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Assessing the leapfrogging potential to water sensitive: the Dutch case of Zwolle

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ABSTRACT

Urban floods can cause significant damage and are expected to become more common due to climate change. Previous research has identified that climate change adaptation in cities requires the development of blue-green infrastructure (BGI), and it is expected that cities can leapfrog to a water-sensitive state by implementing BGI. However, leapfrogging is context-dependent, and little is known about how governance factors affect leapfrogging, particularly in midsize cities. This paper addresses this knowledge gap, providing empirical insights into leapfrogging by assessing the governance factors that support or restrict BGI implementation in Zwolle (The Netherlands) towards reaching a water-sensitive state. For the analysis, we employ a governance assessment tool and three catalytic factors that promote leapfrogging. The results show that the governance context supports leapfrogging at a moderate to high level. This means that while the governmental levels and stakeholder networks collaborate to support climate change adaptation of the city, new legislation on BGI and citizens' involvement in climate change adaptation projects could increase the leapfrog possibilities for Zwolle in achieving its goal of becoming climate-proof by 2050.

Key words: blue-green infrastructure, flood management, leapfrogging, medium size city, urban water transition, water governance

HIGHLIGHTS

- The three leapfrogging catalysts are present in Zwolle's BGI projects.
- Zwolle requires the support of higher governmental levels to become climate-proof.
- There is high integration of the climate change adaptation policy.
- Actors' networks support the bottom-up implementation of BGI projects.
- Collaboration of governmental actors with residents enhances leapfrogging chances.

1. INTRODUCTION

Urban floods are increasing worldwide, and climate change, land-use change, urban growth, and aging infrastructure are some of the main factors (Bonasia & Lucatello 2019). Urban floods are estimated to increase (Ward *et al.* 2017), and the losses in Europe could reach 23.5 billion Euros by 2050 (INTERREG 2 Seas Mers Zeeën 2013). The impacts of climate change are expected to be experienced at the local level (Carter *et al.* 2015) in growing urban areas (Rangari *et al.* 2021), with cities suffering the main impacts. Examples of this situation were seen in July 2021 when mainly small and medium size cities in Germany, The Netherlands, and Belgium were affected. To reduce flood risks and their impact on urban infrastructure and communities, flood management is critical (Ekwueme 2022). While local governments have played a key role in the design and implementation of climate adaptation policies (Lesnikowski *et al.* 2021), such adaptations need to take place at the local, regional, and transnational levels (Adger *et al.* 2005) within specific governance contexts. In this vain, recent studies have demonstrated that (multi-actor) governance is crucial for cities to adapt to (climate extremes, such as floods, as well as droughts and heatwaves). Moreover, collaboration between different policy sectors and stakeholders is vital to accelerating climate change adaptation processes in the cities (OECD 2019a, 2019b) and innovative strategies must consider uncertainty, flexibility, and adaptability to enable an urban water transition (Larsen *et al.* 2016) to support cities' climate change adaptation.

Under these circumstances, challenges associated with having too much water, such as floods, are driving urban water management agendas (O'Donnell *et al.* 2021). To address these challenges, climate change adaptation requires strategic investments to provide sustainable solutions (Brown *et al.* 2008) that can help to reduce vulnerability (Carter *et al.* 2015). Blue-green infrastructure (BGI) is among those strategic investments that support cities against climate change (Brears 2018). BGI refers to using blue elements, like rivers, canals, or ponds, and green elements, such as trees, forests or parks, in urban and land-use planning (O'Donnell *et al.* 2021). Implementing BGI means shifting from hard/grey, mono-functional infrastructure to a nature-based, multifunctional infrastructure (Casiano Flores *et al.* 2019a). In addition, BGI needs a systemic approach that includes resilience and collaborative efforts across multiple policy sectors and scales (Marana *et al.* 2019). This systemic and nature-based approach is also at the core of the European climate change adaptation strategy (European Commission 2021).

Cities such as Melbourne, Rotterdam, and Portland have inspired the implementation of BGI in urban areas (Hoyer *et al.* 2011; Brown *et al.* 2016). However, most studies on BGI implementation, and broadly on climate change adaptation, are about large cities, whereas the research on small and midsize cities remains limited (Özerol *et al.* 2020; Casiano Flores *et al.* 2021). Focusing on small and medium size cities is important as they have less autonomy than large cities, and many measures take place outside the cities' boundaries (Dolman *et al.* 2018). They also lack expertise, human resources, and a large investment budget (Özerol *et al.* 2020). Considering the relevance of midsize cities in Europe and the complexity they face in climate change adaptation, this paper focuses on BGI implementation in Zwolle, a midsize city in The Netherlands, from a governance perspective. Zwolle has been experiencing floods due to extreme rains and droughts during the summer in the last few years (Zwolle 2019). The municipality of Zwolle has understood the importance of implementing BGI, and presented its Adaptation Strategy in 2019 to become a blue-green city (Zwolle 2019). Among the actions considered are storing water in overflow areas and climate-resilient urban design. Furthermore, to accelerate the implementation of climate change adaptation projects in Zwolle and the IJssel-Vecht Delta region, a collaborative network called Climate Campus was established in 2018, and within the network, a 'climate-proof' acceleration team of governmental and non-governmental actors was appointed (Dolman 2019). 'Climate-proof' programmes aim at strengthening the adaptive capacity of the urban system and reducing its vulnerability to climate change, as well as developing strategies and policy instruments for adapting cities and buildings (Albers *et al.* 2015), including BGI.

The city of Zwolle wants to become climate-proof by 2050. This offers the opportunity to analyse both the BGI implementation in midsize cities and their potential to leapfrog to a more advanced water management stage. When looking at the transition of urban water management in cities, research on leapfrogging is still scarce (Watson & Sauter 2011), and presents a weak theoretical background (Binz *et al.* 2012). The leapfrogging concept in transitions literature was developed in the 1980s (Sauter & Watson 2008) and focused on the industry and technology sector (Goldemberg 1998, 2011; Sauter & Watson 2008; Binz *et al.* 2012). Leapfrogging promises to accelerate sustainable urban transitions, mainly in the global south (Nagendra *et al.* 2018; Sindhamani & Dolman 2021), by exploiting the lack of extensive infrastructure networks and implementing BGI (Sindhamani & Dolman 2021). However, from a sustainability perspective, leapfrogging studies are considered simplistic (Binz *et al.* 2012) as leapfrogging requirements are underestimated (Perkins 2003). Nevertheless, leapfrogging is considered by international organisations an efficient approach to climate change (Casiano Flores *et al.* 2019a) that requires changes in current governance frameworks (Vasconcelos & Barbassa 2021). Hence, studying leapfrogging can help better understand the limits of urban water transitions and the governance conditions under which innovative solutions are supported. This is key as the urban water management sector seems unprepared to deal with innovations; there is a legacy from network logic, slow renewal cycles, and high long-term investments (Kammen & Sunter 2016).

The lack of research on leapfrogging from a governance perspective within the transition of urban water management was confirmed by a scientific literature review, which identified only six relevant articles (Casiano Flores *et al.* 2021). Among the published cases were Indonesia (Brodnik *et al.* 2018) with Port Vila, Vanuatu (Poustie *et al.* 2016), San Pedro Cholula, Mexico (Casiano Flores *et al.* 2019a), and Herentals, Belgium (Casiano Flores *et al.* 2021). In order to extend the previous findings, we added to the review the concept of 'sponge city'. The sponge city concept refers to the Chinese government's approach to urban surface water management (Chan 2021). It is an approach that seeks to enhance infiltration, evapotranspiration, and stormwater catch and reuse in urban areas (Zevenbergen *et al.* 2018). While no articles were found in Scopus database, six peer-reviewed articles were found in Google Scholar, with only one discussing leapfrogging possibilities in

Chinese cities (Zevenbergen *et al.* 2018). In this line, is important to highlight that up to now, mainly some major cities in Asia (Singapore, Tokyo, and the Sponge Cities Program in China) have seized the opportunity to leapfrog towards greater water sensitivity (Dolman & Ogunyoye 2018; Qiao *et al.* 2019). These Asian cities have comparable hierarchical, effective and strong institutions of governance in common.

Against this background, a relevant framework to study leapfrogging is the Urban Water Management Transitions Framework (UWMTF) developed by Brown *et al.* (2008). The UWMTF conceptualises the role of water as a driver in the urban evolution, and it has been employed to explain the cities' leapfrogging possibility (Casiano Flores *et al.* 2019a, 2021). Hence, this paper aims to provide empirical insights into leapfrogging by assessing the governance factors that support or restrict BGI implementation in Zwolle to leapfrog to a more advanced urban water management state. Given the governance perspective of this study, it focuses on institutional and political dimensions, which remain understudied (Birkmann *et al.* 2014). The selection of the Zwolle case allows studying a hybrid and polycentric governance system (combination of decentralisation with coordination of autonomous governance units), where the governance modes are balanced and formal institutions are effective (Pahl-Wostl 2019). Moreover, it contributes to the analysis of adaptation measures that serve different purposes (Runhaar *et al.* 2012). The Governance Assessment Tool (GAT) (Bressers *et al.* 2013) will be applied to scrutinise the support of the governance context for this transition, thus, the leapfrogging potential of the city from a governance perspective. The assessment is based on primary data from semi-structured interviews and secondary data from different documents to triangulate and validate the results. The following section explains the UWMTF, which forms the basis to conceptualise leapfrogging. Then, we present the case study description, followed by the methodology used for our analysis. The subsequent sections present the results and discussion, and finally the conclusion.

2. THE URBAN WATER MANAGEMENT TRANSITIONS FRAMEWORK AND ITS RELATION TO LEAPFROGGING

By creating a typology of six city states, the UWMTF identifies essential characteristics of sustainable urban water practices and enables benchmarking at the city level. The traditional progression of a city to reach a 'water-sensitive city' (WSC) state is built on the advancement of prior stages. A WSC has a comprehensive cycle for managing its water resources, is climate change-resistant, and has a multifunctional infrastructure and urban design that encourage water-sensitive behaviour (Brodnik *et al.* 2018). Consequently, rather than being a technology issue, cities' adaptation to floods might be considered a governance issue (Rijke *et al.* 2013). Among the governance issues are fragmented scopes, opinions, and responsibilities that must be addressed in the adaptation processes (Koop *et al.* 2017). According to Bai *et al.* (2016), cities are complex systems where different actors and processes interact at different scales related to geography, institutions, and governance factors. As a result, such factors impact how cities adapt to climate change (Adger *et al.* 2005).

To achieve a WSC state, several disciplines must interact (Salinas Rodriguez *et al.* 2014) and changes that support institutional practices are also necessary (Brown *et al.* 2008). Therefore, the UWMTF posits that an alternative to a linear transition process is that cities can skip some steps to get to a WSC state faster (Salinas Rodriguez *et al.* 2014). The nonlinear process is called leapfrogging: 'By leapfrogging from one state to another, cities can skip parts of the transition pathway and proceed directly to more sustainable infrastructure. This idea relies on experimenting with innovative technology and tailoring existing ideas to a local context' (Brown *et al.* 2016). The transitions require a decentralised approach and are contingent on the institutional context, i.e., the policy and organisational structures (Binz *et al.* 2012). Moreover, institutions can both enable or obstruct innovations entailed by leapfrogging. Hence, the role of institutions and policy processes is key in the context of leapfrogging, and therefore, the study of leapfrogging can largely benefit by adopting a governance perspective (Sauter & Watson 2008). The governance context's key role lies in the potential of governance arrangements to support adaptation strategies (Carter *et al.* 2015). Nevertheless, past research has observed that leapfrogging cases differ between countries, and as such, the conditions under which leapfrogging is feasible are questioned (Sauter & Watson 2008; Binz *et al.* 2012).

Against these challenges, Dolman & Ogunyoye (2019) adapted the UWMTF to examine water infrastructure projects and leapfrogging possibilities in cities (see Figure 1). The framework indicates that cities with single-purpose infrastructure are in the early phase of the transition process, while multifunctional infrastructure is part of more advanced water management stages. It also shows that, in developing cities, leapfrogging can support cities skipping more stages than developed cities because the developing cities have not heavily invested yet in single-purpose systems and, consequently, the maintenance and upkeep of these systems. Most developed cities' implementation of BGI projects lack 'cities as water catchments' practices concerning sustainable water resource management.

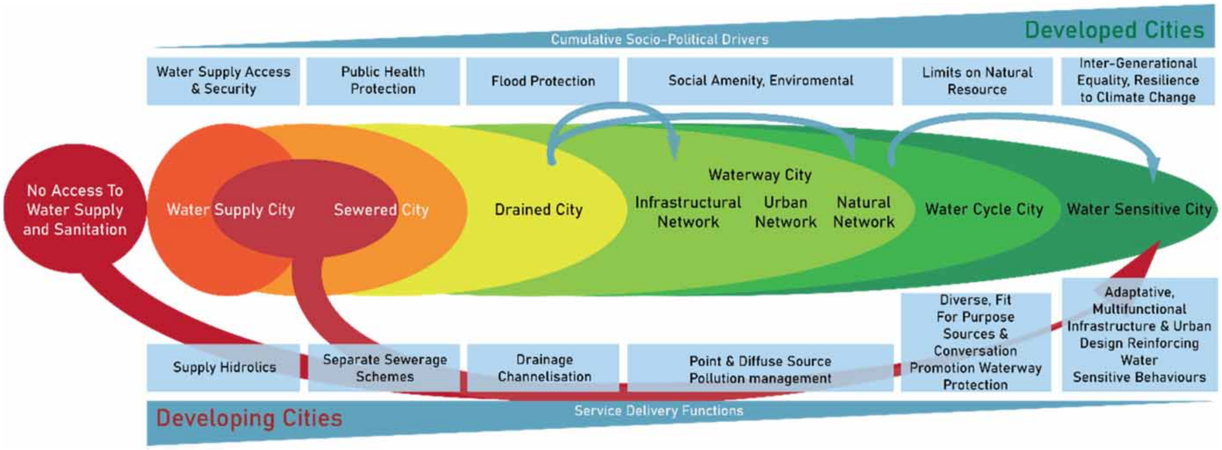

Figure 1 | Adaptation of the Urban Water Management Transitions Framework for leapfrogging in developing and developed cities (Dolman & Ogunyoye 2019).

In this paper, we draw on the adaptation from Dolman & Ogunyoye (2019) to the UWMTF and previous studies using GAT to assess the governance context for leapfrogging systematically (Casiano Flores *et al.* 2019a, 2021).

3. METHODS

3.1. Case study Zwolle, The Netherlands

Zwolle is a medium size Dutch city with a population of 130,666 inhabitants (SWING 2022). It is a delta city of the IJssel and Vecht rivers in the province of Overijssel. The Overijssel province is located in the East of The Netherlands, a country famous for its flood risk approach and polycentric governance system (Pahl-Wostl 2019). The Overijssel province has contributed to integrating the water and spatial planning regulations. Subnational and local governments work closely to implement projects, including BGI, to decrease flood risks. It also plays an important role in climate change adaptation both at the regional and local levels. It participates in several water-related projects and programmes, including flood risk management. For instance, the IJssel-Vecht Delta Programme aims for a future-proof, water-safe delta and involves the collaboration of the province, regional, and local governments, residents, entrepreneurs, and social organisations. There are also networks working in climate change adaptation, such as Room for the River Vecht, in which more than 13 governmental and social organisations (including the municipality of Zwolle) collaborate towards sustainable development of the Vechtdal catchment. The network expects around 23 projects focused on this area in the coming years (Spatial Adaptation Knowledge Portal 2018).

Zwolle municipality has a total area of 11,936 hectares, of which 11,067 are land and 869 are water (100 hectares is 1 km^2) (AlleCijfers 2022). Figure 2 shows the location of Zwolle. The average density is 2,094 addresses per km^2. The municipality of Zwolle has 61,437 households (AlleCijfers 2022). The average income per capita in the municipality is €28,600, which places it in an intermediate income level. Living with water is an essential part of the cultural heritage in Zwolle. The historical development of the city within its water systems was recognised as an inspiration for climate adaptation in Zwolle. Building on its water heritage, a cohesive BGI network in the city can be developed and expanded, with room for water-sensitive projects at the neighbourhood scale (Dolman 2022). This is important as Zwolle is vulnerable to floods (SWING 2022) from three sides: (1) IJsselmeer (inflatable barrier Ramspol), (2) the main river system of IJssel and Vecht, and (3) the local water system of Sallandse Weteringen. Also, storms with heavy rain in Overijssel and Germany can cause an increase in water levels in the city centre (Zwolle 2019).

Zwolle aims to become climate-proof by 2050, and it is one of the cities where pilot projects were implemented in the context of the EU Interreg project CATCH. This project aims to accelerate the climate resilience process by redesigning the cities' urban water management (Dolman *et al.* 2018). Zwolle has been classified within Drained and the Waterway city states (Dolman & van der Meer 2021). One of the CATCH pilot projects was the development of the Zwolle Climate Adaptation Strategy (CATCH an Interreg North Sea Region 2017). This targeted strategy was developed in 2019 in the context of

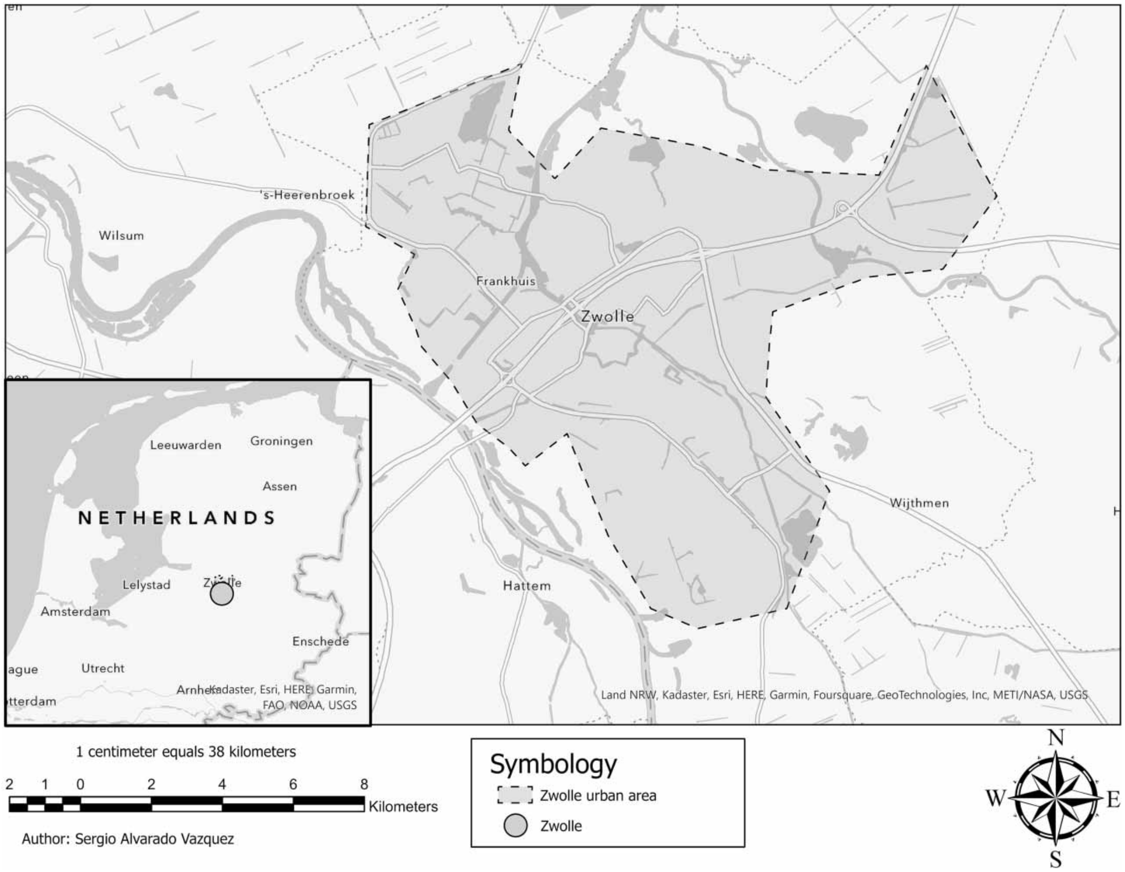

Figure 2 | Location of Zwolle City.

increasingly extreme weather conditions and urban flooding in order to be climate-resilient by 2050. The Zwolle Adaptation Strategy is built on six building blocks, including (1) spatial elaboration in a 'blue-green' city; (2) the 'new normal' for professionals; (3) private action perspective; (4) regulations; (5) financing; and (6) monitoring and navigation (Dolman 2019). Furthermore, the strategy is built on three blue-green spatial design principles (Dolman 2021) and collaborative spatial planning (Spatial Adaptation Knowledge Portal n.d.).

The first principle refers to sufficient urban sponges for detaining, retaining, or delaying rainwater. In this respect, the Municipality of Zwolle, together with residents and businesses, collectively work to expand Zwolle's sponge effect at the neighbourhood/district level (Zwolle 2019). The second principle is the blue-green city network on which 'sponges' can drain excess water and discharge and storage. To address this principle, the Adaptation Strategy aims for a blue-green grid at the urban level, which entails a joint responsibility between the municipality and the Regional Water Authority Drents Overijsselse Delta (WDODelta) for the construction of the grid (Spatial Adaptation Knowledge Portal n.d.). Finally, the third principle refers to emergency valves for the blue-green network and overflow areas where water can temporarily go in extreme situations. This is related to the 'water-resilient Zwolle' plan at the regional water system level, in which the responsibility is borne by the central government, the province of Overijssel, the WDODelta, and the municipality (Royal Haskoning DHV 2019; Dolman 2021).

The municipality of Zwolle also actively engages residents in measures related to clime change. For example, after a Neighbourhood-by-Neighbourhood survey conducted in 2016, residents reported concerns about flooding in the Stadshagen district. Against this context, the city started the SensHagen project that encourages residents to measure temperature and air quality through sensors in their gardens (Zwolle n.d.). There is also a web form where residents can report flooding in the city, indicating the exact location on a map (Zwolle 2022a). Another relevant local initiative is the 50 Tinten Groen (50 Shades of Green), organised by and for residents of Zwolle's district Assendorp. This non-profit organisation is built on a collective neighbourhood approach to make the neighbourhood greener and more sustainable, resulting in more than

40 projects up to now. It has received financial support from the municipality of Zwolle, the province of Overijssel, the WDO-Delta, and the collaborative support of Windesheim Honours College (50 Tinten Groen 2022).

3.2. The Governance Assessment Tool and its application

The GAT applied in this research is related to the UN's fifth methodology type, which is referred to as an 'integrated method to assess the governance of water' and is described as a tool with a highly academic character. The methodology has its roots in the contextual interaction theory (CIT), which has proven useful for comparison across governance structures (Bressers & Kuks 2003). CIT is a theory of policy implementation that considers the implementation process as a multi-actor interaction driven by the involved actors (Bressers & Kuks 2004; Bressers 2009; Boer de & Bressers 2011; Boer de 2012; Bressers *et al.* 2015). Moreover, it can be used to analyse multi-level settings with interdependency among the involved actors (Casiano Flores *et al.* 2017, 2019b). CIT has been employed to compare various cases around the world. For example, for developed countries, there is a comparison between The Netherlands, Belgium, France, Spain, Italy, and Switzerland (Bressers & Kuks 2004). Another study compares 48 cases located in The Netherlands, the United States, and Finland (Owens & Bressers 2013). For developing countries, Mexico (Casiano Flores *et al.* 2018, Alvarado Vazquez & Casiano Flores 2022), a study includes Indonesia, China, and Vietnam (Spratt 2008), and another one focuses on five local municipalities in South Africa (Mohlakoana 2014).

The GAT is used to assess how the governance context supports or restricts the implementation of BGI. We employ the GAT to identify the leapfrogging potential of the city of Zwolle from a governance perspective. The GAT is a framework that considers contextual factors in policy implementation rather than 'universal remedies' (Ostrom *et al.* 2007; Gupta *et al.* 2013; Pahl-Wostl 2015). Compared with other approaches, the GAT addresses the 'effectiveness' component of the OECD Principles on Water Governance, and its origins can be traced to successful EU research projects (Boer de & Bressers 2011; Bressers *et al.* 2016). The GAT has been employed to assess the water governance context in various European countries (Vinke-de Kruijf *et al.* 2015; Bressers *et al.* 2016; Vikolainen *et al.* 2017) and the leapfrogging capacity of a medium size city in Mexico (Casiano Flores *et al.* 2019a) and in a small size city in Belgium (Casiano Flores *et al.* 2021).

The GAT understands governance as 'beyond merely government' and is considered a supportive or restrictive context for decision-making and implementation. The GAT clusters the governance context into semi-normative qualities and descriptive-analytical elements (Casiano & Boer de 2015). The descriptive-analytical element refers to 'dimensions of governance' that describe the governance regime (Bressers & Kuks 2013) and assesses the governance quality. The elements include multi-level, multi-actor, multi-faceted, multi-instrument, and multi-resourced. In addition, the GAT includes four semi-normative qualities to identify what status of the five governance elements contributes to stimulating, rather than restricting, the governance context for implementing and realising water management policies. These four criteria are defined by four corresponding questions (Bressers *et al.* 2016):

- *Extent*: Are all relevant elements in the five dimensions, considered?
- *Coherence*: Are the five dimensions elements supporting, rather than contradicting, each other?
- *Flexibility*: Are multiple roads to the goals permitted and supported, depending on opportunities and threats as they arise?
- *Intensity*: How strongly do the elements in the five dimensions urge changes in the status quo?

The five dimensions of governance, together with the four qualities, comprise the 'GAT matrix' model (Bressers *et al.* 2015). Supplementary Table A1 displays the matrix and the questions around each dimension which aid a governance context systematic analysis. The operationalisation of the GAT matrix can be found in Supplementary Table A2. The table is an evaluation matrix developed on previous studies that identified three catalysts for leapfrogging (Brodnik *et al.* 2018): (a) trans-disciplinary science, which considers that solutions entail an integral perspective and a shared vision and knowledge from various stakeholders, rather than a mono-disciplinary approach; (b) cross-sector partnership, which refers to the relevance of cross-sector collaborations, including academia, industry, government, and civil society; and finally, (c) innovation experiments, which provide the opportunity to learn by doing and to do by learning as along with sharing knowledge to adapt to local contexts the proposed solutions (Brodnik *et al.* 2018). Hence, leapfrogging needs experimentation with innovative technologies and to adapt them to the local context (Brown *et al.* 2016). By considering the three catalyst factors in the GAT operationalisation, we aim to provide a systematic assessment. Systematisation is relevant for complex settings as it allows practices to consider the context and corresponding dynamics (O'Toole 2004). This evaluation matrix (Supplementary

Table A2) was previously employed to assess leapfrogging potential of medium and small size cities (Casiano Flores *et al.* 2019a, 2021).

As leapfrogging is context-dependent and we have a limited understanding of the enabling factors of leapfrogging, this research employs the GAT through a case study (Zwolle) approach. A case study is 'an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-world context' (Yin 2013, p. 16). This approach is relevant for studies in which the context can make a difference (Kaarbo & Beasley 1999). Case studies can help to complement theory (Lieberman 2005), generalise theoretical propositions (Yin 2009), and contribute to the cumulative development of knowledge (Flyvbjerg 2006). More particularly, in the case of urban water transitions, in-depth case studies can advance our understanding of the dynamics behind water transitions. Furthermore, this approach promises to enhance the explanatory capacity of transition frameworks (de Haan *et al.* 2015).

To examine the case of Zwolle in depth, we collected primary data by conducting semi-structured interviews with nine key respondents, including industry experts. We also collected and analysed secondary data from reports, project websites and presentations, and policy documents. Each interview was conducted separately using an interview protocol with semi-structured questions to allow the respondents to explain their roles and points of view (van Rij 2008). The interview protocol was built upon the GAT matrix (for more information about the questions, see Supplementary Table A1) and clustered into six sections focused on: (1) Three questions on general information about BGI projects implemented in Zwolle, including those the interviewees have been involved in or know about; (2) Four questions on the collaboration of the different governmental levels when implementing BGI; (3) Five questions on the collaboration between governmental and non-governmental when implementing BGI projects; (4) Four questions on agreements and disagreements between the different actors, considering their perceptions and goals; (5) Five questions on the availability and use of the different policy instruments that could support or hinder the BGI projects; and (6) Four questions to identify the responsibilities and instruments available and employed by the different actors to support the project. The interviews targeted key stakeholders involved in developing BGI in Zwolle. The in-depth, semi-structured interviews took place in the second half of 2020 and the first half of 2021. Overall, the interviews lasted 1 h. Table 1 shows the affiliation of the interviewees and their description.

To assess each matrix cell (see Supplementary Table A1), the interviews were analysed and compared individually to reach a general conclusion. This analysis was triangulated with data from secondary sources to enhance internal validity. Triangulation is critical in research that includes semi-structured interviews, as it helps to obtain a more comprehensive picture of the situation being studied (Natow 2020), while it enhances the credibility of qualitative research (Ospina *et al.* 2018). Moreover, the use of various sources from different methodologies, including different types of qualitative data collection, such as interviews and desk research help to corroborate initial findings and permit the inclusion of additional information (Natow 2020). Building on previous GAT applications, the quality degree of each dimension was compared with the other dimensions to determine the general assessment per quality (Casiano Flores 2017; Vikolainen *et al.* 2017; Casiano Flores *et al.* 2019a, 2019b). Supplementary Table A2 displays the conditions to assess each cell from low to high. Section 4 presents the governance context assessment for leapfrogging in our selected case, Zwolle.

Table 1 | Affiliation of the actors interviewed

Stakeholder category	Organisation	Description
City Government	Municipality of Zwolle	Two interviews, one with a policy advisor on spatial adaptation and the other with a senior urban planner.
Regional Government	Water Authority of Drents Overijsselse Delta	Interview with a policy advisor on climate adaptation.
Academia	University of Applied Sciences (Zwolle)	Interview with senior researcher and lecturer on social innovation.
Network	Climate Campus	Interview with a team member focused on governmental and private organisations.
Industry/experts	Arcadis Zwolle Buro MA.AN Sunny Rain Solutions Amfibia Solutions	Four interviews, one with a project manager for urban water and climate adaptation. Two owners of the companies and one entrepreneur for urban climate challenges.

4. RESULTS

The matrix in Table 2 summarises the results obtained from the governance assessment. These results are explained in a systematic manner below, considering the order of each governance dimension: (a) Levels and Scales, (b) Actors and Networks, (c) Problem perspectives and Goal ambitions, (d) Strategies and Instruments, and (e) Responsibilities and Resources.

4.1. Levels and scales

4.1.1. Extent

High: Actors from all levels are involved in implementing BGI projects. The participation of local governmental actors has increased in the last decade. Professionals from different departments are involved in climate adaptation projects, including policy advisors, water managers, and health officers. The province and the Water Board are also involved as they support different projects with the national government, such as the Deltaplan Ruimtelijke Adaptatie (DPRA – Delta Plan on Spatial Adaptation) and the Nationale Adaptatiestrategie (NAS – National Adaptation Strategy). Among the type of projects being implemented at the local level are the aforementioned green roofs and street gardens. The projects are implemented with the involvement of the residents in many cases. The citizens also receive subsidies from governmental actors.

4.1.2. Coherence

High: Actors from all levels work together and trust each other to implement BGI projects. The province of Overijssel is open to collaboration with local governments, and the municipality of Zwolle is not an exception. The provincial government provides support to other cities in its territory. At the local level, the residents are also aware of climate change and are interested in the topic. When there are projects, the different actors involved are interested in seeing their own goals reflected in such a project. In general, there are two types of projects, those where the government invests in public spaces and bottom-up initiatives in private-property spaces. While the government is organised in sectoral ways to implement projects as strengthening dykes and widening rivers, or networks, such as Climate Campus, focus on supporting bottom-up initiatives. Some examples of government projects are the Wadi (swale) roundabout for the Rembrandtlaan and the Diezerbrink shopping area climate-proof, while some community projects are a rain butt on the street and the water storage gardens (Regio Zwolle 2021).

4.1.3. Flexibility

Moderate–high: The type of project plays a role in deciding who will be the main leading actor. Nevertheless, there is participation from the different governmental levels. One example is the IJssel-Vecht Delta Programme that includes the different governmental levels aligned with institutions. Another is Room for the River Vecht, which involves 13 governmental and non-governmental organisations. They aim to invest in dozens of larger and smaller projects that contribute to flood risk management, nature, recreation and tourism, agriculture, and spatial quality. In another project, the regional water authority works with the municipalities by looking for efficient approaches. One of them are the rainwater catchment systems at the house level. The existence of these different projects shows the diversity of actors and their collaborative approach.

Table 2 | Results of the Governance Assessment, Zwolle

	Qualities of the governance regime			
Governance dimensions	**Extent**	**Coherence**	**Flexibility**	**Intensity**
Levels and Scales	High	High	Moderate–high	High
Actors and Networks	Moderate–high	Moderate–high	Moderate–high	Moderate–high
Problem perspectives and Goal ambitions	Moderate–high	Moderate–high	High	Moderate–high
Strategies and Instruments	High	Moderate–high	High	Moderate–high
Responsibilities and Resources	Moderate–high	Moderate–high	Moderate–high	Moderate–high
Final assessment	**Moderate–high supportive**	**Moderate–high supportive**	**Moderate–high supportive**	**Moderate–high Supportive**

4.1.4. Intensity

High: All levels work together to support behavioural change favouring BGI projects. Relevant examples are the Climate Campus and Room for the River Vecht networks created to support the city's climate adaptation. The national government and the Delta Commission are also very active through the NAS and the DPRA. One example from the DPRA is the construction of an underground bicycle shed (5,500 bicycles) at the Zwolle railway station, which will be used to increase the water storage capacity. In addition, it can be used as temporary water storage to help to prevent floods in the homes and offices of the nearby Assendorp district (Deltaprogramma 2021).

Furthermore, Zwolle received special status from the Nationale omgevingsvisie (NOVI – National Environmental Vision) (Zwolle 2021). Being recognised as a NOVI area means that Zwolle is part of a long-term partnership with the national government to develop the region further into a climate-robust and economically vital area that aims to provide a permanent, attractive living environment. There are also programmes promoted by the province, and the city is actively promoting BGI projects.

4.2. Actors and networks

4.2.1. Extent

Moderate–high: Several non-governmental actors participate in the development of BGI. However, participation with residents still faces some challenges. In general, the participation of non-governmental actors has increased in the last decade. While this participation is accepted, some governmental actors feel that there are some cases in which social actors are active only because they have some political or very particular interest in their agenda. Full social participation is still complex and faces difficulties due to the lack of expertise of some residents. In the words of an interviewee, 'How a professional can follow a non-professional'.

Through projects, such as the Zwarte Water, the river is being transformed into a recreational site and biodiversity area (Zwolle 2022b). Even though residents are taking part in the projects, their experience is described as difficult. Universities also participate in various projects, describing their primary role as knowledge providers and generators. Hence, they see themselves as enablers in the process. Meanwhile, other active non-governmental actors include 50 Shades of Green and private sector experts who work on projects such as water infiltration and rainwater catchment systems. Although residents' involvement is still challenging, there are several citizen initiatives according to the local government. The partners of the IJssel-Vechtdelta programme aimed to increase the involvement of young people in the water projects in their own environment to make them more water-conscious. That is why secondary and preparatory schools from the municipalities of Zwolle, Kampen, and Zwartewaterland offer the educational project Advisors of the Future free of charge (Natuur en Milieu Overijssel 2018). Finally, Climate Campus also plays an important role in connecting active citizens with governmental actors.

4.2.2. Coherence

Moderate–high: There is a cross-sectoral collaboration to implement BGI projects. It is institutionalised, stable, and trustworthy, yet our interviewees acknowledge that building trust is a process and takes time. Some minor issues are present, mainly between governments and companies/entrepreneurs. In general, the actors trust each other to implement BGI projects. However, some private actors do not feel fully understood by the government. For example, sometimes, they are asked to present projects to compete, and they need to find a balance between presenting their project and sharing their ideas with governmental actors and their competitors. According to some interviewees, building trust requires that different actors can have an understanding, and for some actors, it is still a new language. In this regard, some governmental actors acknowledge that companies are not equal partners, and this should be improved to have effective collaboration. Along the same line, some specialists recognise that they play an important role as they have knowledge that governmental actors lack.

4.2.3. Flexibility

Moderate–High: The stakeholder network allows the inclusion of new actors, supports leadership based on the type of project, and creates social capital in favour of the BGI projects. For instance, to stimulate social capital, there has been a project where residents are asked to invite their neighbours to receive additional support for projects. '50 Shades of Green' has been active in this type of project. Governmental actors also mentioned that they invite stakeholders to participate whenever they think they can contribute to the project. This is how some Climate Campus and the Water authority's projects were implemented. In this regard, an entrepreneur mentioned that to promote green roofs Climate Campus organised a talk and presentations. As a result, the project evolved into a make-yourself eco-roof 'plants' package that nowadays can be found in stores. Similarly, a governmental actor also mentioned, 'we use citizens' knowledge to connect citizens' ideas with city projects'.

4.2.4. Intensity

Moderate–High: There is a cross-sectoral coalition of stakeholders to support behavioural change in favour of BGI projects, the Climate Campus being an example. Nevertheless, the different actors recognise multiple challenges. BGI's are seen as projects that relate to heat stress, health, warm weather, and quality of life. Yet, the relationship still depends on the project sector. It is also acknowledged that there is room for integrating sectoral aspects within each existing network. Not all networks are working together. Sometimes, actors also find it complicated if many stakeholders are involved. However, there is an interest from the different actors to continue taking the integration further, including collaborations of citizens with citizens.

4.3. Problem perspectives and goal ambitions

4.3.1. Extent: moderate–high

High: Cross-sectoral and trans-disciplinary perspectives are considered. According to most industry experts, Climate Campus is open to supporting projects and ideas. Yet, an expert mentioned that it is not fully open to the public, as there is a type of unspoken membership. Some groups still lack representation, such as those involving social workers. Furthermore, social actors acknowledge that despite the openness of governmental actors, there is still room to improve methods and techniques that can permit all voices. Sometimes, people hesitate to share ideas at the beginning of the process. Along the same line, at the local level, interviewees acknowledged that some departments are still adjusting to new ways of working, so there is still a transition.

4.3.2. Coherence

Moderate–high: The cross-sectoral and trans-disciplinary perspectives support each other. The general goals and visions are shared among the different actors, but disagreements exist on achieving them as each actor has their own agenda. According to an industry expert, a shift is still needed in how some governmental actors see things. According to an expert, this is the reason things are still not advancing as they could be: 'There are many people talking and few doing'. Despite this situation, agreements among key sectors such as the government, companies, and education are common. However, this is more challenging when it comes to the involvement of citizens.

4.3.3. Flexibility

High: It is possible to reassess goals during the implementation of BGI projects. Several projects, such as roof gardens and rainwater systems, are evaluated yearly and need to meet legal requirements. The long-term projects are also reassessed, and each phase is evaluated. In general, various applications are in place to monitor climate adaptation at the local level, among them the Water-Sensitive City Index and the CATCH dashboard (Dolman & van der Meer 2021). However, the main issues reported by the interviewees are about who is responsible for what at the beginning of the project. For example, a governmental actor mentioned that projects are implemented considering the following steps: 'We make an initial plan, then we look for solutions, what can people do and once we all agree then we go to accomplish it'. Once the different actors accept a project, it can occur that 'There are so many captains on the ship'. In general, governmental actors are aware that certain flexibility is needed. An advantage of being a midsize city is that many people know each other by name, facilitating interaction. Furthermore, as an interviewee from the local government mentioned regarding the opportunities to reassess projects: it is important to understand that 'the city is not finished but is always in urban transition… There is the idea of finishing the project, but it does not mean that the city is finished'.

4.3.4. Intensity

Moderate–high: Changes are required in some of the actors' perspectives to achieve the implementation of BGI projects. While, in general, actors accept BGI projects, according to some interviewees, there are still sectors that need to change their perspective to understand and favour BGI projects. Among them is the agricultural sector. Inside the government, there is also some room for improvement. For example, some people working on projects related to the rivers still have a mono-disciplinary approach, as this is the way they have been working for several years. In addition, some residents question BGI interventions in their area when they feel affected. However, it is important to highlight that this is becoming less common. While people used to be concerned about costs, nowadays, they acknowledge the benefits of BGI projects more.

4.4. Strategies and instruments

4.4.1. Extent

Moderate–high: Innovative strategies, including pilots, are considered by the stakeholders. As seen in the case description, various projects are taking place in the city. However, some private actors consider there is still room to scale up some projects, such as the plastic road or the rainwater catchment systems. In the case of the plastic roads, this was a project that called important media attention. The idea was to develop a bicycle lane with hollow blocks made of recycled plastic. This type of lane could help store stormwater, but it did not translate into projects or new legislation. There is still no legislation that obligates companies to install BGI. Hence, despite the efforts from the Water Board to request the use of rainwater inside the new constructions and to avoid the discharge to the street infrastructure, its implementation is difficult to monitor. There is no legislation on BGI for real estate developers, so it is very difficult to demand that new houses include BGI. Among the most accepted projects are those about widening the river. Nevertheless, some politicians must change their thinking as they still focus on grey or mono-functional infrastructure such as dykes. In this regard, it is important to continue supporting BGI pilots to continue innovating.

4.4.2. Coherence

Moderate–high: The institutionalised instruments and strategies support specific innovative strategies. Yet, strict regulations still complicate the implementation of BGI projects. Among them are those related to aesthetics and architectural value. There are cases where residents want to implement a project in monumental houses or old buildings, but there are restrictions as they have historical value. Mobility and transport regulations are also very strict too. For example, there have been issues with permeable pavement for car and bike lanes. Although this pavement facilitates rainwater infiltration, its maintenance is more expensive and requires a specific look. For example, the streets in the city centre have a specific colour, and the new pavement needs to match it, which is difficult to do with permeable pavement. According to some governmental actors, there is fragmentation in urban planning and in the strategies and projects that are being implemented. There are currently legislation proposals that are aiming for a more integral approach. One of them focuses on the residents and their role at the neighbourhood level to play a more active role in climate change adaptation and energy transition.

4.4.3. Flexibility

High: The actors can combine and use different instruments to implement BGI projects if the law supports them. A good example is Spoorzone, a neighbourhood beside the train station. It was a very dense and compact area with a high risk for floods. This area is now being transformed by building green areas where the inhabitants used to park their cars. To achieve this, the inhabitants gave away their parking spots to the municipality, and the Water Board supported the development of the gardens. Other projects include the rainwater catchment systems, where the Water Board subsidises the inhabitants' projects. According to some interviewees, the different actors involved seek for innovation opportunities.

4.4.4. Intensity

Moderate–high: Stakeholders consider that minor changes in their strategies from current practice are needed to increase the implementation of BGI projects. While various BGI projects are being implemented as part of Zwolle's adaptation to climate change, some actors consider that there is still an opportunity to improve the legislation. This legislation could facilitate more involvement of residents by allowing more creativity to reach adaptation. Currently, Zwolle is developing its own set of standards for climate-resilient developments and buildings, but until now, only Amsterdam has adopted legislation to stimulate BGI. However, the actors try to create synergies among their projects, and there is support from the different governmental levels. Another strategy that should be considered is to increase the scope of the current networks, as this is still limited, and work between networks is still under development.

4.5. Responsibilities and resources

4.5.1. Extent

Moderate–high: Most stakeholders have assigned responsibilities and resources to implement BGI projects. The different governmental actors have financial resources for BGI projects. The actors acknowledge that Zwolle is a wealthy city, and in general, there is clarity on how the responsibilities are assigned. The issue sometimes is how the resources can be accessed. According to some experts, the requirements to get projects funded are sometimes difficult. However, governmental and non-governmental actors acknowledge that a co-creation approach allows them to have the required project resources. Moreover, the availability of resources is related to the success of the projects. For example, since green roofs were well-accepted by the residents, the resources assigned were insufficient. In this sense, although in many cases resources are present, there is the feeling that more resources are needed. This is the case with the plan for the maintenance of the sewage.

4.5.2. Coherence

Moderate–high: The responsibilities and resources of each stakeholder are generally clear for supporting the cross-sectoral and trans-disciplinary implementation of BGI projects. Nevertheless, BGI implementation is not a common practice. There are some projects in which different governmental actors collaborate. However, it is challenging to combine different projects among the governmental actors. While the governmental actors have tried to combine funds for spatial projects and maintenance of existing BGI projects, they also acknowledge that it is just starting.

4.5.3. Flexibility

Moderate–high: The actors can pool their responsibilities under effective accountability mechanisms to implement BGI projects, but some restrictions exist. A co-creation approach is starting, so it is still focused on short-term projects. Recently, there has been a new way to create the budget in the municipality, but this still requires more flexibility from the national government. In addition, when subsidies are obtained from the national government, there are various restrictions. For example, the national government can also provide support through the Regio Deal but not with a direct subsidy. In the case of local projects, these are paid for by the local institution and then reimbursed by the national government, which means the local institutions must be able to fund the project in the short term.

4.5.4. Intensity

Moderate–high: The actors consider that there are resources for implementing BGI projects, but they could be increased. The residents are supported with funding from the municipality, the province, and the Water Board via different programmes. For example, due to the interest from residents in green roof projects and the active involvement of non-governmental organisations, the assigned resources were insufficient to meet the demand. For the companies, it would be important to strengthen programmes that help them to innovate in aspects such as the circular economy, which is part of the Water cycle city state of the UWMTF. However, more skilled people with knowledge are needed to achieve the city's ambitious goal of becoming climate-proof by 2050. In addition, while projects have support, the creation of the Climate Campus has faced some financial challenges. In this regard, an actor from the water authority highlighted that 'Zwolle is very ambitious, so there is not enough money to finance all the projects… The city is already seen as one of the most progressive'.

5. DISCUSSION

The operationalisation and application of the GAT allowed a systematic understanding of the governance context in Zwolle by identifying the status of the three catalyst factors for leapfrogging (trans-disciplinary science, cross-sectoral partnership, and the implementation of innovation experiments). To achieve this, we used five governance dimensions and four governance qualities. The qualities were generally assessed as moderate–high supportive. These results can be considered reliable as most interviewees consistently reported similar and complementary statements, and the triangulation process via the analysis of secondary data from documents confirmed those statements.

When looking at extent and coherence, which combined assess the integration of the governance context, we can see a high integration of the policy from a multi-level governance perspective. This integration results from the collaboration among the different governmental levels. Multi-level collaboration is key to supporting climate change adaptation (Birchall *et al.* 2021). While there are still some challenges regarding the inclusion of citizens, important steps are being taken by governmental and non-governmental actors to increase their participation in BGI projects. Currently, there are several taking place. The qualities of flexibility and intensity are related to the 'quest for control' dilemma, which focuses on distrust or uncertainty versus trust and understanding (Boer de 2012). Zwolle shows that this is already well-developed. According to the interviews, the actors already have an important experience working together, and being a medium sized city has facilitated them to know each other. In general, the assessment confirms that The Netherlands is a hybrid governance system and an example of both adaptability and achievement of water management goals where one can expect synergies rather than conflicts (Pahl-Wostl 2019).

When using the governance qualities to identify the three catalyst factors of leapfrogging, named trans-disciplinary science, cross-sector partnership, and the implementation of innovation experiments, we can see that the three of them are present to an important degree. However, there is potential for improvement. Trans-disciplinary science, according to the interviewed actors, is present, and we can witness it in the variety of BGI projects being developed in the city. BGI projects are related to heat stress, health, and quality of life. Besides, the participation of multiple governmental agencies focused on water and urban development at the different governmental levels, Climate Campus and Room for the River Vecht networks have facilitated the inclusion of experts and organisations with different backgrounds in implementing BGI. The participation of the different experts has also supported the creation of social capital in favour of BGI projects' implementation. This finding confirms that urban climate resilience policies and strategies require the participation of public, private, and social sectors (Özerol *et al.* 2020). However, several aspects could still be improved. For example, some experts feel that Climate Campus is not a fully open network as there is an unspoken membership. At the same time, governmental actors acknowledged that there is no equal treatment with the private sector, while the private sector considers that they play an important role in providing knowledge that governmental actors lack. Furthermore, according to some interviewees, there are still governmental actors working on projects related to the rivers with a mono-disciplinary approach.

Regarding cross-sectoral partnerships, we found that all the governmental levels are involved, and they agree that their own goals are considered in implementing BGI projects at the local level. In this regard, and from the local perspective, we can see that the upper governmental levels support the city's ambitious plans, and there is an alignment of the goals with the upper levels (e.g., being a NOVI area). This support helps to reduce the tension between the ambitious goals of the city and the typical struggle of medium size cities in terms of resources. Moreover, this support seems key in the climate change adaptation transition. In this regard, our results confirm previous research on leapfrogging, which has identified the relevance of the role of upper governmental levels, including the subnational governments' (Casiano Flores *et al.* 2021). There are also partnerships beyond the governmental actors, where non-governmental actors participate in the development of BGI. In addition, networks such as Climate Campus play an important role in supporting bottom-up initiatives and various projects where the different sectors play different roles. In addition, governmental and non-governmental actors acknowledge that a co-creation approach allows them to have the required project resources. Within this approach, we could confirm that local governments in The Netherlands are shifting towards more networking, stimulating, and facilitating roles (Mees *et al.* 2019). Also, the development of networks within local governments is being part their governance strategies (Aylett 2015). However, participation with residents still faces some challenges. Full social participation is still complex and faces difficulties due to the lack of expertise of some residents, yet various projects are already taking place. It is also acknowledged that there is room to integrate sectoral aspects, including disadvantaged groups, within each existing network and strengthen the cooperation between the existing networks.

There are innovation experiments that involve all governmental actors and bottom-up initiatives. The innovative strategies include pilots with the participation of different stakeholders. Among the innovative strategies are green roofs, which have already passed a pilot stage and have become part of the strategies. However, some private actors consider that there are projects that could be scaled up such as the plastic road and they consider it important to continue supporting BGI pilots to continue innovating. Similarly, it is important to look at regulations that still hamper the implementation of BGI projects, such as those related to aesthetics and architectural value. In this regard, legislation on BGI could further strengthen its implementation and increase flexibility.

6. CONCLUSION

This paper aimed to assess the governance factors that support or restrict the implementation of BGI in the midsize city of Zwolle to transition towards a more advanced urban water management state. The governance context was generally assessed as moderate–high supportive. The three leapfrogging catalysts and the high level of integration between actors and policies demonstrate that the governance context supports BGI implementation in Zwolle. When comparing these results with similar studies in small and medium size cities, such as Herentals in Belgium and San Pedro Cholula in Mexico, we identify that leapfrogging seems unrealistic in less developed contexts (San Pedro Cholula). Meanwhile, in a moderately supportive context (Herentals), leapfrogging can be considered an acceleration of the transition process (Casiano Flores *et al.* 2021). When the three leapfrogging catalysts in the less developed context are examined, it is revealed that the governance system does not support neither trans-disciplinary science in the projects, nor innovation experiments. This lack of support also negatively affects the development of cross-sectoral partnerships. However, when we look at the moderate supportive context, trans-disciplinary science and innovation experiments are present, mainly at the subnational level, and it supports the city, facilitating cross-sectoral partnerships. In a highly supportive governance system, such as Zwolle, where trans-disciplinary science, cross-sectoral partnership and the implementation of innovation experiments are present, there is a higher possibility of leapfrogging to become climate-proof by 2050. We also confirm that local authorities play a key role in climate change adaptation and the inclusion of private actors (Klein *et al.* 2017). Still, as a medium size city, there is a degree of dependence on subnational governments regarding climate governance. Hence, these findings also support the relevance of subnational water management schemes in addressing water policy fragmentation (Cacal & Taboada 2022). Moreover, the limited participation of subnational governments could hinder the transition possibilities of small and medium size cities (Casiano Flores *et al.* 2019a; Casiano Flores & Crompvoets 2020).

The above findings improve our understanding of leapfrogging in urban water transitions. Despite the expectations of international organisations and some scholars; with the support of the GAT, we have not identified a governance context where leapfrogging occurs. Although the governance context is supportive in the case of Zwolle, the city's advanced water state should also be acknowledged. The high level of collaboration in Zwolle is not common for cities in early states of the UWMTF. Hence, these findings still question whether leapfrogging is possible. Studies in other contexts, such as China are cautious, as leapfrogging is contextual, it requires technological and governance innovations, learning from pilots and peer learning processes (Zevenbergen *et al.* 2018). Moreover, leapfrogging in an advanced polycentric governance context, as the Dutch, can also be seen as an acceleration of the climate adaptation process, rather than leapfrogging. Therefore, this needs to be verified by following Zwolle's transition or additional cases in developed governance contexts where co-creation approaches occur.

The results are relevant for academics, policymakers, practitioners, (international) organisations, and society in general, as they show the governance conditions that support leapfrogging catalysts. The enormous challenges of urban water management transitions lie ahead of many cities, and it is critical to learn from cases where innovations are happening (Kammen & Sunter 2016). In this regard, this study can be considered an example of how integration across policy and sectors is taking place in favour of BGI projects. Future research could assess cases where national and international actors are compensating for the lack of capacity of lower governmental levels. Alternatively, as the concept of leapfrogging has been related to technological transitions, another line of research can focus on the role of digital technologies in water management to facilitate leapfrogging. Innovations in both technology and governance can play a role in the progress towards climate change adaptation in cities. While this study has been limited to the understanding of the governance context, it can be used as a base for future studies on water management transitions that integrate governance and technological innovations.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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