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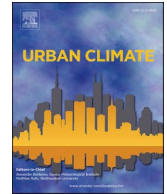
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Understanding the institutional work of boundary objects in climate-proofing cities: The case of Amsterdam Rainproof

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ABSTRACT

Creating climate-proof cities typically comes with institutional barriers between public and private parties. Therefore, local governments are increasingly establishing local climate adaptation networks through which collective knowledge and action can be developed. We aim to understand how these networks can initiate institutional change that enables a climate-proof city. To this end, we theorize that boundary objects – either conceptual or material artifacts – that allow different groups to work together without consensus are important instruments of institutional work strategies that aim to change or disrupt established institutional structures. Our case study of Amsterdam Rainproof in the Netherlands, a frontrunner in urban climate networks, shows that shared concepts and models developed in city networks seem to primarily contribute to capacity building (generating interdisciplinary knowledge about a climate-proof city), agenda-setting (underscoring the urgency of climate adaptation), and the creation of new normative identities (climate adaptation as the joint responsibility of urban actors). Accordingly, boundary objects in the case study transform the cultural-cognitive and normative pillars of institutions, while the regulative pillar (enforcement and sanctioning) is more difficult to change. Altogether, our case study analysis suggests that local climate adaptation networks might not result in a climate-proof city in the short term but can provide a better breeding ground for climate-proofing cities in the long run.

1. Introduction

The climate-proofing of cities is one of today's most profound urban challenges, as local impacts of climate change are increasingly experienced by cities across the globe. Traditional solutions (i.e., sewage systems and related civil engineering works) are often ill-equipped to deal with heavier rainfall, more extended periods of drought, and heatwaves. Furthermore, they are highly costly to expand (Dai et al., 2018). Consequently, urban governments are turning to a broader pallet of solutions, including blue and green infrastructure that mimics natural processes, such as green roofs, pocket parks, and permeable paving. Although traditional infrastructure operators continue to play a central role in urban climate adaptation, they are dependent upon the actions of other actors to jointly develop and implement blue and green infrastructure on public and private land (Dovers and Hezri, 2010; Measham et al., 2011). Climate measures often come with co-benefits, such as economic development, nature preservation, tourism and recreation,

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and health and wellbeing (IPCC, 2022), and are therefore also of interest to actors in other fields.

Because of this cross-sectoral nature of climate adaptation, its implementation is often presented as an inter-organizational challenge accompanied by a wide range of barriers (Uittenbroek et al., 2013; Oseland, 2019; Wamsler et al., 2020). Cooperation within and outside the municipal government, i.e., between municipal departments (different sectors) and local stakeholders (e.g., private developers, housing associations, community initiatives), is needed. In general, communicating with and mobilizing other actors is likely to enhance the development, planning, and implementation of climate-proofing measures. One core strategy currently pursued by local governments is the establishment of new local networks around the topic of climate adaptation (Carmin et al., 2012; Frantzeskaki, 2019). Examples of local climate adaptation networks (LCANs) are Brusseau (Brussels, Belgium), Climate Ready Boston (USA), and Water Sensitive Rotterdam (the Netherlands). They can also extend to trans-local networks, such as the C40 Cities Climate Leadership Group and the Asian Cities Climate Change Resilience Network (Fünfgeld, 2015). These networks arise because knowledge, resources, and expertise for urban climate adaptation (and broader goals) are fragmented among stakeholders from different domains (Wamsler et al., 2020; Willems et al., 2021). Collaboration between these stakeholders has proven difficult due to competing interests, lack of information, resource constraints, and misaligned institutional frameworks (Measham et al., 2011; Uittenbroek et al., 2013; Oseland, 2019; Birchall et al., 2022).

Thus far, the functioning of local climate adaptation networks has been under-researched, and questions remain on how actors involved in local climate adaptation networks convene themselves, translate viewpoints and start collaborations. By adopting an institutional analysis lens, we operationalize LCANs as a bundle of practices that reflect the interaction between new and old institutions. Institutions can be understood as the formal and informal norms, values, rules, and regulations that guide actors' actions (Scott, 2001). They condition the interactions between actors (Salet, 2018) and become interpreted and re-interpreted in daily activities (Healey, 2007). Actors in local climate adaptation networks can jointly develop new norms and allocate responsibilities differently, spurring institutional change. Thus, they conduct institutional work to create, disrupt, or maintain institutions (Lawrence et al., 2009, 2013). However, how they succeed or fail remains unclear. To this end, we enrich institutional work theory with the concept of boundary objects (Star and Griesemer, 1989; Star, 2010). Boundary objects transcend the barriers between different actors and domains, as they are artifacts – either conceptual or material – that allow different groups to work together without consensus (Star, 2010). The opaque definition of the concept is part and parcel of its function to cross boundaries between domains because its interpretive flexibility allows different groups to use the object.

Our research question is: *how are boundary objects used in institutional strategies by local climate adaptation networks (LCANs) to promote a climate-proof city?* To this end, we develop a theoretical framework that combines insights from institutional work theory with the concept of boundary objects. This enables us to understand the role of agency in cutting across boundaries and enabling institutional change. We apply this framework to a single case study of the local climate adaptation network Amsterdam Rainproof, based in the Netherlands and launched by the public water utility company Waternet. This network is considered an international frontrunner (Dai et al., 2018) and has been around since 2013, which allows us to take stock of the boundary objects developed as well as the institutional work of and within the network. Hence, the single case offers an opportunity to assess the applicability of the framework and the usefulness of combining boundary objects with institutional work. It will provide empirical indications of how this might work for other LCANs.

The article is structured as follows. In section 2, the theories behind boundary objects and institutional work are introduced and combined into a conceptual framework. The methodology in section 3 explains the case study approach in more detail, introduces the case study, and covers the data collection and analysis. Section 4 presents the results: we first discuss the boundary objects present in the case study and then show their institutional influence. The fifth section consists of a discussion of the findings and their broader implications. Section 6 presents the conclusions and suggests directions for future research.

2. Theoretical framework

Institutional change in the water sector is a collaborative effort, i.e., not obtained by a single actor but the result of interactions between actors and their institutional contexts (Beunen and Patterson, 2019; Giezen, 2018). The concept of boundary objects can supplement institutional work theory to help our understanding of how actors jointly pursue institutional change by developing joint concepts and strategies and how actors (others or the same) intentionally or unintentionally work to maintain the current institutional structure.

2.1. Boundary objects

One key strategy for the mobilization and collaboration of actors to create urban climate adaptation measures is establishing boundary objects (Levina and Vaast, 2005). Boundary objects are defined by Star and Griesemer (1989) as an object that is part of multiple social worlds to facilitate communication between them. They facilitate the co-production of knowledge (Star, 2010). For example, boundary objects can improve the usability of climate information (e.g., risks, exposure, and impacts) among the actors involved (Lemos et al., 2014), because boundary objects allow actors with different institutional logics to communicate and collaborate (Franco-Torres et al., 2020). Boundary objects should be instrumental to the parties on both sides of the boundary by, for example, offering concepts, resources, and tools (Guston, 2001). To illustrate, a concept such as resilience can function as a boundary object, as it could bring stakeholders together by linking stakeholder ambitions (Brand and Jax, 2007). Similarly, material tools such as a shared repository (Star and Griesemer, 1989) or a simulation model (Dewulf et al., 2013) can be boundary objects since they help translate viewpoints and interests between actors. Thus, boundary objects can be both material (tools, models) and immaterial

(concepts, frames) (Star and Griesemer, 1989; Willems et al., 2022).

Establishing boundary objects is often a deliberate, strategic act by a public actor (Spee and Jarzabkowski, 2009). For instance, a government can launch a new tool or concept to start a dialogue and collaboration. The interpretive flexibility of the boundary object allows for actors from different backgrounds to join this dialogue (Star and Griesemer, 1989). Accordingly, it is crucial to create a boundary object that is concrete enough to be appealing yet vague enough to ensure a variety of actors can relate to it. Accordingly, they move back and forth between settings where different logics come together and settings that are dominated by a single discipline (Star, 2010; Steger et al., 2018). Deliberately created boundary objects are not automatically embraced or used by other actors (Levina and Vaast, 2005); they need to offer something that an actor individually cannot obtain, such as resources, authority, expertise, or inspiration.

As Star (2010) discusses, boundary objects can lead to standardized practices among the actors involved. In other words, they can potentially become mainstreamed and institutionalized, where the principles embodied by a boundary object are embraced more widely and become the norm (Salet, 2018). The initial interpretive flexibility of a boundary object may diminish as standardization turns boundary objects into infrastructure (Steger et al., 2018). The dynamic “lifecycle” of boundary objects (Steger et al., 2018: 155; see also Star, 2010) illustrates that boundary objects can be employed as part of strategies to disrupt, establish, or maintain institutional practices and thus become tools for institutional work.

2.2. Understanding institutional change

To understand the dynamic interaction between boundary objects and institutions, we will use Institutional Work theory (Lawrence et al., 2009, 2013). This body of work studies the interactions between institutions and actors’ actions within and upon those institutions (idem). Institutional work does not treat institutions as exogenous factors that are fixed but rather as general rules of conduct that are enacted and re-enacted in concrete situations (Powell and Colyvas, 2008). It emphasizes the work done by actors in creating, disrupting, and maintaining institutions that it considers dynamic and relational (Lawrence and Suddaby, 2006). It has been applied to different fields, such as organizational studies (Radaelli et al., 2017; Labelle and Rouleau, 2017), environmental research (Bergsma et al., 2019; Beunen and Patterson, 2019), and urban planning (Bisschops and Beunen, 2019; Giezen, 2018). In line with other institutionalist perspectives, institutions are socially constructed and, therefore, only in effect as they are affirmed and reaffirmed in practice (Salet, 2018). This can be intentional or non-intentional, actively or passively, consciously or unconsciously (Healey, 2007; Lawrence et al., 2013).

Institutional work theory is based on Scott’s (2001) notion of institutions, considering institutions as “comprised of regulative, normative, and cultural-cognitive elements that, together with associated activities and resources, provide stability and meaning to social life” (Scott, 2008: 48). This conceptualization builds further on the sociological stream of institutional analysis, in which institutions follow a logic of appropriateness (March and Olsen, 1989). This means that institutions – both formal structures and informal practices – demonstrate what is considered legitimate behavior, seen in, for instance, rules and norms, and impact social behavior (Scott, 2008).

There are three pillars underlying institutions (Scott, 2001, 2008). The first pillar is regulative and concerned with both formal and informal rule-setting, monitoring and enforcing. The second pillar, normative, consists of a prescriptive, evaluative, and obligatory dimension and focuses on what is considered appropriate (March and Olsen, 1989). The third pillar – cultural-cognitive – puts symbolic systems centrally and relates to using common frames and shared symbols. Institutional work theory looks into how strategies impact one or more of the three pillars.

Following Spee and Jarzabkowski (2009), one of these strategies can be establishing boundary objects as artifacts to change, maintain, or disrupt institutions. Using boundary objects can lead to institutional conflicts and innovations, as boundaries between actors can be breached and bolstered (Zietsma and Lawrence, 2010). As Sajtos et al. (2018) show, boundary objects can impact the three pillars of institutions differently. The interpretive flexibility of a boundary object allows for collaboration and can result in the reframing of belief systems. Consequently, interpretive flexibility can, in particular, impact the cultural-cognitive pillar of institutions. Out of these new understandings, new moral guidelines may emerge, for which new coordinated arrangements are needed. This will affect the normative pillar of institutions. Subsequently, the cooperative arrangements are likely to define new roles, interests, and identities for actors, mandating new regulative pillars (Sajtos et al., 2018).

These strategies are related to different domains of influence. Giezen and Bergsma (Bergsma et al., 2019; Giezen, 2018) distinguish the internal, the transactional, and the external environment upon which actors work on institutional change. Much work in innovative

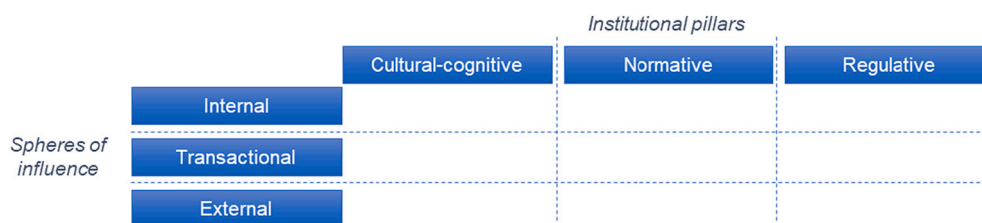


Fig. 1. An analytical framework to understand the potential impact of boundary objects on the three pillars of institutions and the three spheres of influence.

practices goes into changing, disrupting, or maintaining the institutional patterns of the internal environment of their organizations. Moreover, quite often, the ambition is to create institutional change in the transactional environment of actors where there is a direct influence. This is especially true for cross-sectoral fields such as climate adaptation. The external environment is, per definition, outside of the immediate sphere of influence but can still be impacted as new practices spread through different actors in the transactional environment.

An example would be that a waterboard cannot change a national law but must lobby politicians to implement its desired change. It is essential to understand that these social systems are relational and thus it differs per actor, what its sphere of influence is, and the strategies it can therefore apply. Actions by other actors in the external systems can lead to impacts on the actors' possibilities to act. A change in legislation is a clear example of an institutional change in the external environment that could disrupt institutions within a particular actor's transactional and internal environment. Fig. 1 presents a framework that helps to analyze the potential impact of boundary objects on the three pillars of institutions as well as the three environments.

2.3. Conceptual framework

We consider the development of boundary objects, either conceptual or material, as a strategic activity employed by public actors (Spee and Jarzabkowski, 2009). Put differently, developing boundary objects is a form of institutional work that can lead to either institutional creation, maintenance, or disruption. The state of institutional work can be seen in the impact of boundary objects on the three environments (Bergsma et al., 2019; Fig. 2). Applied to urban climate adaptation, we will investigate the boundary objects that public actors (water authorities) developed to construct local climate adaptation networks.

The impact on each type of environment can be specified using the three pillars of institutions: cultural-cognitive, normative and regulative (Scott, 2008; Fig. 1). Combining Figs. 1 and 2, we can examine how conceptual and material boundary objects 'work' in different environments and how boundary objects affect the three institutional pillars differently. Accordingly, we can specify the use of boundary objects. Moreover, the assessment can lead to improved strategies that do not solely impact, for example, the cultural-cognitive pillar but also the normative and regulative ones (Sajtos et al., 2018).

3. Methodology

3.1. Case study approach

We have followed a qualitative case study strategy common in institutional work research (Lawrence and Suddaby, 2006; Battilana et al., 2009). We selected the city of Amsterdam since it is internationally recognized as a frontrunner in terms of urban water management (Arcadis, 2016; Dai et al., 2018). The local water authority Waternet, together with the City of Amsterdam, has been actively engaged in creating climate adaptation measures and transforming institutions, as seen in the establishment of the network Amsterdam Rainproof. Consequently, we expect this case study to reveal boundary objects and institutional work instances.

Amsterdam Rainproof is a program founded by the public water utility company Waternet in 2013. It works as a networking structure for urban actors in Amsterdam. Waternet aims to mobilize urban actors (real estate, community initiatives, garden sector) to create a rainproof city. To this end, the Amsterdam Rainproof team has invested in public campaigns, knowledge dissemination, stakeholder mobilization, and the establishment of pilots. The program was initiated after a cloudburst event in Copenhagen in 2011. Initially, the Amsterdam Rainproof network would temporarily exist for two years, but this was later extended to six years. Waternet provided an amount of 1.75 million euros to hire nine professionals to facilitate the network. About half of the team already worked for Waternet or the City of Amsterdam, which was assumed to benefit from the institutionalization of new practices. The team combines diverse backgrounds such as engineering, urban design, and communication. To mark its independent position from the local

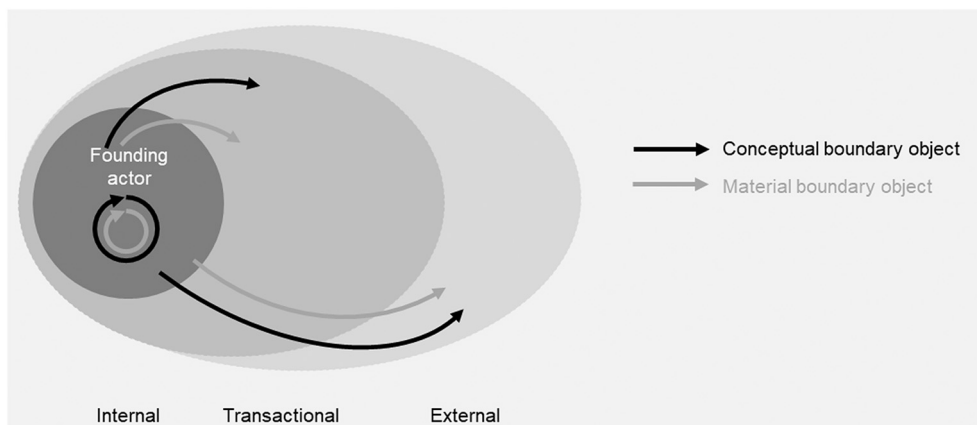


Fig. 2. Development of boundary objects as a strategic activity influencing three spheres of influence.

governments, the Amsterdam Rainproof team operated from the cultural enterprise *Pakhuis De Zwijger*. In this location, multiple local community groups can be found. Moreover, the Amsterdam Rainproof team was allowed to use its own logo and images in its communication without referencing Waternet or the City of Amsterdam.

Amsterdam Rainproof distinguishes eight key actors in its network (Amsterdam Rainproof, n.d.): governments, academia, designers and consultants, neighborhood initiatives, real estate developers and owners, the garden sector, entrepreneurs and insurance companies, and other platform organizations. These actors can participate actively or passively in the network. The core team acts as a matchmaker, linking parties and their ambitions to each other. Furthermore, the core team can act as a client, commissioning small subsidies and activities for other parties in the network. For example, the core team could subsidize a neighborhood initiative or initiate a new design competition in which the private sector participates.

3.2. Data collection and analysis

The data for this article was collected as part of an NWO VerDuS SURF research project that examined the networks of Amsterdam Rainproof and Water Sensitive Rotterdam in the Netherlands. Three forms of data were collected in Amsterdam. First, an interview series with key actors in Amsterdam Rainproof ($n = 14$) was conducted between October 2019 and January 2020. Interviewees included the team that has founded and facilitated the Amsterdam Rainproof network, and participants in the network, working for either local governments (Waternet and City of Amsterdam), the private sector, or communities (see [Table 1](#)). At the start, core team members and active participants were approached for the interviews. Through purposive snowball sampling, more interviewees were selected to cover the eight key actors in the network (see 3.1). The interview guide focused on three topics: (1) the involvement of each interviewee in the network and their motivations for being involved (to understand the instrumentality of being part of the network), (2) the activities that were organized by the Rainproof network and interviewees' participation in them (to understand knowledge co-production and collaboration in the network, including the role of boundary objects), and (3) the comparison between work practices in the network versus in their 'home organizations' (to get a sense of the institutionalization process). The interviews were fully transcribed. Second, a list of policy documents ($n = 7$) was collected, consisting of documents presenting and evaluating the Amsterdam Rainproof strategy, developed by the Amsterdam Rainproof team and by the founding member Waternet ([Table 1](#)). The (internal) documents accounted for the development of the Rainproof network and were acquired via the core team. The interview transcripts and documents were compared to verify claims made either in the documents or the interviews. Third, preliminary findings and observations were presented during two workshops with the team of Amsterdam Rainproof and their peers in the local government, in December 2019 ($n = 12$) and in March 2020 ($n = 5$). The workshops helped to understand the evolution of the network and disseminate findings within Waternet and the City of Amsterdam.

The first author coded the interview transcripts and documents in the computer program Atlas.ti. The framework presented in [section 2.3](#) was used to develop a code tree ([Table 2](#)). On the one hand, the boundary objects were coded by focusing on conceptual and material elements. Conceptual boundary objects were found by looking into discursive practices (shared frames of reference, framing of the issue, and the network). In contrast, material objects were coded by looking into tangible tools and instruments that smoothed knowledge exchange and collaborations. On the other hand, we coded activities in the network and clustered them along the three system levels: the internal, transactional, and external dimensions. The coding outcomes are presented in [sections 4.1](#) (conceptual and material boundary objects) and [4.2](#) (institutional work), followed by a discussion in [section 5](#).

Table 1

List of interviewees and documents used for analysis.

#	Interviewees	Documents
1	Community manager Amsterdam Rainproof	Waternet (2012) Joining forces in urban water management: Amsterdam Waterproof
2	Strategic advisor Amsterdam Rainproof	Waternet (2013) Amsterdam Rainproof: Rain – Water of Value. Action Plan
3	Advisor pilots and projects Amsterdam Rainproof	Waternet (2014) Programme Plan Amsterdam Rainproof
4	Founder NL Greenlabel (private sector)	Waternet (2015) Amsterdam Rainproof. Action Plan (continued)
5	Director NL Greenlabel (private sector)	Waternet (2016) Platform and network Rainproof: a strategy towards and after 2017
6	Strategic advisor Waternet (local government)	Waternet (2016) Platform and network Rainproof: variants for next steps
7	Strategic advisor Amsterdam Rainproof (mainstreaming)	Waternet (no date) Amsterdam Rainproof Magazine
8	Urban designer City of Amsterdam (local government)	
9	Vice-chair Tuinbranche Nederland (private sector)	
10	Coordinator Buurtgroen020 (green community initiatives)	
11	Senior policy advisor sustainability City of Amsterdam (local government)	
12	Van der Tol landscaping company (private sector)	
13	Developer Frank Lee (private sector)	
14	Lecturer University of Applied Sciences Amsterdam (academia)	

Table 2
Codebook.

Key concept	Codes
<i>Boundary objects</i>	Conceptual: concepts, frames, meanings, slogans, phrases Material: tools, instruments, models
<i>Institutional work</i>	Cultural-cognitive pillar: symbols, frames, identities Normative pillar: norms, prescriptions Regulative pillar: legislation, rules, enforcement, sanctioning
<i>Spheres of influence</i>	Internal, transactional, external

4. Results

4.1. Boundary objects developed by the Amsterdam rainproof team

4.1.1. Conceptual boundary object: rainproofing the city

The team of Amsterdam Rainproof launched the concept of ‘rainproofing the city’ to appeal to as many stakeholders as possible. Three meanings were attached to this concept by team members to target a variety of actors. First, the team decided to focus solely on rainwater to prevent the topic from becoming too broad: “*What really helped was the narrow focus. Initially, it was about climate adaptation, but this was changed into just rainwater at the advice of the [Waternet] board. [...] It made the challenge very concrete, graspable and visible*” (#7). The concept was narrowed down to the impacts of cloudbursts, as “*you could demonstrate the impacts with data of risks*” (#6). The Waternet employee continued: “*We had [rain] events continuously, and those were getting heavier. Incidents of cloudbursts and flooding increased*” (#6).

Similarly, focusing on rainwater created urgency: “*That extreme cloudburst was demonstratable. [...] So, people knew we had to take action*” (#6). A stakeholder from the local university confirms: “*It is raining more often and heavier, therefore it was helpful in that regard to have a peak shower sometimes. The problem became more visible.*” (#14). If the focus had been put on climate adaptation in general, interviewees argued that this would create confusion of what to include and what not: “*We were initially not happy with the narrower definition, but in hindsight, this has been a good choice. [...] We could more easily defend ourselves to others.*” (#7) As a civil servant from the City of Amsterdam put it, “*It is simple, manageable and clear.*” (#11).

Second, addressing the impacts of cloudbursts was framed by the team as a collective responsibility of urban actors rather than a government responsibility. A team member explains:

“*We executed a cloudburst simulation, which showed that we could not [tackle the impacts] by ourselves as part of the municipal sewage responsibilities. [...] We only own public property, but [taking measures there] would not suffice. We had to look for private property owners.*” (#3).

For water managers in the Netherlands, this has been quite a shift from the past. While they used to guarantee water safety at all times, they have now started to communicate that they cannot secure this anymore. Consequently, the issue of rainproofing the city has been positioned outside the civil engineering domain and conceptualized as a shared responsibility for urban actors: “*Collaboration is key, Waternet cannot do it by itself.*” (#1). Rainproofing the city, thus, implies that each urban actor starts to implement rainproof-thinking in its daily routines. In this framing, the water authority Waternet is not steering the agenda but must become more receptive and accommodating to other stakeholders to link rainproof thinking to their regular practices. Positioning the Amsterdam Rainproof team outside the Waternet agency helped demonstrate the joint responsibility of becoming rainproof. A private company explained: “*It is good to have this separate entity. It is evident what it stands for. It is a catchy phrase, first of all!*” (#12). For example, the Amsterdam Rainproof team was operating from the cultural enterprise Pakhuis De Zwijger, where many community initiatives in Amsterdam gather. Accordingly, the team from Amsterdam Rainproof could reach out more easily to these groups. An employee from Waternet argued: “*[Amsterdam Rainproof] is a neutral platform in the sense that it tries to hear other voices. You do not have the solution or single truth as a government.*” (#6). The “neutral” platform was conceptualized further with a distinct communication strategy and logo to demarcate its external position from the government.

Third, the Amsterdam Rainproof team presented rainproofing the city as an opportunity. “*We have always searched for that positive tone; we did not want to present a doom scenario. We had a positive logo full of colors. We aimed to show solutions and what you could do with water.*” (#3). The team of Amsterdam Rainproof noticed that providing such a positive integrative frame helped link climate adaptation goals with broader urban development. In many cases, climate adaptation solutions would have multiple benefits regarding public health, property values, or biodiversity that could get other urban actors on board. According to a civil servant of the City of Amsterdam, Amsterdam Rainproof has become “a fun policy issue”: “*You did not talk about the threat. You could discuss it, but you framed it as something fun to get started with.*” (#11) The “sparkling character” was accompanied with the mandate by Waternet to implement

Table 3
The boundary objects in the case study.

	Boundary object		Function
1	Rainproofing the city	Conceptual	Mobilizing: defining the urgency, as well as opportunities and possibilities
2	3D mapping tool	Material	Co-production of knowledge: linking urban climate adaptation with urban regeneration
3	Website	Material	Shared repository: sharing best practices and practical tips and tricks

solutions, so “it was not a small group of people with wild ideas. No, they had budget and power too.” (#8) By stating that “every drop counts,” each actor is encouraged to take actions on their property.

In conclusion, the conceptual boundary object developed by the Rainproof team for rainproofing the city highlights the tangibility (focus on rainwater), the joint responsibility (a concern for everyone), and the opportunities it could bring (multiple benefits). Together, these elements provide a common point of reference for actors to start taking action and unite actors: some are motivated by the urgency, while others are attracted by the co-benefits (Table 3).

4.1.2. Material boundary objects: a simulation tool and a shared repository

Our analysis reveals that the Amsterdam Rainproof team developed two material boundary objects. First, an essential start for the Amsterdam Rainproof team was the simulation model on cloudbursts they developed. A Rainproof team member elaborated: “For a long time, nobody wanted to mention the type of cloudburst that we should calculate with. But I knew we needed something to calculate with; you need a base.” (#2). Another Waternet employee recalled:

“We ran a model in which the cloudburst consisted of 100 and 160 millimeters of rainwater. ‘That will never occur here,’ people said, ‘why would you do this?’ The point was, we knew that that peak shower will come eventually.” (#6).

The simulation model was used to demonstrate the cloudburst impacts on public and private properties and the urgency of cloudbursts for other actors in the city. Building further on this, the team of Amsterdam Rainproof developed digital “rainwater bottleneck maps” (Fig. 3; left) that showed the areas in the city that would be threatened most. The most vulnerable neighborhoods could be identified, and discussions could be started with urban planners, designers, and property owners responsible for these places. On top of the bottleneck maps, the team presented the most significant urban developments in the city to connect the need for rainproof-thinking with urban regeneration opportunities (Fig. 3; right). Like the conceptual boundary object, the team aimed to provide solutions and think about opportunities. As a result, the team reasoned that linking development maps with flood maps would make it easier to discuss the need for rainproofing the city with relevant urban actors. Thus, the shared issue of rainproofing the city could be embraced by other actors, while still leaving space for their own interests and ambitions. The maps – as a boundary object – helped to create a common point of reference and align and mediate interests.

Second, the Amsterdam Rainproof team created a website that functioned as a shared repository for hands-on knowledge of rainproofing the city and provided an overview of initiatives across the city. The website includes practical tips and tricks on how to take measures tailored to different groups (e.g., individual homeowners, housing associations, real estate companies). Regarding the digital map, a civil servant explained: “They [the team] have pictured all successful initiatives on a map to bridge all people who care about this issue; it has become concrete.” (#8). The map shows community initiatives and businesses working on rainproofing the city. According to a Rainproof team member: “With the map on the website, you could put initiatives in the spotlight. Sharing success stories is a powerful tool.” (#3). Other interviewees stated that the website was attractive because of the colorful, positive and friendly design (Fig. 4). In that regard, the opensource Amsterdam Rainproof logo was a powerful tool that urban actors could use to affiliate themselves with the network, showing, for example, that their community initiative was rainproof. Notably, the logo “does not relate to the government” (#3) and has a distinct identity. To conclude, the website provided a shared language and resources for a variety of actors, operating as a joint repository to which in principle everybody could contribute.

In summary, the material boundary objects (summarized in Table 3) developed are tools to bring stakeholders together (3D simulation tool) and transfer information (website as a shared repository). Actors could subsequently adopt the communication strategy and principles by using the Amsterdam Rainproof logo in their initiative.

4.2. Boundary objects for institutional strategies

This section will discuss how the conceptual and material boundary objects are used as institutional work strategies to transform institutions. The results are structured along with the three environments distinguished in the theoretical framework (summarized in Table 4).

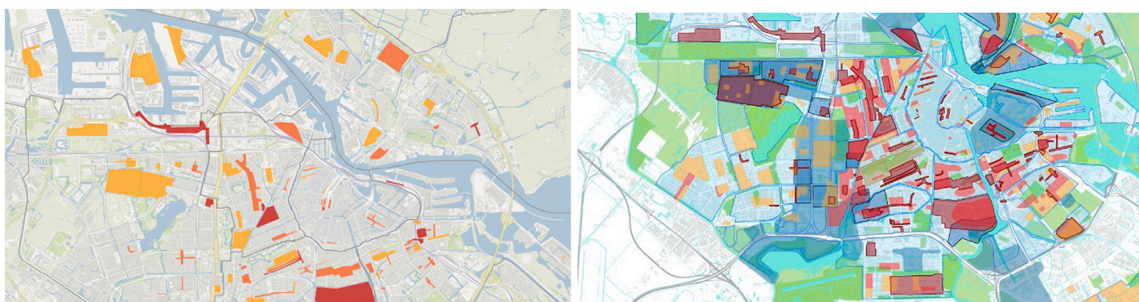


Fig. 3. Left: rainwater bottlenecks in Amsterdam. Right: bottlenecks combined with urban development in Amsterdam. Source: Amsterdam Rainproof.



Fig. 4. Amsterdam Rainproof website. The text states: “Is your garden ready for the next cloudburst?”. Source: Amsterdam Rainproof.

Table 4
Impact of the boundary objects on the three institutional pillars.

	Institutional work in the internal environment: Waternet and City of Amsterdam	Institutional work in the transactional environment: the local Rainproof network	Institutional work in the external environment: beyond the local level
<i>Conceptual object: rainproofing the city</i>	New symbolic systems and tools that present climate adaptation as an urgent need and opportunity, moving it outside the engineering domain Normative and legal prerequisite: “Rainproof-check” returns in public documents and handbooks	Treating water safety as a mutual responsibility, “Rainproof-label” for private and civic actors (non-coercive), and establishment of rainwater ordinance for new properties in the City of Amsterdam	Raising awareness about climate adaptation, using Rainproof principles elsewhere: establishment of national Community of Practice (‘Samen Klimaatbestendig’), and local spinoffs (Amstelveen Rainproof, Amersfoort Rainproof)
<i>Material object: 3D simulation tool</i>	Interrelationships between the urban water system and urban fabric are clearly demonstrated, presenting opportunities for collaboration and leading to new principles for rainproof urban development		Incorporating rainproof urban development into new platforms and policies elsewhere (other cities and national level)
<i>Material object: website</i>	Knowledge dissemination of climate adaptation practices that contribute to more livable		and sustainable cities

4.2.1. Internal environment

For the internal environment, we consider the two public actors that have established Amsterdam Rainproof: the local authority Waternet and the City of Amsterdam. For each actor, we will discuss the impact of the conceptual and material boundary objects on the internal environment of the actor’s organization.

First, Waternet is responsible for the complete water cycle in the city of Amsterdam. A core task is creating a robust water system that can withstand cloudbursts, which are likely to increase due to climate change. Rooted in the domain of hydraulic engineering, Waternet typically adheres to rational decision-making using asset management principles that compare risks, costs, and performance of hydraulic infrastructures. The conceptual boundary object of rainproofing the city has set a new norm, prescribing that the infrastructures have to be rainproof. Moreover, the new perspective on urban climate adaptation aims to get climate adaptation out of the hydraulic engineering domain, which has a profound impact on the normative pillar of institutions. To illustrate, interviewees mentioned that engineers are used to thinking about bottlenecks and solving the biggest ones. The new credo of ‘every drop counts’ challenges this and appreciates more minor interventions. The normative element also resonates with the other two institutional pillars.

Regarding the cultural-cognitive dimension, the boundary objects (rainproofing the city, but also the 3D simulation map) represent new symbolic systems that approach urban climate adaptation challenges not as a risk but as an opportunity for urban regeneration and livability. Examples include disruptive pilots in the Rivierenbuurt, leading to more water-sensitive urban designs and product development, such as Rainbeer (beer created from rainwater). The regulative pillar returns in how the conceptual boundary object of

rainproofing the city in particular can be rule-setting, defining a new allocation of responsibilities between public and private parties in taking adaptation actions.

The second actor is the City of Amsterdam, specifically its urban planning and design department. The department aims to create multi-functional public spaces that accommodate different interests (such as mobility, leisure, and water storage). The department is willing to create more blue and green infrastructure to create more rainwater storage, yet this comes with land-use claims (e.g., the retention capacity has to be traded off against housing developments). The conceptual boundary object of rainproofing the city helped the City of Amsterdam overcome this trade-off because the multi-functional character of blue and green infrastructure is underscored, and urban development can be approached more holistically. Furthermore, the opportunities that climate adaptation can bring are highlighted. Consequently, the boundary object particularly influenced the normative and cultural-cognitive institutional pillars. The simulation tool, as a material boundary object, helped operationalize the multi-functionality and explicit trade-offs. For example, the tool demonstrated the interrelationships between the urban water system and the urban fabric, both in terms of threats and opportunities. Accordingly, this boundary object also fulfilled a rule-setting role (regulative pillar) and defined a role in understanding between planners, engineers, and developers. Here, the material boundary object complemented the conceptual boundary object and is affecting all three institutional pillars.

Interestingly, the boundary objects helped create new property rights by defining new norms and practices. A few team members of Amsterdam Rainproof were busy with changing regulations and procedures within the City of Amsterdam and Waternet to make 'rainproof-thinking' stick and prevent it from being just a new perspective. To illustrate, existing handbooks on designing public spaces in Amsterdam have incorporated a "rainproof-check". In addition, new policies (such as the Vision Public Space) mention the issue of rainproofing the city. Currently, the norm of being able to store 60 mm on one's own property is also applied in the new rainwater regulation for new properties in Amsterdam ('rainwater ordinance'). These instances show an incremental change in the definition of new property rights.

4.2.2. Transactional environment

Besides Waternet and the City of Amsterdam, a diverse group of urban stakeholders has participated in the Amsterdam Rainproof network, including community initiatives, private sector and research institutes (Willems et al., 2022).

First, several community groups have participated in Amsterdam Rainproof events or projects because they pursue similar sustainability-related goals (urban gardening, renewable energy production, urban agriculture). These initiatives may have different motivations, but the conceptual boundary object (rainproofing the city) can help link community goals on the neighborhood level to broader sustainability-related goals, such as climate adaptation. As a result, the boundary object operates as an important normative and regulative signifier, which community groups can take on. The website functioned as a shared repository (the material boundary object) and had a cultural-cognitive function as a new mutual system, where each initiative was placed on a map. It also performed an educating function, providing, for instance, hands-on knowledge on how to rainproof your garden.

The private sector consisted particularly of the garden sector, i.e., private companies that sell goods and services for the gardens of businesses and citizens. The conceptual boundary object of rainproofing the city defined new rules and norms for the (re-)development of gardens, for instance, by 'greening' and 'depaving' gardens. Some companies in the garden sector saw opportunities for distinguishing themselves from the pack by labelling themselves as sustainable and rainproof and attracting new customers. The Rainproof repository and logo were used to back this claim. Consequently, we again see a combination of cultural, normative, and regulative impacts on institutions, although without much enforcement or sanctioning.

Lastly, Amsterdam Rainproof also approached real estate owners to stimulate rainproof measures. Several public and private actors welcomed this. For example, companies from Amsterdam's financial district (*South Axis*) established collaborations with Amsterdam Rainproof to create green roofs. The University of Applied Sciences also participated intensively with the Rainproof team, as it had ambitions to green its real estate.

In the collaborations between, on the one hand, Waternet and the City of Amsterdam and, on the other hand, the urban actors, the conceptual boundary object of rainproofing the city helped to re-construct the identities of both sides (cultural-cognitive). The object emphasized the joint responsibility and the positive benefits the creation of rainproof measures offered the city, therefore also having a clear normative and prescribing element. The Amsterdam Rainproof website operated as a cultural signifier that communicated the new norms further. The new identity for the water authority Waternet meant that it would not be the hierarchically operating urban water manager looking at engineering solutions to expand existing sewage systems. The boundary object helped Waternet to reposition itself in a more facilitative role, in which it becomes part of urban planning and design processes.

On the one hand, Waternet provides input to such processes – being one of the stakeholders in the planning process. On the other hand, it has important 'veto-power', as specific water safety measures must be implemented by it. Consequently, it has to balance its tone: sometimes being open and receptive to others, occasionally being strict and enforcing.

At the same time, urban actors are becoming more involved in realizing urban water safety. This could potentially make the management of the urban water system more decentralized and participatory, yet it also requires actors to take more responsibilities on board. For now, Waternet's identity is changing towards actors that can also contribute to urban climate adaptation – having the "every drop counts" phrase in mind. The normative associations with urban climate adaptation are also shifting. Interviewees underscored the change from a more risk-based approach to a more opportunity-driven perspective that can spur urban development. The foundations of water management practices become more embedded in urban planning processes and have a more positive orientation towards the risks associated with cloudbursts.

Moreover, seizing these opportunities is framed as a responsibility of public and private parties. Therefore, the normative association with taking action for climate adaptation is changing from a government-driven responsibility to a mutual responsibility. The

material boundary objects helped to ‘think through’ and practice these new principles, most notably through the simulation tool. Yet, additional regulatory measures were also promoted and implemented. The rainwater ordinance mandates that new developments and properties accommodate a minimum of 60 l rainwater per m².

Regarding the construction of normative networks, the Amsterdam Rainproof team helped set up a network of actors through events and pilot projects. These events and projects embody ‘rainproof-thinking’ and set norms about approaching urban climate adaptation. The website can be considered a platform to ‘touch base’ with these principles. Amsterdam Rainproof has become a well-known network within the administrative boundaries of Amsterdam, but its membership is less clear. Urban actors can voluntarily join the network and label themselves as rainproof but can just as easily withdraw themselves. Thus, Rainproof events and pilots have a limited capacity for compliance and sanctioning (regulative pillar). Only indirectly, for example, by not providing subsidies, could the Rainproof team (re-)enforce their principles.

4.2.3. External environment

In line with the theory, the boundary objects have had a minor impact on the external environment. We see new linkages emerging on the urban level between hydraulic engineering, spatial planning, and urban design, and domains such as health and social services. The notion of rainproofing the city was translated into these domains, linking climate change impacts with public health and wellbeing impacts. As such, the conceptual boundary object had a signaling and agenda-setting function.

On the national level, the Delta Programme has been developing a sub-program on climate adaptation where Amsterdam Rainproof was used as a best practice. To illustrate, the Amsterdam Rainproof model has been adopted in other cities in the Netherlands (e.g., Amersfoort Rainproof, Arnhem Klimaatbestendig). Likewise, the national policy is defined by ‘Samen Klimaatbestendig’ (Together Climateproof). The conceptual boundary objects supported cultural-cognitive and normative institutional change and regulative change to a lesser extent.

Considering the international level, Amsterdam Rainproof has always been looking for inspiration elsewhere. Copenhagen’s approach after local cloudbursts inspired the network in 2013. Simultaneously, the Amsterdam Rainproof network inspires other places, such as Melbourne and New York. For instance, Amsterdam Rainproof influenced the rebuild-by-design competition in New York and involved Rainproof team members. Again, the conceptual boundary object of rainproofing the city could readily be embraced by other parties.

The boundary objects enhanced the advocacy power of the Amsterdam Rainproof network, as the local alderman, and high-ranked public officials attended the networking events and pilots. Because of the opportunity-driven approach and showcasing of best practices, interviewees recall that administrators liked to join such events. The creation of new networks linked to Amsterdam Rainproof can also have an agenda-setting impact, putting the issue of rainproofing the city on the political agenda. To illustrate, the new coalition in Amsterdam that started in 2017 was more green-minded, which was a window of opportunity for the Rainproof actors. At the same time, the events and pilots often came without many obligations, so some interviewees questioned the institutionalization of the newly constructed identity and practices. They warn that, so far, mainly intrinsically motivated individuals in the city have been reached.

5. Discussion

The discussion reflects upon three elements highlighted in the theoretical framework: the interrelationships between conceptual and material boundary objects, the impact of boundary objects on the three institutional pillars (Fig. 1), and the three spheres of influence (Fig. 2).

Our case study demonstrates how the conceptual and material boundary objects complement each other, combining agenda-setting elements with knowledge co-production and collaborations (Table 3 and 4). The material boundary objects can be considered a manifestation of the conceptual boundary object of ‘rainproofing the city,’ for example, with the website that operates as a shared repository and where actors can find the shared principles. Moreover, the material boundary objects contribute to education, operationalizing the cultural-cognitive symbols of the conceptual boundary object. The 3D-simulation tools helped, for example, urban planners and designers to learn about the influences of cloudbursts on the built environment and the interrelationships between the urban water system and the urban fabric (cf. Dewulf et al., 2013). Accordingly, the boundary objects have put forward new institutional norms and values for the urban water management discipline. While this article primarily focuses on the ‘successful’ boundary objects, there are also smaller and less prominent boundary objects that did or did not succeed in achieving their aims. For example, collaborations with the real estate sector were more difficult to achieve through voluntary cooperation. However, as this research focused on establishing a relation between the two fields of knowledge, we took the most prominent three boundary objects as the core units of analysis.

The boundary objects seen in the case of Amsterdam Rainproof functioned as an agenda-setting vehicle that proposes new identities and normative frameworks with regard to urban climate adaptation and water management, adopting a positive tone that replaces a more traditional, silo-based (engineering-driven) perspective (Ashley et al., 2020). Accordingly, the boundary objects contributed predominantly to institutions’ cultural-cognitive and normative pillars. In line with previous literature (Sajtos et al., 2018), boundary objects have more difficulty affecting the regulative pillar. Boundary objects can set new collaborations in motion between public and private parties, yet often in single pilots or one-time events that do not pass “obligatory passage points” for institutionalization (Franco-Torres et al., 2020: 44). New rule systems – such as the rainwater ordinance – originate from ideas generated in the Amsterdam Rainproof network but are pursued by individual actors in their home organizations. In other words, the boundary objects define new standards adopted by others and can return in new legislation. This has been a more long-term process that falls outside the scope of the

network. [Suddaby and Viale \(2011\)](#) refer to these changes in the external environment as field-level change. This means that the boundaries of the field have changed. In follow-up research, it would be interesting to invert the analysis and see how field-level changes evoke the creation of new boundary objects to gain a greater understanding of causal relations.

Looking at the three spheres of influence, previous research ([Giezen, 2018](#); [Bergsma et al., 2019](#)) has demonstrated how utility managers have mainly put efforts into changing the internal and transactional environment to better respond to a changing context, for example, circular and climate-proof ambitions. Our findings confirm these insights, as seen in how the Amsterdam Rainproof network was used as a tool to transform the internal organization from the outside inwards. Nevertheless, we observed that the platform might become a stranger and lose influence by positioning the network too far outside the internal environment. Our findings also demonstrate that the boundary objects affect the transactional environment. This is in line with [Bisschops and Beunen's \(2019\)](#) work that looked at a new citizen organization making an effort to change the transactional context and get a seat at the table in an urban development project.

The boundary objects have had a minor impact on the external environment because more fundamental standardization and institutionalization remain problematic with the current boundary objects ([Star, 2010](#); [Sajtos et al., 2018](#)). To illustrate, the boundary objects are 'soft' tools with limited sanctioning and enforcing power, making it difficult to impose new public norms (cf. [Salet, 2018](#)). Since the main goal was to appeal to as many actors as possible, the Amsterdam Rainproof team has stayed away from sanctioning and preferred to be a 'friendly' party. The limited enforcement implies that institutionalization is hampered ([Star, 2010](#)). The institutional space the team has created for itself provides freedom (i.e., being different from the norm), which provides opportunities for innovative collaborations. However, it also implies that the team operates in a niche with limited responsibility and could mean that the dominant norm remains unchallenged. To illustrate, some actors that link themselves with the Amsterdam Rainproof principles often do not want to become the norm, as they like to picture themselves as frontrunners or pioneers.

Moreover, mainly intrinsically motivated groups of stakeholders have been reached that are concerned about the physical environment (see also [Lenzholzer et al., 2020](#)). The values and principles they embody may be at odds with the values of other actors in the city ([Anguelovski et al., 2016](#); [Rudge, 2021](#)). Operating in a (self-created) niche makes influencing the external environment more difficult, as institutional patterns are and need to be embedded into practices. Altogether, boundary objects seem to be particularly useful for influencing the internal and transactional environment.

6. Conclusions

Creating a climate-proof city usually comes with various institutional and organizational barriers ([Uittenbroek et al., 2013](#); [Oseland, 2019](#); [Wamsler et al., 2020](#)). New local climate adaptation networks (LCANs) are one way of overcoming these barriers, yet they need to develop a shared language and principles. We operationalize these networks as a new bundle of practices that could create, disrupt, or maintain institutions. To understand how actors develop joint practices – and thus potentially transform institutions – integrating Institutional Work theory with the concept of boundary objects is helpful as an analytical instrument. Our research question was: *how are boundary objects used in institutional strategies by LCANs to promote a climate-proof city?* We presented insights from the innovative Amsterdam Rainproof network in the Netherlands following a qualitative single case study approach.

We conclude that the boundary objects in our case study are valuable instruments for changing the cultural-cognitive and normative pillars of institutions, as they can function as agenda-setting and capacity-building vehicles that define new norms and provide new interpretation schemata. The current set-up of the studied boundary objects gives less space for enforcement, so the regulative pillar is more difficult to transform in our case study. The establishment of LCANs does not automatically result in a climate-proof city in the short term. However, it is likely to provide a more fertile breeding ground for incorporating blue and green infrastructures in the city in the long run. As such, boundary objects can define new normative conditions for social interaction ([Salet, 2018](#)). For example, new practices and principles in the Amsterdam Rainproof network have become slowly included in urban design handbooks and legislation. Our findings illustrate that boundary objects can produce new cultural norms that various urban actors embrace. However, the friendly, appealing character of the boundary object also comes with limited enforcement and sanctioning possibilities.

Altogether, LCANs have the potential to overcome the institutional barriers typically discussed in urban climate adaptation literature ([Uittenbroek et al., 2013](#); [Oseland, 2019](#); [Wamsler et al., 2020](#)). The boundary objects developed by the facilitators of the network enhance their ability to mobilize actors and link knowledge, resources, and expertise with each other to cross the disciplinary and organizational boundaries needed for the creation of a climate-proof city. As such, boundary objects become an integral and crucial part of institutional work strategies. As these networks and boundary objects are usually initiated solely by urban water managers, they have not become fully used or institutionalized yet (cf. [Levina and Vaast, 2005](#)). Future research could look into the temporal dimension of boundary objects, i.e., how they become standardized practices ([Star, 2010](#)) or widely accepted public norms ([Salet, 2018](#)). A second important research avenue is a more critical reflection on the outcomes to which the boundary objects aim to contribute. Research is increasingly pointing towards potential negative side-effects of climate adaptation, such as spatial injustice (e.g., green gentrification) ([Anguelovski et al., 2016](#)). However, the boundary objects witnessed in our case study predominantly frame climate adaptation as an opportunity for urban regeneration that will bring multiple benefits, neglecting spatial justice concerns ([Ashley et al., 2020](#)). More attention can be paid to how local networks can bridge the opportunities and potential negative side effects.

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Author statement

Hereby we certify that both *authors* have seen and approved the final version of the manuscript being submitted. They warrant that the article is the *authors'* original work, has not received prior publication and is not under consideration for publication elsewhere.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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