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Emerging citizen contributions, roles and interactions with public authorities in Dutch pluvial flood risk management

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ABSTRACT

This article focuses on the emerging role of citizens and their increasing contributions to local pluvial flood risk management in the Netherlands. A qualitative research approach is followed with semi-structured interviews, and analysis of policy documents and media reports. A typology of physical resources and actions, knowledge and advocacy activities shows evidence of locally focused citizen contributions to pluvial flood risk management in the Dutch city of Arnhem. We find that this emerging citizen role is being shaped by traditional authority-led interactions, creative and dialogical approaches to citizen engagement, and citizen-initiated contributions that then interact with authorities.

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Pluvial flooding; flood risk management; citizen initiatives; Netherlands; authority-citizen interactions; flood resilience

Introduction

Pluvial flooding is emerging as a 'critical issue' (Rosenzweig et al., 2018, p. 1) in water management and is expected to worsen due to urban growth and development combined with climate change-induced increases in extreme rainfall intensity and frequency (see also Hegger et al., 2016; Schanze, 2018).¹ Furthermore, future heavy rainfall events are predicted to overwhelm existing sewerage systems (Scott, 2013), and the traditional approach of continuing to expand sewer system capacity is increasingly seen as costly, unsustainable and inadequate in coping with these events (Rosenzweig et al., 2018; Van Riel, 2011). These concerns with traditional flood risk management (FRM) approaches have led to a growing interest in resilience in pluvial FRM. The concept of 'flood resilience' represents an acceptance that floods may happen, despite defences being in place, and also emphasizes reducing potential flood consequences and 'living with floods' (Forrest, Trell, & Woltjer, 2019; Liao, 2012; Scott, 2013). Approaches that accommodate excess rainwater and reduce pluvial flood consequences require changes in land use in the local urban environment: land that is owned and controlled by citizens. Therefore, the shift to flood resilience implies a potential role for citizens in local FRM.

Research has found evidence of an emerging role of communities and citizens in local FRM (Edelenbos, Van Buuren, Roth, & Winnubst, 2017; Forrest et al., 2019; Geaves & Penning-Rowse, 2015; Harris, Shaw, Scully, Smith, & Hieke, 2017; McEwen, Holmes,

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Quinn, & Cobbing, 2018; O'Brien, Ambrose-Oji, Morris, Edwards, & Williams, 2014a; Seebauer, Ortner, Babicky, & Thaler, 2018). This increasing involvement of citizens is driven by both flood experiences and national policy agendas, such as the Participation Society in the Netherlands, that seek to stimulate citizens to be more active and willing to take a greater role in their local milieu (Seebauer et al., 2018; Verhoeven & Tonkens, 2013). The contributions and emerging roles of citizens in local FRM can have implications for local flood resilience and for more holistic FRM approaches that draw on broader knowledge and expertise than in the past (Forrest, Trell, & Woltjer, 2017; Forrest et al., 2019; McEwen et al., 2018; McEwen & Jones, 2012; O'Brien et al., 2014a).

The emerging roles and contributions of citizens can also have implications for established authorities already engaged in local FRM. There have been efforts to understand how public authorities, which have traditionally been responsible for FRM, can and should interact with citizens (e.g. Harris et al., 2017; O'Brien et al., 2014a). Citizen contributions, whether arising from public authority interventions or from citizens themselves, may help find FRM solutions in collaboration with public authorities (Harris et al., 2017; Twigger-Ross, Orr, Brooks, & Saduaskis, 2016). These interactions between citizens and authorities can lead to changes in the distribution of tasks and responsibilities between the government and local citizens, with the government potentially retreating from some of its tasks (Begg, 2018). Therefore, it is important not only to understand the emerging roles of citizens in local pluvial FRM, but also to see how they influence the division of responsibilities in local flood resilience.

Analysis of an emerging role of citizens in FRM has been undertaken in many Western countries with recent flood experiences, including England, Germany, North America and Australia (Seebauer et al., 2018). However, in the Netherlands there has been a lack of public debate on FRM, and in particular on the role of civil society in FRM (Terpstra & Gutteling, 2008), probably due to the high level of perceived flood safety, and the Dutch government being primarily responsible for FRM. This has resulted in low citizen FRM participation and flood risk awareness in the Netherlands (Hegger, Mees, Driessen, & Runhaar, 2017; OECD, 2014; Terpstra & Gutteling, 2008; Wehn, Rusca, Evers, & Lanfranchi, 2015). Citizens' pluvial flood risk awareness is particularly low, as it is not generally considered as important or threatening as river and coastal flooding, despite the tens of millions of euros' worth of damage and disruption it has caused in the Netherlands (NOS, 2016; Van Riel, 2011). However, the growing risk and experience of pluvial flooding in the Netherlands (Dai, Wörner, & van Rijswijk, 2018; H20, 2016; PBL, 2015), a more active citizenry in water management (Duijn, van Buuren, Edelenbos, van Popering-verkerk, & Van Meerkerk, 2019), and encouragement by the Participation Society policy agenda (Verhoeven & Tonkens, 2013) are the context for citizens to be increasingly interested and engaged in local FRM. Acknowledging this new phenomenon, this article focuses on the potential and actual role of citizens in local pluvial FRM. Furthermore, it analyzes how public authorities position themselves in this changing FRM landscape and how they relate to the different citizen roles and contributions.

This article focuses on the Dutch city of Arnhem, which is selected for its recent experiences with pluvial flooding (2011, 2014 and 2016) and the predictions of worsening pluvial flooding in the future (Trell & van Geet, 2019). Further justification for this selection is that in recent years the public authority (Municipality of Arnhem) has been actively engaging with pluvial FRM and looking for ways to more actively involve citizens in pluvial

FRM (De Gelderlander, 2014; Verhoeven, 2016). In doing this, the municipality has been raising awareness about the redistribution of roles and responsibilities (Trell & van Geet, 2019). Furthermore, several citizen initiatives focusing on pluvial flood risk have been set up in Arnhem in recent years (Arnhem Klimaatbestendig, 2019).

We first analyze the potential contributions of citizens in local pluvial FRM to clarify their potential roles. We then discuss how public authorities interact and collaborate with the emerging citizen initiatives while also trying to define a new role for themselves in the changing FRM landscape. We draw on qualitative data from in-depth semi-structured interviews with both representatives of public authorities and local citizen initiatives, policy documents, and media reports. Thus we can critically reflect on the changing roles of both citizens and local authorities as well as the implications for local flood resilience.

An emerging citizen role in pluvial FRM

Changing citizen roles in FRM

Traditionally, the design, implementation and maintenance of FRM approaches have been predominantly a responsibility of public authorities (Pahl-Wostl, 2009). There has been a dominance of top-down, command-and-control approaches to water management in European countries (Pahl-Wostl, 2009). However, there is an ongoing transition from government to 'governance' in water management and FRM, which subtly implies a greater role for non-state actors. This broadening of the circle of involved actors is part of the 'social shift' in FRM (Nye, Tapsell, & Twigger-Ross, 2011) and it is therefore not surprising that in recent years there has been growing evidence of an emerging role for non-state actors, such as citizens, in local FRM (Edelenbos et al., 2017; Forrest et al., 2019; Geaves & Penning-Rowsell, 2015; McEwen et al., 2018; O'Brien, Ambrose-Oji, Morris, & Edwards, 2014b; Seebauer et al., 2018). Beyond simply being consulted or involved in ad hoc activities, citizens have also become organized in several different ways through flood action groups (Forrest et al., 2017; Geaves & Penning-Rowsell, 2015; McEwen et al., 2018; Twigger-Ross et al., 2016), participating in FRM as flood volunteers (O'Brien et al., 2014a, 2014b) or setting up various bottom-up citizen initiatives (Seebauer et al., 2018).

To explore citizen roles and contributions in pluvial FRM, this article develops a typology of different forms of contributions based on the existing literature. This typology will be used in the data analysis to help identify and classify citizen contributions to pluvial FRM in Arnhem. Previous attempts to identify and classify citizen contributions to FRM make a distinction between the emergency response to a flood disaster and the time period when there is no imminent flood threat (e.g. Forrest et al., 2019; Seebauer et al., 2018). However, the emergency phase is less prominent for pluvial flooding in the Netherlands since it is a flat country where pluvial flooding causes damage and disruption but is not considered a cause of casualties. Therefore, citizens in the Netherlands do not typically have a direct role in the emergency phase of pluvial flooding, but play a role after the floodwaters have receded. Based on this, we analyze the role of citizens when the floodwaters have receded.

Table 1 presents a summary of recent work on citizen contributions to local FRM. Three categories of citizen contributions were developed inductively based on this research: physical action and resources; knowledge; and advocacy activities. This typology can help

Table 1. Overview of citizen contributions to local flood risk management (FRM).

Physical Action and Resources			
Risk mitigation	Consequence reduction	Creating and accessing resources	Providing resources
Implementing natural flood defences; clearing and removing debris from watercourses; leaf litter clearing; installing river gauges; maintaining rivers; operating and maintaining authority FRM assets; creating temporary water storage areas; erecting flood walls and installing property-level protection; diverting rainwater from roofs into gardens	Helping clean and decontaminate flood-affected households; closing flood doors and activating flood pumps; purchasing insurance products or self-insuring; restoring utilities and services	Setting up and maintaining flood stores; creating databases of vulnerable people; community and online fundraising for FRM; accessing local community funds; bringing authorities together to raise funds; investing in warning systems; training volunteers to contribute to FRM	Distributing funds through donations and grants to those affected and FRM schemes
Knowledge			
Gathering knowledge	Verifying/updating existing knowledge	Providing knowledge to authorities and citizens	
Surveying waterways; checking river gauges and river monitoring; identifying watercourse blockages and obstructions; providing scientific observations	Revising hazard maps; supporting mapping of flood processes; augmenting, validating and challenging expert knowledge; correcting and verifying authority data on previous flood impacts; updating knowledge on 'pinch points' and drain locations	Reporting and informing authorities of impending flood incidents; reviewing and providing input to authority flood plans; supporting the exchange of knowledge between citizens and authorities; acting as a source of flood knowledge for residents; assisting with flood insurance queries; creating and supporting community flood warning systems; warning residents of potential imminent flooding; disseminating flood warnings and alerts	
Advocacy activities			
Campaigning for authorities to change FRM approach		Raising awareness of flood risk and of potential citizen FRM actions	
Lobbying for flood defence schemes; persuading authorities to take responsibility for a flood; campaigning for investment in local FRM; actively pressuring and seeking to influence authorities; objecting to planning applications; opposing further urbanization; petitioning against building on flood plains; objecting to new building developments that would increase flood risk		Raising awareness of flooding by working with schools; promoting the uptake of local flood warden services; promoting flood risk awareness in households; handing out leaflets, publishing in newspapers, producing videos, creating online training modules, using websites and social media to raise awareness of flood risk and actions citizens can take; running art exhibitions on previous floods; carrying out yearly flood training; encouraging the installation of property-level protection measures	

Sources: Coates, 2015; Dai et al., 2018; Edelenbos et al., 2017; Forrest et al., 2017, 2019; Geaves & Penning-Rowsell, 2015; Hegger et al., 2017; McEwen & Jones, 2012; McEwen, Garde-Hansen, Holmes, Jones, & Krause, 2017; O'Brien et al., 2014a, 2014b; Raadgever et al., 2016; Seebauer et al., 2018; Thaler & Priest, 2014; Twigger-Ross et al., 2016; Wehn et al., 2015.

identify and classify citizen contributions in Arnhem. The first category, physical actions and resources, has two components that are closely connected. Citizens can play a role in flood risk mitigation or flood consequence reduction (Coates, 2015; Forrest et al., 2019; Geaves & Penning-Rowsell, 2015), as well as being resource creators (e.g. creating flood stores with emergency equipment – Forrest et al., 2017; Seebauer et al., 2018), resource accessors (e.g. accessing funds for the community and local area – Forrest et al., 2019;

Geaves & Penning-Rowsell, 2015; O'Brien et al., 2014a) or resource providers (e.g. distributing funding to the flood-affected – Forrest et al., 2019; Seebauer et al., 2018).

The second category relates to knowledge contributions. Although knowledge can be understood as a resource, it is different from physical resources such as finances. Citizens have an important role in contributing to knowledge about local flood risk and to knowledge exchange with technical experts, public authorities, and residents in flood risk areas (Forrest et al., 2019; O'Brien et al., 2014a; Seebauer et al., 2018; Wehn et al., 2015). In the knowledge category, citizens can have an important role as knowledge gatherers (e.g. providing local context and flood risk knowledge to authorities – McEwen & Jones, 2012; O'Brien et al., 2014b; Twigger-Ross et al., 2016) and knowledge verifiers (e.g. revising hazard maps – Seebauer et al., 2018) for the actors traditionally in charge of FRM, in addition to being trusted FRM knowledge providers (e.g. providing knowledge on flood insurance – Forrest et al., 2017; Seebauer et al., 2018) for fellow citizens.

The third category can be summarized as 'advocacy activities'. These can target public authorities or fellow citizens. In both cases, citizens play a role in influencing FRM through lobbying, campaigning and persuading (Forrest et al., 2017; Geaves & Penning-Rowsell, 2015; Raadgever et al., 2016; Thaler & Priest, 2014; Twigger-Ross et al., 2016). Citizens can raise awareness of flood risk and of FRM actions their fellow citizens can undertake (Forrest et al., 2019; McEwen et al., 2018; O'Brien et al., 2014a; Seebauer et al., 2018), which extends beyond distributing knowledge. To increase flood risk awareness, citizens can be informed through providing knowledge or persuading them. The latter is more related to influencing and advocacy (e.g. disseminating knowledge through online and paper-based information – Dai et al., 2018; Geaves & Penning-Rowsell, 2015), hence its inclusion in the third category. Opposing local developments that could increase flood risk may be a particularly relevant role for citizens in pluvial FRM. However, it has also been noted that too much negative lobbying can be counter-productive in the longer term and lead to authorities being more defensive towards bottom-up initiatives (Edelenbos et al., 2017). Through advocacy activities, citizens are thus assuming a role that tries to change the perspectives and FRM approaches of public authorities as well as of their fellow citizens.

The emergence of these citizen contributions has implications for traditional FRM actors, such as public authorities, which are in the process of reinventing a new role and position for themselves in pluvial FRM in the Netherlands. Therefore in addition to exploring the emerging roles of citizens, we also consider the interaction between citizens and public authorities and how the authorities perceive the role division in pluvial FRM.

Interactions between citizens and authorities

In the Dutch context, public authorities still have a dominant role and the primary responsibility for pluvial FRM. However, these public authorities may need to reinvent their own role and look for ways to interact with, involve or facilitate citizens in the context of increasing citizen engagement.

Traditional, authority-led interaction with citizens allows the authority, as the initiator, to define the 'scope, moments and methods of participation' in FRM (Edelenbos et al., 2017, p. 50). This means that the role of citizens in these interactions is already decided by the public authorities. But dissatisfaction with public authorities may stimulate citizens to

initiate their own involvement in FRM (Geaves & Penning-Rowsell, 2015), during which they may interact with public authorities. These interactions could be reacting to government FRM interventions (Edelenbos et al., 2017) or opposing proposed FRM plans (Roth & Warner, 2007). Citizens may informally collaborate and share resources with authorities (Forrest et al., 2017) or use more formalized approaches, such as the Community Flood Resilience Pathfinder Scheme in England (Twigger-Ross et al., 2014) or through elected representatives in water boards in the Netherlands. Alternatively, citizens may take the initiative and develop their own ideas on how to contribute to local FRM and thus not be restricted by public authorities defining the scope of their role (Edelenbos et al., 2017).

The public authorities, particularly in the Dutch context, can be expected to have a strong influence on the role of citizens in FRM and on the contributions that they can and will make. Research indicates that previous interactions with public authorities can influence citizen initiatives' expectations from authorities, which affects the citizens' engagement in FRM (Geaves & Penning-Rowsell, 2015) as well as the 'success' of citizen initiatives in FRM in general (Edelenbos et al., 2017). For example, public authorities acting defensively towards local initiatives (Edelenbos et al., 2017) can be a reason for the lack of citizen involvement and interaction with authorities. On the other hand, public authorities may perceive these initiatives as being able to take FRM action without being constrained by legal and administrative rules (Seebauer et al., 2018). Therefore, public authorities may instead embrace citizen action and see it as an opportunity to improve local pluvial FRM in ways they cannot achieve alone.

Considering that citizen initiatives in pluvial FRM are a relatively new phenomenon in the Netherlands, it can be expected that the public authorities are in the process of searching for ways to best react and interact with them. Previous research indicates that the division of responsibilities in such contexts is not completely clear (Terpstra & Gutteling, 2008; Trell & van Geet, 2019). How public authorities, who are traditionally in charge of FRM, interact with citizens is influenced by the perception these authorities have of the division of roles and responsibilities (Trell & van Geet, 2019). By extension, this perception influences the possible and actual contributions and roles of citizens in pluvial FRM. Therefore to explain the potential for citizen contributions in pluvial FRM, we also focus on how the public authorities perceive the division of roles and responsibilities and how they interact with citizens in FRM.

Pluvial flooding and shifting roles in pluvial FRM in the Netherlands

Pluvial flood experiences in the Netherlands

The Netherlands has recently experienced intense pluvial flooding in the south-western and northern areas (2004), Rotterdam (2009), Amsterdam (2010), Arnhem (2011, 2014 and 2016) and North Brabant and Limburg (2016 and 2017) (Pieters, 2016; Spekkers, Kok, Clemens, & Ten Veldhuis, 2013; Trell & van Geet, 2019; Van Riel, 2011). Pluvial flooding in the Netherlands costs approximately €90 million per year, and this could increase to €200 million per year, based on predictions of more frequent periods of extreme rainfall in the future (NOS, 2016), and therefore pluvial flooding is a growing concern for the Netherlands (H20, 2016; PBL, 2015).

However, pluvial flooding is often not perceived to be as serious as coastal and fluvial floods in the Netherlands (Van Riel, 2011). It may not cause significant damage, and the impacts may not be recorded, which can result in it being seen as a risk that needs action in the future. It has been referred to as an 'invisible hazard' (Houston et al., 2011, p. 1), as there are no visible signs that homes are at risk until a heavy rainfall event occurs. In Dutch, pluvial flooding is *wateroverlast*, or 'water nuisance', implying that it is not expected to cause casualties or severe disruption. This stands in sharp contrast to the translation of coastal or fluvial flooding, which is called *overstroming* ('flood'/'inundation') and is associated with casualties and widespread disruption. Overall, the issue of pluvial flooding is not prioritized in the same way as other forms of flooding and climate adaptation, despite the financial damage it has caused.

Pluvial FRM in the Netherlands

In the Netherlands, public authorities (provinces, municipalities and water boards) still have a dominant role in pluvial FRM. Provinces and municipalities are authorities with a range of responsibilities at the regional and local levels, respectively. Provinces and municipalities have an elected council and are democratically organized, with a civil service that implements their policies. The municipality is responsible for managing rainwater in urban spaces by providing drainage or transporting it to treatment plants (Havekes et al., 2017). Individual households are responsible for pluvial flooding on their own private property, but the municipality still has a 'duty of care' for extreme pluvial flood events (Wiering, Green, van Rijkswijk, Priest, & Keesen, 2015). Water boards are functional agencies with an elected council and board. They are responsible for waterway drainage and management, for taking a regional perspective on monitoring and altering the water levels, and for managing excess water stored in rural areas, which helps accommodate predicted heavy rainfall and reduce the likelihood of urban flooding (Havekes et al., 2017). However, water boards are increasingly being involved in local pluvial FRM due to their responsibility for processing sewage water collected through municipal systems.

National-level plans (e.g. the Dutch Delta Plan 2018) outline a greater role for non-state actors, such as communities and citizens. There have been efforts to increase citizen involvement through workshops and consultation sessions (Wehn et al., 2015), engaging citizens in spatial planning projects (Dai et al., 2018), and providing subsidies for bottom-up projects (Mees et al., 2016). There are also increasing attempts to get citizens to take more personal responsibility and interest in FRM through online resources² and the 'Week of Our Water' event (H2O, 2017).

There are signs of public authorities attempting to involve citizens and community-based initiatives in Dutch water management and local pluvial FRM, but there is much variation in their approaches and their success (Duijn et al., 2019; Edelenbos et al., 2017; Rioned, 2014). Local public authorities in the Netherlands are working with other organizations to involve citizens in pluvial FRM, such as the Arnhem Climate-Proof Platform (Platform Arnhem Klimaatbestendig, 2019) and Amsterdam Rainproof (2016). However, there are challenges in mobilizing citizens in the Netherlands due to their low flood risk awareness (Hegger et al., 2017; OECD, 2014; Terpstra & Gutteling, 2008; Wehn et al., 2015) and the constitutional expectation of the government to maintain flood safety (Wehn et al., 2015).

Methodology

The article reports on the emerging role of citizens and the interactions between citizens and public authorities, with qualitative data collected from semi-structured interviews and analysis of policy documents and media reports. As established, Arnhem is illustrative of pluvial flood risk in the Netherlands and features emerging practices of citizen contributions.

We conducted 12 in-depth semi-structured interviews, each between one and three hours and conducted in English (key interviewees in [Table 2](#)). Some interviewees were interviewed twice. Interviews were also conducted with national-level actors: one academic, a member of Stichting Rioned (a Dutch urban water management and sewerage organization), and a member of the Steering Group on Spatial Adaptation for the Delta Plan 2018. These national-level interviews were relevant for a better understanding of national-level FRM as well as the Dutch FRM landscape, but quotes from the interviews are not used in the article and therefore they are not listed in [Table 2](#). Semi-structured interviews were conducted with three representatives of the Municipality of Arnhem involved in pluvial FRM who were selected based on their role in interacting with citizens. The first key municipality representative was identified due to their role in putting pluvial flooding on the agenda for local policy makers after the 2014 floods in Arnhem. This key municipality representative interacts with citizens in pluvial FRM activities and has authored several important policy documents that we analyzed. Snowball sampling was then used with this first key representative to identify other municipality representatives who were engaged in pluvial FRM (as part of Team Wateroverlast, or Team Pluvial Flooding) and had experience with interacting with citizens on pluvial FRM. The circle of potential interviewees from a citizen perspective in Arnhem is limited by the often informal and emergent nature of citizen roles and contributions. Therefore, we chose to identify umbrella organizations that worked with multiple citizen initiatives and knew of informal and emergent citizen activities taking place in Arnhem. Three umbrella organizations were identified based on interviewee recommendations and verified through the media report analysis: the Arnhem Climate-Proof Platform (Arnhem Klimaatbestendig), Green Arnhem (Groen Arnhem) and Climate Active Neighbourhoods. These organizations identify and support citizen initiatives and activities relating to pluvial flooding and other rainwater-related urban issues (e.g. greening of neighbourhoods). Importantly, they did not only coordinate citizen initiatives, but their members also took an active, hands-on role in pluvial flood-related issues in different neighbourhoods of Arnhem. For example, representatives of the Arnhem Climate-Proof Platform and Climate Active Neighbourhoods were involved in coordinating existing citizen initiatives, but also worked on setting up new citizen initiatives in their own neighbourhoods in Arnhem. These umbrella organizations were thus expected to have an overview of citizen initiatives and activities in Arnhem as well as experience with being involved in pluvial FRM as citizens themselves.

The interviewees were asked open-ended questions about their experiences of managing pluvial flooding, the emerging roles and contributions of citizens, interactions between citizens and authorities, and authorities' perceptions of citizens. The interviewees used visual aids (e.g. computer-based flood models) and maps to explain pluvial flood risk and FRM in Arnhem. The interviews were recorded and transcribed verbatim before being coded both by the three categories (physical actions and resources;

Table 2. Overview of key interviewees and interview codes.

Role(s)/organization(s)	Year	Interviewee Code
Role relating to flood risk management and policy, part of Team Wateroverlast, Municipality of Arnhem	2017, 2018	MUN1, 2017; MUN1, 2018
Role relating to sewerage systems and flood modelling, part of Team Wateroverlast, Municipality of Arnhem	2018 (twice)	MUN2, 2018
Role relating to urban design and the chair of Team Wateroverlast, Municipality of Arnhem	2018	MUN3, 2018
Role in identifying and supporting citizen initiatives relating to greening in Arnhem (Groen Arnhem)	2018	GRO1, 2018
Role in organizing neighbourhood initiatives and in citizen initiatives relating to pluvial flooding in Arnhem (Arnhem Climate Platform and Le Far West)	2018	ACP1, 2018
Role in organizing neighbourhood initiatives and supporting neighbourhoods relating to climate change adaptation and pluvial flooding (Climate Active Neighbourhoods and 026 Regenton)	2018 (twice)	CAN1, 2018

knowledge; and advocacy) and in terms of the type of interaction in specialist coding software, ATLAS.ti. This was done in combination with an emergent approach that coded further contributions, roles and interactions that emerged from the data collection process.

Media reports and policy documents were used to complement and contrast the knowledge gained from the interviews. These data sources were used to better understand the Arnhem pluvial flooding and FRM context, identify citizen contributions, and illustrate the perceived role of citizens among the authorities.

The Arnhem Climate-Proof Platform website was used to identify further citizen initiatives in Arnhem. References to media reports are included in the research findings where relevant to illustrate the story and to relate to interviewee data. The policy document analysis included 13 documents from Arnhem, with key documents listed in the Appendix and discussed in the empirical findings section. Relevant policy documents were identified through desk-based searches of online documents relating to pluvial flooding from the authorities in Arnhem and supplemented by documents provided by interviewees. These documents were read and references to interactions with citizens, citizen roles and contributions, and pluvial FRM approaches were identified. Analysis of the interviews, policy documents, media reports and information from the Arnhem Climate-Proof Platform website allowed a nuanced understanding of Arnhem's pluvial flood context and the contributions and roles of citizens.

Research findings and discussion

Pluvial flooding: experiences, perceptions and approaches in Arnhem

Arnhem experienced severe pluvial flooding in the northern part of the city, above the Nederrijn River, in 2014 (Arnhem Pluvial Flooding Action Plan, 2014; Arnhem-North Pluvial Flooding Approach, 2015; De Gelderlander, 2014), 2016, and then again in 2017 (MUN1, 2018). The most damaging and extreme recent pluvial floods were in 2014 (Figure 1). The northern part of the city is on a gradient, which causes rainfall to flow towards the low-lying neighbourhoods and collect there during extreme rainfall events (Arnhem Pluvial Flooding Action Plan, 2014). In addition to the disruption to traffic and the flooding of cellars through underground windows (*koekoekkelder*), the city hospital was flooded in 2014, which

illustrates that pluvial flood risks have not been adequately addressed in the past. The city's impermeable surfaces and shared sewer system resulted in rapid overflowing of the sewers and consequently in street-level flooding (Arnhem Pluvial Flooding Action Plan, 2014).

Interviewees from the Municipality of Arnhem predominantly perceived pluvial flooding as a disruption that disappears within a few hours, although there is recognition of 'pinch points' where it was known to cause more significant disruption. Interviewees also perceived pluvial flooding as a future problem (GRO1, 2018; MUN1, 2018). In a similar vein, policy documents revealed that extreme rainfall events are perceived as the biggest threat to Arnhem in the future (e.g. Water Management Plan, 2015), and public authorities are attempting to take it into account when expanding existing urban areas (MUN1, 2017).

As a response to the threat of pluvial flooding, and in the aftermath of the 2014 floods, the Municipality of Arnhem developed a pluvial flooding action plan (Arnhem Pluvial Flooding Action Plan, 2014). In addition, a Pluvial Flooding Team was set up by the municipality after the 2014 floods (MUN3, 2018). In the aftermath of the 2014 floods, critical infrastructure such as the hospital in Arnhem received some extra funding, but for other cases, the focus was on 'being creative' in seeking pluvial FRM solutions (MUN1, 2018). After the 2014 floods, the Municipality of Arnhem decided to seek pluvial flooding solutions that tackle multiple other problems in addition to pluvial flooding, to look for spatial solutions before technical solutions, to prevent damage to property, and to collaborate with residents (Arnhem-North Pluvial Flooding Approach, 2015). This decision was due to limited resources, as the Municipal Sewerage Plan 2014–2018 did not allocate

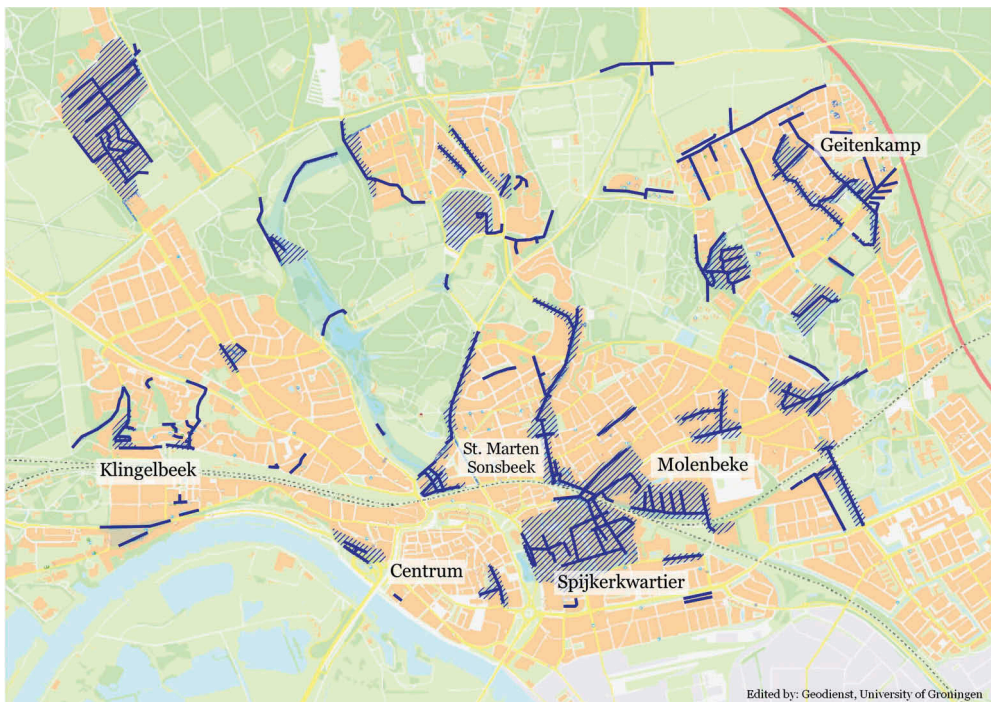


Figure 1. Map of Arnhem showing the extent of the 2014 floods (dark blue shows areas that were flooded). (source: Arnhem-North Pluvial Flooding Approach, 2015).

funds to pluvial flooding, because it was not seen as a problem at the time of compiling the plan (MUN1, 2018; MUN3, 2018; MUN2, 2018). However, the 2018 municipal elections in Arnhem led to the Green Left (Groen Links) political party taking a leading role in forming a coalition. Interviewees reported that recent floods in Arnhem and climate change in general were discussed in the elections and that there was greater political interest in the subject, which has led to expectations of additional funding for pluvial FRM and the 'greening' of areas in the future (MUN1, 2018; MUN2, 2018; MUN3, 2018).

There is a growing acknowledgement within the municipality that some pluvial flooding will happen and that citizens will need to accept that the municipality cannot prevent pluvial flooding in extreme rainfall events (MUN1, 2018). The enormity of the problem of pluvial flooding led to interviewees stating that they could not solve it alone and that it was a 'shared responsibility' between the municipality and citizens. A response to the Spijkerkwartier neighbourhood campaigning group by the Alderman for Public Space also emphasized that local pluvial FRM was a collaborative effort between residents and the government and that there was space for new ideas from residents to make Arnhem more water-resistant (*waterbestendiger*) (Municipality Letter, 2016). Furthermore, policy documents encourage municipalities to take a leading role in climate adaptation, acknowledge that both top-down and bottom-up initiatives can provide solutions (Climate Adaptation in Arnhem, 2010), and support the creation of civic initiatives (Arnhem's Green Vision, 2018).

Citizen roles and contributions to local pluvial FRM

To explore citizen contributions to local pluvial FRM, the interview data were coded, supplemented by relevant media articles, and sorted into physical action and resources, knowledge, and advocacy activities (Table 3).

Physical action and resources

A number of risk mitigation actions by citizen collectives were made possible by residents coming together to access financial resources. For example, the Green Arnhem West community group won the Municipality of Arnhem's annual Neighbourhood Prize in 2016 and used the prize money to replace parts of the pavement with grass tiles that cars could still park on, but which also stored rainwater (GRO1, 2018; Arnhem Klimaatbestendig, 2017). Unfortunately, the technical aspects of the greening in this experiment failed, but it was not a failure of citizen engagement, and the experiment provided experience that could be used in future projects (GRO1, 2018). Another example came from the Molenbeke neighbourhood, where citizens made use of the Arnhem-based AANjaagfonds [Neighbourhood Support Fund] scheme to install rain barrels (*regentonnen*) and green roofs in their neighbourhood (De Gelderlander, 2018).³ The installation of rain barrels was part of a citizen-initiated and Arnhem-based project called 026 Regentonnen to encourage citizens to decouple their properties (De Gelderlander, 2018; CAN1, 2018).⁴ The decoupling (*afkoppelen*) meant that rainwater would be stored on the individual property in rain barrels instead of flowing into the publicly maintained shared sewer system. This reduces the volume of rainfall that enters the public sewer system and thus the likelihood of it being overwhelmed, causing street-level flooding (CAN1, 2018). The replacement of paved road parking areas and the installation of rain barrels are both risk mitigation actions that were supported by the Municipality of Arnhem and an Arnhem-based project



Table 3. Citizen contributions to local pluvial flood risk management (FRM) identified in Arnhem.

<i>Physical action and resources</i>		
<i>Mitigating risk</i>	<i>Reducing consequences</i>	<i>Creating and accessing resources</i>
<ul style="list-style-type: none"> Installed rain barrels (Molenbeke and St Martins Sonnbeek) Installed green roofs (Molenbeke and Green Arnhem West) Greened parking area (Green Arnhem West) 	<ul style="list-style-type: none"> None identified 	<ul style="list-style-type: none"> Green Arnhem West won the Neighbourhood Prize 2016 Accessed AANjaagfonds to support scheme to install rain barrels (Molenbeke) Accessed EU Interreg funds Accessed cheaper materials by purchasing at scale
<i>Knowledge</i>		
<i>Gathering knowledge</i>	<i>Verifying/updating existing knowledge</i>	<i>Providing knowledge to authorities and citizens</i>
<ul style="list-style-type: none"> Citizens took photos and videos and uploaded them to social media Citizens in Molenbeke did surveys with residents before the 'post-flood neighbourhood walks' The Spijkerkwartier online flood platform gathered ideas and opinions 	<ul style="list-style-type: none"> Photos and videos uploaded to social media were used by authorities to verify flood models 	<ul style="list-style-type: none"> Provided local flood experiences to authorities through social media Provided ideas for Geitenkamp neighbourhood renewal Provided ideas, knowledge and potential FRM solutions to public authorities during post-flood neighbourhood walks in Arnhem
<i>Advocacy activities</i>		
<i>Campaigning for authorities to change FRM approach</i>		
<ul style="list-style-type: none"> Citizens complained after pluvial flood events caused household damage Citizens in Molenbeke directly challenged authorities' suggestions in 'post-flood neighbourhood walks' Attended a council meeting (Spijkerkwartier) Wrote an open letter (Spijkerkwartier) Used the Spijkerkwartier online platform to organize campaigning and keep residents updated 	<ul style="list-style-type: none"> Encouraged citizens to buy rain barrels (026 Regentonnen project) Ran Climate Carousels (Klingelbeek) Ran morning walks (Green Arnhem West) Publicized measures citizens can take in the local Molenbeke newspaper 	

using funding from the European Regional Development Fund. A citizen-run but municipality-funded Neighbourhood Platform also provided resources. Resource benefits could also be accessed by citizen initiatives, such as the benefits of purchasing at scale. For example, citizens in the Molenbeke neighbourhood coordinated their efforts to receive a discount on materials for the installation of green roofs on 25 homes (CAN1, 2018; De Gelderlander, 2018).

These contributions were focused more on mitigating flood risk (e.g. installation of rain barrels, green roofs and grass tiles) as opposed to the consequence-reducing activities (e.g. installation of flood pumps, stockpiling of recovery equipment) identified in the literature.

Knowledge

Citizens played several knowledge-related roles in pluvial FRM in Arnhem (Table 3). They took photos and videos of the Arnhem pluvial floods in 2014, 2016 and 2017 and shared them on social media; see Dijkgraaf (2014) for an example. The video provides information on the streets flooded, including the speed of the water and the scale of potential damage and disruption. By sharing these media, the citizens were acting as knowledge gatherers and (perhaps unintentionally) knowledge verifiers, by providing information that could be used by public authorities to improve and verify their flood models (MUN2, 2018).

A number of post-flood neighbourhood walks were undertaken by public authorities through neighbourhoods after the 2014 floods (CAN1, 2018; MUN2, 2018; MUN3, 2018; De Gelderlander, 2015). Before the walks, the Municipality of Arnhem surveyed local residents to gather knowledge about the recent floods (MUN1, 2018; MUN2, 2018). In some neighbourhoods, active citizens also gathered knowledge from other residents that was then shared with public authorities (CAN1, 2018). In Molenbeke and Spijkerkwartier, there were resident-initiated surveys, with 120 responses received in Molenbeke, and door-to-door canvassing to understand the problems faced by residents (CAN1, 2018; MUN2, 2018; De Gelderlander, 2015). In addition to this knowledge-gathering role, citizens also played a knowledge-providing role by providing ideas and suggestions during the neighbourhood walks and for the Geitenkamp neighbourhood redevelopment. Overall, knowledge contributions were predominantly visual (photos and videos) and experiential knowledge from the flood events. While knowledge was gathered, no coordinated collection of quantitative data for experts to use was identified.

Advocacy

Many of the advocacy activities happened in the aftermath of the 2014 floods, with individual residents complaining of basement flooding to the municipality, police and fire service (MUN1, 2017; MUN2, 2018; Arnhem-North Pluvial Flooding Approach, 2015). The municipality tried to visit as many properties as possible to talk to residents about their flood damage and to suggest how to make repairs and prevent such damage in the future (MUN1, 2017). Citizens in Molenbeke were able to provide place-specific ideas directly to public authorities during the post-flood neighbourhood walks (CAN1, 2018). Citizens in Spijkerkwartier created an online flood platform to gather local ideas and opinions for pluvial FRM and to coordinate their efforts to influence authority approaches to FRM (MijnSpijkerkwartier, 2016). They also wrote an open letter to the city council (MijnSpijkerkwartier, 2015a) listing residents' expectations of the public authorities and demanding action. The Spijkerkwartier Floods (Wateroverlast Spijkerkwartier) group also encouraged fellow residents to meet and to attend a municipal council meeting together, as a way to 'strengthen their case' (MijnSpijkerkwartier, 2015b). This campaigning

role was strongest in the direct aftermath of the 2014 floods; there were no signs of it continuing in 2018–2019.

Citizens also took a role in increasing fellow citizens' awareness of flood risk and actions that can be taken. 'Climate carousels' were organized in the Klingelbeek neighbourhood by local residents. These were events where interested residents visited different local properties that showcased pluvial FRM measures:

The idea behind that [Climate Carousels] was that people like to peek at their neighbours' gardens, because we are all curious. And I think that [seeing the activities] really helped, because if you're saying that it's a really good example and it's on the other side of the city, just go and have look on your own, no one goes. But now we organize it really simply. ... We start at 3 PM, we end at 5 PM, then we also have a drink, and everybody's happy. ... People were really enthusiastic, and at every house the owner said something about what they did, why they did it, and also something about the costs. ... So that people really got an insight into what they could do for themselves and whether it's difficult to take action. (ACP1, 2018)

Similar activities were organized by Green Arnhem West in the form of 'morning walks'. The walks showcased examples of climate change adaptation measures (rain barrels, green roofs, etc.) that residents had installed on their properties and encouraged others to do the same:

I think showing good examples to neighbours is also very important. You see that my neighbour has this and this, I also want to do that. They have a green schoolyard, I also want a green schoolyard. That company has a green roof, I also want a green roof. (GRO1, 2018)

There were limited attempts to raise flood risk awareness, and nothing was identified relating to being ready to face (and cope with) an actual pluvial flood event. Furthermore, we identified no attempts to challenge the authorities' knowledge or to object to new development plans.

Authorities' interactions with and perceptions of citizen roles

Authorities' interactions with citizens

The interaction between public authorities and citizens in pluvial FRM in Arnhem happened at the initiation of both the municipality and the citizens.

First, public authorities took the lead in pluvial FRM in some instances and were therefore able to better control the scope, moments and methods of interaction with citizens (Edelenbos et al., 2017). In one case, the Municipality of Arnhem held consultation meetings with local residents on planned developments (MUN1, 2018). These meetings were initiated by the municipality to present options for the development (i.e. they had chosen to interact after the options had been chosen) and discuss the planned developments with residents. This form of relatively top-down consultation also served as a means of expectation management by the municipality: 'They [the residents] wanted everything. ... Then finally they came around to the fact that the municipality has limited resources and cannot do everything. ... Choices need to be made' (MUN1, 2017).

The Municipality of Arnhem also initiated interactions with residents as part of the Geitenkamp neighbourhood redevelopment, which aimed to replace the sewer network.

The project was authority-led, but the municipality aimed to improve the neighbourhood and to include opportunities for local residents to make suggestions to improve the redevelopments (MUN1, 2018; MUN2, 2018; MUN3, 2018). There was some existing mistrust of authorities in the neighbourhood (MUN1, 2017). Accordingly, the municipality decided to broaden its approach and find a different way to encourage residents to air grievances about their neighbourhood in general. The municipality hired comedians as intermediaries to knock on doors and ask local residents about their well-being and how they would like the neighbourhood to look. Thus, the Municipality of Arnhem attempted a more creative and dialogic approach to engage with local residents:

The first idea was just that they [the residents] could air their grievances, and then the second time it was to ask them what they'd like to change in the area. ... Although they are funny [the comedians], they collect stories, and these stories they use to 'tear down the wall' [between authorities and residents]. (MUN1, 2017)

As mentioned, the Municipality of Arnhem engaged in post-flood neighbourhood walks in the aftermath of the 2014 floods. Municipality officials circulated surveys in advance of these neighbourhood walks to identify flood-related problems and potential solutions (MUN1, 2017; MUN2, 2018). During the walks, officials discussed potential spatial and technical solutions with citizens, and later they used the information collected from discussions and surveys to create the Arnhem-North Pluvial Flooding Approach (2015), which was then used to deliver the final pluvial flooding action plan (MUN1, 2018; MUN2, 2018). However, contrary to municipality expectations, some residents appeared to be 'surprised and angry' that they were asked for solutions:

They [the residents] were angry that we [the municipality] asked for cooperation. We thought, well if we ask for cooperation, we get more ideas, because these people will know from the area probably more specific information than we have. ... But also people were surprised: 'Oh, that's not our problem. You should do something about it.' (MUN2, 2018)

The municipality also tried to incentivize and facilitate citizen action to reduce paving and increase greenery on private property. They participated in Operatie Steenbreek [Operation Stone-breaking], a national programme that encourages municipalities to work with garden centres; residents who remove their garden paving stones can exchange them for plants and greenery at the garden centres. This authority-initiated approach was not fully implemented in Arnhem: a free service took stones away, but no greenery was provided in exchange.

Second, citizens initiated FRM-related action and then interacted with public authorities for local FRM. For the green road parking areas, an agreement was reached between Green Arnhem West and the municipality, with the latter funding the installation (at €2,000) as part of a trial, with the intention of extending it to other neighbourhoods (Arnhem Klimaatbestendig, 2017a). However, there were also conflicts between citizen-initiated actions and authorities. The campaigning group in Spijkerkwartier complained of pluvial flooding in the aftermath of the 2014 floods (Mijnspijkerkwartier, 2015a, 2015b). These interactions were initiated by citizens, but required a response from the authorities, with the Municipality of Arnhem responding to the campaigning group and visiting individual residents to offer help. These interactions concerning the green road parking areas and campaigning groups appeared organically and unexpectedly, but also had the benefit of

being more adaptable and unconstrained by the administrative and legislative rules guiding public authorities.

These citizen-initiated activities had a snowballing effect, which led to more citizens taking action in pluvial FRM:

The more initiatives you have, the more I think there will be. Sort of like a snowball effect, because then we see, wow, in that neighbourhood they're all getting green roofs, and they're decoupling their houses, and I want to do that too. ... So I think [citizen action is] becoming more and more strong. (GRO1, 2018)

In the midst of these citizen-initiated actions, the municipality is in the process of reflecting on its existing role in local pluvial FRM. Interviewees from the umbrella organizations reported that different citizen initiatives working on FRM believed that the authorities should not fully withdraw from FRM, but should reflect on their position and on how to support citizen initiatives: 'The government is taking a step back, but they should look at what is the role of the government – how can they be helping while standing next to citizens?' (ACP1, 2018).

Authorities' perceptions of citizen roles and contributions

The research identified different perspectives held by authorities with regard to the emerging role of citizens in pluvial FRM. Policy documents and interviewees reported that the problem of pluvial flooding was so enormous that the municipality alone could not solve it (MUN2, 2018). Furthermore, representatives of the Municipality of Arnhem reported that the division of land ownership within the cities meant that other actors also needed to participate. In Arnhem North, only a small proportion of land is owned by the public sector: the private sector (including citizens) owns 93% (Arnhem-North Pluvial Flooding Approach, 2015). Authorities interviewed argued that they could not make significant changes to the privately owned land and that there was a need for the landowners to be more active (e.g. MUN2, 2018). The perception that landownership is important and thus citizen involvement is needed may be behind the authority-initiated interactions focusing on neighbourhood redevelopment, encouraging greening (e.g. Operatie Steenbreek), and supporting the replacement of pavement by green tiles (e.g. Green Arnhem West).

Policy documents and interviewees also indicated that cost-cutting was a reason for increasing citizen involvement (MUN1, 2018; MUN3, 2018; MUN2, 2018). The economic crisis affected pluvial FRM and led to a more 'sober approach' with repairing and replacing sewers of poor quality being prioritized (Municipality Sewerage Plan, 2015). As part of this, citizens are expected to take good care of their property and to take measures to reduce pluvial flooding if appropriate (Water Management Plan, 2015).

Willingness and ability of citizens

In Arnhem, there is a risk in expecting different citizens to all be willing and able to contribute to local pluvial FRM in a similar way. There was a variation in the neighbourhoods with some having active and capable citizens who were willing and able to contribute to local pluvial FRM, while in others this did not happen (MUN1, 2018; MUN3, 2018; MUN2, 2018; CAN1, 2018; ACP1, 2018; GRO1, 2018). In some cases, citizens were interested in coming together at certain moments for small festivities (e.g. Easter

and New Year's drinks), but not in coming together consistently to take part in sustained action for pluvial FRM (ACP1, 2018). Some citizens were annoyed at being asked for solutions; they believed that it was the municipality's problem, not theirs (MUN2, 2018): 'The information from the citizens is very useful and important, and we use that information, but after that, they think, "I told you, it's your problem"' (MUN3, 2018).

Willingness to contribute can also be tightly connected to the ability to contribute. In Geitenkamp, when the comedians engaged with residents, they were not always successful, with some residents having more pressing issues in terms of 'getting through the week' and also having negative feelings towards the municipality, which limited their participation in FRM actions (MUN1, 2018). The incentivization of action through Operatie Steenbreek in Arnhem was not considered a success; very few citizens chose to get involved. They may have not known about the scheme, or may have chosen not to take action (MUN3, 2018). Also, urban greening is not always an option; some citizens are renting their home and cannot change their garden, so they are excluded (MUN3, 2018). However, the presence of residents with relevant expertise and a strong connection to the neighbourhood, besides making contributing 'fun' for citizens, can lead to more 'fertile grounds for [citizens] starting new projects' and being willing to contribute (ACP1, 2018; GRO1, 2018).

The growing expectation of greater citizen contributions to pluvial FRM needs to be coupled with an understanding that there will be variations in their willingness and ability to do so.

Insights beyond Arnhem

We focused on the city of Arnhem, but there are potential lessons for other urban contexts that traditionally also have a strong reliance on public authorities for FRM. The findings from the Arnhem case could be relevant to other contexts where citizen engagement complements formal urban planning and water management arrangements. For example, citizens in these contexts may be annoyed or unwilling to contribute to FRM as they may consider it to be solely a government responsibility. It can be recommended that public authorities first explore the local flood experiences of those affected (as in the post-flood walks in Arnhem) and then seek to identify and support the ideas and initiatives of local citizens, to encourage them to take on different roles and responsibilities in pluvial FRM. Furthermore, the creative and interactive approaches used in Arnhem to engage citizens in pluvial FRM can also be applied to other similar contexts.

The typology developed in this article (Table 1) has value beyond the Arnhem case in the identification of potential citizen roles and contributions in local pluvial FRM. It can also be used as a tool for encouraging a diverse range of citizen contributions in cities facing similar pluvial flooding problems as Arnhem. Our findings also provide insights for cities aiming to increase citizen engagement around other forms of flooding. For example, the insight that citizens have a relevant role in showcasing and increasing awareness of potential citizen FRM actions could be valuable in the context of fluvial FRM, where public authorities are seeing low citizen uptake of property-level protection and flood-proofing of homes. The knowledge-gatherer and knowledge-verifier roles identified here could

also help public authorities better understand the nature and challenges of other forms of hazard events they are experiencing for the first time.

Conclusions

This article focused on the emerging role of citizens in local pluvial FRM in the Netherlands. Traditionally, citizen flood risk awareness in the Netherlands has been low (Hegger et al., 2017; Terpstra & Gutteling, 2008; Wehn et al., 2015), and this, together with pluvial flooding being seen as a 'water nuisance' and not a disaster, has led to limited citizen involvement in pluvial FRM. However, recent pluvial flood events and predictions of more extreme rainfall in the Netherlands have led to more attention to pluvial FRM, and in particular to the potential role of citizens.

This article contributes to wider FRM discussions by exploring the emerging roles and contributions of citizens in local pluvial FRM in the Netherlands. A typology based on the literature (physical action and resources; knowledge; advocacy activities) was developed to identify and analyze citizen contributions. Citizens contributed to physical action and resources with flood risk mitigation roles, although we did not see them playing a role in flood consequence reduction, which is an important part of flood resilience. Furthermore, knowledge gatherer, knowledge disseminator and knowledge verifier were prominent roles undertaken by citizens. They also played advocacy roles, although these were time-dependent and faded as time passed after the flood. An emergent approach to the data analysis enabled the identification of two further citizen roles that were not initially captured by the typology: showcasing (acting as trusted sources of knowledge and advocates for forms of property-level pluvial FRM) and experimenting (trying small-scale forms of pluvial FRM and taking risks that authorities could not take themselves).

The findings are also relevant in the context of public authorities trying to define a new role for themselves in the changing FRM landscape. We analyzed discussions of public authorities' interactions with and perceptions of the emerging citizen initiatives in FRM, which are closely connected to this challenge of defining their new role. Traditional, authority-initiated consultations were identified, where the authorities were able to control the scope, means and methods of interaction. However, more dialogic approaches were also found, where innovative practices (including the involvement of comedians) were used to encourage citizens to get involved in FRM and share their ideas.

The insights from Arnhem may act as inspiration for other urban contexts with a strong reliance on the government for FRM, and the typology developed here could be relevant for exploring and better understanding potential citizen roles in pluvial FRM and beyond. Authorities can create a dialogical space for citizen action, which complements traditional public authority roles. This allows space for the self-initiation of activities and visible actions by citizens that contribute to pluvial FRM and flood resilience. However, the willingness and ability of citizens to engage in pluvial FRM initiatives are both concerns that public authorities need to consider when embracing the approach where citizens have a greater role in FRM. Therefore, our research suggests that public authorities need to provide a space for citizens to play a supplementary role in local pluvial FRM and at the same time take into account variations in citizens' willingness and ability to contribute to local pluvial FRM and flood resilience.

Notes

1. This article follows recent work (e.g. Schanze, 2018) in understanding 'pluvial flooding' as related to heavy rainfall at the local level with no direct relation to the main river networks, as opposed to 'flash floods', which relate heavy rainfall to river networks and cover a larger spatial scale.
2. For example, <https://overstroomik.nl/> shows how high the water can get in your neighbourhood.
3. The AANjaagfonds scheme was set up by a group of residents to support citizen initiatives in Arnhem and funded by the European Regional Development Fund (Aanjaagfonds, 2018).
4. Named after the Arnhem area's telephone code (026).

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Appendix Overview of key documents referenced in the paper.

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