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Addressing the adaptive challenges of alternative stormwater planning

Hanna Kvamsås

Department of Geography, University of Bergen, Bergen, Norway

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).

CONTACT Hanna Kvamsås hanna.kvamsas@uib.no Department of Geography, University of Bergen, PO Box 7802, Bergen 5020, Norway

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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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Notes on contributors

Hanna Kvamsås is a PhD Candidate at the Department of Geography and the Centre for Climate and Energy Transformation (CET), University of Bergen and at NORCE Norwegian Research Centre AS.

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