



Implementing climate change adaptation through mainstreaming at the local level—a comparative case study of two municipalities in the Netherlands

Franziska Baack^{1,2} · Gül Özerol² · Joanne Vinke-de Kruijf¹ · Johannes Halman¹ · Stefan Kuks²

Received: 17 March 2023 / Accepted: 26 February 2024
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Abstract

Governments face increasing urgency to adapt to climate change. However, there is a persistent gap between needed and implemented adaptation. The implementation of adaptation often takes place at the local level, making municipalities crucial actors, particularly regarding mainstreaming adaptation into various sectors. While mainstreaming has the potential to bring many benefits, it does not necessarily result in the implementation of adaptation. Its contribution to the adaptation process over time and the resulting implementation at the local level remain poorly understood, exacerbating the adaptation implementation gap. To advance the understanding of mainstreaming for implementation, we synthesize the emerging debates on adaptation mainstreaming with the literature on environmental policy integration and offer a framework towards a nuanced conceptualization of mainstreaming. Our results from a case study of two Dutch municipalities show that managerial actions precede the acceleration of implementation in the built environment and point to a learning curve. Furthermore, mainstreaming focuses on the water sector, built environment and green infrastructure, with little attention paid to the intersection of heat stress and drought with other sectors, while differences in the implementation of adaptation in the two cases hint at the influence of the local context. We conclude that there is no blueprint to implement adaptation, and while local preferences determine the sectors where integration and implementation occur, consideration of long-term future climate change is lacking in both cities' mainstreaming of adaptation implementation. Our framework allowed identifying the potential and pitfalls of mainstreaming adaptation towards implementation at the local level.

Keywords Environmental policy integration · Local government · Climate change adaptation · Implementation · Mainstreaming

Introduction

Impacts of climate change are becoming more severe, increasing the necessity to adapt to climate change (hereafter *adaptation*) at all levels of government (Intergovernmental

Panel on Climate Change—IPCC 2022). Because many of the impacts are local and require a local response, implementation of adaptation actions is often placed at the local level (Castán Broto 2017; Revi et al. 2014; Carter et al. 2015; Aguiar et al. 2018; Fazey et al. 2018; Corfee-Morlot et al. 2011; Siders 2017; Braunschweiler 2022), and municipal governments have been identified as key actors of adaptation to spearhead this local response (Revi et al. 2014; Lesnikowski et al. 2021). Municipalities differ in their adaptation efforts within and across countries (Lesnikowski

Communicated by Robbert Biesbroek

✉ Franziska Baack
f.r.baack@utwente.nl

Gül Özerol
g.ozerol@utwente.nl

Joanne Vinke-de Kruijf
joanne.vinke@utwente.nl

Johannes Halman
j.i.m.halman@utwente.nl

Stefan Kuks
s.m.m.kuks@utwente.nl

¹ Department of Civil Engineering and Management, University of Twente, Drienerlolaan 5, 7522 NB Enschede, The Netherlands

² Department of Technology, Policy, and Society, University of Twente, Drienerlolaan 5, 7522 NB Enschede, The Netherlands

et al. 2019). Their actions span from assessing localized climate change impacts, to making plans, earmarking financial resources, and collaborating with other actors (Guyadeen et al. 2019; Hughes 2015; Mimura et al. 2014; Moser et al. 2010; Runhaar et al. 2012; Uittenbroek 2016; Fünfgeld 2015; Rivas et al. 2021; Woodruff 2018; Castán Broto and Bulkeley 2013; Doherty et al. 2016; Woodruff and Stults 2016). They take all these actions as part of the adaptation process with the goal of implementing adaptation by building grey infrastructure, for example, stormwater drains, by adopting nature-based solutions, such as restoring streams (Uittenbroek 2016; Dannevig et al. 2012; Campos et al. 2017; Keskitalo et al. 2016; Bowler et al. 2010; Bissonnette et al. 2018), or by delivering adaptation services, such as cooling centers (Meerow and Keith 2022).

Despite all of the aforementioned studies, the 2022 IPCC report identifies a significant gap between necessary and currently realized adaptation (IPCC 2022, van den Ende et al. 2022, Rogers et al. 2023). One strategy commonly proposed to increase implementation at all levels is mainstreaming, which refers to the integration of adaptation goals into other sectoral policies, processes, and programs (Biesbroek 2021; Runhaar et al. 2018; King 2022; Aylett 2015; Huck et al. 2020). In this paper, mainstreaming is understood as a range with multiple degrees (Albers et al. 2015; Reckien et al. 2019, 2018; Lyles et al. 2017; Braunschweiler and Pütz 2021), from a dedicated approach focusing on adaptation as its only goal to an integrated approach, in which adaptation is one of several goals. This range can be applied across categories that encompass the actions along the adaptation process, namely (1) regulatory actions, such as plans; (2) managerial actions, for instance, resources; (3) inter-organizational actions, such as networks; and (4) programmatic actions, which include implemented infrastructure projects (Widmer 2018; Runhaar et al. 2018). Certain actions such as the implementation of nature-based solutions in urban projects usually address multiple goals and are integrative by default (Adams et al. 2023).

While mainstreaming carries the potential to bring many benefits, mainstreaming adaptation into sectoral plans or policies does not necessarily result in the implementation of adaptation at the local level. The contribution of mainstreaming to the adaptation process over time and to the actual implementation of adaptation at the local level remains poorly understood. This scientific knowledge gap exacerbates the adaptation implementation gap. Whether they are descriptive or explanatory, previous studies on local adaptation often focus on the success of adaptation plans or pilot projects at the local level (Braunschweiler and Pütz 2021, van den Ende et al. 2022, Pot et al. 2022, Di Giulio et al. 2018, Picketts 2018, Zimmermann 2018). At the same time, a lack of implementation built into municipal policies, administrative processes, and long-term plans

remains one of the main barriers towards implementation at the local level (Rogers et al. 2023). Both administrative processes and long-term plans point to the temporal aspect of a shift from adaptation planning and pilot projects towards broader adaptation implementation, as do other studies (Fu 2020). However, research with a longer-term view towards implementation lacks frameworks that allow systematic identification of adaptation actions (Eckersley et al. 2018; Mabon et al. 2019; Pasquini and Shearing 2014; Pasquini et al. 2015), which in turn hinders identifying (categories of) actions that support institutionalization, and gaps in mainstreaming in terms of sectors or impacts. To systematically identify these shifts in a municipality's approach towards its adaptation implementation over time and thus contribute to bridging these knowledge and policy gaps, we aim to create a nuanced understanding of mainstreaming in municipal adaptation processes across multiple categories and degrees of mainstreaming.

We specifically address the research question: "How do municipalities' adaptation approaches and their implementation change over time with respect to categories and degrees of mainstreaming?" This question is answered in two steps. First, we synthesize the literature streams on adaptation and mainstreaming into a consistent and nuanced conceptual framework for the local level. And second, we apply this framework to identify the puzzle pieces of a broad range of adaptation mainstreaming actions preparing the observed implementation of adaptation at the local level. To this end, we conduct two case studies, which allows us to investigate developments over time (Yin 2014). The Netherlands is selected as case study context, given its supportive and well-developed context for the water- and especially flood-related aspects of adaptation, being a low-lying, delta country with a long history of water management and flood risk management (Hoppe et al. 2014; Kamperman and Biesbroek 2017; Vinke-de Kruijf 2013). Recently, adaptation received more attention as an independent policy issue in the Netherlands, but a high degree of integration with the water sector remains (Massey and Huitema 2016). Therefore, integration with the water sector is expected, whereas integration with other sectors is unknown. We chose to compare within a country, rather than across countries, because local governments in different countries have divergent responsibilities and authorities. The selected cities, Enschede and Zwolle, have been engaging with adaptation since the early 2010s. Both cities implemented adaptation projects but followed different paths. As such we expect the two cities to exhibit differences in their approaches to mainstreaming regarding the categories and degrees of mainstreaming as well as the sectors relevant for integration.

The remainder of the paper is organized as follows: in the "Theoretical background" section, we review theoretical approaches to mainstreaming and present our

conceptualization. In the “[Methodology](#)” section, we describe the methods employed. In the “[Case studies](#)” section, we present the results per case, followed by a “[Comparison of the cases](#)” and the “[Discussion](#)”. Our framework proved useful for the systematic discovery of all adaptation-related activities, which enabled the identification of crucial actions preceding implementation. We conclude that mainstreaming adaptation in implementation is well under way in urban planning, maintenance of the public space, and water management once certain administrative processes are in place. This systematic approach also emphasized that integration into other sectors and regarding heat and drought as well as considerations of future climate change is still lacking, highlighting the potential and pitfalls of adaptation mainstreaming. We elaborate these remarks in the “[Conclusion](#)” section.

Theoretical background

There is no single agreed-upon conceptualization of mainstreaming, but two uses are common (Adams et al. 2023). The first one provided above is influenced by the concept of Environmental Policy Integration (EPI). EPI describes the integration of environmental objectives into other policy sectors to tackle causes of environmental degradation rather than its symptoms (Persson et al. 2018). Integration in this context refers to the “process of embedding” adaptation or other environmental concerns across siloed domains (Biesbroek 2021). The second use of mainstreaming encompasses the idea of institutionalization, i.e., shaping the “mainstream” (Adams et al. 2023). Both meanings are often implied at once through terms such as “embedding.” Mainstreaming of adaptation is considered a specific form of EPI (Adelle and Russel 2013; Biesbroek 2021). The use of mainstreaming rather than integration can be traced back to the development context (Adelle and Russel 2013; Huck et al. 2020), where other uses, such as gender mainstreaming, were already common. Within the context of urban adaptation, six sectors are particularly relevant for mainstreaming: water, energy, transportation, built environment, green infrastructure, and social services (Araos et al. 2016).

Two distinct lines of discourse shape our conceptualization of mainstreaming. The first is concerned with the expression of integration and the degree to which it is present in implementation, for instance, as a range of integration (Persson et al. 2018; Lyles et al. 2017). The second discusses different categories or types of actions to achieve integration (Wamsler et al. 2014; Widmer 2018; Runhaar et al. 2018; Underdal 1980). In the remainder of this section, we first elaborate on the categories and degrees of mainstreaming, and then present our overall conceptualization.

Categories of mainstreaming adaptation at the local level

Conceptualizations of adaptation mainstreaming identify different strategic actions at all levels of government. In her pioneering work, Wamsler proposes six categories of actions (Wamsler 2015; Wamsler et al. 2014; Wamsler and Pauleit 2016). She distinguishes mainstreaming through: (1) add-on, (2) programmatic, (3) inter- and intra-organizational, (4) regulatory, (5) managerial, and (6) directed mainstreaming (Wamsler et al. 2014; Wamsler 2015). These categories target various areas of the adaptation process, from projects to policies, to the management of municipal resources. Based on this diversity, we define an action, whether it is mainstreamed or dedicated, as any deliberate step towards implementing adaptation by a (local) government. Integration in actions preceding implementation does not necessarily lead to implementation (Runhaar et al. 2018), sometimes intentionally (Biesbroek and Candel 2020). Our definition of action might include disingenuous attempts, but assessing the intent of each action is outside the scope of this study.

Previous studies have grouped actions in different configurations of categories and under different names (Wamsler and Osberg 2022; Runhaar et al. 2018; Widmer 2018; Braunschweiger and Pütz 2021). Throughout these studies, the actions themselves remain largely the same. Additionally, the actions and their operationalization give a comprehensive overview of ways in which municipal governments can pursue the implementation of adaptation. To reflect our understanding of adaptation and mainstreaming, specifically at the local level, we define the following four categories of adaptation mainstreaming actions. While they are based on Runhaar et al. (2018) and Wamsler and Pauleit (2016), we focus on categories that describe *how* adaptation is done *at the local level*:

- *Regulatory actions* include any form of regulation, such as plans and policies. This category has not been altered from the original conceptualization (Runhaar et al. 2018; Wamsler and Pauleit 2016).
- *Managerial actions* refer to changes in the administrative structure, such as the distribution of personnel and resources across departments (Runhaar et al. 2018). We have merged intra-organizational actions with managerial actions as they both cover issues pertaining to personnel, budget, and responsibilities for adaptation within the municipal organization, with one focusing on structures from the entire organization down to individual departments and one on collaboration across departments.
- *Programmatic actions* describe the implementation of adaptation at the program or project level and in on-the-ground operations (Wamsler and Pauleit 2016; Runhaar et al. 2018). These include the “add-on” category, which

refers to dedicated adaptation projects, proposed by Wamsler et al. (2014).

- *Inter-organizational actions* promote collaboration and networking with other municipalities, individual sectors, or stakeholders (Runhaar et al. 2018). These actions include all forms of municipal networks, whether they are dedicated to adaptation, or integrate adaptation, for instance, into broader goals of sustainability or resilience.

Directed actions refer to support from higher levels of government that subsidize or mandate adaptation (Wamsler and Pauleit 2016; Runhaar et al. 2018), which can explain why actions across the four categories are being taken by municipalities. It is excluded as a category for the following reasons: First, the subsidy or policy action is taken by actors other than municipalities and outside the scope of the study, while possible outputs of the directed actions are covered by the other categories. Second, including directed actions as the only one of several explanatory factor does not answer the why question. Additionally, at the local level directed actions function as context for the municipalities' actions. Investigating context for a multitude of identified actions is beyond the scope of this paper.

Degrees of mainstreaming adaptation at the local level

Connecting adaptation with other sectoral policies is often described as present or absent, even if different forms of mainstreaming are depicted. This becomes a problem when comparing actions. The common but fuzzy definition of mainstreaming as “integrating climate change adaptation objectives into existing sectoral policies and practices” (Runhaar et al. 2018) facilitates this, because it does not specify the term integration and its inherent differences in extent (Persson 2004). The literature on EPI addressed this issue by defining three different degrees of integration. However, it is possible to implement adaptation actions without any form of integration. For instance, a government can issue a stand-alone adaptation strategy or dedicate funding to be used solely for adaptation actions. These actions can be sorted into the mainstreaming categories above, but not into any degree of integration as they are defined by being dedicated to adaptation (Uittenbroek et al. 2013). Based on our conceptualization of adaptation mainstreaming, we add a fourth degree that is characterized by being dedicated to adaptation. This has been called contradictory, and dedicated actions were excluded from some conceptualizations of mainstreaming (Runhaar et al. 2018). We offer two arguments for the inclusion. Firstly, we conceptualize mainstreaming as a range, and thus include the point zero (dedicated) as the start of the range, instead of some other

arbitrary point. Secondly, while adaptation is emerging as its own field (Massey and Huitema 2016), the lines between dedicated actions and mainstreamed actions remain blurry: Are dedicated adaptation resources in a sectoral budget truly dedicated, or do they constitute prioritization by the sector and does this change as the field matures? Our inclusive definition enables us to analyze all actions contributing to the implementation of adaptation, including but not limited to the integration of adaptation into other sector policies, processes, and projects, based on the following degrees of mainstreaming:

- *Coordinated*: Actions of a government do not contradict each other or undermine adaptation goals (Lafferty and Hovden 2003; Runhaar et al. 2009; Persson et al. 2018; Widmer 2018).
- *Harmonized* activities by other sectors with environmental/adaptation goals (Lafferty and Hovden 2003; Persson et al. 2018; Runhaar et al. 2009; Widmer 2018). Here, adaptation is treated as an equal goal among other goals. “Win–win,” “co-benefits,” “synergies,” or “added-value” approaches fall into this degree. The aim is to achieve adaptation goals alongside other goals. This interpretation of adaptation mainstreaming is prevalent in the adaptation literature.
- *Prioritized*: Drawing on Lafferty and Hovden (2003), we argue that the point of mainstreaming adaptation is the implementation of adaptation in those sectors, while preventing maladaptation for other sectors. As a result, it might sometimes be necessary or desirable to prioritize adaptation without precluding the pursuit of other policy goals. Thus, developments in other sectors can be driven by adaptation goals (Lafferty and Hovden 2003; Persson et al. 2018; Runhaar et al. 2009; Widmer 2018). A great example by Lafferty and Hovden (2003) is government policies prioritizing economic growth regardless of sector.
- *Dedicated*: Actions whose sole purpose is to facilitate adaptation, such as dedicated resources and projects (Uittenbroek et al. 2013)

All four degrees of mainstreaming apply to all four categories. While several studies have identified different combinations of categories and degrees of integration, our categorization builds mostly on Widmer (2018). For some definitions, we also drew on Runhaar et al. (2018) and other relevant studies. Not all actions qualify as implementation. We distinguish between groundwork and implementation (Lesnikowski et al. 2011). Groundwork actions are first steps to prepare for implementation, such as resources, assessments, plans, or networking. In the context of this study, implementation refers to changes in the built environment or delivery of services by the municipal government. While

certain governmental actions can lead to implementation by other actors, we exclude policy instruments like regulation and subsidies from the implementation category, as assessing in how far they contribute to changes in the built environment is a different type of study and outside the scope of this paper (see Mees et al. 2013 for an example). Both groundwork and implementation can occur dedicated to one or more impacts of climate change or mainstreamed into other sectors. Unlike Lesnikowski et al. (2011), we consider all of these actions to be part of adaptation, since we view adaptation as the “process of adjustment to actual or expected climate and its effects” (Adgard and Schipper 2014), rather than purely an outcome. As such, the continued assessment of climate impacts is as much a necessary part of the adaptation process as the adjustment of goals in long- and short-term plans. This process-oriented view includes an aspect of temporality and thus necessitates a longitudinal perspective. Longitudinal in this context refers to research investigating change over time and in a retrospective manner (Corden and Millar 2007). While the degrees, categories and actions themselves do not reflect this temporality, the fine-grained nature of the framework enables the analysis of data over a decade to show possible trends and patterns in adaptation actions.

Methodology

As we are interested in exploring different municipal approaches to adaptation mainstreaming, we adopt a multiple-case study approach (Yin 2014). This section explains our case study selection as well as how data were collected and analyzed.

Case study selection: the Dutch context and the cities of Enschede and Zwolle

The Netherlands is seen not only as a frontrunner in adaptation (Mees and Surian 2023) but also as a global exporter of water management experiments and solutions (Bulkeley 2022). Since the National Adaptation Strategy was devised in 2007, other institutional arrangements such as the national Delta Programme were established (Kamperman and Biesbroek 2017; Hoppe et al. 2016; Pot et al. 2022). The Delta Plan Spatial Adaptation (DPSA), shaping Dutch national adaptation policy (Mees and Surian 2023), identified four impacts of importance to the Netherlands: pluvial flooding, heat stress, drought, and fluvial flooding, and defined the goal to make the Netherlands “climate-proof” by 2050 (Ministry of Infrastructure and the Environment and Ministry of Economic Affairs 2017). At the local level, adaptation received little attention outside of traditional water-related duties before 2018 (Hoppe et al. 2014; Reckien et al. 2018).

Studies investigating projects and the integration of adaptation at the local level identified adaptation initiatives, which were almost exclusively water-related (van den Berg and Coenen 2012; Swart et al. 2014). Since 2018, a national mandate in the DPSA (Ministry of Infrastructure and the Environment and Ministry of Economic Affairs 2017) for all governments, including municipalities, to analyze their climate-related vulnerabilities and design an adaptation implementation plan until 2020 has significantly increased adaptation activities at the local level.

Within the Netherlands, we focus on the two largest municipalities in the Province of Overijssel: Enschede and Zwolle. While both cities are comparable in terms of size (approximately 160,000 and 130,000 inhabitants respectively), they face partially different challenges from climate change. Zwolle, in the far West of the Province, faces the risk of river floods due to its low-lying location in the IJsseldelta (4 m above sea level) whereas Enschede, in the East of the Province (at 42 m above sea level), faces risks of severe pluvial flooding. As urban centers, they contend with similar problems regarding heat. Despite being mid-size cities, they are both considered adaptation frontrunners within the Netherlands and engaged with the topic since the early 2010s (Özerol et al. 2020). As noted above, even though many Dutch municipalities have taken up adaptation over the last few years, only a limited number of them engaged with the topic continuously before 2018. The cases of Enschede and Zwolle provide the longitudinal data we are interested in. While some bigger cities in the Netherlands, such as Rotterdam (Huck et al. 2020), are also implementing adaptation actions, our selected mid-sized cities are much more representative of Dutch municipalities than its largest cities. Additionally, they differ significantly in their choice of adaptation mainstreaming actions regarding implementation. This difference makes them interesting for comparison because their similar governance context and comparable adaptation challenges would suggest the actions paving the way for adaptation implementation to be similar as well, whereas the differences in implementation are unexpected.

Data collection and analysis

Most of the data were collected as part of a regional collaboration project, CATCH+, between December 2018 and June 2020 through interviews, two workshops, and participant observations. The CATCH+ project was a spin-off of the EU Interreg project CATCH, an international research project on water sensitive cities in North-West Europe (Waterschap Vechtstromen 2022). We interviewed six civil servants for the Enschede case. One interviewee, the chair of the regional water and adaptation network, was interviewed twice, once with a regional focus. We interviewed four civil servants from Zwolle in three interviews and one person from the

regional adaptation network. Most of the interviewed civil servants contributed to adaptation actions within their organization for more than 10 years, during most of the study period. In addition, the CATCH project provided interview transcripts with three people from Enschede and seven people from Zwolle. Furthermore, we collected and analyzed 24 policy visions and plans, 14 additional project-related documentations, and consulted 15 websites for further information (e.g., adaptation strategies, coalition agreements, municipal sewage plans from 2010 onwards) between October 2018 and November 2022. We found most documents online, but some were provided by the municipalities. (For an overview of all relevant primary data and details about the interviews, please see Table 2, 3, and 4 in the Supplementary Material.) To ensure readability of the text, we refer to sources for Enschede with EN-x and the respective number, to sources for Zwolle with ZW-x and the respective number, and the project reports with B-x. We used these different sources to triangulate our findings. All data presented in the [supplementary material](#) were used to compile and analyze the actions presented in the “[Case study](#)” and “[Comparison of the cases](#)” sections. We do not refer to every source in the text, as we do not discuss all actions. A detailed description of the contents of the workshops, participants, etc. can be found in the workshop documentation online [B-1, B-2]. The participants ranged from water planners responsible for adaptation, and a water and adaptation policy advisor at the municipality Enschede, to a spatial planner and water planner at the municipality Zwolle, to (adaptation) project leaders at the water authority Vechtstromen and the Province of Overijssel. Both workshops took place in person.

We followed an iterative process for data analysis, using Atlas.ti 22 and Excel 2016. In a first step, two questions guided our analysis to create the timeline of adaptation for each city and identify all actions each municipality implemented: (1) When did actions for mainstreaming adaptation first appear in each municipality’s policies, plans, projects? (2) What kind of actions were implemented in which sectors? In a second step, we validated the timeline with actors from each municipality and discussed the actors’ perspective on implementing adaptation through integrated versus dedicated actions in a workshop. This provided insights for instance into the sector they saw as most relevant or appropriate for implementation. After this, we sharpened our conceptualization of mainstreaming by operationalizing each degree for all actions across the four categories, which is detailed in Table 1 including distinct references. If an action has no reference, we created the definition. Then, the first author conducted a second round of coding focusing on the degree of integration. Lastly, we re-examined our coding for the categories and degrees of mainstreaming to ensure consistency. Most actions could be clearly assigned a category and degree based on our operationalization. Six actions

were difficult to assign to a specific degree or category. We discussed which degree or category was more appropriate for each action. Our final judgement was determined by the quality and quantity of evidence for a certain degree or category, and our overall understanding of the action. The practitioners were not involved in this process. Ideally, two researchers would have coded all data independently to ensure the reliability of the operationalization. Unfortunately, this was not feasible. Given the small number of actions that was not clear in the first round (three out of 75 for each, degrees and categories), the operationalization allows for replicability.

Case studies

In this section, we analyze the actions taken towards mainstreaming adaptation in Enschede and Zwolle over the past decade. Figure 1 summarizes the actions in each city across distinct categories and degrees of mainstreaming. For a detailed overview of all actions, please see Figs. 2 and 3, and Table 5 in the Supplementary Material.

The case of Enschede

Our analysis shows that Enschede undertook 40 distinct actions between 2011 and 2022 (see Fig. 1). These actions took place in two phases. The first phase is marked by coordinating adaptation within regulatory actions [EN-4; EN-6; EN-11; EN-32]. Addressing pluvial flooding due to extreme rain entered Enschede’s water sector in 2011, connecting water management projects to a changing climate that exacerbated their necessity [EN-5; EN-11]. In 2012, eleven locations prone to pluvial flooding were defined [EN-32]. Additionally, the municipality switched to a risk-based financial water management approach in 2014 [EN-7; EN-4]. “Adaptation” as opposed to pluvial flooding became explicit in 2015 [EN-6]. Enschede joined Hengelo and Almelo for a “Climate Active City” cooperation the same year [EN-39; EN-40].

In the second phase from 2016 onwards, adaptation increased in importance. The eleven problem areas were identified as at high risk under the new risk-based management. They were transformed into an implementation program of adaptation projects [EN-4]. This approach evolved into adaptation-driven urban development. Its implementation started in 2017 with the first large-scale project with an explicit adaptation element to rebuild a local stream in the city [EN-28]. The municipality implemented projects in seven of the eleven locations, including a central street downtown, implemented between 2018 and 2020 [EN-15; EN-5]. In this phase, Enschede increasingly integrated adaptation into other sectors, in their programmatic, managerial,

and regulatory actions [EN-1; EN-2; EN-4; EN-13; EN-15]. Enschede is trialing an integrated area-based managerial action [EN-31], which aims to integrate the budgets for different domains to tackle multiple problems at once through a “Dynamic Investment Agenda” [EN-31; EN-34]. However, the implementation in the public space remains focused on adaptation (Warbroek et al. 2022). The municipality also integrated adaptation into an urban re-development project around the central train station [EN-15], and recent plans on housing, parks, road maintenance, and the rural landscape [EN-2; EN-30; EN-35; EN-37]. The latest sewage plan from 2022 prioritizes adaptation through an area-oriented approach [EN-15].

The case of Zwolle

Over the past decade, Zwolle undertook 35 actions (see Fig. 1). The overwhelming majority (25 out of 35) exhibit some degree of integration. This tendency to integrate adaptation into other domains is evident from the beginning. Zwolle started with two workshops in 2013 [ZW-12], following a regional cooperation program, the IJssel-Vechtdelta [ZW-12]. The adaptation goals in the workshop report included the integration of adaptation into the water agenda [ZW-11], and the idea of implementing adaptation through spatial development. The programmatic actions, which increased over the years, largely follow this edict, with two exceptions, one dedicated assessment of water nuisance in 2013 [ZW-5] and one dedicated implementation project in 2021 [ZW-28]. All other projects integrate adaptation into urban developments, such as the redevelopment of the area around the central train station, a new housing development [ZW-29], or into smaller maintenance projects of residential streets, such as renovating pavements to increase rainwater infiltration capacity [ZW-28].

Since 2015 Zwolle pursued adaptation more intensely, with a focus on collaborating with various stakeholders, for example, a local adaptation network around the “Climate Active City” program. The adaptation network led to the implementation of pilot projects, such as the citizen-led greening of a street in 2016, and a follow-up network in 2017 connecting the municipality, companies, education institutions, and societal actors. This is one of several local and regional networks and long-term cooperations that the municipality started or joined, most recently a nationally funded regional network piloting climate adaptive urban deltas in 2021 [ZW-26]. Another emerging pattern in regulatory actions is the coordinated or harmonized integration of adaptation into city-wide water management and spatial development plans, starting with the water agenda in 2015 [ZW-11], the sewage plan 2016–2022 [ZW-5], and the Vision on Spatial Planning and the Environment 2021 [ZW-17]. Even

the dedicated Adaptation Strategy addresses the integration of adaptation into spatial development [ZW-16]. However, adaptation is not prioritized in sectoral plans. One notable exception is the budget in the latest sewage plan, which prioritizes adaptation [ZW-32].

Comparison of the cases

In this section, we compare the cities over time across categories and degrees of mainstreaming and regarding sectors and implementation. As Fig. 1 shows, both municipalities introduced and implemented various actions across all categories and with different degrees of mainstreaming over the course of the last decade. Enschede started earlier, in 2011, whereas Zwolle has caught up in the number of actions since 2016. Actions prioritizing adaptation are rare in both municipalities. Overall, Zwolle prefers actions that integrate adaptation, but do not focus on it, whereas Enschede has almost as many actions dedicated to adaptation or prioritizing it (19 out of 40) as more integrated ones (21 out of 40). Regarding degrees of mainstreaming, both cities employ coordinated actions initially, but their number decreases over time, whereas the number of harmonized actions increases.

Regulatory actions

Adaptation first appears as regulatory mainstreaming in the form of plans. Both municipalities advance adaptation through integrating it into various regulatory actions over the years, in the early years especially the water sector. Markedly, this is the only mainstreaming category in which both municipalities prefer some degree of integration over dedicated actions. Regulatory actions in Enschede show a clear progression in the degree of integration over the past decade throughout different sectors. From coordinated [EN-04] to harmonized [EN-11] and finally prioritized adaptation, first in the water sector [EN-15], then in other sectors, such as housing and economic development. While the early plans in Zwolle are water-related, they stress the necessity of integrating adaptation into urban development, through maintenance in the public space and the pursuit of inter-organizational collaboration. One of only three dedicated regulatory actions is Zwolle’s Adaptation Strategy. It nevertheless focuses on integrating adaptation into other sectors, especially urban development. Most of its water-related plans and visions harmonize adaptation whereas most others sector plans coordinate it. Both municipalities also integrate adaptation into their plans for parks and urban green. Zwolle developed a “Vision on Spatial Planning and the Environment” in 2020, and Enschede integrated adaptation into visions for the different sectors, such as housing, landscape, and the economy since 2019.

Table 1 Operationalization of adaptation mainstreaming actions per category for dedication and coordination (adapted from Widmer 2018)

	Coordinated Cross-sectoral coordination to avoid contradictions and to realize synergies	Harmonized Inclusion of adaptation objectives on equal terms with sectoral objectives	Prioritized Favoring adaptation in sectoral policies; redesigning processes for adaptation	Dedicated Stand-alone adaptation, no integration into sectoral objectives
Regulatory				
Long-term visions and strategies, broad scope, few if any details	Symbolic consideration in long-term visions—no adaptation outcomes (Uittenbroek et al. 2014)	Integrated visions, e.g., sustainability (Reckien et al. 2019); sectoral strategies integrating adaptation as an equal interest (Widmer 2018)	Adaptation as guiding objective for all policymaking, including sectoral strategies (Widmer 2018)	Dedicated adaptation vision (Reckien et al. 2019) or single-impact strategy, e.g., floods (Lyles et al. 2017)
Short-term adaptation plans;	Connecting plans through reference; symbolic consideration—no adaptation outcomes (Uittenbroek et al. 2014)	Integrated plans, e.g., sustainability (Reckien et al. 2019); sectoral plans integrating adaptation as an equal interest (Widmer 2018)	Adaptation as guiding objective for all plans, including sectoral (Widmer 2018)	Dedicated adaptation (Reckien et al. 2019) or single-impact plan, e.g., floods (Lyles et al. 2017)
Managerial				
Personnel in the form of mandates and staff to work on adaptation	Temporary staff for adaptation projects, adaptation as an extra task without any extra time (Uittenbroek et al. 2014)	Adaptation is added to the sectoral task portfolio and adaptation units are established in key sectors (Widmer 2018)	Complementary sectoral adaptation across departments units can set agenda and have veto rights (Widmer 2018)	A separate adaptation department or unit (Uittenbroek et al. 2013)
Financial resources for adaptation	limited financial resources for pilots	Systematic inclusion of adaptation into sector budgeting (Jordan and Lenschow 2010); other sectors provide institutionalized resources	Sectoral budgets systematically prioritize adaptation (Jordan and Lenschow 2010), provide substantial resources	Financial resources dedicated to adaptation (Runhaar et al. 2018)
Adaptation education or training of municipal staff	Superficial education across departments on adaptation, e.g., one-off short events	Substantial education across departments on adaptation (Runhaar et al. 2018)	Substantial re-training of staff across departments	Ongoing education of dedicated staff (Runhaar et al. 2018)
Internal collaboration on adaptation between departments	Interdepartmental information exchange is established on a voluntary and temporary basis (Widmer 2018)	(Institutionalized) cooperation among departments (Runhaar et al. 2018)	Formally required interdepartmental cooperation including conflict mediation mechanism (Widmer 2018)	No cooperation/ coordination/ communication with other departments or sectors
Programmatic				
Vulnerability assessments, stress tests	Selected vulnerability assessments (Widmer 2018)	Systematic vulnerability assessments following a standard procedure (Widmer 2018)	Systematic vulnerability assessments guide policymaking; priorities are decided (Widmer 2018)	General climate impact assessment, not translated into sector-specific vulnerabilities
Projects to change the built environment that include adaptation	Symbolic consideration of adaptation in projects but no adjustment of designs	Significant changes to projects based on adaptation (Runhaar et al. 2018)	Adaptation driving sectoral projects, such as urban development and water	New projects with a sole focus on adaptation (Wamsler et al. 2014)
Monitoring and evaluation of adaptation in projects	Monitoring practices are discussed and outlined (sector-specific) (Widmer 2018)	A consistent overall M&E system is adopted (Widmer 2018)	Adaptation impacts of sector actions are prioritized for all M&E	M&E only for explicit/ dedicated adaptation action

Table 1 (continued)

Inter-organizational				
Participation in (adaptation) networks	Networks employing framing around adaptation without concrete actions	Networks involving adaptation (Runhaar et al. 2018)	Sector networks that prioritize adaptation	Participation in adaptation networks (Runhaar et al. 2018)
Collaboration with external stakeholders on adaptation	Occasional consultation of other sector actors and authorities (Widmer 2018)	Regular participative processes with other sector actors and authorities (Widmer 2018)	Inclusion of other sector actors and authorities into decision-making (Widmer 2018)	Inclusion of other adaptation actors and authorities into decision-making (Widmer 2018)

Managerial actions

Most managerial actions in both municipalities took place between 2015 and 2018. Nevertheless, their respective approaches differ in two aspects: the source of financial resources and inter- versus intra-departmental cooperation. Both municipalities dedicate financial resources in their budgets, but the sources for the adaptation budget were different. Enschede's switch to a risk-based management enabled its use of the sewage fee, a nationally authorized fee collected by municipalities to manage stormwater and groundwater, to pay for the adaptation projects addressing pluvial flooding. The water department in Zwolle started using the sewage fee for adaptation projects recently, although it does not see itself in charge of adaptation [ZW-32]. Previously, Zwolle only had a small budget dedicated to adaptation [ZW-33].

When it comes to staff, both municipalities hired communication advisors for adaptation in the last few years, Zwolle in 2017 [ZW-6], and Enschede in 2020 [EN-17]. Both have assigned clear responsibilities for adaptation, provide resources and training, and collaborate across departments and within the organization [EN-1; EN-7; ZW-1; ZW-6]. They also educate staff in other departments on the implications of adaptation for their respective departments. Despite these similarities, the staff working on adaptation differs significantly. Zwolle pursues an integrated strategy for its adaptation team, which consists of members from different departments, such as water, urban planning, or social services and they strive to integrate adaptation within their respective domains [ZW-1; ZW-6]. In Enschede, the adaptation staff is firmly rooted in water planning [EN-13]. However, the same department covers urban development and water planning, so collaboration on a project basis is institutionalized in a different way and irrespective of adaptation [EN-1].

Inter-organizational actions

Both municipalities consistently engage in inter-organizational collaborations and networks from 2015 onwards, by participating in or initiating networks and by collaborating with external stakeholders. They both participated in European collaborations focused on adaptation and the frontrunner network "Climate Active City," which integrated adaptation and mitigation. They collaborate in dedicated adaptation networks and regional water networks that have taken up adaptation as part of a national policy. Both cities are the largest in their respective networks and have a frontrunner position. Noticeably, Zwolle engages in more inter-organizational actions and started earlier with external collaboration. Several of those coordinate adaptation with economic development, where adaptation is often framed as a tool for economic growth. In contrast, Enschede has been participating in harmonized collaborations, most of which are related to water. Both municipalities also collaborate with different actors. Zwolle often collaborates with the water authority and Province. While Enschede collaborates with the regional water authority, horizontal cooperation among municipalities is more frequent than vertical cooperation with higher levels of government.

Programmatic actions and implementation

Programmatic actions, in the form of assessments of the problem situation, are another type of early action. The implementation of projects in the built environment only started in 2015. Both municipalities use different degrees of integration at the project level to secure additional funding where possible by considering the needs of other departments. Enschede implemented measures in nine projects, three of which were dedicated and three prioritized adaptation [EN-3–4; EN-11; EN-21–22; EN 24–25; EN-33;

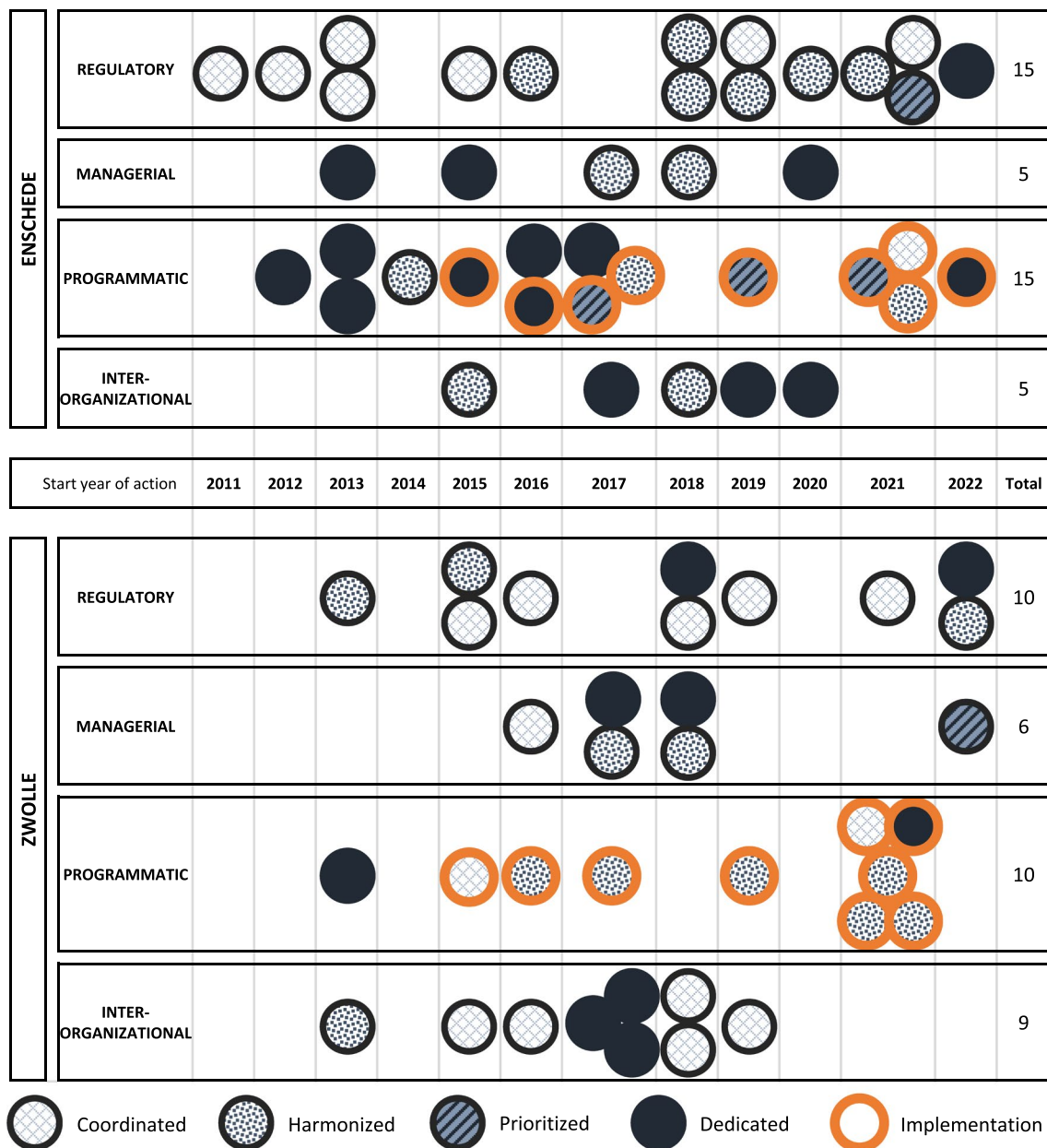


Fig. 1 Overview of actions in Enschede and Zwolle between 2011 and 2022. This figure is based on and summarizes the analysis of all the collected data presented in the [supplementary material](#)

EN-38], six of which were part of a large-scale urban re-development program driven by the need to adapt to pluvial flooding. All the prioritized projects were integrated into the water sector. Only recently has Enschede begun to integrate adaptation significantly into other urban re-design projects, such as the redevelopment of the area around the central train station [EN-24–25], including a traffic-restructuring [EN-15], and one on private property [EN-10; EN-21–22]. Zwolle implemented adaptation measures in nine projects, with only one dedicated and none prioritized [ZW-5–6;

ZW-8; ZW-13; ZW-15; ZW-20; ZW-28–32] and started implementing more adaptation through urban development projects in the last few years, as well as in smaller maintenance projects. They are driven by the needs of the area, for example redeveloping the district around the central train station or a new housing development. With one exception [ZW-28], adaptation is not the driver behind these projects, but instead among the guiding principles of urban re-design. Neither municipality pursues consistent monitoring and evaluation of projects, yet.

Mainstreaming across sectors and impacts

Across all actions, the water sector is crucial for both cities. Particularly in Enschede, most plans are from the water sector, most projects were driven by water-related adaptation and integrated into the water sector, and the financial and personnel resources stem from the water sector. Only recently has the city begun to integrate adaptation into general urban planning and projects. In Zwolle, the water sector plays an important role for adaptation as well, as plans, especially in the beginning, were water-sector related. However, implementation was focused on mainstreaming adaptation into urban planning and maintenance of public spaces from the beginning. Almost all sources mention integration into urban development as a focus for adaptation. Additionally, economic development features prominently in Zwolle. Green infrastructure is the only other sector instrumental to the implementation of adaptation in both cities, namely through green(-blue) measures and increasing urban green, for instance, during street maintenance [EN-35; ZW-28]. Sustainability, energy, transport, social sector, and health are all mentioned as sectors for integration or as sectors that would benefit from the implementation of adaptation measures. However, these mentions stay rather vague and mostly in the context of broader integrated approaches, such as in the Vision on Spatial Planning and the Environment in Zwolle, or the Integrated Investment Agenda in Enschede [ZW-17; EN-23; EN-28].

The importance of the water sector is also noticeable regarding the addressed climate impacts. Of the four impacts outlined by the DPSA, three, namely pluvial flooding, heat, and drought are relevant for both cities, while fluvial flooding is addressed by higher levels of government in Zwolle, and it is not relevant for Enschede. Enschede only started to address heat and drought from 2018 onwards, after the DPSA came into effect. While heat and drought are occasionally mentioned in earlier documents, especially along with the benefits of green(-blue) solutions, they only received attention in newer efforts. For example, the Vision on Housing pinpoints the need to address heat stress, indoors and outdoors [EN-37], and the Rural Area Vision mentions the need to address drought [EN-30]. Zwolle does mention heat and drought more regularly from the beginning [ZW-11; ZW-12], but does not address these impacts individually, unlike flooding [ZW-28]. Overall, both municipalities address pluvial flooding, drought, and heat simultaneously through green (-blue) measures but pay limited attention to the intersection of especially heat and drought with other sectors.

Discussion

In this paper, we set out to answer the question “How do municipalities’ adaptation approaches and their implementation

change over time with respect to categories and degrees of mainstreaming?” The two cases show that mainstreaming evolves over time, at different speeds in different sectors. The water sector plays a strong role in mainstreaming adaptation, but differently in both cities. In Enschede, especially in the first few years, adaptation is dominated by the flooding aspect, similar to the development of adaptation at the national level (Massey and Huitema 2016). In Zwolle, however, the water sector never took sole responsibility for adaptation. Rather, integration into urban planning, and the maintenance of public spaces was seen as the way to achieve implementation. Enschede’s pivot towards this direction in the last few years indicates that while the more dedicated and water-driven approach might accelerate implementation, sustaining the effort might be more feasible when integration focuses on urban planning and maintenance. Integrating adaptation into urban planning to increase its effectiveness is not a new idea (García Sánchez 2022). However, the potential of integration into maintenance of the public space should be emphasized.

A large part of the observed implementation focused on green(-blue) measures, or what is referred to in the literature as nature-based solutions. These have gained popularity in both cases over the study period, as well as elsewhere (Adams et al. 2023), because of their potential to tackle multiple impacts and reduce the cost of adaptation (Dodman et al. 2022). This could become problematic, since nature-based solutions are predicted to lose (some of) their effectiveness once warming passes 1.5° (IPCC 2022), which is predicted to be exceeded within the next 20 years (Lee et al. 2021). All adaptation options have the potential to become maladaptive under changing conditions (New et al. 2022). However, we could not find evidence of the reflexivity required to address the challenge of short-term versus long-term impacts of climate change in the adaptation actions.

Additionally, both cities combined integrated green–blue measures with dedicated infrastructure solutions specifically addressing flooding. The same does not apply for heat and drought impacts. As a result, the intersection of these impacts with other sectors remains unaddressed. This echoes the development of adaptation at the national level (Mees and Surian 2023). Some criticize mainstreaming adaptation as leading to incremental adaptation and potentially being unable to close the existing gap (Bednar-Friedl et al. 2022), and addressing heat and drought solely through green–blue infrastructure supports this view. Supplementing integrated actions with dedicated ones, as is the case for flooding, can help meeting the adaptation needs for all impacts. It can also be argued that in the two cases, a lack of mainstreaming is part of the problem. As our analysis shows, mainstreaming adaptation so far focused on integrating flood adaptation into water- and urban infrastructure, and a lack of integration of heat stress and drought into other sectors.

Both municipalities are quite similar in their governance context and challenges as mid-sized Dutch cities, which explains the similarities we identified. Their adaptation pathways converge over time which suggests that our findings could apply to other Dutch cities. However, the dominance of the water sector, which is well documented for the Dutch context, might mean that pathways in other countries could look different, at least regarding the sectors in which urban adaptation mainstreaming occurs. Nevertheless, a recent study on small German municipalities also found water-focused adaptation through reactive, incremental projects (Buschmann et al. 2022). The longitudinal perspective highlights that municipalities take different managerial actions to overcome initial barriers concerning responsibilities and resources. van den Ende et al. (2022) came to similar findings, though they employed a different methodology, namely a mechanistic explanatory approach. Our findings add to studies focusing on shorter time frames, pilot projects, or specific steps within the adaptation process (Ekstrom and Moser 2014; King 2022). Moreover, we showed that implementation accelerates over time, which indicates a learning curve. Especially regarding the implementation gap, this points towards opportunities for accelerated implementation. Realizing local implementation can be aided by institutionalizing adaptation within the municipal organization. Enschede and Zwolle both employ different managerial actions in creative ways to utilize existing resources for implementation. These administrative processes point towards potential mechanisms overcoming constraining mechanisms hindering the implementation of adaptation (Uittenbroek 2016).

Applying the longitudinal perspective along with the framework we adapted from Widmer (2018) for the local level, allowed mapping the evolution of adaptation actions for both cities. This approach offers valuable insights into implementation progress at the local level. At the same time, applying the framework also highlighted its limitations and the limitations of this study. Firstly, concerning the framework, one of the reasons we excluded directed actions was because of their cross-cutting nature. The analysis showed similar problems with the inter-organizational category. These actions encompassed collaboration with stakeholders on implementation projects, plans, education, or even provision of resources, and depending on the form of collaboration and other aspects, we did attribute them to other categories. Like directed actions, we suggest treating this category as cross-cutting as well (Runhaar 2016), or focusing on policy instruments stimulating implementation by other actors in a separate study (Brinke et al. 2022). Second, because we could not code the entire data set by multiple researchers, the intersubjectivity of the operationalization of our framework remains limited. Third, the scope of this study did not allow for an investigation of directed actions across multiple levels

of government. However, the most influential national level adaptation policy, the DPSA, was adopted in 2018 halfway through the study period and did not require action beyond an adaptation strategy in the remaining period. While directed actions influenced both cases somewhat, it is not the only driver behind the implementation of adaptation in the cases. Many preparatory actions took place earlier and can thus serve as examples of organizing a shift towards adaptation implementation in the absence of systematic higher-level support. Nevertheless, combining our local level approach with Widmer's (2018) national level approach by treating directed actions as the cross-cutting multi-level dimension of the framework would allow a thorough identification of adaptation mainstreaming actions across levels.

Conclusion

While mainstreaming has the potential to bring many benefits, its contribution to the implementation of adaptation at the local level and its change over time remain poorly understood, exacerbating the adaptation implementation gap. In this paper, we aimed to create a nuanced understanding of mainstreaming in municipal adaptation processes across categories and degrees of mainstreaming to contribute to closing this gap. Both municipalities started adaptation slowly. Over time, their projects in the built environment increased not only in number and size, but also in complexity. These trends confirm a learning curve for implementing adaptation at the local level. Accelerating implementation necessitates speeding up the learning process for other municipalities. Our comparison also highlighted the potential and possible pitfalls of mainstreaming adaptation towards implementation. Mainstreaming adaptation through green–blue measures into urban planning, water management, and maintenance of the public space seems to be gaining momentum once the necessary processes are in place and both cities chose different actions to do so. At the same time, our study highlights a lack of mainstreaming into sectors other than water and urban development and the limited attention to climate impacts, such as heat stress and droughts, pointing towards possible pitfalls of mainstreaming. And while adaptation is being implemented, the lack of reflexivity regarding future climate conditions requires attention. It is important to identify means of integrating long-term perspectives or more reflexive approaches into mainstreaming to ensure adaptation not only to current but also future climate change.

Future research can provide insights into contextual factors and explain the different but converging pathways both cities took towards implementation. For instance, case studies that examine the relationships between mainstreaming and contextual factors (van den Ende et al. 2022), as well as medium-N and large-N comparisons can provide the diverse

evidence to draw conclusions about the feasibility of certain mainstreaming actions across a range of sectors in specific contexts. Such evidence could reveal contextualized pathways to institutionalizing local adaptation. Applying our framework from a longitudinal perspective in other contexts would also enable comparing the prevalence and relevance of mainstreaming actions and their degree of integration and allow the identification of patterns (Lesnikowski et al. 2021).

Thus, we conclude that cities follow different adaptation paths with diverse mainstreaming outcomes. Contextual factors, such as problem emergence and definition, preference for certain solutions, as well as local political factors, might explain why these paths and outcomes differ. Our research method, combining a nuanced framework with a longitudinal perspective is useful to make differences in adaptation paths visible. This is a crucial step towards explaining differences that result from contextual factors.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s10113-024-02214-7>.

Acknowledgements The research that forms the basis for this article was co-funded by the CATCH+ project in the Province of Overijssel, The Netherlands. We would like to thank all CATCH+ partners. We would also like to thank the three anonymous reviewers for their insightful and constructive comments.

Funding This work was supported by the Province of Overijssel through the CATCH+ project

Data Availability The publicly available data analysed in this article is included in the Supplementary Material. The data generated for this article is available upon reasonable request and with permission from the interviewees.

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