing knowledge creation and deliberation.

4.2. Understanding the need for political support and clarification of responsibility

At K1, the second most discussed topic was the frequent lack of (and need for) political support to prioritize climate adaptation in local planning. This was repeatedly attributable to politicians' lack of knowledge and will to act. Although municipal planners are often at a considerable distance from the political agenda, some had found that climate-related events like floods, stormwater events, or landslides had highlighted climate adaptation. At K2, the discussions on political support reflected a need to promote political ownership and institutionalize climate adaptation in municipal planning. One group even suggested that municipal climate adaptation work needed a new type of organization that should be more task oriented. The participants requested broad political anchoring in municipalities and counties, including anchoring of climate adaptation in overarching municipal and regional plans. Several groups at K2 promoted dialogue-oriented planning processes to address such challenges and called for the inclusion of politicians at early stages of the planning processes.

Responsibility and accountability were also widely discussed in connection to the role of politicians at both Klimathons. At K1, the municipal practitioners talked about the fragmentation of accountability, stating that although all the actors had a common responsibility for climate adaptation, none was generally accountable. Specifically, different groups asked for authorities to clarify responsibilities for issues such as sea level rise and stormwater management. To resolve this, they asked for clarification of the overarching responsibility for climate adaptation at the national level, and for actors at all levels to be assigned a specific role. Preparing a comprehensive overview of the existing roles and responsibilities at the national level was also seen as a step toward a structure of accountability.

Regarding local climate adaptation processes, these results suggest extensive uncertainty and confusion concerning the lack of responsibility. However, a nuanced interpretation of the demand for political anchoring, will and support and clear responsibility suggests that municipal planners desire political support more than actual involvement in climate adaptation. At K1, several suggestions concerned politicians' support in the planning process, whereas at K2, politicians were directly mentioned as important actors in the proposal for formal climate networks. In continuation, one may also interpret this situation as symptomatic of the sectoral boundaries that cut across both the internal organization of the municipalities, and across the actors that municipalities engage with in climate adaptation governance. Political involvement could thus be a strategy for legitimizing adaptation processes, but such legitimizing comes with a potential downside for experts and bureaucrats: it opens the door for political engagement to interfere with professional discretion.

4.3. Understanding the need for cross-sectoral collaboration between and within institutions

From the start, the collaborative hackathon method aimed to overcome fragmentation and knowledge silos in climate governance. At K1, the coordination challenges were raised in the majority of the group discussions. The groups often reported a lack of interdisciplinary and cross-sectoral collaboration, as well as a lack of holistic thinking in local governance. In addition, some participants indicated that divergent understandings of the important issues were a considerable challenge.

Engagement with research environments was generally presented as important to local adaptation work. The groups also called for more contact with the private finance sector and the need for “knowledge brokers” between sectors and disciplines. At both Klimathons, several participants perceived the Klimathon to be an arena for interdisciplinary collaboration between the public administration and the research environments. Some groups suggested establishing new networks and strengthening existing ones. Importantly, the collaboration platforms discussed aimed to promote the participation of a variety of actors in terms of ownership and identity in the climate work. However, these suggestions lack specificity concerning the effects and practicalities of networked or collaborative arrangements.

At K2, one group considered managing water matters more holistically by including them directly in the municipality's mainstream planning processes. The solutions concerned developing more flexible municipal plans with better adaptation to local climate effects. They suggested the creation of a specific governance authority, such as a “Water Office”, that would gather competencies, skills, and knowledge and have clear authority over water matters.

A recurring topic at both Klimathons was the need to gather and share examples and best practices from municipalities and actors that had progressed furthest with practical climate adaptation measures. One group at K2, working on the theme of nature, agriculture, and cultural heritage, suggested developing a platform to document these best practices and propose solutions to common problems. The proposed platform was seen both as a possible inspirational database of solutions and a basis for further data collection and development of new pilot projects.

The theme of laws and regulations was discussed substantially as a solution more than a challenge. The main arguments concerning laws and regulations at K1 showcase the need for binding guidelines and consistent interpretation and implementation of regulations across municipalities. At K2, one group specifically proposed stricter requirements for climate adaptation in existing laws and regulations.

5. Discussion and conclusion: Lessons from the Klimathons

At the onset of this paper, we asked how collaborative climate hackathons coproduce local adaptation knowledge, and what this coproduction method reveals about local climate governance. In section 3, we presented the methodological choices of our collaborative climate hackathons in detail. In section 4, we discussed the empirical patterns that we drew from the climate hackathons. Here, we highlight the more general analytical findings from the Klimathons.

The coproduction of knowledge in collaborative hackathons can be useful for understanding local climate adaptation in ways that recognize the complexity of factors affecting governance processes. We can use the results from hackathon-type events to gauge the perspective of municipal practitioners and tease out insights from their engagement in collective problem solving. The Klimathons helped us navigate the complexity of local climate adaptation (Bremer and Meisch, 2017; Dilling et al., 2017) by shifting the focus to how different actors make sense of and work on adaptation and showing the intertwining and interdependence of potential drivers for adaptation. As for what the collaborative climate hackathon method reveals about local climate governance, there are several engaging lessons.

The first lesson concerns the importance of increasing the competence of local planners and decision-makers in using available knowledge, allowing knowledge to become an empowerment for actors in climate governance. The Klimathon participants called for more knowledge brokers, more local scale climate data, more practical examples of best practices, and more coproduction of knowledge with researchers. Simultaneously, the discussions on political and institutional factors noted the slow and conflicted processes of receiving and acting upon knowledge, as well as the importance of contextualizing knowledge (making generalized knowledge applicable to the specificities of localities).

While the lack of knowledge is typically cited as a key barrier to adaptation (Ekstrom and Moser, 2014), our material suggests that too much knowledge can be an equal hindrance. It seems that creating additional knowledge brokers has clear costs and creates new institutional pathways to be navigated. Nevertheless, improved competence in knowledge generation and application could facilitate local adaptation governance because it lays an important foundation for political and administrative engagement and skills, sets targets, and applies the working strategies and measures to achieve them.

These reflections illustrate how the cross-sectoral groups at Klimathon discussed and understood the causal processes to pursue climate adaptation goals and actions (Biesbroek et al., 2015). Developing climate knowledge and building competence is influenced by political will, leadership and funding (Moser et al., 2019), and the Klimathon dialogues show concretely how intertwined and interdependent these processes can be.

Second, the practitioners at the Klimathons called for political *leadership*, although not necessarily political *involvement* per se. The groups concretely lamented the lack of climate engagement of most politicians and the related lack of resources. While political leadership is frequently identified as a core driver of adaptive governance, adaptive capacity and funding (Dilling et al., 2017; Moser et al., 2019), the Klimathon dialogues reveal how the participants equal political leadership with political support, and how this political support is necessary for generating resources for adaptation measures.

A related finding, supporting existing literature (Dannevig et al., 2013), agenda-setting weather events seem to increase political support followed by resources, but not necessarily other forms of political involvement, like deeper political ownership or engagement in administrative processes (Ekstrom and Moser, 2014). In this context, unlocking effective climate adaptation requires municipalities to have strong institutional capacity, including public officials equipped to implement prioritized measures when disaster strikes. This underscores the complex and often unpredictable interactions between adaptation drivers.

Importantly, Klimathon participants signaled that they need room to maneuver to implement solutions based on existing knowledge. Several groups emphasized the difficulty of balancing the holistic management of climate adaptation while setting priorities within the given economic, knowledge, and political constraints. In addition, they called for greater capacity to regulate and clarify roles and responsibilities. Such clarification may inform climate governance because it defines the people responsible for jobs and for paying the costs.

The Klimathon dialogues thus reveal the participants' collective understanding, making it possible to nuance and understand previously identified adaptation knowledge. The interventions also reveal that there are significant disagreements and divergent understanding of relevant laws, regulations and responsibility between practitioners working within the same governance system.

Finally, our findings suggest that, if systematized, collaborative coproduction of knowledge might help local adaptation governance, which in Norway is still characterized by notable confusion about how to adapt to climate change (Orderud and Naustdalslid, 2020). It was evident that it was unclear to many practitioners in the field exactly who was responsible for various governance tasks, even in a well-governed context such as in Norway. Resolving this divergence is important, given the gap between the perceived need for climate information and its use (Lemos, 2015). A common explanation for confusion and failure to implement effective climate adaptation in Norway is the lack of coordination between municipal departments and with regional and national stakeholders (Amundsen et al., 2010; Neby, 2019; Westskog et al., 2017). Collaborative trials like the Klimathon events can help overcome what is often seen as an overarching barrier to adaptation—that is, insufficiently coordinated and ineffective governance processes that hamper the exchange of knowledge and sharing of responsibility (Cashmore and Wejs, 2014).

Although the interactions at the Klimathons did not resolve all disagreements and divergent understandings, they allowed participants to renegotiate boundaries between actors and communities, knowledge systems, and challenges, and they prompted participants to expand and adjust their perspectives on climate adaptation. Because the implementation of climate adaptation measures and governance processes are dynamic and messy political processes that include many actors and voices, the coproduction of knowledge in the form of collaborative hackathons may help legitimize the shared proposals.

The interest and engagement by the participants in the two collaborative climate hackathons suggest that practitioners gain in competence and were empowered to become further involved. Thus, collaborative climate hackathons can promote collaborative professional learning processes, which might help practitioners make sense of the complexities they face in everyday governance.

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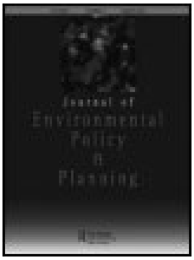
Paper 2



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Addressing the adaptive challenges of alternative stormwater planning

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ABSTRACT
Municipal water sectors shift from building traditional grey stormwater infrastructure to ambitious plans for holistic blue–green infrastructure due to climate vulnerability. The shift requires new ways of thinking, working, and collaborating, and we need to understand and address the new planning challenges the shift creates. While existing stormwater literature explores a range of technical, institutional, and financial barriers to alternative stormwater implementation, we hold the shift requires a deeper understanding of holistic and flexible stormwater management approaches. In this context, we investigate adaptive challenges like norms, practices, uncertainty, and new ways of collaborating across sectors in alternative stormwater planning in Norway. The studied planning processes exemplify how the need for making stormwater measures legally binding in municipal planning changes work practices in municipal water sectors. A novelty of the paper is that it shows how water departments take leadership of formal planning processes and adopt the planning department's language and working methods. We find that the studied municipalities promote cross-sectoral collaborative approaches that create space for professional negotiation and mediation and invite a deeper understanding of other's interests and views. We hold that such approaches could contribute to more holistic and flexible planning approaches, securing long-term sustainable stormwater management.

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1. Introduction

Urban areas are increasingly vulnerable to climate change, especially extreme precipitation episodes that can cause severe infrastructure damage and water source contamination (Bohman et al., 2020; Carter & Jackson, 2007; Hovik et al., 2015; Jiang et al., 2017; O'Donnell et al., 2017). As climate change challenges are amplified (Pachauri et al., 2014) and traditional stormwater infrastructure struggles to handle the increase in large downpours, alternative blue–green approaches like open waterways, swales, rain beds, and green roofs have emerged (Alves et al., 2019; Carter & Jackson, 2007; Dhakal & Chevalier, 2016; Travaline et al., 2015; Voskamp & Van de Ven, 2015).

Blue–green infrastructure is a collective term for sustainable blue and green solutions that utilize underlying ecosystem functions to deliver multiple benefits, like discharge-peak attenuation, water storage, energy savings, urban cooling, air quality improvement, and groundwater recharge (Alves et al., 2019; Voskamp & Van de Ven, 2015). The concept incorporates nature-based solutions, sustainable urban drainage systems, stormwater best management practices, and green infrastructure (Raymond et al., 2017; Voskamp & Van de Ven, 2015). Though the different alternative stormwater management solutions, like green infrastructure, increasingly provide stormwater management services, they are by no means mainstream (Matsler, 2019).

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Shifting stormwater infrastructure from invisible underground pipeline systems to blue–green stormwater measures on the ground can provide new opportunities for sustainable urban areas (Haase et al., 2017; Lund, 2018). It further requires new forms of collaboration by various actors and sectors, creating potential conflicts of interest and new planning challenges (Kati & Jari, 2016; Lund, 2018). Franco-Torres et al. (2020) describe the shift to alternative stormwater management as part of a new urban water paradigm, addressing growing social, technological, and environmental complexity and uncertainty. Although a considerable body of literature explores a range of technical, institutional, and financial barriers to implementing alternative stormwater measures (Dhakal & Chevalier, 2017; Jiang et al., 2017; Matthews et al., 2015; Meerow & Newell, 2017; O'Donnell et al., 2017; Qiao et al., 2019; Thorne et al., 2018; Wihlborg et al., 2019), the shift requires a deeper understanding of the holistic and flexible approaches to stormwater management (Alexandre, 2018; Bohman et al., 2020).

O'Brien and Selboe (2015) argue that even if a growing adaptation literature explores the factors, capacities, and processes contributing to successful adaptation, there is still a significant mismatch between current adaptation strategies and the full scope of the climate change problem. The slow implementation of alternative blue–green stormwater solutions (Jiang et al., 2017; Wihlborg et al., 2019) and the rigidity and change-resistance in traditional urban water paradigms (Franco-Torres et al., 2020) are examples of such a mismatch. O'Brien and Selboe (2015) hold that addressing adaptive elements of climate change (e.g. values, worldviews, mindsets, interests, norms, beliefs, practices, and approaches to change) is necessary to secure long-lasting, sustainable climate adaptation and transformation. In current stormwater literature, we see clear calls to address such adaptive elements like clashing norms and practices between different governance paradigms (Lund, 2018), uncertainty concerning alternative stormwater approaches (Thorne et al., 2018), and the need for changing the way of collaborating across sectors in stormwater planning (Bohman et al., 2020).

This paper aims at contributing to a deeper understanding of the new planning challenges the shift to alternative stormwater planning creates. To do this, we explore how to address emerging planning challenges of alternative stormwater management in a changing water sector. Based on the theory of adaptive challenges of climate adaptation (O'Brien & Selboe, 2015), we will analyse how two Norwegian municipalities plan for alternative stormwater management as part of their local climate adaptation work. These two municipalities have developed a specific sector plan for stormwater management, requiring different municipal sectors, professions, and people to discuss, negotiate, and collaborate on stormwater planning in new ways. Our theoretical framework will help explain the individual challenges, the connections between them, and how to address such issues. Few empirical studies have applied this framework to explore norms, practices, and uncertainty in alternative stormwater planning combined. Given that understanding adaptive challenges are crucial to understanding the potential for sustainable climate adaptation and transformation (O'Brien & Selboe, 2015), we believe this analysis can deepen the understanding of holistic and flexible approaches to stormwater management.

First, we ask what adaptive planning challenges emerge when shifting the stormwater management from planning traditional grey underground solutions to planning alternative blue–green infrastructure on the ground. Second, we ask how municipalities can address these identified challenges.

The article proceeds as follows. Section 2 provides a theoretical framework to identify and analyse the emerging planning challenges of alternative stormwater management. Section 3 describes the qualitative methods and the fieldwork in the Norwegian municipalities. Section 4 presents the empirical findings from the alternative stormwater management planning in Bergen and Tromsø. Section 5 discusses the findings, their implications, and concludes.

2. The adaptive challenges of alternative stormwater planning

2.1. Adaptation and transformation in the water sector

There is a growing research interest in adaptation, tied to the recognition that climate change is already affecting species, ecosystems, economic sectors, livelihoods, and human security in most of the world (O'Brien, 2017). There is also a growing consensus that the pace and magnitude of global environmental change demand a fundamental, radical, and rapid change toward sustainability (Feola, 2015; Nelson, 2009; O'Brien, 2017; O'Brien & Selboe, 2015; Pelling, 2011). Adaptation to climate change can be understood as resilience, transition, or transformation; the first contributes to passive acceptance of unjust conditions and increased vulnerability, while the latter challenges established values, organizations, and power (Pelling, 2011). O'Brien and Selboe (2015) argue that climate adaptation is a social, cultural, political, and human process and hold that understanding how adaptive elements influence adaptation is critical to understanding the potential for societal transformation. Correspondingly, we maintain that analyzing relevant adaptive elements of stormwater planning is crucial to address the emerging challenges in municipal stormwater management.

The theory of adaptive challenges of climate change and societal transformation (O'Brien & Selboe, 2015) builds on Heifetz et al. (2009) organizational leadership literature. The concepts of adaptive challenges have originally no direct connection to climate adaptation and can also apply in other contexts of organizational or societal change. From this perspective, challenges can be separated into two categories: technical problems and adaptive challenges (Heifetz et al., 2009). Current know-how can solve technical problems, and a typical example used to reduce climate vulnerability in the water sector is building more robust infrastructure. Adaptive challenges, on the other hand, are actions of change that require changes in people's and organization's mindsets, beliefs, values, norms, and practices (Heifetz et al., 2009). Most challenges contain technical and adaptive elements, but problems occur when we try to solve adaptive challenges with technical responses alone (Heifetz et al., 2009). Solving adaptive challenges is demanding and involves trying new ways of working, tolerating losses, and gaining new capacities (Heifetz et al., 2009). Arguably, alternative stormwater management requires new ways of thinking, planning, and collaborating (Bohman et al., 2020).

Blue–green measures have the potential to shape, challenge, and change life in urban areas in ways other than traditional stormwater management with invisible underground pipelines (Haase et al., 2017). Green and blue urban infrastructure have multiple social, ecological, and technical benefits (Meerow, 2020). They support human health and well-being through water regulation, mitigate urban run-off, and provide recreational benefits (Kati & Jari, 2016). Planning and implementing alternative stormwater management have technical aspects like advanced engineering and new technical solutions (Wihlborg et al., 2019). It also has adaptive aspects and requires alternative urban planning making stormwater an experiential resource, promoting recreation and biodiversity (Kati & Jari, 2016).

2.2. Identifying adaptive challenges

In this paper, we explore empirically how two Norwegian municipalities plan for alternative stormwater management as part of their local climate adaptation work. These two municipalities have developed specific sector plans for stormwater management, requiring different municipal sectors, professions, and people to discuss, negotiate, and collaborate on stormwater planning in new ways. Current stormwater management literature has already identified several emerging challenges like norms and practices (Lund, 2018), uncertainty (Thorne et al., 2018), and the need for cross-sectoral collaboration (Bohman et al., 2020). Based on the theory of adaptive challenges, this study develops an analytical framework to understand how municipalities can address these adaptive challenges.

2.2.1. Professional norms and practices

Bohman et al. (2020) state that it is a challenge that many still consider stormwater management to be a site-specific, technical issue mainly handled by engineers and water professionals. Simultaneously, recent developments in sustainable urban drainage have turned the area into an interdisciplinary professional field of engineers, landscape architects, and urban planners (Meilvang, 2019). The different modes of governance entail different norms, values, and work practices that sometimes clash. There is little research on how these different norms do clash (Lund, 2018). Building shared meaning, trust, networks, and recognition of mutual interdependency can prove difficult in current adaptation planning. It can also challenge the municipal planning culture and calls for a new skill set (Lund, 2018).

Although perceptions, interests, and goals for blue–green strategies vary among professional sectors, Meilvang (2019) describes a new willingness to focus on shared ideas and visions of urban rainwater management that can lead to greener cities and added urban value. According to Meilvang (2019), danish water engineers have long focused heavily on techniques to manage rainwater without drains. However, their early blue–green strategies do not mention goals like creating greener cities or higher quality urban spaces. In this context, Meilvang (2019) found that landscape architects adopted engineering terms to collaborate with the urban rainwater engineers, and this is where the holistic urban water network focus and the green and biodiverse city goals come in. The implication is that blue–green measures can be interpreted both as technical and adaptive challenges and that departing from them as technical solutions hold potential for unlocking transformational properties.

Meilvang (2019) argues that blue–green solutions like local rainwater diversion can serve as a boundary object and a hinge-object because it coordinates separate public sectors and serves as hinges between public sectors, politics, and academia. Current stormwater management literature describes the adaptive challenge of norms and practices in two contrasting ways. When they clash, professional norms and practices are barriers to overcome. When there is room for identifying shared ideas and visions, they are assets coordinating and hinging adaptation work in different sectors.

2.2.2. Uncertainty

Thorne et al. (2018) argue that uncertainty regarding hydrologic performances of blue–green infrastructure creates challenges limiting their widespread adoption. They also emphasize the challenge of delivering socially equitable urban flood risk management and the difficulty with communicating the complex technical and planning issues to the public. According to O'Donnell et al. (2017), social-institutional barriers often pose the greatest hindrance to implementing sustainable water management strategies. Resistance to change represents a particularly relevant socio-institutional barrier to blue–green infrastructure implementation. These are good examples of the complex connections and interactions between technical and adaptive aspects of a problem. Technic solutions must work, and people must understand and confide in them.

When planning successful blue–green measures, educational efforts are central at the different phases of planning, building, and maintenance (Wihlborg et al., 2019). Wihlborg et al. (2019) present new knowledge and perspectives from newly educated employees as a potential driver for blue–green infrastructure implementation. They further present uncertainty and lack of knowledge (e.g. regarding cost-efficiency and practical experience) as barriers to implementation. Wihlborg et al. (2019) recommend monitoring and evaluating constructed solutions and institutionalising systems for knowledge transfers between blue–green pilot projects and the municipal organization. There is a clear need to increase the expertise related to knowledge exchange and sharing between municipal sectors. Arguably, employees working on these issues need a good general knowledge of blue and green issues combined with contacts in other relevant municipal sectors (Wihlborg et al., 2019).

2.2.3. Cross-sectoral collaboration

Planning for sustainable stormwater management requires an early inclusion of holistic solutions in land use planning processes, which requires successful co-operation between the planning and water sectors (Bohman et al., 2020). That is critical when planning for alternative stormwater management, requiring more space and changes in land-use priorities compared with traditional grey approaches (Meerow & Newell, 2017). Bohman et al. (2020) argue that responsibilities and mandates can become blurred when striving toward alternative stormwater solutions because of the lack of clear ownership and institutional affiliations. Further, budgets are often restricted to sectoral investments (Matsler, 2019). Involved actors are also divided according to their roles as clients and contractors rather than as co-creators of sustainable urban environments (Bohman et al., 2020).

With little focus on intersectoral co-operation in municipal climate adaptation, the water sector becomes vulnerable to actions by other municipal sectors like the planning sector (Hovik et al., 2015). Securing ownership of a plan in the relevant sectors and departments and the municipal hierarchy is particularly relevant when solving cross-sectoral issues (Oseland, 2019). Alternative stormwater management unites a range of actors with different identities, interests, and goals, including personal, professional, and political. One can argue that stormwater is an issue that crosses physical and sectoral boundaries, demanding changes in the approaches to cross-sectoral co-operation. This argument makes the need for new ways of doing cross-sectoral collaboration one of the most critical adaptive elements to address in municipal stormwater planning.

2.3. The municipal water sector's role in adaptation in Norway

This section theoretically identifies adaptive challenges in alternative stormwater planning. The challenges overlap considerably as separate norms, practices, and uncertainty are forced together in emerging cross-sectoral collaborations. To discuss how municipal water sectors can address the emerging challenges, we present empirical experiences from alternative stormwater planning processes in the Norwegian municipalities of Bergen and Tromsø. The empirics require elaboration about the Norwegian adaptation and stormwater management context.

Despite a weak but increasing national focus on climate change adaptation, Hovik et al. (2015) have found a strong local focus on climate change adaptation in the Norwegian water sector. They suggest that professional networks taking an agenda-setter role in adaptation strategies may have replaced a defined national adaptation strategy. Based on these findings, the water sector seems to have progressed further regarding climate adaptation compared with other public sectors, which makes assessing the water sector's role in adaptation particularly relevant. In 2015, the Norwegian government published a white paper on the challenges and potential resources of increasing urban stormwater. One recommendation in the white paper, leaning heavily on the Norwegian Planning and Building Act (PBA), was for Norwegian municipalities to make municipal sector plans for stormwater management (NOU:16, 2015).

The Norwegian water sector is expected to be highly exposed to future climate change, mainly due to more intense precipitation (Hovik et al., 2015). Traditional climate adaptation measures to reduce vulnerability in the water sector are primarily directed at coping with increasing climate impacts on water supply facilities, sewerage, stormwater systems, urban waterways, and recipients (Hovik et al., 2015; Meilvang, 2019). The traditional grey sector measures include upsizing pipeline systems and building higher, stronger floodwalls. These measures quickly remove stormwater in a normal situation but are very vulnerable in extreme precipitation situations (Hovik et al., 2015). According to Franco-Torres et al. (2020), there is broad agreement about a new paradigm for urban water systems that can be seen as a local expression of a broader societal transformation attempting to adapt to a more complex and dynamic reality. In this new paradigm, stormwater is a valuable resource contributing to improving urban qualities (Franco-Torres et al., 2020). Reconceptualizing stormwater from a challenge to a resource can also transform the organizational practices in the climate adaptation field (Meilvang, 2021).

In summary, current stormwater management literature has identified several adaptive elements in alternative stormwater planning, but empirical examples and knowledge about how to address them are limited. Our findings from a Norwegian context can illuminate how municipalities can address these identified adaptive challenges based on how municipal employees find new ways to collaborate across sectors and identify common interests and arguments. The study moves beyond a description of the adaptive challenges and suggests solutions that promote a more holistic and transformational approach to stormwater management and local climate adaptation. Before presenting the empirical findings from the municipal sector plan planning processes of Bergen and Tromsø in section 4, we demonstrate our methodological foundation.

3. Methods: studying alternative stormwater planning

3.1. Research locations

To explore how municipal water sectors can address the emerging challenges of alternative stormwater planning, we chose to study a novel planning process. The studied locations, Bergen and Tromsø, were selected because they were the first two municipalities in Norway to develop dedicated municipal sector plans for stormwater management. Bergen is famous for its rainy climate, and there are numerous reports of stormwater incidents and urban floods every year. Tromsø faces challenges related to ice, snow, and freezing of the new blue–green solutions.

Both municipalities have expressed similar and explicit needs for an overarching plan that co-ordinates and promotes stormwater issues within the municipal planning. An early expectation was that these planning processes would bring actors and perspectives together in new and informative ways.

3.2. Observation and interviews

Our empirical data were derived by following the working process of the municipal sector plan for stormwater management in Bergen from spring 2018 to fall 2019, in addition to conducting interviews with professionals involved in the planning processes in both Bergen and Tromsø. After an initial introduction meeting with the Department of Water and Sewer works, the researcher was invited to attend and observe the planning process at working group meetings, reference group meetings with different municipal departments, external information meetings, professional seminars, and information workshops with internal municipal professionals and private consultants.

The observation consisted of listening in and taking notes at meetings, intending not to disturb the process. Importantly, information also comes from field conversations before and after these meetings. This observation method provides an in-depth understanding of the complex planning processes containing a range of different actors and interests.

In addition to the observation, twelve interviews with municipal and private actors were conducted. The researcher selected interviewees based on their involvement in the ongoing planning processes and their knowledge and involvement in urban planning and stormwater management. Five of the interviews were with municipal professionals involved with the planning process in Bergen, conducted in September/October 2019. Six of the interviews were with municipal and private actors working with the planning process in Tromsø, conducted in October 2019. Two of the six interviews in Tromsø were group interviews, each with two interviewees. The researcher also had ongoing communication with the project coordinator in Tromsø and had one online follow-up interview about the planning process in June 2020. See Table 1 for a list of observation points and interviews.

3.3. Analyzing the data

To analyse the qualitative data in this paper, all interviews were recorded and transcribed. The observed meetings and workshops resulted in personal field notes. Besides, the researcher had full access to the minutes from all meetings in the Bergen planning process, thanks to a courteous municipal project coordinator. Indeed, engaged professionals interested in sharing and developing knowledge characterized the entire data gathering process in Bergen and Tromsø. Public records, like minutes from city council meetings, have also been important sources for understanding the planning processes.

The data has been systematised into thematic categories. These categories helped identify emerging adaptive planning challenges and how the municipalities address them. The two studied localities have specific climatic, geographical, cultural, individual, and institutional conditions affecting the planning processes. The thought behind studying alternative stormwater planning in two locations is that it can provide richer and more extensive data material. The data is presented as a story following the phases of the planning processes in the next section.

4. Municipal stormwater sector plans

In section 2, we introduced an analytical framework to analyse how municipalities can address the emerging adaptive challenges in alternative stormwater planning. The framework promoted professional norms and

Table 1. List of observation points and interviews.

Observation at meetings and workshops in Bergen municipality
1. Introduction meeting – Department of Water and Sewer Works, Bergen municipality
2. Meeting/workshop – Department of Water and Sewer Works, Bergen municipality and the Norwegian Natural Perils Pool
3. Project group meeting – Municipal sector plan for stormwater management
4. Project group meeting – Municipal sector plan for stormwater management
5. Reference group meeting – Municipal sector plan for stormwater management
6. Project group meeting – Municipal sector plan for stormwater management
7. Meeting, zoning plans – Bergen municipality and private consultants
8. Information workshop about the Municipal sector plan for stormwater management for municipal departments in Bergen municipality
9. Information workshop about the Municipal sector plan for stormwater management for private consultants in the Bergen area
Interviews with actors in the planning process for the Municipal sector plan for stormwater management – Bergen municipality
1. Interview – Department of Water and Sewer Works
2. Interview – Department of Urban Environment
3. Interview – Department of Planning and Building
4. Interview – Department of Planning and Building – GIS
5. Interview – Department of Planning and Building
Interviews with actors in the planning process for the Municipal sector plan for stormwater management – Tromsø municipality
6. Interview – Department of Water and Sewer Works
7. Interview – Private consultant / former Department of Water and Sewer Works
8. Group interview – Department of Urban Environment, Parks and Recreation
9. Group interview – Private consultants
10. Interview – Department of Planning and Building
11. Interview – Department of Water and Sewer Works
12. Follow-up interview – Department of Water and Sewer Works

practices, uncertainty, and cross-sectoral collaboration in stormwater planning, all previously identified challenges in existing stormwater management literature. The following section presents and analyses adaptive challenges of alternative stormwater, as portrayed in the meetings and interviews about stormwater planning in Bergen and Tromsø. These findings will illuminate what relevant adaptive planning challenges emerge when shifting the stormwater planning from traditional grey stormwater infrastructure to alternative blue–green infrastructure. Based on the discoveries, we will continue to discuss how municipalities can address these adaptive challenges.

Based on the white paper recommendation to make municipal sector plans for stormwater management (NOU:16, 2015), Bergen began the working process in 2017 and passed the sector plan in September 2019. Tromsø presented its planning programme in 2017 and passed the sector plan in May 2020. The planning initiatives came from the water department administrations and were two independent initiatives. Both Bergen and Tromsø initiated their sector plans within the municipal planning strategy and appointed a dedicated project coordinator for the working process. An explicit goal in both municipal sector plans is implementing blue–green measures and alternative stormwater solutions.

4.1. Why a municipal stormwater sector plan?

According to the interviewees (#1, #3, #6, #7, #11), there were three main reasons for making municipal sector plans for stormwater management. First, there was a need for an overarching stormwater management plan to align the countless smaller framework plans and zoning plans affecting stormwater management in current city planning. Second, there was a desire to bring stormwater measures into the municipal masterplan in the next revision to make these measures legally binding. Third, they wanted the Planning and Building Act (PBA) to regulate the planning process, as this demands formal involvement from separate relevant municipal sectors. The reasons for making a municipal sector plan for stormwater management touches upon all three of the identified adaptive challenges.

When the municipal water department actors described their previous planning work, the typical situation over many years had been to come in at the end of the planning process, when it was too late to affect the planning proposal. They had long requested closer collaboration between the planning and water sectors within these municipalities. The water departments had also long focused on developing internal planning competencies. An explicit motivation for initiating the sector plan was gaining support for the water issues in municipal planning and make the water departments' activities more visible (meeting #1, #8, #9, interview #7, #11). That shows how the water sector is changing its way of working to mend lacking cross-sectoral collaborations and the need for interdisciplinary competence.

4.2. The planning processes in Bergen and Tromsø

In Bergen, the process began with internal meetings within the Department of Water and Sewer Works, followed by meetings with the Department of Urban Environment and the Department of Planning and Building, creating a structured work schedule and a dedicated working group. The project coordinator was a water department employee with a background in hydrological engineering. As part of the plan, Bergen developed an online map gathering essential stormwater information. The map intends to be a tool for planners and decision-makers and a spatial input for the next municipal master plan, determining what will be legally binding in future planning (meeting #1, #8, #9, interview #1, #3, #4).

The interviewees (#1, #2, #3) described the Bergen planning processes as proceeding surprisingly quickly and easily, with strong commitment from all parties and few controversies. The technical aspects of the sector plan were portrayed as uncomplicated and straightforward (interview #1). Though the planning process progressed smoothly, one interviewee (#3) noted that it is always exciting when three departments meet to agree on a plan, considering and balancing needs and priorities. The plan needed to stay sufficiently general, while also finding the right detail level (interview #3). Another interviewee (#1) stated that if others had made the plan, it would look completely different. The form and content of the sector plans depend closely on the experiences, competencies, and backgrounds of the working group members (interview #1).

In Tromsø, the project coordinator came from the water department but had extensive planning competence from years of experience as a planner in the planning department. The Tromsø water department had long focused on developing internal planning competence (interview #6, #7, #11). First, Tromsø had to identify local stormwater challenges and vulnerable areas and collaborated with a private consulting firm to do this locally (interview #6, #9). With Tromsø located far north in a sub-arctic climate, they also needed to research and adjust the blue–green measures, like customizing rain beds to freezing temperatures. One technical solution under evaluation was using alternative granular material in rain beds, which do not freeze during winter. A challenge is that this alternative material does not clean the water as sand does, eliminating the cleansing effect of this blue–green measure (interview #6). The alternative rain beds were tested in collaboration with the urban environment department (interview #6, #8). Here, we see examples of technical and adaptive challenges regarding uncertainty combined. The technical stormwater solutions do not fit the local climate conditions and require new and cross-sectoral knowledge development.

As in Bergen, there appeared to be a consensus in Tromsø that the sector plan was necessary and served several different interests at once, accompanied by little controversy and few objections (interview #6, #8, #10, #12). It was mentioned that since this was such an overarching plan, it might be easy to agree to and that when it came time to enact the plan and change people's work routines, things might get more complicated (interview #6). Both sector plans were passed with little to no political-level involvement, discussion, or controversy (interview #1, #3, #6).

4.3. Professional arguments for blue–green infrastructure

Professional groups from three departments collaborated in these two planning processes: water engineers from the water departments, landscape architects, and nature managers from the urban environmental departments, and planners from the planning departments (interview #1, #2, #3, #6, #8, #9). One interviewee (#5) stated that separate professional and departmental interests could complicate blue–green infrastructure implementation, like when open water systems in urban areas can damage cultural heritage, prominent streets, or buildings. For a long time, planners and builders have essentially been able to ignore the underground infrastructure, and demanding space for water in areas that could otherwise be used to build houses has been challenging (meeting #1, #8, #9, interview #1, #6, #7, #11).

Opening waterways and implementing blue–green infrastructure requires municipalities to consider elements like biodiversity, urban landscapes, economy, costs, cultural heritage, flood risk, and safety (meeting #8, #9, interview #2, #5, #10). When planning for blue–green infrastructure, departments and professionals have different administrative and professional interests. The water engineers prioritize cleansing polluted stormwater and handling flood risk. The landscape architects and nature managers prioritize green zones for recreation and biodiversity, and the planners aim to secure space for new housing and transport for growing populations (meeting #1–#9, interview #1–#12).

In meetings and interviews (#1, #2, #3, #5, #6, #7, #8, #9 #10, #11, #12), the internal dialogues between departments and professionals have been described as especially important, as most professionals (naturally) prioritize their professional challenges and interests. Simultaneously, each professional group appears to find it advantageous to identify common interests and gather around shared solutions because doing so secures support for their interests in the planning work.

Based on these experiences, different interests seem to strengthen the argument for implementing open blue–green measures. The water engineers argue for open waterways because this will reveal evils like contamination and provide opportunities for improving water quality (interview #7). The nature managers' argument for open waterways is the potential for fish in the rivers and increasing biological diversity (interview #2). Finally, the landscape architects and the planners argue for open waterways as open water sources can provide a higher urban living quality (interview #3, #8, #10). Each of these arguments alone seems to struggle to be prioritized, but the progressive alternative stormwater management seems to help solve several of the different professional challenges (interview #2).

4.4. Formal and informal collaboration

Since the PBA regulates municipal sector plan planning processes, one interviewee (#11) emphasized that going through the formal process with public hearings and specific deadlines was particularly important for internal cross-sectoral collaboration. Water department interviewees (#6, #7, #11) explained that plans not adhering to the formal PBA process never leave the department. It is possible to ask other departments for input, but none are obliged to answer. In a formal PBA process, relevant departments must discuss and agree upon the plan (interview #11).

The municipalities of Bergen and Tromsø are developing the sector plans internally, with internal coordinators, budgets, and working groups leading the processes. The planning department interviewees (#3, #10) describe the formal PBA working process as known and regular, while the water department interviewees (#1, #11) describe the process as unfamiliar and novel. All the involved actors describe the content as unique and innovative, underlining the importance of developing the first municipal sector plan for stormwater management in Norway (interview #1, #2, #3, #6, #8, #10). That is another example of the need for addressing uncertainty and separate working practices in alternative stormwater planning, which can be aided by formalizing structures supporting cross-sectoral collaboration.

Good communication based on close connections with other departments (e.g. after job changes, shared projects, or after long-term work in the municipality) and in-depth knowledge about other departments was described as making collaboration smoother in these cross-sectoral planning processes (interview #2, #3, #6, #10). These factors are not only central at the department's top levels but throughout the departments. Knowing who to call, formally and informally, and knowing where relevant resource persons are located is crucial for identifying allies and making the planning process run smoothly (interview #2). One interviewee (#1) said the planning process itself was a positive result because people had got to know each other better through collaborating on the new solutions.

In 2019, Tromsø was also at the beginning of developing a new internal cross-sectoral collaboration planning infrastructure. Inspired by an organizational planning model in another Norwegian city, they intended to meet weekly in cross-sectoral groups to develop plans (interview #6, #8, #10). This way, more voices would be heard from the start of the process, which had been requested by the water departments and others for many years (interview #6, #7, #11).

4.5. Technical and adaptive elements combined

As shown theoretically and empirically, planning and building blue–green infrastructure requires new technical solutions and adaptive solutions like new ways of thinking, working, and collaborating. An important question raised in an interview (#6) regarded how blue–green measures would look in the future. For example, rain beds will demand maintenance and material changes. The water departments will need new knowledge, competence, and changing working routines from managing underground pipelines to maintaining surface infrastructure (interview #6). Many locations will also demand double systems with underground pipes that work when it is too cold, and the surface solutions might freeze (interview #7). This notion will require new and closer collaboration between the park and maintenance sections of the urban environment department, the water department, and other relevant departments (interview #6).

The interviewees (#1, #2, #3, #5, #9) consider collecting stormwater information in one place as essential for making the information more accessible. The municipal sector plans for stormwater management in Bergen and Tromsø aim to collect the relevant stormwater information, making it available across departments and sectors, internally and externally.

5. Discussion and conclusion: taking leadership of new areas

Starting this paper, we asked what adaptive planning challenges emerge when shifting stormwater management from traditional underground solutions to blue–green infrastructure. In section 2, we defined professional norms and practices, uncertainty, and new ways of doing cross-sectoral collaboration as relevant adaptive challenges to this shift. In section 4, we presented and analyzed the empirical experiences from two municipal stormwater planning processes in Norway. Here, we highlight the more general analytical findings from the Bergen and Tromsø stormwater planning processes and discuss how municipalities can address these adaptive challenges.

As current stormwater literature already describes certain adaptive elements of stormwater planning, we use this as a framework for analyzing the empirical experiences from Bergen and Tromsø. Table 2 presents an overview of this analysis. The table shows the individual challenges and potential solutions connected to identified categories of adaptive elements. The table also intends to show the close and complex connections between the different challenges and the solutions. A challenge of presenting such empirical material in a table is that the divisions between challenges and solutions are blurry. Additionally, addressing adaptive challenges can even create new challenges. An example is how the municipal stormwater sector plans appear to be a solution to fragmentation in the field while also creating more complex planning collaborations.

To address the first adaptive challenge of potential clashing norms and practices, existing stormwater literature emphasizes building shared meaning, trust, and recognizing mutual interdependency, which has been proved difficult in current adaptation planning (Lund, 2018). The studied planning processes exemplify how the need for making stormwater measures legally binding in municipal planning changes working practices in the municipal water sector. Adaptation measures like blue–green infrastructure have also been called boundary objects and hinge-objects, meaning that they connect separate public sectors and other professional fields and institutions (Meilvang, 2019). The planning processes under investigation here, balancing views, priorities, and professional interests from three municipal departments, show that under certain circumstances, alternative stormwater planning can consolidate professional norms, arguments, and practices.

As most professionals prioritize their professional interests, the stormwater planning actors find it advantageous to identify shared interests and unite on shared solutions because it secures support for separate professional interests like cleansing stormwater or securing biodiversity. In conclusion, leveraging a range of professional interests seems to strengthen arguments for blue–green measures, as progressive

Table 2. Challenges and potential solutions for alternative stormwater planning in Bergen and Tromsø.

Identified adaptive elements in current stormwater literature	Professional norms and practices	Uncertainty in alternative stormwater planning.	Need for new ways of cross-sectoral collaboration
Empirical examples -Challenges	A need for making stormwater measures legally binding in municipal planning	A need for an overarching stormwater management plan	A need for formal structures around cross-sectoral collaboration
Empirical examples -Solutions	The water departments develop internal planning competence over time	The water departments work for visibility and support for water issues in planning	The water departments request closer collaboration with other sectors
	The stormwater sector plans serve several professional interests at once	The stormwater sector plan allows for professional negotiation and mediation	The planning processes proceed quickly, with strong commitment and few controversies
	The separate professional interests together strengthen the argument for blue–green measures	Collecting stormwater information in one place is essential for making the information accessible	The planning process itself is a positive result because it connects people and sectors

alternative stormwater management can help solve independent professional challenges. These collaborative approaches are vital, as there is a tendency to treat collaboration technically and logistically (i.e. by merely inviting people to meetings rather than truly understanding their different interests, values, and views) (O'Brien & Selboe, 2015).

To address the second adaptive challenge of uncertainty concerning alternative stormwater approaches (O'Donnell et al., 2017; Thorne et al., 2018), this paper argues that alternative stormwater planning requires a broad and flexible competence base, as well as building trust in existing knowledge and technology. The studied planning processes seemed to form such a flexible competence-base. In Tromsø, the studied planning process is part of a long-time strategy of building internal planning competence in the municipal water department. In Bergen, the planning process was presented as a positive result because people got to know each other better, both formally and informally, through collaborating on the sector plan. The formal planning format of these processes allows for professional negotiation and mediation and illuminate how formal structures supporting cross-sectoral collaboration can help various actors find common ground and build trust in a stormwater planning process.

Current stormwater literature states the specific need to increase expertise concerning knowledge exchange and sharing between municipal sectors (Wihlborg et al., 2019). In Bergen and Tromsø, an essential part of building the necessary trust across sectors and departments was the explicit planning goals of information and knowledge sharing. A central motivation behind the stormwater sector plans was gathering all stormwater information and making it available to relevant actors. In Bergen, it took the form of an online map. The next challenge will be communicating and building similar trust and relationships with the external private actors, builders, and contractors who usually implement the plans.

To address the third challenge regarding the need for new ways of doing cross-sectoral collaboration (Bohman et al., 2020), attempting new working methods and gaining new capacities is crucial (Heifetz et al., 2009). The stormwater planning processes in Bergen and Tromsø show how these municipalities are already changing their work practices to secure cross-sectoral collaboration by taking leadership over new areas and collaborating on novel professional topics. In these planning processes, water department officials intended to use the formal PBA process of a municipal sector plan to build relationships with relevant municipal departments because they depend on other departments to implement alternative stormwater measures. They also aimed at positioning the water interests into the planning sector and mend the lacking organizational cross-sectoral collaboration culture.

The planning departments are skilled at leading formal planning processes following PBA requirements but are not used to include holistic water solutions in urban planning. The water departments are accustomed to keeping their infrastructure underground, being the last to speak in any planning process. The novelty of these planning processes is that the water departments take leadership of a formal BPA planning process and adopt the planning department's language and formal working methods. This approach could help develop cross-sectoral and holistic adaptation planning because it can affect organizational values and challenge relevant actors to collaborate in new ways. It can also remedy climate vulnerability in the municipal water sectors who depend on other sectors to implement above-ground stormwater measures (Hovik et al., 2015). Such alterations of working practices and the corresponding building of cross-sectoral relationships appear to be essential for internal cross-sectoral municipal collaboration and collaboration with external actors like private contractors and consultants.

Given that understanding adaptive challenges are crucial to understanding the potential for climate adaptation and transformation (O'Brien & Selboe, 2015), this paper has explored how municipalities can address the emerging challenges of alternative stormwater planning. In conclusion, we find that the studied municipalities address the adaptive challenges of alternative stormwater planning in a way that promotes cross-sectoral collaborative approaches that invite a deeper understanding of other's interests and views. We hold that this approach could contribute to more holistic planning approaches. The hope is that understanding and addressing the emerging challenges of alternative stormwater planning will shift municipalities more rapidly toward more holistic and flexible adaptation planning and implementation of blue–green measures, leading to greener cities and added urban value.

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RESEARCH ARTICLE

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Co-benefits and conflicts in alternative stormwater planning: Blue versus green infrastructure?

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Abstract

Blue–green infrastructure (BGI) is often promoted for its co-benefits and multifunctionality. However, this infrastructure is repeatedly planned, implemented and researched almost entirely based on the goals of stormwater management. Thus, more knowledge is required about how co-benefits are perceived and actioned by planning actors. By investigating co-benefits from a value perspective, this paper will contribute to the ongoing debate on how stormwater planning actors address the potential co-benefits and conflicts in the planning and implementation of BGI. The data are derived from policy document analyses and interviews with municipal and private planning actors in Bergen and Tromsø, Norway. The paper argues that municipal water actors are motivated to implement BGI beyond stormwater management goals and approach co-benefits and holistic stormwater management as an ideal in stormwater planning. However, the tensions and conflicts between the co-benefits become more evident in the actual implementation of BGI. The paper finds that when holistic BGI implementation is initiated by the municipal water actors, the stormwater management aspects dominate the BGI implementation. Finally, the paper concludes that even though blue and green values and interests are often conflicted in the implementation of BGI, urban stormwater planning is in the process of developing a blue–green value set based on the potential synergies of co-benefits. The paper therefore empirically illustrates how collective values and interests can develop and unfold across sectors and professional disciplines in BGI planning.

KEYWORDS
blue–green infrastructure, holistic planning, municipal planning, nature-based solutions, stormwater management, transformative adaptation, values

1 | INTRODUCTION

Across the world, human-induced climate change and extreme precipitation episodes have led to extensive stormwater problems and material damage in densely built urban areas (Bohman et al., 2020; Deely et al., 2020; Jiang et al., 2017; Kessler, 2011; Liu et al., 2019; Lund, 2018; O'Donnell et al., 2017). When conventional underground drainage systems are unable to handle stormwater, the response is to increasingly plan for blue–green infrastructure (BGI) to manage stormwater problems above ground (Alves et al., 2019; Brears, 2018; Dhakal & Chevalier, 2016; Flores et al., 2021; Ghofrani et al., 2020; Travaline et al., 2015; Wihlborg et al., 2019). BGI comprises interconnected natural elements such as rivers, streams, canals, ponds, wetlands, water reservoirs and designed landscape elements such as rain gardens, bioswales and green roofs (Liao, 2019; Oral et al., 2020). Such nature-based BGI implementation is currently regarded as vital under the EU strategy on climate change adaptation (Flores et al., 2021). Despite this increased focus on nature as a functional component of urban infrastructure, the implementation of nature-based solutions such as BGI is by no means mainstream (Matsler, 2019).

Based on arguments that adaptation strategies are more likely to be undertaken if compelling co-benefits can be demonstrated (Sharifi, 2021), we need to investigate and understand the role of co-benefits in urban adaptation planning. BGI development processes are suitable for such investigations as they are often based on co-benefits, multifunctionality and multiple benefits arguments (Alves et al., 2019; Hansen et al., 2019; Meerow, 2020; Meerow & Newell, 2017; Raymond et al., 2017). The opportunity to provide co-benefits for multiple actors could play a crucial role in transformative adaptation strategies (Alves et al., 2019; Frantzeskaki et al., 2019; Kvamsås, 2021; Raymond et al., 2017). Transformative adaptation strategies include actions that result in, or intend to result in, transformation (Lonsdale et al., 2015). The paper will investigate the transformative potential of BGI by exploring how local planning actors address the co-benefits and conflicts in the planning and implementation of BGI.

Co-benefits arguments provide holistic approaches to stormwater management and promote the simultaneous solving of multiple problems (Schuch et al., 2017). In this context, we define co-benefits as the additional positive effects and values achieved by a specific mitigation or adaptation measure (Sharifi, 2021). Examples of nature-based BGI co-benefits are water savings, energy savings, air quality improvement, carbon sequestration, biodiversity protection, nature conservation, recreational opportunities and public health benefits (Alves et al., 2019). These co-benefits can represent various actors, values, and interests in adaptation planning. The related concepts of multifunctionality and multiple benefits involve how green infrastructure (natural and designed green spaces) in urban areas provide ecological, social, and economic functions for different actors (Hansen et al., 2019; Matsler et al., 2021).

Daylighting stormwater infrastructure often challenges conventional stormwater management and makes the values, politics, and priorities of stormwater governance more visible as the infrastructure moves above ground (Kati & Jari, 2016). Such visibility could also highlight the conflicts in interests and values in stormwater governance (Finewood et al., 2019; Meerow, 2020). For example, BGI is repeatedly planned, implemented, and researched almost entirely based on the sole benefit of stormwater management goals, showing the potential tensions in the holistic blue–green concept (Meerow, 2020). Current literature describes significant conflicts and barriers in BGI implementation regarding uncertainty, lack of space and knowledge, lack of funding, professional traditions, and fixed mindsets (Dhakal & Chevalier, 2017; Jiang et al., 2017; Matthews et al., 2015; O'Donnell et al., 2017; Qiao et al., 2018; Thorne et al., 2018; Wihlborg et al., 2019). Notably, the interests and values associated with BGI conflicts and co-benefits often relate to specific professionals involved in BGI development, such as water engineers, landscapers, and planners (Meilvang, 2019).

The holistic BGI focus has parallels with transformative adaptation approaches which assert that solving the global climate crisis involves solving intertwined global crises in health, poverty, and nature (Wamsler et al., 2021). The implementation of transformative adaptation also requires human action that demands changes in the mindsets, beliefs, values, norms, and practices of people and organizations (Heifetz et al., 2009; O'Brien & Selboe, 2015). Thus, understanding and addressing the conflicts, co-benefits, and the potential holistic approaches to BGI planning and implementation could be crucial to developing holistic strategies for climate adaptation, which is deemed critical for further societal transformation (O'Brien & Selboe, 2015).

In this context, stormwater governance and planning literature requires more research. While there is much ongoing research into green infrastructure performance, there has been less research on the politics, priorities, conflicts, and trade-offs in BGI planning and implementation (Finewood et al., 2019; Meerow, 2020). Co-benefits and multifunctionality are also elusive concepts, and little information is available on how they are perceived and actioned by planning actors (Hansen et al., 2019). Also, it is unclear why stormwater management goals prevail and why co-benefits and multifunctionality appear to be missing during implementation (Meerow, 2020). Specifically, Meerow (2020) has asked for research on how decision-makers choose what type of green infrastructure is to be installed, and where.

This paper aims to contribute to these knowledge gaps. Drawing on theories on value perspectives and transformative adaptation (O'Brien & Selboe, 2015; Raymond et al., 2017; Rosenberg, 2021), the paper will analyze how BGI is planned and implemented in two Norwegian municipalities: rainy Bergen and freezing Tromsø. In short, the paper will (1) contribute to the ongoing debate on how stormwater planning actors address the potential co-benefits and conflicts in BGI planning and implementation and (2) conclude on how these insights could advance research and knowledge on holistic BGI planning as transformative adaptation strategies.

2 | THEORY: UNDERSTANDING BGI AS TRANSFORMATIVE ADAPTATION

This section will first provide an overview of current blue–green co-benefits and conflicts. It will then elaborate on transformative adaptation strategies and reflect on how to understand the values in holistic BGI planning.

2.1 | The blue–green co-benefit context

Urban drainage is an ancient field with a primary focus on conveying water away from urban areas, dating back to at least 3000 BC. In recent decades, urban drainage and related literature have evolved towards a holistic approach focusing on BGI multifunctionality and co-benefits (Fletcher et al., 2015). BGI comprises interconnected natural and designed landscape elements, including water bodies and green and open spaces. It is closely related to the concept of green infrastructure, which includes regional, peri-urban, and urban green bodies (Ghofrani et al., 2017). BGI comprises aquatic green spaces such as rivers, streams, canals, ponds, wetlands, and water reservoirs. In addition, terrestrial green spaces designed for stormwater management such as rain gardens, bioswales, and green roofs are key elements (Liao, 2019).

Recently, multiple studies have been conducted on blue–green co-benefits and multifunctionality (Alves et al., 2019; Hansen et al., 2019; Matsler, 2019; Meerow, 2020; Raymond et al., 2017). Several studies assessed the value of co-benefits and explored the differences in costs, performance, and societal perception between BGI solutions and the gray and combined infrastructure solutions. Alves et al. (2019) presented a method to include a cost–benefit analysis of flood risk mitigation measures. They concluded that assessing relevant co-benefits when identifying the best adaptation strategies to improve urban flood risk management is crucial to show the efficiency of green infrastructure compared to traditional gray infrastructure. Matsler (2019) highlighted the institutional tensions that emerge from attempting to fit nature into existing asset management practices by valuing and "book-keeping" natural components of green infrastructure such as trees, soil and vegetation.

Raymond et al. (2017) developed a holistic framework for assessing the co-benefits and cost of nature-based solutions across socio-cultural and socio-economic systems, biodiversity, ecosystems, and climate. Ecosystem service frameworks are often used to examine the value of urban ecosystem-based approaches and examine the potential synergies and trade-offs. They also promote a broad framework of nature's contributions to people, recognizing various values associated with other worldviews on human–nature relations and knowledge systems in environmental decision-making (Raymond et al., 2017). As actors in urban areas increasingly turn to BGI and nature-based solutions to solve a range of urban challenges, the interest in green infrastructure's complexities, trade-offs, and politics also grows (Finewood et al., 2019).

Early consideration of the various social, ecological, and economic benefits in planning processes could foster synergies between the optimal provision of multiple green space functions (Hansen et al., 2019). New planning tools like the Green Area Factor tool are emerging in several cities to assess the sustainability of landscape designs and construction based on the proportion of green and built-up areas (Juhola, 2018). While such tools can be helpful in the BGI planning phase, they generally do not offer the capacity to monitor implementation and progress or evaluate the ongoing state of blue–green areas (Juhola, 2018).

In this context, we approach BGI development and the co-benefits focus as representing a holistic planning ideal that seems challenging to implement. While BGI can be a holistic and unifying term because of its multiple co-benefits, it also includes potential tensions, contrasts, and conflicts in alternative stormwater planning that might be blurred by a holistic BGI concept.

2.2 | Conflicts in BGI implementation

In examining the politics of green infrastructure planning in New York, Meerow (2020) argues that the main objective of BGI implementation is stormwater abatement. As stormwater management goals influence the localization of BGI, there is room to improve the strategic planning of multifunctional green infrastructure to benefit selected urban areas (Meerow, 2020). Alternative stormwater management includes solutions such as best management practices (BMP), low impact development (LID), sponge cities, sustainable urban drainage systems (SUDS), and water-sensitive urban design (WSUD) (Fletcher et al., 2015; Matsler et al., 2021). These are closely associated with green infrastructure but range from a greener to a bluer focus, some of them even excluding vegetation (Matsler et al., 2021; Wihlborg et al., 2019). Endorsing green infrastructure mainly as a combined sewer overflow solution narrows the definition of green stormwater infrastructure, fitting it into existing infrastructure politics and practice, while effectively de-emphasizing other co-benefits (Finewood et al., 2019).

Finewood et al. (2019) show how discourses on green and blue–green infrastructure can privilege some values at the expense of others in urban planning, potentially even preventing democratic planning processes. In this understanding, BGI falls under the purview of engineers who mainly promote technical, traditionally hidden and supposedly apolitical engineering solutions. In contrast, green infrastructure can challenge conventional engineering approaches as it is built right in the public eye, next to sidewalks, and on building exteriors, literally bringing the politics of stormwater governance into public view (Finewood et al., 2019).

The introduction of a new technology such as BGI can enlighten the way in which politics connects to infrastructure choices and creates openings for negotiation between contested systems and normative values. Examining green infrastructure and the discursive shift to BGI can provide insight into the politics and power that influence urban form (Finewood et al., 2019). Understanding the power, politics, and values embedded in such a discursive shift could help counter the depoliticization of urban environmental challenges (Finewood et al., 2019). While there is a general awareness of the multiple functions of urban green infrastructure, multifunctionality planning approaches vary considerably between cities (Hansen et al., 2019).

In sum, the current literature on stormwater planning explores selected conflicts and co-benefit-based synergies between the different objectives of blue–green planning. The potential co-benefits are essential arguments for daylighting stormwater infrastructure which, in turn, challenges multiple actors and interests who compete for limited urban space. Approaching BGI development as promoting a holistic planning ideal and acknowledging the tensions and conflicts within this ideal, the paper will continue exploring how a value perspective and transformative adaptation theory might contribute to providing a better understanding of how planning actors address the co-benefits and conflicts of BGI.

2.3 | Transformative adaptation strategies

Much of the adaptation literature uses the transformation concept to describe adaptations beyond the limits of incremental adaptation that also provide (forced or chosen) opportunities for adaptation for organizations or individuals (Pelling et al., 2015). While a transformational adaptation concept can serve as an umbrella term for adaptations associated with societal transformation, a transformative adaptation strategy can refer to the actions leading, or intending to lead, to transformation (Lonsdale et al., 2015). In a world unable to avoid the severe consequences of climate change, adaptation efforts connected to societal transformation are crucial (O'Brien & Sygna, 2013). Furthermore, understanding adaptation as transformation can promote adaptation measures that challenge established values, organizations and power (Pelling, 2011). Thus, in this paper, understanding transformative adaptation as requiring human action that demands changes in the mindsets, beliefs, values, norms and practices of people and organizations (Heifetz et al., 2009; O'Brien & Selboe, 2015) is essential to our understanding of transformative adaptation strategies.

The need to understand transformative climate adaptation stems from an urgency to minimize the risks of maladaptation and climate change vulnerability (O'Brien, 2021). Kates et al. (2012) describe transformational adaptation as forced upon us by crisis, demanding large-scale action, affecting whole regions or resource systems, or involving the complete transformation of a place, or even location shifts. In one way, stormwater management is an appropriate example because climate change, increasing precipitation levels and urban densification are currently forcing change and transformation. Pelling et al. (2015) describe transformative adaptation as adaptive actions that can shift existing systems and institutions onto alternative development pathways before existing adaptation measures are exhausted. Alternative stormwater management has the potential to be such an example of transformative adaptation, potentially affecting and shifting urban life with its range of multiple benefits.

This raises the issue of how it is equally essential to promote transformative adaptation measures that could help people envision and develop a just, equitable and sustainable future for all humans and other actors (O'Brien, 2021). The stormwater management shift from building traditional gray stormwater infrastructure to ambitious plans for implementing holistic nature-based solutions such as BGI also promotes new ambitions to address growing social, technological and environmental complexity and uncertainty (Franco-Torres et al., 2020). This new urban water paradigm reconceptualizes rainwater in cities as a newly valued resource compared to the previous understanding of risk (Franco-Torres et al., 2020; Meilvang, 2021). Using rainwater to enhance the quality of urban space has also become a way for actors to promote their cities as desirable places to live (Meilvang, 2021). Reflecting on which values and interests the co-benefits of BGI are associated with during the process of implementation becomes particularly relevant in this context.

2.4 | The values in holistic BGI planning

There are no value-neutral responses to climate change, and some climate actions will have adverse outcomes for some actors and positive effects for others. Thus, visibility and transparency regarding the values, interests and intentions behind transformative adaptation is critical for equitable climate action processes (O'Brien, 2021). Values can be defined as what people deem to matter, and the role values play in transformation processes is increasingly gaining interest in and outside academia (Rosenberg, 2021). There are multiple ways to conceptualize values, including in the literature on stormwater management. In a BGI co-benefits context, actors emphasize how specific measures can provide added values (Sharifi, 2021). As previously mentioned, co-benefits could refer to ecosystem values, recreational values (Liao, 2019) and economic values (Alves et al., 2019). Several scholars claim that ecosystem service frameworks and land-use planning would benefit from emphasizing non-monetary values more (Kati & Jari, 2016; Raymond et al., 2017). The value of rainwater as a quality in urban settings can also be presented as a distinct value (Franco-Torres et al., 2020; Meilvang, 2021).

Prominent transformation scholars argue that re-politicizing climate change and addressing the root causes of risk and vulnerability requires the conflicting values, interests and different understandings of climate change to be addressed (O'Brien & Selboe, 2015; Pelling, 2011). In line with this argument, we also want to accentuate how the potential synergies between values and interests could contribute to transformative adaptation strategies. Co-benefit interests, objects and values often relate to specific professionals involved in BGI development, such as water engineers, landscapers and planners (Meilvang, 2019). In this regard, Kvamsås (2021) shows that stormwater planning actors from various disciplines find it beneficial to identify shared interests and unified solutions because it ensures support for separate professional interests such as cleansing stormwater or securing biodiversity. This could indicate a potential for developing synergies between interests and values.

Conceptualizing values as being held by individuals differs from conceptualizing them as socially constructed discursive practices used to legitimize society (Rosenberg, 2021). A socially constructed value perspective sees values as being formed collectively rather than individually, making collective values potentially different from what people deem to matter individually (Rosenberg, 2021). This aspect is vital when exploring the connection between co-benefits, values, and actors representing professional disciplines more than individual opinions. Such a value perspective could contribute to the literature on stormwater planning because it helps to highlight what matters to the specific actors in the various phases of BGI planning and implementation. The whole case study could further contribute to understanding BGI as a transformative adaptation strategy, providing empirical examples of how to investigate and address values in adaptation planning.

3 | METHODS: STUDYING BGI PLANNING AND IMPLEMENTATION

3.1 | A case study research approach

In order to explore how stormwater planning actors address the co-benefits and conflicts in BGI development, we have used a case study research approach (Yin, 2009) to investigate local BGI planning processes in Bergen and Tromsø, Norway. The studied locations were selected because they were the first two municipalities in Norway to develop dedicated municipal stormwater sector plans. The cities share a national adaptation policy but have specific local climatic, geographical, cultural, and institutional conditions affecting the two studied stormwater planning processes. Thus, they represent two locations in which BGI measures need specific local adjustments and adaptation. Their experiences could be directly relevant to cities and towns with similar climatic conditions.

Bergen is a port city on the west coast of Norway with a strong identity as Europe's rainiest city (Bremer et al., 2020). Tromsø is a climatically subarctic city located in Northern Norway, experiencing challenges related to precipitation episodes combined with ice, snow and freezing ground (Kvamsås, 2021). The two cities are illustrative examples of municipalities that work purposefully to promote BGI in planning as alternative solutions for stormwater management. They also highlight the challenges concerning slow BGI implementation and mainstreaming. The analyzed sector plans are new but form part of more extensive strategic work on BGI implementation in the two cities, comprising BGI policies and pilot projects. Their experiences of BGI implementation could be relevant for other cities, particularly those in the early stages of BGI development.

In line with the Yin (2009) case study definition, the research involved investigating a contemporary phenomenon within its real-life contexts, acknowledging that the boundaries between phenomenon and context are unclear. The data come from observing policy planning processes, qualitative interviews with relevant planning actors, and a policy document analysis of two municipal sector plans for stormwater management. As social science generally does not produce context-independent theory, this case study approach is well suited to generating the context-dependent knowledge that social science can provide (Flyvbjerg, 2010). As for generalizing the findings of this study, we use analytical generalization and thus generalize the results to broader theoretical propositions, not to populations or universes (Yin, 2009). This is not a sample case (representing statistical generalization) and the goal is to expand and generalize theories (Yin, 2009). In this paper, the case informs alternative stormwater management literature and contributes to transformative adaptation theory (Figure 1).

FIGURE 1 Map of Bergen and Tromsø, Norway. *Source*: Map created using Google My Maps in google.no/maps

3.2 | Observation and interviews

We observed the planning process in Bergen by participating in local working group meetings, reference group meetings with different municipal departments, external information meetings, professional seminars, as well as information workshops with internal municipal professionals and private consultants from spring 2018 to fall 2019. The observations involved listening and taking notes at meetings, with the aim of not disturbing the process. Importantly, information was also obtained from field conversations before and after these meetings. This observation method provides an in-depth understanding of the varying values and interests in a complex planning process. Combining observation methods with, for example, qualitative interviews, can also be a helpful way of obtaining knowledge about a phenomenon from different perspectives, including information the researcher does not directly request (Thagaard, 2009).

We conducted 11 interviews with municipal planning actors and seven interviews with private planning actors in Bergen and Tromsø. The municipal actors were mainly selected based on their involvement with the ongoing planning processes. The private actors in Tromsø were recruited based on their involvement and knowledge of the plan. The private actors in Bergen were recruited mainly from the municipal information seminar about the sector plan for private actors. Most of the municipal planning actor interviews were conducted in person in September and October 2019. The private actor interviews were mainly conducted online in September and October 2020. Three of the 18 interviews were group interviews, each with two interviewees. The researcher also had ongoing communication with the project coordinator in Tromsø and conducted one follow-up interview online about the planning process in June 2020. See Table 1 for a list of observation points and interviews.

3.3 | Data analysis

All interviews were recorded and transcribed by the researcher. Listening to the interviews and transcribing them was the first step to

TABLE 1 List of observation points and interviews

Observations at municipal stormwater planning meetings and workshops in Bergen
1. Introductory meeting—Department of Water and Sewerage, Bergen municipality
2. Meeting/workshop—Department of Water and Sewerage, Bergen municipality and the Norwegian Natural Perils Pool
3. Project group meeting—Municipal sector plan for stormwater management
4. Project group meeting—Municipal sector plan for stormwater management
5. Reference group meeting—Municipal sector plan for stormwater management
6. Project group meeting—Municipal sector plan for stormwater management
7. Meeting, zoning plans—Bergen municipality and private consultants
8. Information workshop about the municipal sector plan for stormwater management for municipal departments in Bergen municipality
9. Information workshop about the municipal sector plan for stormwater management for private consultants in the Bergen area
Interviews with municipal planning actors, Bergen and Tromsø
1. Interview—Department of Water and Sewerage, Bergen
2. Interview—Department of Urban Environment, Bergen
3. Interview—Department of Planning and Building, Bergen
4. Interview—Department of Planning and Building, GIS, Bergen
5. Interview—Department of Planning and Building, Bergen
6. Group interview—Department of Urban Environment, Bergen
7. Interview—Department of Water and Sewerage, Tromsø
8. Group interview—Department of Urban Environment, Parks and Recreation, Tromsø
9. Interview—Department of Planning and Building, Tromsø
10. Interview—Department of Water and Sewerage, Tromsø
11. Follow-up interview—Department of Water and Sewerage, Tromsø
Interviews with private planning actors, Bergen and Tromsø
12. Interview—Private consultant, construction entrepreneur, Bergen
13. Interview—Private consultant, planning firm, Bergen
14. Interview—Private consultant, planning firm, Bergen
15. Interview—Private consultant, engineering, and planning firm, Bergen
16. Interview—Private consultant, landscape gardening entrepreneur, Bergen
17. Interview—Private consultant, advisor water and sewerage, Tromsø
18. Group interview—Private consultants, engineering, and planning firm, Tromsø

gaining an overview of the material and starting the process of interpretation (Braun & Clarke, 2006). In addition, observations at meetings and workshops resulted in extensive personal field notes. The second stage of analysis was to systematize the text material into thematic categories. This analysis approach aligns with thematic analysis methods that can help organize and describe qualitative data material in rich detail and help identify, analyze, and report patterns and themes in qualitative data sets (Braun & Clarke, 2006).

The interviews were structured and provided two sets of basic categories. The first set relates to the planning and implementation processes of the stormwater sector plans and specific BGI measures such as the preplanning phase, planning phase, measure designing phase, implementation phase and the potential maintenance phase. These categories mirror categories in systematic decision-support frameworks such as the adaptive management decision-making framework (Brears, 2018). The second set of categories concerned cross-cutting themes such as knowledge/experience, challenges/opportunities in BGI work, working methods, BGI development over time, as well as local conditions for BGI implementation.

Reflecting on what constitutes relevant themes and categories in qualitative research analysis (Braun & Clarke, 2006), the themes concerning co-benefits and conflicts in the implementation phase became prominent in the material. The process of visiting and observing relevant BGI measures in Bergen and Tromsø was also crucial to understanding the final design. The data material is presented using relevant examples illustrating how the actors perceived and addressed the co-benefits and conflicts in the planning and implementation of BGI in Tromsø and Bergen.

3.4 | Policy document analysis

Document analysis has a long tradition in qualitative research and consists of systematic analysis of written (or audio-visual) depictions (Thagaard, 2009), for example, policy documents. The two documents analyzed here were the Bergen municipal sector plan for stormwater management 2019–2029 and the Tromsø municipal sector plan for stormwater management 2019–2032, both of which are Norwegian policy documents. The document analysis started with a thoroughly review of the two planning documents to identify the main themes. We then constructed a table of all references to the co-benefits/multiple benefits/multifunctionality from the two planning documents. Potential conflicts were categorized in the same way to analyze their role in the policy documents. The categorization helped explain what the two plans emphasized. Furthermore, the categorization demonstrated how co-benefits and conflicts were connected to separate parts of the plan such as the vision, goals and proposed solutions, which further represent concrete implementation phases.

4 | FINDINGS: CO-BENEFITS AND CONFLICTS IN ALTERNATIVE STORMWATER MANAGEMENT

The paper data provide insight into how municipal and private planning actors perceive the co-benefits, conflicts and prioritizations of current alternative stormwater planning and implementation. This section starts by presenting the results of the document analysis of the co-benefits and conflicts in the Bergen and Tromsø sector plans for stormwater management. The section then provides reflections and empirical examples from BGI implementation based on observations and interviews with the relevant planning actors.

4.1 | The Bergen municipal sector plan for stormwater management

The municipal water sector is a progressive actor in Norwegian climate adaptation work (Hovik et al., 2015; Kvamsås, 2021). In 2015, the Norwegian government published a White Paper on stormwater, recommending that municipalities create municipal sector plans for stormwater management (NOU, 2015). As the first municipality in Norway, Bergen City Council approved the Bergen municipal sector plan for stormwater management in September 2019. This sector plan is an overarching stormwater management strategy to handle stormwater in spatial planning. While it is not a legally binding land-use plan, it provides guidelines for legally binding land-use plans and individual building applications according to the Norwegian Planning and Building Act, including the land-use part of the municipal master plan (BergenKDP, 2019).

The sector plan starts by envisioning Bergen as a clean, beautiful and lush blue–green city, preserving biodiversity and its natural water cycles. The sector plan vision states that "stormwater will contribute to better living conditions, a sustainable and resilient urban society, as well as healthy nature". The main goals of the sector plan entail (1) protecting the natural water cycle, (2) making water a resource for biodiversity, (3) making water an element of urban design, (4) making water support ecosystem services, (5) prevent stormwater from contaminating the environment and (6) prevent climate change from creating stormwater problems (BergenKDP, 2019). Thus, there is a clear focus on the multiple benefits of BGI and a holistic mindset that promotes stormwater as a resource in urban planning.

Notably, the mandate of the municipal stormwater sector plan is to prioritize stormwater goals. That is evident from the plan. The plan describes several potential conflicts between the blue–green objectives and urban densification goals, economic interests, as well as pressure on land-use. For example, ambitions for the high utilization of urban space may conflict with space that is needed to address stormwater, depending on the frequency of flooding (BergenKDP, 2019). The strategy of achieving the sector plan goals is focused on coordinating stormwater planning with spatial planning, meaning assessing and determining stormwater solutions in land-use plans. The sector plan promotes specific principles of stormwater management, including focusing on entire precipitation fields when planning, taking into account the potential consequences upstream and downstream, and addressing citizens' health, safety and economic interests. The plan asserts that stormwater requires local treatment and the prioritization of above-ground blue–green solutions. The strategy is based on Norwegian central government planning guidelines, which state that deselecting nature-based solutions for stormwater management requires specific assessment and argumentation (BergenKDP, 2019; Lovdata, 2018).

The Bergen municipal sector plan promotes a three-step stormwater strategy comprising (1) infiltration (rain gardens, bioswales, open ponds), (2) delaying excess water in basins or wetlands, and (3) providing safe flood routes for stormwater peaks. An essential element of this strategy is to separate stormwater from combined sewage systems to help system capacity and water body quality (BergenKDP, 2019). This could help address some problems concerning contaminated stormwater though it is also often necessary to purify contaminated stormwater. According to the plan's visions and goals, the strategy promotes blue–green solutions and concentrates on managing stormwater above ground.

A substantial part of the Bergen municipal sector plan assesses and presents 14 of Bergen's main watercourses. The presentations include descriptions of each precipitation field, its potential for fisheries, recreation, biodiversity status, and water quality. This is an illustrative example of incorporating multiple co-benefits. The sector plan also contains an online map with stormwater information from various sources and an action plan. One of the reasons for creating the online map is to share information about holistic stormwater management across planning areas and precipitation fields (interview #1). The action plan has seven action points: four points about flood zone assessments, one action point about assessing stormwater discharge points, one about stormwater planning for precipitation fields, and the last concerning stormwater separation projects (BergenKDP, 2019). The action plan shows a clear priority of stormwater management goals.

4.2 | The Tromsø municipal sector plan for stormwater management

Tromsø municipal council approved the Tromsø municipal sector plan for stormwater management in May 2020. The sector plan presents a strategy for how the municipality can prepare for more intense precipitation, longer snowmelt periods, floods, and higher storm surges than previously. The Tromsø sector plan promotes climate-adapted and sustainable stormwater management, aspiring to reduce potential damage and rectify capacity issues regarding existing and future water infrastructure. The sector plan outlines three main goals: (1) prevent material damage, (2) protect the environment and water resources, and (3) use stormwater as a resource in urban planning (TromsøKDP, 2020). Each goal involves measures ranging from upgrading the culverts and pipes of conventional stormwater systems to assessing the potential for opening closed streams and preserving wetlands. There is a strong focus on purifying contaminated stormwater.

The sector plan promotes six measures that provide guidelines for legally binding land-use plans and individual building applications according to the Norwegian Planning and Building Act. The measures are as follows: (1) develop a separated pipe-based stormwater system,

(2) ensure water diversion in open streams, (3) promote local diversion of rainwater, (4) introduce the Blue–Green–White Factor planning tool, (5) establish safe flood routes, and (6) ensure stormwater purification (TromsøKDP, 2020). While measures 2, 3, and 4 promote blue–green measures and open solutions, the sector plan promotes the multiple benefits of these measures to a lesser extent compared to arguments about protecting the capacity of existing conventional water infrastructure. One of several possible explanations for this could be the climate and topography of Tromsø, which make it challenging to enjoy the benefits of green infrastructure for large parts of the year.

Stormwater problems in Tromsø vary greatly depending on the season. Rain on frozen ground and freezing stormwater are problematic during fall and winter, and the spring snowmelt creates flooding problems. The conventional water infrastructure struggles when freezing and requires strategies to protect its capacity. The Tromsø sector plan is based on a landscape analysis of runoff and waterways in various local landscapes. The landscape analysis divides Tromsø into three types of precipitation field, describing its potential runoff, ways of directing excess water, pipeline capacity and potential risks. The principle behind the stormwater strategy is to combine several measures to make the system resilient (TromsøKDP, 2020). The three-stage strategy (infiltration, delaying, safe flood routes) needs to be adapted to local conditions because the local climate and landscape provide poor infiltration conditions. The seasonally frozen ground increases the importance of the third stage—safe flood routes. When the multiple benefits of BGI are considered in the sector plan, esthetics, and sustainability are keywords.

The action part of the Tromsø stormwater sector plan is quite extensive, containing action points such as investigations ranging from new calculations of precipitation data to assessing ownership of stormwater infrastructure and adapting municipal building applications to include stormwater issues. Implementation of the sector plan in current municipal administrative procedures and working routines is also a crucial part of the action plan. The action plan promotes skills development, measure testing and adapting rainwater diversion solutions to local conditions (TromsøKDP, 2020). Though the Tromsø sector plan has limited focus on the multiple benefits of BGI, BGI is still a key part of the strategy, primarily represented by the locally adapted Blue–Green–White Factor planning tool. However, it could be argued that the stormwater management objectives of the Tromsø municipal sector plan for stormwater management seem to take precedence over multiple co-benefits, including the green elements.

4.3 | How planning actors perceive co-benefits in alternative stormwater planning

There has been increased focus on BGI in Norway over the last decade. Several planning actors have highlighted a severe stormwater flooding event in Copenhagen, Denmark in 2011, emphasizing how the Danish experiences concerning BGI planning have been inspirational for BGI development in Norway (interview #7, #16, meeting #1). A private planning actor explained how they are currently changing the design and color of their company's logo to blue and green to communicate sustainability to their customers as blue–green values are becoming an integral part of urban planning (interview #14). Although blue–green measures are increasingly valued in urban planning, their implementation is still slow. Green elements are often deselected in order to create parking spaces, universal design (urban environments that provide universal access for all), or cultural heritage considerations (interview #13, #5).

In Norway, BGI is primarily combined with conventional and underground pipeline infrastructure, particularly in already built-up areas with existing infrastructure (interview #1). The traditional way of handling increasing precipitation and stormwater is upgrading and resizing the pipes. However, a planning actor stated that "when we have accidents and flooding, it is rarely because of an under-dimensioned pipe, but because of a breach in the whole design" (interview #1). Another planning actor explained that stormwater management is not about millimeter accuracy: "You can never dimension your way out of potential flooding" (interview #17). These statements illustrate what several of the interviewed BGI practitioners say; that the blue–green focus is not just about handling stormwater but about thinking holistically, considering more than one goal, and looking beyond your limited planning area (interview #1, #7, #17). Notably, the two new sector plans that promote blue–green values and multiple benefits are quite overarching. The planning actors emphasized how the potential conflicts often become more challenging when it comes to the details of implementation (interview #1, #7).

4.4 | How planning actors perceive conflicts in alternative stormwater planning

The fact that the Norwegian Planning and Building Act promotes holistic stormwater management (Lovdata., 2021) was essential for creating the Tromsø stormwater sector plan. A key measure of the Tromsø sector plan is a planning tool developed by municipalities in south-eastern Norway called the Blue–Green Factor (BGF). The BGF tool is similar to planning tools like the Green Area Factor (GAF) tool, which aims to assess the sustainability of landscape design and construction based on the proportion of green and built-up areas (Juhola, 2018). The BGF tool aims to raise the status of blue and green urban spaces and calculates the degree of blue–green solutions in zoning plans. As snowmelt contributes to the stormwater problems in Tromsø, the municipality adjusted the tool to take into account local climatic conditions by adding a W for White—as in snow—in the now local Blue–Green–White Factor (BGWF) (TromsøKDP, 2020).

In creating the Tromsø sector plan, there were some concerns about the BGWF. One of these concerns was about whether the method would receive local approval as some actors might perceive it as creating additional construction costs. One of the goals of the sector plan is to incorporate the BGWF in the next municipal master plan in Tromsø. An argument for using the BGWF is that it enhances the quality of outdoor space and promotes blue and green values (interview #7). Even with these arguments, there were concerns from urban environment actors regarding how the BGWF would shape green area development. When planners and builders focus on reaching some calculated sum of points, it could affect how parks and recreational areas are designed (interview #8). Discussions about snow deposits and valuing snow deposits have been prominent in the BGWF development. It is not unusual to deposit snow from roads in parks and playgrounds. According to urban environment planning actors, this is problematic as road snow contains contaminants and heavy metals, leaving green areas contaminated when the snow melts (interview #8).

In addition to the BGWF, the local diversion of stormwater is key to the Tromsø stormwater plan. Such measures are closely associated with green infrastructure but can also deselect green solutions. The contrast between blue and green objectives and interests are physically visible in rain garden structures in Tromsø, where plants are not guaranteed (interview #7, #8). In a Tromsø schoolyard, new rain gardens have been built purely from sand and stones. The rain gardens have no plants due to practical considerations such as climatic conditions (when will it be green?), maintenance (gardening resources) and children playing (children could destroy the plants while playing). A planning actor questioned whether it was really a rain garden "when it is a bathtub containing sand and stones" (interview #8). The goal of this measure was to prevent flooding in the schoolyard and in the basements of adjacent houses. In these rain gardens, the green co-benefits disappeared.

Still, Tromsø municipality works on adapting rain gardens to freezing temperatures, appropriate to a sub-arctic climate. In a pilot project, the municipality tested alternative granular materials in rain gardens that do not freeze during winter. One of the challenges is that this alternative material does not purify the water in the same way as sand, eliminating the water purifying effect of this blue–green measure (interview #7, #8). Table 2 summarizes the findings in this section, presenting BGI development from before the concrete

TABLE 2 BGI co-benefits and conflicts in Bergen (B) and Tromsø (T)

Co-benefits	Conflicts
Preplanning phase	
Blue–green value development	*Blue–green value development*
B/T: ideas and values related to sustainability, holistic approaches and blue–green urban qualities have increasingly become prominent in urban planning over the last decade	B/T: although the blue–green measures are increasingly valued in urban planning, their implementation is still slow
Planning phase	
Visions/goals of the plans	*Visions/goals of the plans*
B: explicit and holistic blue–green visions in the plans. The main goals focus on broad multifunctionality and co-benefits T: clear focus on preparedness in the plans. The main goals concern potential damage reduction and using water as a resource in urban planning	B/T: the mandate of the municipal stormwater sector plan is to prioritize stormwater objectives B/T: the blue, green and blue–green goals compete with urban densification goals, economic interests, as well as pressure on land-use
Designing phase	
Strategy/measures	*Strategy/measures*
B: clear focus on holistic management of precipitation fields and managing stormwater locally using green surface solutions; combine BGI with conventional systems T: combine open blue–green surface solutions with upgrading and securing conventional systems; intention to add green elements	B: ambition for the high utilization of urban space may conflict with the space needed to address stormwater, depending on the frequency of flooding T: promote blue–green planning tools that can shape (blue–)green area development
Implementation phase	
Action plan/experiences	*Action plan/experiences*
B: actions include assessing flood zones, discharge and separation projects: the multifunctionality and co-benefits are less explicitly present T: extensive action plan including knowledge development, skills development and institutionalization of the sector plan goals, holistic thinking concerning developing stormwater planning	B: green elements are often deselected to accommodate other interests, potential conflicts become more challenging in the implementation phase T: example: rain gardens built purely from sand and stones; a lack of plants due to climatic conditions, maintenance and schoolyard recreation options
Maintenance phase	
Sector plan/experiences	*Sector plan/experiences*
B/T: the sector plans are the first stage of a long-term strategy to develop blue–green solutions B/T: planning actors must test and adapt blue–green solutions to local climatic conditions	B/T: build combined solutions because surface solutions challenge existing infrastructure solutions and local conditions B/T: planning actors need time and resources to test solutions (and try-and-fail)

planning work to beyond the implementation stage in Bergen and Tromsø. The findings will be discussed further in section 5.

5 | DISCUSSION: ADDRESSING BGI CO-BENEFITS AND CONFLICTS

At the outset of this paper, we argued that holistic BGI development could promote transformative adaptation strategies based on its focus on holistic co-benefits (Alves et al., 2019; Frantzeskaki et al., 2019; Kvamsås, 2021; Raymond et al., 2017). We further argued that understanding this transformative potential could benefit from a value perspective (Heifetz et al., 2009; O'Brien & Selboe, 2015; Rosenberg, 2021). The paper has two aims: (1) to understand how stormwater planning actors address the potential co-benefits and conflicts in BGI planning and implementation, and (2) to conclude how these insights could advance research and knowledge on holistic BGI planning as transformative adaptation strategies.

BGI in Bergen and Tromsø is generally planned and implemented based on initiatives from actors in their respective municipal water departments. The two studied stormwater sector plans are examples of such initiatives. These planning processes actively seek to involve actors from other relevant municipal sectors, such as planning and urban environmental departments, which represent other interests and values. The sector plans explicitly focus on stormwater management as is their mandate, but they also include a focus on holistic co-benefits. For example, the Bergen municipal sector plan has a holistic blue–green vision and six main goals that explicitly focus on broad multifunctionality and co-benefits such as preserving biodiversity and supporting ecosystem services. The visions, goals, strategies and measures demonstrate a desire to transform urban space, combining multiple blue and green interests and goals.

However, the focus on holistic co-benefits is less explicit in the current Bergen action plan, which mainly focuses on flood zone assessment and handling contaminated discharge. This could affect the prioritization of blue or green objectives and elements in BGI implementation. Additionally, the experiences of local municipal and private planning actors demonstrate how green elements are often disregarded in the BGI implementation phase to accommodate interests such as parking spaces and other competing infrastructure. This complements findings in Meerow (2020), showing how water quality targets dominate BGI planning. Importantly, private actors are key to the BGI implementation phase, and their room to maneuver is often heavily dependent on the regulations and initiatives of the municipality.

In the Tromsø sector plan, securing the current water infrastructure and cleansing contaminated stormwater are the main priorities. The Tromsø plan initially focused on preparedness, flood damage control and capacity issues in the existing and conventional stormwater systems. This may partially be due to local climatic conditions that does not always benefit from added green elements. Still, the Tromsø sector plan includes pilot projects that test and adapt blue–green measures to local climatic conditions as part of the planning work. This demonstrates a clear interest in developing blue–green solutions, even when the local climate is not necessarily favorable. The Tromsø action plan also includes extensive and detailed action points with a holistic focus on knowledge development, skills development, and the intention to institutionalize the sector plan goals and develop the entire field of stormwater planning. This indicates that holistic BGI planning is about more than just combining multiple interests and functions. It is also about promoting cross-sectoral collaboration and knowledge development.

Based on these reflections, this paper argues that municipal water actors are motivated to implement BGI beyond stormwater management goals and approach co-benefits and holistic stormwater management as an ideal in stormwater planning. From the Bergen and Tromsø stormwater sector plans and implementation processes, we note a considerable focus on holistic stormwater planning ideals, efforts to develop new knowledge, involve other relevant actors and develop locally appropriate solutions. The potential tensions and conflicts between co-benefits become more evident in actual implementation, which corresponds with the current literature (Finewood et al., 2019). We find that when holistic BGI implementation is initiated by the municipal water actors, the stormwater management aspects dominate the BGI implementation.

Building on the insights that municipal water sector actors seem motivated to implement BGI beyond stormwater management goals, a value perspective contributes to the literature on stormwater planning by highlighting what matters to the specific actors in the various phases of BGI planning and implementation. Kvamsås (2021) previously demonstrated how stormwater planning actors from various disciplines find it beneficial to identify shared interests and unified solutions because it ensures support for their separate professional interests. This could indicate a potential for developing synergies between interests and values. We have previously defined values as what people deem to matter, collectively, as much as individually (Rosenberg, 2021), and have ascribed BGI interests to specific professionals such as water engineers, landscapers, and planners (Meilvang, 2019). Consequently, we can now identify and reflect on how the relevant values are associated with the various co-benefits.

Building on the multiple ways of understanding values in BGI development (Alves et al., 2019; Franco-Torres et al., 2020; Kati & Jari, 2016; Meilvang, 2021; Raymond et al., 2017; Sharifi, 2021) and the Bergen and Tromsø experiences, we will argue that water actors generally are associated with a set of collective blue values, promoting stormwater management goals and interests. As a potential contrast, urban environment actors commonly connect to a set of collective green values concerning biodiversity protection and recreation objectives. In the developing holistic BGI planning ideal that focuses on co-benefits, these values seem to merge into a new blue–green value set that still can encompass contrasts and conflicts, particularly in the vulnerable implementation phase. This is visible, for example, in the discussions concerning using the BGWF planning tool in Tromsø, where awarding points to various blue, green and blue–green measures could reveal conflicts between the different blue and green interests and values.

6 | CONCLUSION: DEVELOPING BLUE–GREEN VALUES

This paper has shown how planning actors perceive and act on co-benefits and conflicts in BGI planning and implementation. Since it is critical to make the values, interests and intentions behind adaptation visible and transparent to promote equitable and transformative climate action processes (O'Brien, 2021), we have reflected on the connections between actors, values and interests in local BGI development. We conclude that even though blue and green values and interests are often conflicted in the implementation phase, a blue–green value set based on potential synergies from co-benefits is being developed in urban stormwater planning. The prevailing interests in BGI implementation will generally depend on which actor (and associated value set) is initiating and leading the planning and implementation process, combined with the local climatic conditions.

While municipal water actors are being forced to develop new infrastructure solutions because of stormwater risks and injury/damage to people and property, the green values concerning biodiversity protection do not have the same status. If they are to demand more space for the green elements in BGI, the actors who represent green values may need to take increasingly active and leading roles in BGI development processes. One way to promote such leadership could be providing arenas for continued cross-sectoral collaboration and BGI knowledge development. In a world striving to put an economic value on trees, soils, and vegetation and where BGI can be built without green elements (Matsler, 2019), prioritizing green elements beyond what serves human interests could potentially be truly transformative.

Finally, the paper contributes to understanding BGI as a potential transformative adaptation strategy (O'Brien & Selboe, 2015; Pelling, 2011; Wamsler et al., 2021) by providing empirical examples of investigating and handling the co-benefit values and interests in local adaptation planning. These empirical examples illustrate how collective values and interests can develop and unfold across sectors and professional disciplines in BGI planning.

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