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Resilience through placemaking: Public spaces in Rotterdam's climate adaptation approach

Discussion Paper, No. 1/2021

Provided in Cooperation with:
German Institute of Development and Sustainability (IDOS), Bonn

Suggested Citation: Peinhardt, Katherine (2021) : Resilience through placemaking: Public spaces in Rotterdam's climate adaptation approach, Discussion Paper, No. 1/2021, ISBN 978-3-96021-138-9, Deutsches Institut für Entwicklungspolitik (DIE), Bonn, https://doi.org/10.23661/dp1.2021

This Version is available at:
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Discussion Paper 1/2021

Resilience through Placemaking: Public Spaces in Rotterdam's Climate Adaptation Approach

Katherine Peinhardt

Unterstützt von / Supported by

Alexander von Humboldt Stiftung / Foundation

Resilience through placemaking: Public spaces in Rotterdam's climate adaptation approach

Katherine Peinhardt

Bonn 2021

Discussion Paper / Deutsches Institut für Entwicklungspolitik
ISSN (Print) 1860-0441
ISSN (Online) 2512-8698

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Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://dnb.d-nb.de abrufbar.
The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data is available on the Internet at http://dnb.d-nb.de.

ISBN 978-3-96021-138-9 (printed edition)

DOI:10.23661/dp1.2021

Printed on eco-friendly, certified paper

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This research is the outcome of a German Chancellor Fellowship (Bundeskanzlerstipendium), as supported by the Alexander von Humboldt Foundation

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Abstract

Urban public spaces are an opportunity for comprehensive climate adaptation and improved resilience. As a key part of a city's physical infrastructure, it has long been clear that public spaces can be physically reinforced to absorb or weather the shocks of the climate crisis. As a result, many public spaces are designed to materially resist local impacts of the climate crisis, but fewer have seen efforts to harness their potential for improving social resilience. It is increasingly clear that the unique role of public spaces in civic life positions them to enhance not only physical resilience, but also to support the types of interpersonal connections essential to addressing shared challenges like the climate crisis. Through a "placemaking" approach, both of these goals can be layered into a single space: meaning that public spaces not only protect people from climate hazards, but also provide socially vibrant places and contribute to social cohesion.

As climate-adaptation plans become more widespread in cities across the globe, innovators such as the City of Rotterdam are leading the way by incorporating public spaces into their strategy. The most prominent example of this change is *Waterplein Benthemplein*, an early example of a "water square", which absorbs excess stormwater while providing public space. This paper, based on a paradigmatic case study, examines the policy context for Rotterdam with regard to public spaces, climate adaptation, and long-standing practices around water management. It continues with an observational analysis of Waterplein Benthemplein, which provides best practices of, and potential pitfalls for, public space projects aimed at adaptation and/or resilience building.

To successfully work towards a resilient public realm, cities must evolve their practice relating to public spaces in four areas: the ways public spaces are subject to the outcomes of community engagement, and how public spaces are designed, programmed and managed. With these four areas in mind, Waterplein Benthemplein marks a paradigm shift for the inclusion of a public space in urban climate adaptation. In practice, the water square has seen mixed success: on the level of physical resilience building, its strengths are in its design and amenities, and when speaking of social resilience, the square is most effective in its programming and use. Meanwhile, the square has opportunities to be enhanced through climate-informed community outreach, improved and specialised management practices, and accessibility, among other efforts. The City of Rotterdam has continued to change its approach to both public spaces and climate adaptation – serving as a continually evolving example for cities facing climate hazards, particularly those facing hydrological risks.

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Abbreviations

KNMI	Royal Meteorological Institute of the Netherlands
IPCC	Intergovernmental Panel on Climate Change
R2C	Right to Challenge programme
ZoHo	Zomerhofkwartier (Neighbourhood)

Executive summary

Climate adaptation is an urgent imperative for cities, where the density of people and assets amplify the impact of events such as flooding, heat waves, and other life-threatening climate hazards. As cities begin to chart a map for climate adaptation, it is increasingly apparent that the way communities are designed, and how their public spaces are used, can be a factor in how well they adapt in an era of climate change. Precisely because they are a part of the physical landscape of a city, public spaces are often seen as opportunities to enhance **physical resilience** to climate change. But an often-overlooked chance for public spaces to help cities adapt lies in their ability to support **social resilience**. Many public spaces are designed to materially resist local impacts of the climate crisis, but fewer have seen efforts to harness their potential for improving social resilience. Nonetheless, it is increasingly clear that the unique role of public spaces in civic life means that they can support the types of interpersonal connections essential to addressing shared challenges such as the climate crisis.

In the process of climate adaptation, public spaces are uniquely positioned to be sources of both physical and social resilience by juxtaposing physical features designed to tangibly prepare an area for the impact of climate hazards with considerations for the building of social cohesion. Both of these qualities can be simultaneously enhanced through the lens of *placemaking,* a movement that promotes highly sociable, accessible public spaces that are created based on the vision of the broader community.

Innovators such as the City of Rotterdam are leading the way on the placemaking front, taking action to incorporate public spaces into municipal climate-adaptation strategies. The most prominent example of this change is Rotterdam's *Waterplein Benthemplein,* an early example of the "water square" model of a public space that absorbs excess stormwater. This paper includes a new conceptual framework for social and physical resilience in public spaces. To meaningfully apply this framework to Rotterdam and its water square, the paper also outlines the policy context for Rotterdam with regard to public space and climate adaptation, which informs an observation-based analysis of the performance of the space. This analysis, based on fieldwork and interviews, informs broader insights into best practices in enhancing climate resilience through public spaces.

This study finds that Waterplein Benthemplein in Rotterdam performs with mixed success in metrics of physical and social resilience; nonetheless, it demonstrates the value of layering the two in the context of the public realm. The square's strengths in physical resilience building lie in choices made around design and amenities, and in measures of social resilience the square performs best on metrics of programming and use. Opportunities for comprehensive resilience efforts still remain in Rotterdam's wider approaches to community engagement, programming, and management practices in the square.

More specifically, efforts in public-space-based climate resilience could be strengthened by implementing the following four recommendations:

- further development of climate risk-informed community outreach
- ongoing monitoring of climate-resilient public spaces and consistent implementation of specialised management techniques in water squares

- creation of programming sensitive to climate hazards such as heat
- improvements to accessibility in public spaces.

These takeaways and recommendations offer insights not only for Rotterdam's situation, but also for any community working on climate adaptation or on projects relating to public space. Rotterdam's outcomes show clearly that public spaces can both enhance and be enhanced by climate-resilience strategies, while offering an early set of best practices for effectively making this connection.

Just as the City of Rotterdam has continually adjusted its approach to designing and managing climate-resilient public spaces, other communities can learn from the successes and challenges observed in *Waterplein Benthemplein*. The City of Rotterdam serves as a continually evolving example for cities working toward a more comprehensive and socially sensitive approach to climate adaptation, with outcomes and lessons learned that are particularly useful to cities in coastal or riverine environments. But just as no two public spaces are alike, no two communities will have the same approach to climate-resilient public spaces, meaning that Rotterdam's approach is informative, but not prescriptive. Even so, the concept of harnessing public spaces as an opportunity for enhanced physical and social resilience is one that can be applied to the adaptation plans of cities around the world.

1 Introduction

The concept of public space as a building block for *physical* resilience to climate change has emerged as a topic of research in recent years. However, the concept of *social* resilience to climate change as cultivated in, and supported by, public spaces has received far less attention. Public spaces bridge the gap between physical and social resilience in that they are both opportunities for spatial interventions to prepare cities to face climate hazards, and also highly social places where much of public life as we know it takes place. It follows that public spaces can be a part of comprehensive resilience building and climate adaptation at the city level. But thus far this opportunity has been under-recognised.

Cities face unique climate hazards. Their density and agglomeration of infrastructure make them highly vulnerable to the impacts of the climate crisis – but these traits also give rise to unique opportunities such as resilience building through public spaces. Port and coastal cities, in particular, are some of the most visibly impacted places in a warming climate. Approximately 800 million people live in coastal cities that are projected to experience sea level rise of up to 0.5 meters by 2050, where the current pattern of urbanisation "not only concentrates people and property in areas of potential damage and disruption, it also exacerbates those risks – for example by destroying natural sources of resilience such as coastal mangroves and increasing the strain on groundwater reserves" (World Economic Forum, 2019, p. 7). This concept of urban climate vulnerability has been well-explored in other research. It is clear that both slow-onset and more acute climate-change impacts will deeply impact both the physical and social landscape of cities:

> In urban areas climate change is projected to increase risks for people, assets, economies and ecosystems, including risks from heat stress, storms and extreme precipitation, inland and coastal flooding, landslides, air pollution, drought, water scarcity, sea level rise and storm surges. These risks are amplified for those lacking essential infrastructure and services or living in exposed areas. (IPCC, 2014)

As a response, climate adaptation is a growing field of research and practice, including in urban settings.

In creating climate adaptation strategies, many cities aim to keep abreast of current and future climate hazards – perhaps most apparently in cities facing coastal or broadly water-related risks. Coastal and river cities like Rotterdam have long adapted to hydrological risks, which are now exacerbated by climate breakdown – hazards such as increased precipitation, drought, coastal flooding, subsidence and storm surges. Due to its physical landscape, Rotterdam has long been a leader in urban water management, adapting to local hydrological hazards through a network of flood control measures. Building on this history of water management innovation, the City of Rotterdam has updated these strategies to suit its particular climate hazards (Rotterdam Climate Initiative, 2013). Moving forward with evolving climate-adaptation strategies, Rotterdam's approach increasingly acknowledges a broader range of climate hazards. But for the purposes of this research paper, what is perhaps most worthy of note is that in recent years Rotterdam's climate-adaptation strategies directly acknowledge the role of public space. Rotterdam is now an innovator in this arena, incorporating the public realm into its ever-evolving adaptation strategies at the municipal scale.

In part because of actions taken in cities like Rotterdam, urban climate adaptation and resilience have both emerged as topics of lengthy discussion in recent years. But even as the

body of research around adaptation grows, and its implementation evolves into a more formalised community of practice (IPCC, 2014, p. 8), adaptation plans often fail to incorporate adequate considerations for the resilience-building value of social ties. In other words, social resilience merits further exploration in the urban climate-adaptation narrative. This case study-based paper makes new connections between climate adaptation and public spaces through the dual lens of physical and social resilience. This work is timely in that the linking of climate resilience as it pertains to public space (including the processes of community outreach/engagement, design and amenities, management, and programming and use) is in its early stages, both in research and in policy and practice.

This discussion paper breaks down the barriers between climate adaptation and practice in the arena of public space, creating a new conceptual framework for social and physical resilience in the public realm. By examining adaptation within the context of a public space in Rotterdam, the analytical approach to this paper aims to explore resilience metrics as layered into the various areas of practice relating to public space: community engagement, design and amenities, programming and use, and management. The aim of this paper is to examine how a juxtaposition of physical resilience and social resilience can best be implemented – reinforcing the ability of the public realm to physically weather hazards induced by climate change, while also enhancing it as a foundation of social activity in a community. This novel framework and its metrics for physical and social resilience can be applied and adapted for use in any public space, in that they provide a set of concrete, but adaptable, measures by which communities, including in developing and emerging economies, can inform or evaluate their progress on using their public spaces to support climate adaptation and resilience.

This paper examines the best practices to adopt to ensure that public spaces enhance both physical and social resilience to climate change. The paper describes a new framework for measuring physical and social resilience in public spaces. It applies this framework to a paradigmatic case study in Rotterdam's Waterplein Benthemplein water square, examining how public spaces are being included in broader urban climate-adaptation policy, while examining strategies used to enhance physical and social resilience through public space. This case study-based paper extracts approaches, challenges, and barriers to an approach to climate resilience and adaptation with a focus on public spaces from a city considered to be a forerunner in the field. It will also discuss to what extent and how other cities can learn from Rotterdam's outcomes.

This paper is structured as follows. First, a literature review lays the groundwork for this study of Rotterdam's Waterplein Benthemplein, with sub-sections on the state of policy and practice around urban climate adaptation, public spaces, and the concepts of physical and social resilience as related to the public realm. The following section comprises an analytical framework, which outlines two complementary sets of metrics (physical resilience and social resilience) for evaluating resilience and climate-adaptation efforts focused on public spaces. A methodological framework section follows, which has three sub-sections: the first explains the choice of case study; the second highlights observational techniques used in this particular paper; and the third details outreach-based techniques. After this, the case study section includes sub-sections about the background of Waterplein Benthemplein, and an overview of Rotterdam's landscape of climate risks and of local policies that govern public spaces and climate adaptation. The following section outlines empirical findings and observations of the water square. These findings are divided into sub-sections based on the

areas of practice outlined in the literature review: community engagement, design and amenities, programming and use, and management. The discussion section contains the resulting analysis of the aforementioned empirical findings, with two sub-sections based on the two sets of metrics outlined in the analytical framework section. The paper ends with sections that provide recommendations and conclusions, including broader messages around the applicability of this framework to other communities.

2 Literature review

Public spaces can be a link for physical and social resilience in the face of climate change, and an opportunity for people-centred climate adaptation. But to understand how public spaces can be integrated into urban climate adaptation and resilience efforts, an exploration of the state of play in climate adaptation, the value of public spaces, and the standards applied to the way they are created and managed is required. Accordingly, this literature review examines the following: urban climate adaptation and resilience (2.1); physical and social resilience and how they relate to public space (2.2); and practices relating to public spaces in a broader sense (2.3).

These concepts, and the increasingly apparent relationships between them, are then translated in Section 3, as part of the Analytical Framework, into two sets of metrics (physical resilience and social resilience), which are applied to the case study of Rotterdam.

Box 1: Guiding definitions

Climate adaptation "practices refer to actual adjustments, or changes in decision environments, which might ultimately enhance resilience or reduce vulnerability to observed or expected changes in climate" (Adger et al., 2007, p. 720). Adaptive ability intersects with the capacity for reflexivity, which

> refers to the ability of actors and institutions to critically reflect on their own performance (especially their environmental impacts), and to reshape their goals, practices and values accordingly in order to wisely navigate complex, contested and changing human–environmental systems (Earth Systems Governance, 2018, p. 68).

Disaster risk, as defined by the IPCC, "signifies the possibility of adverse effects in the future [deriving] from the interaction of social and environmental processes, from the combination of physical hazards and the vulnerabilities of exposed elements" (Cardona et al., p. 68).

Hazards, as defined by the IPCC, "refer to the possible, future occurrence of natural or human-induced physical events that may have adverse effects on vulnerable and exposed elements" (Cardona et al., p. 68).

Heat hazards refer to temperature-related impacts on places and people, and includes, among other things, heat waves and heat stress/thermal discomfort.

Hydrological hazards that affect cities and their public spaces include **flooding** (i.e. coastal), and severe **stormwater runoff.**

Placemaking is defined by Project for Public Spaces as

> a collaborative process by which we can shape our public realm in order to maximise shared value […] [facilitating] creative patterns of use, paying particular attention to the physical, cultural, and social identities that define a place and support its ongoing evolution. (Project for Public Spaces, "What is Placemaking?")

Placemaking, as a movement within the urbanism community, is a human-centred practice based on creating places that reflect the vision of the community (Project for Public Spaces, "What is Placemaking?").

Box 2 (cont.): Guiding definitions

Public space is

> an area or place that is open and accessible to all peoples, regardless of gender, race, ethnicity, age or socio-economic level. These are public gathering spaces such as plazas, squares and parks. Connecting spaces, such as sidewalks and streets, are also public spaces […] Well-designed and maintained public space is critical to the health of any city. Such gathering spaces allow for social mixing, civic participation, recreation, and a sense of belonging. (UNESCO, "Inclusion through access to public spaces")

Features like openness, connectivity, inclusion, and accessibility, however, are not a given, and depend heavily on the way the public space is designed and managed.

Project for Public Spaces is a non-profit organisation that advocates for and implements placemaking projects in collaboration with communities around the world.

Social capital

> refers to the productive value of social connections, where productive is here understood not only in the narrow sense of the production of market goods and services […] but in terms of the production of a broad range of well-being outcomes (Scrivens & Smith, 2013, p. 9).

Alternatively, social capital can be conceptualised as "a person's or group's sympathy toward another person or group that may produce a potential benefit, advantage, and preferential treatment for another person or group of persons beyond that expected in an exchange relationship" (Robison et al., 2002, p. 19). Social capital can be supported by social infrastructure (below).

Social cohesion includes, among other foundational factors such as common values and civic culture, domains such as social networks/capital and place attachment and identity. Respectively, these correspond with social interaction and civic engagement, and the "intertwining of personal and place identity" (Forrest & Kearns, 2001, pp. 2127-2129).

Social infrastructure, which can take the form of public space, is what supports the creation of social capital.

> Social infrastructure is not 'social capital' – a concept commonly used to measure people's relationships and interpersonal networks – but the physical conditions that determine whether social capital develops […] People forge bonds in places that have healthy social infrastructures – not because they set out to build community, but because when people engage in sustained, recurrent interaction, particularly while doing things they enjoy, relationships inevitably grow (Klinenberg, 2018, pp. 4-5).

Social resilience is most simply outlined by some as the "capacity to respond" to a given change, and can be summed up by a combination of "persistability, adaptability, and transformability". In other words, social resilience is an iterative process, exemplified by "coping with future crises by learning, through undergoing shocks and distress, about which actions are more or less appropriate in the context of uncertainties" (Keck & Sakdapolrak, 2013). It is enhanced by social cohesion, which is heavily dependent upon social capital and social infrastructure (see above).

Urban resilience (here standing for **physical resilience**) is the "ability of a city to absorb disturbance and recover its functions after a disturbance" (Tromeur, Menard, Bailly, & Soulie, 2012).

Vulnerability, as defined by the IPCC, is "the propensity of exposed elements such as human beings, their livelihoods, and assets to suffer adverse effects when impacted by hazard events" (Cardona et al., p. 68).

Source: Author

2.1 Urban climate adaptation and resilience

For the purposes of the climate-adaptation focus of this paper, "**adaptation** practices refer to actual adjustments, or changes in decision environments, which might ultimately enhance resilience or reduce vulnerability to observed or expected changes in climate" (Adger et al.,

2007, p. 720). Adaptation centres on systems, environments, and people being able to weather shocks through advance preparation; it is, and has long been, carried out in both formal and informal ways, ranging from the personal to the institutional and policy level. Today, adaptation is increasingly seen as an urgent and necessary addition to ongoing work in the realm of climate mitigation, in order to avoid widespread loss of lives and livelihoods, in addition to the breakdown of ecosystems and economic damages (Global Commission on Adaptation, 2019, pp. 2-3).

When compared to mitigation, climate adaptation is a comparatively novel field of research and formalised practice. Nonetheless, the clear scientific consensus around the hazards posed by the climate crisis has elevated adaptation as a priority of international climate governance. Since the 2007 Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC), adaptation has been seen as a vital part of climate negotiations, receiving attention through the creation of an Adaptation Fund and the adoption of the 2010 Cancun Adaptation Framework. Though mitigation remains a more visible priority in terms of global policy, adaptation is increasingly seen as a critical imperative (Bulkeley & Tuts, 2013, p. 646). Adaptation has received steadily growing attention in climate publications, including adaptation- and vulnerability-themed reports released by the Intergovernmental Panel on Climate Change (IPCC), which, since 2014, has been increasingly focused on a risk-sensitive approach to adaptation (IPCC, 2014, p. 4). But because adaptation is in its early days, existing planning tends to be heavily focused on "predict and prevent" paradigms. This approach leads to practices that are not comprehensive, and leave little flexibility to adapt to unexpected climate events or engage in a learning process that adjusts to changing local impacts (Tyler & Moench, 2012, p. 312).

At the scale of cities, it is increasingly clear that climate adaptation must be an urgent priority. Coastal cities face a unique level of risk in terms of hazards such as rising sea level and intensified storm surges, which already displace people, and will continue to do so, and may accrue a projected annual cost of more than $1 trillion by 2050 (Global Commission on Adaptation, 2019, pp. 2-3). As adaptation grows as an "institutionalised field of action", various cities of differing development status are taking a wide range of approaches to include it in their respective climate plans (Anguelovski & Carmin, 2011, pp. 1-2). Many cities have been building up their strategies to adapt and respond to climate change since the 1990s, efforts that are increasingly being recognised by the international climate governance community (Bulkeley & Tuts, 2013, p. 647). In doing so, intergovernmental climate bodies such as the IPCC also note that the landscape of climate risk in cities is uneven, implying that challenges to adaptation can be exacerbated by inadequate infrastructure, housing, and service provision. Resilient infrastructure, supported by improved policies and capacity for participatory community-scale adaptation, can reduce these vulnerabilities (IPCC, 2014, p. 18).

But adaptation policy and practice has yet to mainstream considerations for public spaces, both at the scale of international policy and at the local level. In terms of linking public spaces to climate-adaptation efforts, few international climate-adaptation strategies mention public spaces – and when they do, the narrative focuses primarily on physical protection, and not on the social benefits of shared spaces. Documents such as the IPCC's *Fifth Assessment Report on Climate Change 2014: Impacts, Adaptation, and Vulnerability* mention green spaces (which may include public spaces), but the description of their value, in the context of the report, is often limited to ecosystem services. In terms of urban planning

choices that can affect adaptation, the report highlights the importance of adequate infrastructure and services, which could be argued to (non-explicitly) include provision of access to public space. Mentions of "social safety nets" and "reliance on social networks" focus mainly on livelihood security, distribution of food and water, emergency care, and public health measures, with little mention of the shared spaces that make these types of collaborative relief efforts possible. "Place-specific" adaptation strategies, as well as the potential for co-benefits for social well-being, are highlighted as a guiding approach for adaptation practice (IPCC, 2014, pp. 27, 25), but all in all, public space remains at the periphery of climate-adaptive strategy.

One step toward linking urban adaptation and sustainability with public spaces comes in the form of the 2016 New Urban Agenda, which provides a deeper dive into sustainable cities, informing the implementation of city-focused Sustainable Development Goal 11. The agenda, which resulted from discussions at the Habitat III conference, emphasises the importance of green public spaces, coupled with adaptation as implemented through urban planning and choices around infrastructure (United Nations, 2016). Policy papers that, like the New Urban Agenda, emerged from Habitat III, recommended that national urban policies advance the "creation, protection and management of public space as a means to generate wealth, improve well-being and advance urban productivity". Habitat III and the resulting New Urban Agenda and policy papers also recognised the complexity of public space planning and management, acknowledging the role of gender dynamics in public spaces, as well as issues of accessibility and inclusion (United Nations, 2017, p. 28). International urban development paradigms are beginning to feature the connections between the concepts of public space and sustainability.

Meanwhile, existing thought leadership on climate adaptation is still in the early stages of meaningfully incorporating strategies based on public space. Reports such as the Global Commission on Adaptation's flagship report *Adapt now: A global call for leadership on climate resilience* emphasise that avoiding losses is the most widespread motivation for investing in adaptation efforts. Nonetheless, the report outlines the importance of a more comprehensive view of adaptation that includes social outcomes and centres on people. To do so, the report shows adaptation as a tripartite opportunity, offering avoided losses, economic benefits through risk reduction, and social/environmental benefits. Of potential relevance to public spaces are the report's suggestions for nature-based solutions, green infrastructure, climate-resilient design, and water-management strategies, paired with the report's emphasis that "hard" infrastructural solutions alone are not the answer. Public spaces such as roads, community gardens, and "green spaces in cities" are explicitly mentioned in the report, and are portrayed as opportunities to reduce urban heat and manage water. The report highlights that Rotterdam's green spaces improve "community cohesion and quality of life", in addition to controlling flooding, while the Netherlands' "Room for the River" project helped control flooding while offering the chance to create new parks and recreational spaces. Accordingly, the report predicts social benefits (which could be argued to include space for recreation and access to parks) to be among the earliest to accrue from adaptation projects, regardless of the environmental outcomes. The document shows that adaptation has evolved to increasingly recognise the simultaneous opportunity to address social issues while building up climate resilience, including improvement of the public realm (Global Commission on Adaptation, 2019, pp. 4, 6, 12, 14, 37). Through recent thought leadership such as this, the proverbial stage is set for public space to feature as part

of climate-adaptation strategies, but its substantial potential remains beyond the scope of mainstream research and practice.

A lack of standards and norms for formalised urban adaptation planning means that the field is fairly flexible and, thus far, tailored to the broader agendas of a given implementing city (Anguelovski & Carmin, 2011, pp. 1-2). So far, many cities take action based on the use of risk and vulnerability assessments, which may be targeted at specific threats or sectors, such as biodiversity or infrastructure. Adaptation action often either starts with a dedicated strategy, or with the incorporation of adaptation into other sector-focused plans, such as those for transport or infrastructure. Initial actions are often followed by some level of formalisation, often through the formation of dedicated climate units either within existing departments or as a cross-department initiative (Anguelovski & Carmin, 2011, pp. 1-2; Archer et al., 2014, p. 345). As a result, adaptation planning varies widely across cities, often due to differing combinations of three variables: the qualities and priorities of local stakeholders, institutional structures and precedents, and the natural and socioeconomic landscape of a given place (Lehmann, Brenck, Gebhardt, Schaller, & Sußbauer, 2013, p. 80).

Current adaptation plans also exist at the mercy of climate impacts that carry a significant degree of unpredictability or variability, which means that at the local scale, planners can face challenges in identifying adaptation priorities (Tyler & Moench, 2012, p. 312). These uncertainties, along with the relative novelty of this community of practice, means that adaptation planning remains primed for innovation, which has perhaps already begun on a targeted scale. Practices such as flood management are shifting to be more risk-informed and adaptive. Promisingly, communities of practice around the adaptation and/or the management of particular risks such as floods appear to be adopting more integrated and less reactive approaches (Ward, Pauw, van Buuren, & Marfai, 2013, p. 532). But beyond this, the field of adaptation could further incorporate strategies based on public spaces.

Meanwhile, new paradigms are emerging that offer promise in moving towards more socially oriented adaptation practice. To start with, participatory approaches are acknowledged as key to effective climate adaptation (Global Commission on Adaptation, 2019, p. 5). At the same time, **community-based adaptation**, or CBA, is a relatively new model for institutionalising participatory approaches within the adaptation planning process. This community-based adaptation model can be mobilised to address the existing gaps in governance, filling in for inadequate regulatory policy (i.e. building codes), emergency preparedness, insurance infrastructure, and financial and legal systems (Archer et al., 2014, p. 345). This multilevel model for governance is aimed specifically at supporting the vulnerable members of a community, which here refers to "residents of a particular area who are vulnerable to similar climate impacts". Depending on the existing governance structures in a given place, community-based adaptation can be framed as either an integral new part to, or a way to deconstruct, the existing systems governing adaptation efforts (Archer et al., 2014, p. 346). Despite this movement towards more inclusive models of urban climate adaptation, a gap remains in terms of linking this progress to public spaces.

Promisingly, some cities have begun to put the connection between public space and climate adaptation into action via public space projects or mentions of public space in adaptation strategy documents. For example, Ahmedabad, India has incorporated protocols for public spaces, such as parks in their Heat Action Plan (NRDC, 2018). Other cities, such as Copenhagen and Rotterdam, have made plans to adapt public spaces to climate change,

using parks as simultaneous opportunities for stormwater management and recreation (Københavns Kommune, 2011, p. 11). These forerunners show the possibilities for an emerging trend of cities recognising public space as an asset in their plans for climate adaptation. But as a general rule, we are still in the early days of public spaces being formally leveraged as supporting spaces for urban adaptation paradigms and enhanced resilience to the impacts of climate change.

2.3 Physical and social resilience and public spaces

Because the paradigm of urban resilience is, thus far, generally focused on physical phenomena, physical resilience as it is implemented in cities generally bears a similar definition to **urban resilience**, more broadly. The latter can be summed up as the "ability of a city to absorb disturbance and recover its functions after a disturbance" (Tromeur et al., 2012). It follows that **physical resilience** in cities usually refers to the ability to materially withstand or lessen the impact of hazards, often through changes to infrastructure and/or design.

Much of contemporary resilience planning is focused primarily on "hard" physical strategies such as the building of sea walls, and nature-based or "green" strategies such as the construction of bioswales, leaving out socially oriented strategies that could, in combination with these other approaches, strengthen the ability of a given community to adapt to climate change. Surprisingly, the social aspects of resilience are often overlooked in the realm of public space:

> Place-based approaches to community resilience are often related to the local techno-physical conditions of public space. The function of public space as a place which encourages social contact receives more recognition when it comes to addressing urban development challenges in general. (Ley, 2019, p. 168)

Although it is often the case that "engineered and technological options" are employed as adaptation strategies, and are often linked to disaster risk and water management paradigms, the clarity of the relationship of adaptation to social outcomes is growing (IPCC, 2014, p. 8). This opportunity is quite often overlooked, but promising new approaches to adaptation recognise the role of social capital as a vital ingredient in well-rounded adaptation and resilience practice – a first step toward including public spaces in adaptation strategies (World Economic Forum, 2019, p. 7).

Social resilience is outlined as the "capacity to respond" to a given change, and can be summed up by a combination of "persistability, adaptability, and transformability" (Keck & Sakdapolrak, 2013). It is a "people-centred concept which encompasses coping, adapting, and the transformative capacities required to face the effects of a variety of shocks and times of stress" (Ley, 2019, p. 167). In other words, social resilience is an iterative process, exemplified by the agents and institutions involved in adaptation efforts continuously demonstrating responsiveness, resourcefulness, and capacity to change course and learn (Tyler & Moench, 2012, p. 316).

Sociologists like Klinenberg note that to understand the resilience of a community in the face of a crisis or disaster, research is needed that is more contextual and place-based,

involving deep community engagement and broad fieldwork. This type of work must examine

> community-level practices that fall outside the scope of quantitative studies – such as the ways in which residents use sidewalks and public spaces, the role of commercial outlets in stimulating social contact, the strategies through which residents protect themselves from local dangers, and the role of community organisations and institutions in providing social protection. (Klinenberg, 2015, pp. 85-86)

The social aspects of resilience building that public spaces provide are less concrete than the physical aspects of resilience, which means that, by nature, they are harder to measure. It follows that the underpinning behaviours for social resilience – those that lead to collaboration in times of need – are still under-represented in the narrative around what role public spaces can play in terms of building climate resilience.

Social resilience is crucial to adaptation because

> formal and informal ties coordinate action and diffuse information among citizens and policymakers as they seek to solve social problems. While most recognise the value of social networks in our everyday lives, disaster recovery policies often overlook and at times upset these resources in their efforts to deliver necessary physical and material aid to victims. (Aldrich, 2010, p. 2)

It is **social infrastructure**, and the **social capital** (see Box 1) it supports, that provide the foundations for collective recovery – creating crucial and fast-acting "informal insurance" among members of a community. As a result, "communities with more trust, civic engagement, and stronger networks can better bounce back after a crisis than fragmented, isolated ones" (Aldrich, 2010, p. 4). These types of resilience-boosting connections and networks are not only important within communities, but can also be fostered on a "translocal" scale. "Locally rooted and internationally networked" approaches to community challenges can harness horizontal learning to the benefit of local placemaking or resilience-building projects (Ley, 2019).

As urban form adapts to reflect the impact of climate change, resilience efforts must ensure that physical infrastructure is layered with social considerations: "A strategy of resilience will involve more than changes to our physical infrastructure. Increasingly, governments and disaster planners are recognising the importance of social infrastructure: the people, places, and institutions that foster cohesion and support" (Klinenberg, 2015, Preface). Communities have demonstrated that in the post-disaster recovery process the most important factors for resilience were often intangible, social qualities: "citizen involvement in mitigation efforts, effective organisational linkages, ongoing psychosocial support, and strong civic leadership in the face of rapidly changing circumstances" (O'Neill, et al., 2016, p. 67). This type of "softer, social infrastructure" is often what determines outcomes during and after the recovery process, especially when physical infrastructure such as communications, electricity, or storm protection systems fail (Klinenberg, 2018, p. 15).

2.4 Public space practice

Public spaces have already been identified as tools for physical resilience in cities. Whether they serve as distribution hubs for post-disaster aid, absorb stormwater during heavy rains, or provide a buffer to coastal sea level rise, it is clear that public spaces can be mobilised as part of climate-adaptation and urban-resilience practice. But, so far the focus on these types of physical resilience features often crowds out consideration of social factors, which are a key element of what well-functioning public spaces inherently provide:

> public spaces […] act as social outlets that enhance the general wellbeing of individuals, as well as the general wellbeing of collective society. It is therefore suggested that the lack of public spaces can threaten public welfare and social harmony within the urban realm. (Attia, 2011, p. 10)

The divide between the possibilities for building physical and social resilience into public spaces is perhaps because, on a broader scale, the conversation around public spaces that "invite human flourishing" has long been one that pits design (physical traits) against community involvement (social performance) (Attia, 2011, pp. 10-11). But when applied to the adaptation of public spaces to climate change, this dichotomy is unnecessarily limiting. Public spaces must be seen as opportunities to combine the physical and the social in adapting to climate change. By integrating the interlinked paradigms of physical and social resilience, communities can ensure that public spaces both remain highly social places that enhance urban living while helping communities to adapt to climate-change impacts through their physical features.

Much like the use of public spaces, the processes that create and support public spaces are cyclical and constantly evolving. In no particular order, public space practice includes: community engagement (outreach), design and amenities, programming and use, and management (Peinhardt & Storring, 2019).

The process of **community engagement** engages community experts "at the very beginning (in the case of a new development) to set the priorities and vision for the public space in question, and keeps them involved throughout implementation and beyond" (Peinhardt & Storring, 2019). When present, this outreach can take many forms, from pop-up engagements to more traditional charrettes (participatory urban planning workshops), and is usually led by non-profits, municipal authorities, or external consultants. All of the subsequent three areas of practice relating to public space must continuously draw upon this community engagement in order to maintain a deep and authentic connection with the vision of the users of the public space.

Public space **design** encompasses its physical layout, including its topography, routes of access, and connections within and without the public space. Design contributes not only to who can access a space and when, but also whether people feel safe, comfortable, and included when they use it. **Amenities** include the physical equipment in a public space that, in an ideal scenario, accommodates users, including (but not limited to) seating, restrooms, shade structures, games and equipment associated with programming. Any nature and greenery present in a given place falls somewhere between a design choice and an amenity. These design and amenity decisions are usually driven by design experts (i.e. landscape architects, urban designers, engineers), whether hired or employed by a given city or management authority, as well as the management staff for a given public space (see below).

Programming and use includes all of the formally and informally organised activity that takes place in a space. It can be scheduled or spontaneous, active (involving a user's physical presence) or passive (leisurely involvement on a flexible basis). Programming is an important way for a public space to change itself over time, and continuously reflect the vision of its users and draw upon the assets of the surrounding community. Programming and use, when it is actively managed, is generally led by staff of the management organisation for a given place. This varies, however, in that staff can be part of a dedicated management organisation for a given public space, or members of a municipal parks and recreation or public works department. Their programming plans can also be informed by non-profits or external consultants who recommend a suite of activities for a given space, as well as potential implementing partners (i.e. local businesses).

Management of public spaces includes the daily operations of a public space, and includes (but is not limited to): programme planning, hiring, maintenance, finance, partnership management, and other administrative tasks. Management operationalises all of the previous three areas of practice relating to public space, and must evolve over time to match the changing tastes of users, and adapt to the physical realities of the space. Management of a public space takes many forms, but is often undertaken by municipal parks and recreation departments, or by individual management entities (private or public) dedicated to a given public space.

Since the 1990s, the concept of **placemaking** has placed the human experience and community know-how at the centre of city-building. Through organisations such as Project for Public Spaces, placemaking has begun to guide the urban planning narrative towards recognition of the importance of shared urban spaces. Placemaking is defined as

> a collaborative process by which we can shape our public realm in order to maximise shared value […] [facilitating] creative patterns of use, paying particular attention to the physical, cultural, and social identities that define a place and support its ongoing evolution. (Project for Public Spaces, "What is Placemaking?")

This human-centred and place-centred approach is executed at a variety of scales by people from diverse backgrounds, ranging from community activists to professional planners. It emphasises attachment to place, the need to draw on local knowledge and assets, and ongoing observation of and experimentation with public space. As it relates to resilience, "'placemaking' can be understood as a community resilience effort, as both processes indicate collaborative action in the public realm with the aim of strengthening social ties beyond physical infrastructure and the confines of urban design" (Ley, 2019, p. 169).

The way the aforementioned practices are undertaken determines the performance of the public realm: Choices made regarding community engagement, design and amenities, programming and use, and management are among the main factors that determine how well a public space serves the needs of its visitors. Though public spaces serve different purposes for everybody, it is worth noting that well-functioning public spaces share some general traits; high-performing public spaces enhance social cohesion, provide activities for people of all ages and abilities, connect with nearby spaces and institutions, and are comfortable and appealing to visitors (Project for Public Spaces, "What Makes A Successful Place?").

Table 1: Qualities of successful public spaces
Sociability: Provision of opportunities for improved social contacts
Uses and activities: Provision of inclusive, engaging programming
Access and linkages: Accessibility, connection to surrounding neighbourhood
Comfort and image: Attractiveness to users, ease of use
Source: Project for Public Spaces, "What Makes a Successful Place?"

3 Analytical framework

This section introduces the analytical framework for this study. In the framework, metrics for physical resilience (3.1) and social resilience (3.2) will be examined through the lens of each of the four areas of practice relating to public space: community engagement, design and amenities, programming and use, and management.

3.1 Physical-resilience metrics

With regard to **community engagement**, physical resilience in public spaces relies on the integration of observed and projected climate risks for a specific location. Awareness and consideration of locally specific climate hazards that face a community are the starting point for climate-sensitive community engagement.

In terms of **design and amenities**, "resilient" physical systems stand in contrast to "robust" systems, which are often dependent on individual "hard protective measures". Instead of relying on a single physical feature like a sea wall, resilient systems emphasise flexible and interconnected features. This is because they demonstrate certain traits: flexibility and diversity (including spatial and functional diversity), redundancy and modularity, and the ability to fail safely (Tyler & Moench, 2012, pp. 312-313). The tailoring of design and amenity choices in a space to confront specific local climate hazards also demonstrates physical resilience building, and can be strengthened by the use of local climate data in the design process. Design choices and amenity choices that enhance the ability to resist and absorb shocks caused by climate hazards are also critical measures of success in this realm (Alexander, Priest, & Mees, 2016).

In terms of **programming and use**, physical-resilience efforts can be successful when climate data informs the types of programmes that take place in a public space, and when physical resilience features support activity and use.

When it comes to **management**, staffing choices for managing a public space can ensure that the maintenance and cleaning of the space maintain connection with broader goals for physical resilience. Depending on the structure of a city's public works or property management teams, this can be demonstrated through the supervision of, or collaboration with, staff working on physical climate-adaptation initiatives. Ongoing monitoring for efficacy of resilience features also ensures that the physical features of the space are performing properly – maintaining their ability to enhance physical resilience.

Table 2: Physical-resilience indicators in public spaces	
Community engagement	• Integration of observed and potential climate risks (both gradual- and sudden-onset) into community engagement process
Design and amenities	• Flexibility and diversity of function[a] • Redundancy and modularity[a] • Ability to fail safely[a] • Design and amenity choices tailored to full range of local climate hazards • Design choices enhancing ability to resist, absorb[b] • Choice of amenities enhancing capacity to resist, absorb[b]
Programming and use	• Use of climate data in decisions around types of programming taking place in a public space • Physical resilience features support activity and use
Management	• Staffing choices for property management reflect integration with adaptation goals • Ongoing monitoring for efficacy of resilience features • Creation of specialised management plan and/or strategies to accommodate resilience features
Notes: [a] Tyler & Moench, 2012, pp. 312-313; [b] Alexander, et al., 2016 Sources: Author	

3.2 Social-resilience metrics

As with physical resilience above, social-resilience metrics for public spaces will also be examined through the lens of each of the four areas of the public space community of practice.

Within **community engagement**, the process must be resourceful, with an appropriate thoroughness, representativeness, and diversity of community engagement (Tyler & Moench, 2012, p. 315). The outcome of the process must also demonstrate genuine and deep listening, and a responsiveness of community engagement leaders to the vision of the community (Tyler & Moench, 2012, p. 315). Another metric for social resilience to climate hazards is an awareness that leads to resilience becoming part of the vision of the community. It follows that if climate resilience is meaningfully a part of the community engagement process, visitors to the space will feel that the space has enhanced resilience in the community. And, in general, a well-executed community engagement processes will lead to a sense of stewardship by users.

Design and amenities can make a public space more socially resilient by making it an inviting and welcoming place. This can be done by providing for flexible and diverse uses. It is also crucial that accessibility and inclusion remain central to both the design and amenity choices of a space. It is worth noting that physical adaptation efforts can conflict with this goal.

To enhance social resilience, the **programming and uses** of the public space must encourage social interaction and provide for inclusive activities, aiming for meaningful

inclusion of people, regardless of age, ability, gender expression, race, and migration background. Programming and activities should also reflect the preferences of the community, and reflect partnerships with local organisations and stakeholders. Successful programming is also characterised by diversity and variety.

In terms of **management**, an adaptable and learning-centred approach will enhance social resilience, providing room for experimentation and iterative change that makes placemaking successful (Tyler & Moench, 2012, p. 315). Ongoing evaluation on the basis of use and perception of visitors/users is also crucial to making sure that a public space truly serves its community. Involvement of users in management through volunteer and stewardship activities can also be an opportunity for the accumulation of social capital in the context of a given public space.

Table 3: Social resilience indicators in public spaces

Community engagement	• Resourcefulness of community engagement leaders, i.e. thoroughness, representativeness, and diversity of community engagement [a] • Responsiveness of community engagement leaders to community vision [a] • Resilience as part of the vision of the community • Sense of stewardship by users
Design and amenities	• Flexibility and diversity of use [a] • Accessibility and inclusion through design • Accessibility and inclusion through amenities
Programming and use	• Encouragement of social interaction • Inclusivity of activities (age, gender, ability) • Reflection of the preferences of the community • Connectedness to local partners • Variety of uses and programming
Management	• Adaptability and learning-centred approach[a] • Ongoing evaluation on the basis of use and perception of its users • Involvement of users in management (i.e. volunteer opportunities)

Notes: [a] Tyler & Moench, 2012, p. 315
Sources: Author

This analytical framework is the basis for this study, but also provides a basis for future research on climate resilience through the lens of public space, and can be adapted to the particular landscape and climate risks of a given community.

4 Methodological approach

This section discusses the selection of the case study (4.1) and outlines the observational (4.2) and outreach-based (4.3) research methods employed in this study, which are qualitative and based on long-standing ethnographic practices designed for use in evaluation of the public realm. Observational methods include fieldwork (public space observation, which will consist of field notes and mapping exercises) while outreach methods include targeted interviews.

Crucial to bear in mind is that all of these methods have taken place within the context of a global pandemic, COVID-19. Accordingly, social distancing measures have impacted the ways these qualitative methods are carried out, limiting travel for the purposes of case-study research, in-person engagement and surveying for public health and safety reasons.

4.1 Case study selection rationale

This section outlines the reasoning behind selecting Rotterdam and its public spaces as a case study in physical and social resilience building.[1] Rotterdam is well-recognised as a forerunner of urban climate adaptation, especially with regards to flood-risk management. The city's longstanding vulnerability to storm surges was made particularly apparent in 1953 when Rotterdam was narrowly spared the worst effects of a storm surge on the North Sea. The event gave way to innovative thinking in water management, building on practices such as dike construction that had been in place in the region since 1000 BCE. Now, various international, national, and municipal initiatives govern the way Rotterdam manages flood risk. Multi-level and multi-actor water governance has improved in the last 15 years in Rotterdam, but "problems in aligning local, regional, and national policies" remain (Ward, et al., 2013, p. 530). Though "the dams, dikes and land reclamation have brought the dangers and risk of flooding under control and the wetlands of the inner-dike city have been drained", ongoing efforts at water management, among other adaptation goals, are underway in Rotterdam. Infrastructure such as dikes are often incorporated into the fabric of the city, providing green or recreational space (Rotterdam Climate Initiative, 2013, pp. 15-16, 42).

Public spaces have now increasingly become a part of Rotterdam's approach to climate adaptation – a strategy that can be scaled for use in a variety of contexts, in cities around the world facing any permutation of the wide range of present and projected climate hazards. Combining public space, placemaking, and climate-adaptation and resilience research is relatively new, so this paradigmatic case study of Rotterdam and its Waterplein Benthemplein public space project (as part of the wider "Climate Proof ZoHo" initiative) can form the basis for further research into climate resilience practices based on public spaces (Flyvbjerg, 2006, p. 230). Through this project, Rotterdam has combined improvements to public spaces with improved climate-adaptive features, serving to make the surrounding community more physically and socially resilient. As mentioned in the

1 This study was originally intended to have a broader geographical range of case studies, including public spaces in developing countries. The COVID-19 pandemic hindered the range of possibilities for travel to sites and informed the choice of a single case study.

introduction, the goal of this case study-based approach is to collect lessons learned from a city that is innovating in the field of climate-adaptation and resilience projects centred on public spaces.

4.2 Observational methods and process

Observation methods and techniques for this research were based on the Toolkit for the Ethnographic Study of Space (TESS), which details a process for observing public spaces pioneered by sociologist Setha Low. Selected techniques from the TESS method include field notes, on-site public-space mapping of multiple types (activity, movement, physical traces), and subsequent analysis (Low, Simpson, & Scheld, 2018). It is important to note that all of the observations for this case study were carried out during an active global COVID-19 pandemic that has impacted the way people use and interact in public spaces.

Taking field notes on a public space is a fairly open-ended technique in which the field worker notes down the conditions in a space and makes observations of its features, the types of human interactions and uses that take place during a site visit. Activity mapping involves map-based records of human activity in the selected observation site. Movement mapping involves visual representations of the ways and directions in which people move within and through the selected site. Physical traces mapping involves record-keeping of different physical objects that give insights into the ways people use or maintain the space, for instance rubbish, leaves, or standing water (Low, Simpson, & Scheld, 2018).

These on-site methods contributed to an analysis of the performance of the Waterplein Benthemplein, and the corresponding notes and maps were analysed using the four areas of practice outlined in the analytical framework: community engagement, design and amenities, programming and use, and management.

All of the observational methods involved convenience sampling: observing only the behaviour of visitors who happen to use the space during observation periods.

4.3 Outreach methods and process

Targeted interviews with local stakeholders also informed the case-study research. Purposive sampling was employed to include: municipal employees, design professionals, policymakers, and non-governmental organisation (NGO) employees, among others.[2] These interviews provided context behind either local climate-adaptation policy or specific public-space practices. All feedback gathered through outreach-based methods was coded into the different areas outlined in the analytical framework: community engagement, design and amenities, programming and use, and management.

2 Due to COVID-19 social distancing, these interviews largely took place over the phone or digital conferencing platforms.

5 Climate risks and local policy context

This section presents the broader context for the selected case-study city of Rotterdam, including: climate risks and challenges facing the city (5.1), background information on Waterplein Benthemplein – the public space that forms the basis of the case study, (5.2), and relevant local and regional policy (5.3). These points of context will lend valuable clarity to analysis in later sections.

5.1 Climate risks and challenges

Rotterdam's main climate risks centre on water management, and include heavy rainfall, flooding, sea level rise, and storm surges. Rotterdam has also experienced increased risk of drought (and may continue to do so), which can lead to water-quality issues, saltwater intrusion, shipping disruption, and lower water tables that cause structural problems for pipelines, roads, and houses built on wooden piles. Overall, climate projections for Rotterdam's growing population highlight the likelihood of milder winters and hotter summers, with more frequent and intense rainfall year round (Rotterdam Climate Initiative, 2013, pp. 14, 35). Drought and subsidence also pose an issue for Rotterdam residents. Some neighbourhoods are subsiding by up to 20 mm a year, though the average city-wide is between 2 and 10 mm a year (Jorg Pieneman, personal communication, 3 June 3 2020). Many of these risk factors are particularly high because of Rotterdam's location on a delta of the Rhine and Meuse rivers. Much of Rotterdam sits below sea level, particularly in inner-dike areas, where certain neighbourhoods lie more than 6 m below. As such, the city and its inhabitants are heavily influenced by the levels of surrounding rivers and the sea, to which the city is connected by the *Nieuwe Waterweg* (New Waterway) (Rotterdam Climate Initiative, 2013, p. 15).

Rotterdam also faces risks related to heat. Not only have there already been four heat waves in Rotterdam between 2000 and 2018, but this risk is magnified by urban design. According to surveys, at least 30 per cent of residents report having difficulty finding places to cool off in the centre of the city (Rotterdam, 2020, p. 33). Heat waves and the effects of the intensified "urban heat island" pose a risk to human health and well-being, as well as to local flora and fauna (Rotterdam Climate Initiative, 2013, pp. 14, 35). This stands to exacerbate the existing distinct public health impacts of hot days in the Netherlands, with records showing that the "amount of deceased persons increases by 12 per cent during heat waves" (Kennis voor Klimaat, 2011).

5.2 Case study background: Waterplein Benthemplein

Various public space projects in Rotterdam have contributed to adaptation efforts: underground water storage in Museum Park and the creation of space for more surface water in *Zuiderpark*, for example. However, an outstanding adaptation project in Rotterdam is Climate Proof ZoHo, a district-wide initiative in *Zomerhofkwartier* or "ZoHo" that includes Waterplein Benthemplein. Waterplein Benthemplein is the paradigmatic case study for this discussion paper.

The "water square" concept was created by architects at De Urbanisten in 2005, and was made "official policy" under Waterplan Rotterdam 2, which encouraged the implementation of pilot projects. The water square concept consists of a public space that serves a second function as a stormwater management feature, often containing a series of gutters and basins designed to flood and collect water on days of heavy precipitation (De Urbanisten, "Water Square Benthemplein"). Based on the 2007 Waterplan Rotterdam 2 (see Section 5.3.2), the water square concept was to be implemented in neighbourhoods with little space to expand open water areas. The plan identified project opportunities in the *Noord* and *Zuid* districts (North and South districts) of Rotterdam – the Noord district being where ZoHo lies, in the broader *Agniesebuurt* neighbourhood.

The *Klimaatbestendige Aanpak Agniesebuurt* (climate-proof approach for Agniesebuurt) guides multiple climate-sensitive public space projects in and around Rotterdam's Agniesebuurt district. This approach includes the prominent and multi-faceted Climate Proof ZoHo project, which began in 2014 (Rotterdam, "Klimaatbestendige aanpak Agniesebuurt"). The ZoHo district-wide project covers a "19th-century urban district with closely spaced houses and relatively little public space and greenery". The initiative involves stakeholders that include municipal staff, local entrepreneurs, nearby residents, designers at the firm De Urbanisten, the *Schieland* and *Krimpenerwaard* water board (HHSK), and the *Havensteder* housing association (Barfoot, 2017). The Climate Proof ZoHo plan continues to draw on the principles outlined in the Rotterdam Climate Adaptation Strategy (see Appendix C), and aims to support the adaptation policy by confronting specific climate risks in the Zomerhofkwartier: floods, rain, droughts, and heat. The project received financial support from the Ministry for the Infrastructure and Environment, *Mooi Nederland* (a subsidy scheme for "Beautiful Netherlands"), and the European Union's fund for territorial cooperation, Interreg IV (De Urbanisten, s.a. "Climate adaptive ZoHo").

Projects like the Waterplein Benthemplein, completed in 2013, have been incorporated into the broader Climate Proof ZoHo plan. Although it is not the only water square in Rotterdam, the Waterplein Benthemplein is noteworthy for its integration of features such as a skateboard basin and basketball court, as well as its inclusion in the district-wide approach for ZoHo.

Table 4: Project information, Waterplein Benthemplein

Funders	City of Rotterdam, water boards, special European and Dutch funds
Cost	€4 million
Project type	water task, spatial quality
Design	Water square by De Urbanisten
Timeline	2011–2014
Size	5,500 m^2 (9,500 m^2 with street parking)
Water storage capacity	1,800 m^3
Source: De Urbanisten, "Climate Adaptive ZoHo"	

The Waterplein Benthemplein was designed not only to transform an under-performing square, but also to specifically address the rain and stormwater hazards mentioned in the district-wide climate-proofing plan. Previously, the Benthemplein was a hardscaped "interstitial" space between buildings. It had a few trees that offered shade, but otherwise

offered very little reason to linger or gather in the space (Centre de Cultura Contemporània de Barcelona: Public Space, 2014). The City of Rotterdam supported the project with the aim of making climate-adaptation and water-management efforts more visible to locals and visitors, improving the urban environment, and creating a space for leisure and recreation. According to Florian Boer, one of the co-founders of the urban research and design firm De Urbanisten that was hired to do the outreach and design of Waterplein Benthemplein: "It started for water management purposes and also to make a showcase out of how water management infrastructure can be a public space. Instead of making a technical amenity underground, it could also be a public space" (Florian Boer, personal communication, 8 May 2020). Funding of €4 million was split among stakeholders: 25 per cent came from "special European and Dutch funding", 50 per cent from the City of Rotterdam, and 25 per cent from water boards. Up to 40 per cent of this funding was earmarked for spatial projects, while the majority (60%) was intended as a water-management initiative (De Urbanisten, "Water Square Benthemplein").

Figure 1: Waterplein Benthemplein

Source: De Urbanisten, s.a. "Climate Adaptive ZoHo", photographer Ossip van Duivenbode.

The design of Waterplein Benthemplein is defined by three main stormwater management basins and their corresponding catchment areas, which double as space for public use. The basins' design addresses both flooding and drought in that they store water and release it slowly into the soil and nearby *Noordsingel* waterway, rather than diverting it into often-overwhelmed sewerage systems. According to Boer:

> after the rain has been temporarily stored in the basins, it goes [through] an infiltration device and… into the soil. We keep the water that falls on the place, in the place. We simulate as if it were not paved, even though it is, because we want to facilitate all sorts of activities. The rain does not disappear into sewage, but is, via a delayed device, brought back into the soil. (Florian Boer, personal communication, 8 May 2020)

As mentioned above, the design of the basins was based primarily on the findings and strategies outlined in Waterplan Rotterdam 2, and not on locally specific climate data. Accordingly, the square's basin design is aimed at maximising water storage, while other local climate hazards such as heat were not prioritised (Florian Boer, personal communication, 8 May 2020).

As part of the broader Climate Proof ZoHo suite of climate-adaptation interventions, the water square is not the only resilience-oriented public space in the area. Close by are the ZoHo Rain Garden (Regentuin), which contains locally designed rain barrels in the shape of the letters in "ZOHO", the Katshoek Rain(a)way Garden, and projects along the Hofbogen, a former railway viaduct, which includes the elevated Luchtpark (De Urbanisten, s.a. "Climate adaptive ZoHo"). The Luchtpark is likely to become part of the future development of a longer, elevated Hofbogenpark. When finished, the "green city park" is purported to feature a "smart and circular" water system and space for recreation along a total length of 2 km. This public space project is among the seven identified in the "Stronger Through" initiative (*Sterker Door*) announced in early 2020, which identified initiatives in the public realm that would support recovery and social distancing during COVID-19 as well as wider resilience goals (Rotterdam, s.a.,"Hofbogenpark"; Rotterdam, 2020b).

Waterplein Benthemplein falls in the designated Noord-Ost area of Rotterdam, for the purposes of management and cleaning. The square comprises cultural and religious institutions, as well as commercial and educational buildings, with the public space at its centre. The square itself is directly bordered by a franchise of David Lloyd fitness centre, the Waterpleinkerk church, a campus of the Zadkine College, the Jeugdtheater Hofplein, and the Graphic Lyceum trade school. Nearby in the ZoHo neighbourhood are organisations such as the Wijkcoop (a neighbourhood cooperative of local businesses), housed in the iconic ZoHo Building, and multiple retail and dining establishments along the Hofbogen. In other words, the square itself is immediately bordered by primarily non-residential uses, but the surrounding neighbourhood does indeed have existing and forthcoming housing stock. In 2020, the City of Rotterdam announced new development plans in the ZoHo district to be undertaken by the Leyten/Stebru consortium. At least 550 new homes will be created, alongside live/work spaces and new rooftop green landscapes that will be connected to the future Hofbogenpark. Current plans, as outlined by developers, highlight integration of climate-adaptive measures in the project (Stebru, s.a.). The ZoHo district-level council (*raad*) as well as groups such as ZOHO Citizens, a network of Zomerhofkwartier-based entrepreneurs and organisations, are being consulted as part of the planning process for this new development (Raymond van den Broek, personal communication, 26 August 2020).

5.3 Local and regional policy

Rotterdam's City Council (*Gemeenteraad*) and associated committees, is chaired by the mayor, and represents the administrative leadership of Rotterdam's municipal government. Its committees include: Construction, Housing and Outdoor Space Committee (BWB); Energy Transition, Sustainability, Economy and Mobility Committee (EDEM); Major Projects, Organisation and Finance Committee (MPOF); Safety and Governance Committee (VB); Employment, Income, Integration, Debt and Poverty Reduction Committee (WIISA); Care, Education, Culture and Sport Committee (ZOCS); Commission for the Examination

of the Accounts (COR) (Rotterdam, s.a., "Gemeenteraad"). As mentioned below, it also has specific members dedicated to certain areas of work such as neighbourhood engagement.

The City Council receives input and area-specific agendas from many resident-based representative leadership groups, such as Rotterdam's 12 area commissions (*Gebieds-commissie*) of nine to 15 members. These commissions are accompanied by similar groups in other districts, including 14 Ward Councils (*Wijkraden*) and six Ward Committees (*Wijkcomités*), each of which consists of five members. These three groups play similar roles, and comprise elected area representatives that not only advise the City Council, but also conduct community engagement, disburse subsidies for resident-led initiatives, and oversee the execution of district agendas (Rotterdam, "Gebiedscommissies...").

5.3.1 Public space policy and community engagement

Rotterdam's spatial development is guided by the City Vision (*Stadsvisie*), the two pillars of which focus on a strong economy and an attractive and inhabitable urban environment. Attracting visitors, building new housing stock, offering space to creative and knowledge-sector workers, investment in public space (including greening and climate-adaptive water-management efforts) are among the strategies outlined in the current version of the document. Much of this, especially the adaptation and public space goals, is intended as a collaboration with other cities in the Randstad region of large metropolitan areas in the Netherlands. According to the municipality, this strategy comes as the result of thousands of conversations with Rotterdam residents (Rotterdam, "Stadsvisie").

The City Vision also coincides with an Environmental Vision (*Omgevingsvisie*) document, which outlines goals for a "compact, productive, circular, inclusive, and healthy" city. Within goals around inclusivity, the vision specifically mentions social resilience and accessibility. Under "healthy city" goals (climate-proofing and proximity to greenery) and "productive city" goals the document emphasises the importance of encouraging social interactions (Rotterdam, "Omgevingsvisie 5 Perspectieven"). The public realm is also governed by a Vision for Public Space 2019–2029 (*Visie openbare ruimte 2019-2029*) which aims for a coherent approach across green and public spaces in Rotterdam, and mentions initiatives such as water squares and green roofs. The vision emphasises climate adaptation, connectivity, accessibility, inclusion of all ages, and sustainability as driving values behind public space initiatives (Rotterdam, "Visie Openbare Ruimte").

To execute broader urban planning goals, Rotterdam's Urban Development (*Stadsontwikkeling*) department has four sub-departments. The Area/Regional Development and Quality Department (*Gebiedsontwikkeling & Gebiedskwaliteit*) oversees area/regional development, area/regional operation, and real estate. The Economy and Sustainability Department (*Economie & Duurzaam*), oversees projects such as green roofs. The Urban Planning Department (*Stedelijke Inrichting*) includes space and housing, traffic and transport, and construction and home supervision. Lastly, the Project Management & Engineering Department includes a Project Management Office and an Engineering Office (Rotterdam, "Stadsontwikkeling").

In terms of public space management, the City Management (*Stadsbeheer*) includes Public Works (*Openbare Werken*), Clean City (*Schone Stad*) and Monitoring & Security/

Enforcement departments (*Toezicht & Handhaving*) (Rotterdam, s.a. "Stadsbeheer"). This department oversees public spaces, as well as the water department that houses climate-adaptation initiatives. Within Public Works there is also a policy advisory body, gardeners, and project managers of renewal projects in public spaces. Under the Clean City department fall cleaning (*Reiniging*) and waste collection (*Inzameling*), including in public spaces, which was previously handled by an agency called Roteb. Though climate adaptation mainly falls to the City Management department, staff of the Urban Development department also work on climate issues in Rotterdam, with landscape architects and developers integrating adaptation goals within broader city plans (Jorg Pieneman, personal communication, 3 June 2020).

The cleaning sub-department of the Stadsbeheer's Clean City department is in charge of regular cleaning and management of public spaces. A team manager heads up a group of four team leaders who are responsible for certain neighbourhoods of the city (i.e. Noord Ost). These areas are divided into many different zones for the purposes of planning. Team leaders oversee foremen who manage teams of cleaning staff who handle an average of 1.5 such zones a day (Bartjan Zilverberg, personal communication, 8 September 2020). Recently, a strategic Asset Management Plan has guided maintenance practices for public space and other municipal assets, and is guided by a set of core values: safety, availability [of public space], environment and health, quality of living environment, resilience, image, laws and regulations, and economy. In reference to this plan, Team Manager Joop Polfliet notes the importance of management in Rotterdam: "public management is the new design" (Joop Polfliet, personal communication, 25 August 2020).

Regular public space cleaning is managed through software called *Stadsbeheer Mobiel*, through which staff can see residents' reports of maintenance issues, leave comments, or mark areas as finished with cleaning. Staff do not often leave comments on a space unless an issue arises that falls under the responsibility of another team (i.e. greenery falls to Public Works). Within the different geographic teams of the cleaning sub-department (i.e. Noord Ost), there are meetings that present opportunities for staff to discuss ongoing problems, both internally and with other departments, i.e. with the neighbourhood directors in the Monitoring and Enforcement department (Wim van Tiggele, personal communication, 26 August 2020).

This approach has now been combined with a two-year trial run of a separate programme called "Data-Controlled Cleaning", which relies on public space inspection by cleaning team leaders, and subsequent reporting of maintenance needs (or lack thereof) for purposes of more targeted cleaning efforts and long-term data collection. Uptake on this new system is mixed, according to some team leaders who prefer to rely on the day-to-day judgment of foremen than on their own reports filed in the software. Nonetheless, team leaders see the value in long-term data collection for the purposes of seasonal maintenance planning, among other things (Bartjan Zilverberg, personal communication, 8 September 2020). Members of the cleaning team note that a more data-driven approach might move management from a "reactive" paradigm to a more proactive and problem solving-oriented approach (Joop Polfliet, personal communication, 25 August 2020). Staff have noted that the Data-Controlled Cleaning programme is more effective in suburban areas, and does not work as well in higher-maintenance places such as water squares (Wim van Tiggele, personal communication, 26 August 2020).

In addition, residents can submit maintenance issues online, or use a third party-developed smartphone app called *BuitenBeter* to report issues such as litter, waterlogging of a space, pavement or street furniture issues, among other public space challenges (Rotterdam, s.a., "Reiniging"). Locals can also use a municipal hotline to report maintenance issues in public spaces, but the ability to filter reports and direct issues to the proper departments remains a challenge (Bartjan Zilverberg, personal communication, 8 September 2020).

Public space management also sometimes involves the Public Works team, which is in charge of managing plants and greenery (Bartjan Zilverberg, personal communication, 8 September 2020). This team often contracts arborists and pruning specialists for green spaces. Governed by a code of conduct for flora and fauna (*Gedragscode Flora- en faunawet*), the general approach to management of public greenery is one that aims for biodiversity and a good image for public space (Rotterdam, s.a., "Groenonderhoud").

As for **community engagement**, there are multiple routes for residents to engage with municipal staff, and vice versa. Methods of formalised community engagement include residents' evenings, consultative (council-proposed) referendums, advisory (resident-proposed) referendums, a neighbourhood service desk and various routes to report issues online. A dedicated Alderman for Neighbourhoods also tours Rotterdam's districts in a tuk-tuk vehicle, to gather input in person (Rotterdam, "In Gesprek").

Rotterdam also has many community-level governance and engagement initiatives that delegate tasks and responsibilities to community members. Neighbourhood directors, of which there are 14 (one for each area), are part of the process for managing public spaces. The neighbourhood director is a first point of contact for residents, and acts alongside colleagues in the Public Works, Clean City, and Monitoring and Enforcement departments. The neighbourhood director is in charge of handling complaints, monitoring projects and events, and keeping abreast of ongoing construction or road work (Rotterdam, "Wijkregisseurs").

Combining open and transparent practices in management and community engagement, Rotterdam's municipal Self-Management (*Zelfbeheer*) programme makes space for community-led efforts in green and/or public spaces. Once registered with the city authorities, the approval process for this bottom-up public-space management connects residents with their neighbourhood directors as well as with district gardeners, as appropriate. Successful applications include a management plan and agreement between grassroots public space managers and the city, as well as stipulations that the managed space remains open to all users (Rotterdam, s.a., "Zelfbeheer"). One example of this type of opportunity is the Right to Challenge, or R2C, programme through which Rotterdam residents can apply to take over tasks usually handled by the city. Applicants "challenge" the city with an application to take over the management of public spaces, using redirected city funds (Rotterdam, s.a., "Right to Challenge"). However, this programme has been met with some criticism from leaders of grassroots-oriented groups who claim that it prompts municipal staff to find ways to implement projects more cheaply than residents can, and that it attracts more applications from and serves higher-income neighbourhoods, creating an accessibility and equity issue (John Jacobs, personal communication, 11 May 2020). Nonetheless, the programme opens lines of communication between residents and municipal staff, and opens the door to placemaking efforts.

5.3.2 Environmental and climate-adaptation policy

Water governance and climate adaptation are closely linked in Rotterdam. Plans like Waterplan Rotterdam 2 (launched in 2008) guided water management planning at the local scale, and came as a result of multi-level collaboration between the City of Rotterdam and regional water boards. The regional water boards of relevance to Rotterdam include the Hollandse Delta Water Board, the Higher Board of Schieland and Krimpenerwaard, and the Higher Water Board of Delfland. Waterplan Rotterdam 2 integrated with the goals outlined in the municipal City Vision document that extends to 2030. The plan also intentionally overlapped with other urban issues relating to public spaces, synchronising pilot projects that combine flood risk management with urban planning (e.g. water squares, green roofs, roof parks), for example (Ward et al., 2013, p. 530). The main challenges confronted in Waterplan Rotterdam 2 are sea level rise, increased rainfall leading to flooding, and the demand for high water quality. The document clearly linked these water management goals with simultaneous enhancement of Rotterdam's public realm. The plan made district-level suggestions sensitive to the realities of Rotterdam's urban form, noting that projects such as green roofs and water squares (see below) would be most suitable for dense urban areas in which the digging of additional water storage was not feasible.

The plan is unique in that it has linked the active implementation of public space projects with water management, and championed innovative interventions such as water squares, or public spaces that store water (Rotterdam, 2007). Originally launched in 2008, the plan faced implementation issues during the 2009 financial crisis and was re-launched in 2013 with practical updates to the implementation plan, all based on the same overall goals and vision. The plan shifted water management approaches in Rotterdam from framing water as a challenge to approaching it as an asset to be put on display, as well as an opportunity to improve public spaces. The plan also marked the inclusion of landscape architects and urban planners into water-related climate-adaptation strategies, rather than remaining solely in the domain of engineers (Jorg Pieneman, personal communication, 3 June 2020). Municipal staff who worked on the plan worked across disciplines and attempted to write it in coordination with other strategies such as the City Vision (John Jacobs, personal communication, 11 May 2020).

Informed by the Waterplan Rotterdam 2, and by multiple successive climate-adaptation strategies (see Appendix C), Rotterdam's adaptation measures are today guided by municipal strategies, as outlined in adaptation-centred documents, *Weerwoord* and *Rotterdam Weather Wise Urgency Document*. Unlike preceding strategies, such as the Rotterdam Climate Change Adaptation Strategy, which emphasised that hydrological risks are "under control" but in need of ongoing adaptive measures, the *Rotterdam Weather Wise Urgency Document* has, as the title implies, a tone of urgency. Rotterdam residents pushed this document forward on the agenda after experiencing a range of water-management issues, from flooding to subsidence, which led to requests for a city-scaled equivalent of the national Delta Programme. According to municipal advisors for the City of Rotterdam, Rotterdam Weather Wise is a "living document", still under development today, which connects with other municipal goals, including the creation of 20 additional hectares of green space and the protection of homes from flooding and heavy rainfall. The plan is based on locally generated maps of climate risks, many created by climate advisors working on various workstreams, among them groundwater, drought, and heat (Jorg Pieneman, personal communication, 3 June 2020). Much like the national-scale Delta Plan, and the previous

Rotterdam Climate Change Adaptation Strategy, Rotterdam Weather Wise uses up-to-date climate risk scenarios generated by KNMI (Royal Meteorological Institute of the Netherlands), but it also uses a "stress test" approach that maps vulnerabilities in the city, as mandated by the National Delta Plan on Spatial Adaptation (Rotterdam, 2020a, p. 27).

The *Rotterdam Weather Wise Urgency Document* contains approaches to six challenges: rainfall, heat, drought, sea level rise, quality and/or quantity of groundwater, and land subsidence. The plan overlaps with many goals set more broadly for the city of Rotterdam. Those include goals to "increase the percentage of properties that do not have an increased risk of flooding in the event of heavy rainfall from 88 per cent to 90 per cent [and] add 20 hectares of green space by 2022 compared to 2018", as well as more "indirect" goals regarding community engagement, air quality, and emissions reductions. Moreover, the plan coincides with challenges outlined in broader strategies, such as the Spatial Vision for Rotterdam: migration to the city, the energy transition, the circular economy, digitalisation, mobility, and a "network" society that links initiatives across the city. The resulting outline for municipal involvement in the plan involves collective goal-setting and opportunity identification with the community, collaborative implementation, knowledge creation, area-specific adaptation plans, and other goals that were set by the city council outside the context of the plan (Rotterdam, 2020a, pp. 14, 19).

In terms of water-management efforts (both for flooding and drought), the document focuses on a mix of water-retention capacity-building measures. The approach includes specific measures such as the expansion of greenery and water-sensitive management of green areas, and the creation of water storage on both public and private property (Rotterdam, 2020a, p. 28). These types of water-management measures also have implications for groundwater (both excessive and insufficient) and subsidence challenges. These two challenges, while pressing, primarily pose risks to private properties rather than public spaces: for example, for residents whose homes are built on wooden pile foundations (Rotterdam, 2020a, pp. 40, 43).

In terms of management of heat risk, recommendations are made for enhanced greenery, as well as shade and "heat-resistant construction and design" in new developments and public spaces, alike. Additionally, the strategy mentions as a goal the creation of plans for heat events for "managers of green spaces, urban infrastructure and health specialists" as well as a local heat plan (Rotterdam, 2020a, p. 31). The document also highlights a digital heat risk "app" intended for use on smartphones, called Extrema Rotterdam. The app communicates personalised strategies for residents with regard to heat safety and heat risk awareness and displays maps with "cool spots and drinking water locations within the city". The app comes out of a multi-city collaboration with Athens and Paris (Rotterdam, 2020a, p. 23). A local heat plan is under development as part of Weather Wise Rotterdam, with the municipal health department taking a lead role on the cross-department strategy (Johan Verlinde, personal communication, 13 August 2020).

Table 5: "Next Steps" in the Rotterdam Weather Wise Urgency Document		
Public space measures	Public space/private property measures	Private property measures
• Public space projects • Public real-estate projects • School and sports facility projects • "Embedding in primary processes and organisation" • Example-setting pilot projects • Knowledge generation and sharing	• Risk communication at the district scale • "Broad communication"	• "Incentive scheme, regulations and agreements" • Multi-purpose rooftop projects
Source: Rotterdam, 2020, p. 49		

Today, the municipal City Management and City Development (*Stadsbeheer* and *Stadsontwikkeling* respectively) departments collaborate and manage the Rotterdam Weather Wise strategy. Municipal advisors for the City of Rotterdam note that today's adaptation efforts are based on a multi-part strategy: incentives and regulations for existing private property, incentives and regulations for new developments, public space interventions, and community engagement (Jorg Pieneman, personal communication, 3 June 2020; Johan Verlinde, personal communication, 13 August 2020).

Measures relating to private property include regulations for new and re-developed properties and example-setting through adaptation features on municipal infrastructure. Meanwhile, locals can apply for subsidies ranging from €1,500 for small-scale climate adaptation on their own property, to €50,000 for larger projects. Subsidies are distributed according to the type of adaptation project: "€500 per added cubic meter of water storage, €5 per added square meter of uncoupled area and €10 per added square meter of realised green area". The website for Weather Wise Rotterdam also connects residents to subsidies provided by the Hollandse Delta and Delfland Water Boards (Rotterdam's Weerwoord, 2020). In the context of new developments, namely of housing stock, climate-adaptation regulations include requirements for developers of new buildings to build water storage into their projects, with the ability to empty within 24 hours (Jorg Pieneman, personal communication, 3 June 2020). Now, private property is being emphasised by municipal employees as a crucial element to the success of adaptation projects. Because only 40 per cent of Rotterdam's land is public space, this increased effort at community engagement has leaned heavily on involvement with the private sector (i.e. through housing corporations): "We have to involve private homeowners. In Rotterdam for instance, housing corporations own about 50 per cent of the houses in Rotterdam, so we have to involve private owners." As Rotterdam Weather Wise continues to develop, it has increased focus on awareness-building and investments made on private property and by social housing corporations (Jorg Pieneman, personal communication, 3 June 2020).

Public space is mentioned multiple times as part of a vision of a climate-adapted Rotterdam: "The public space has a water retention capacity at district level that can prevent damage in the event of heavy rainfall or long periods of drought" (Rotterdam, 2020a, p. 7). Beyond

providing a backdrop for adaptation features, municipal staff see public space projects as a chance to "solve social problems" and create safer communities. But this motivation is not purely social. Projects such as water squares also continue to receive investments as attractive, cost-effective alternatives to more traditional and costly enlargement of sewer pipes (Jorg Pieneman, personal communication, 3 June 2020).

According to City Management Senior Advisor for Climate Adaptation and Urban Water Management Jorg Pieneman, "within Rotterdam Weather Wise, now, far more effort is put into community-building, creating awareness, and how to create measures being taken on private grounds". Community engagement for the document was a complex undertaking, as different neighbourhoods experience climate impacts with differing levels of severity and underlying awareness. At the scale of a single street, various residents can simultaneously have problems with a lack of water and flooding (Jorg Pieneman, personal communication, 3 June 2020). Nonetheless, Rotterdam Weather Wise exhibits a more community-oriented approach than previous strategies, and engages with experts and locals in multiple ways: through preliminary outreach and questionnaires; consultation with expert networks like Water Sensitive Rotterdam (see Appendix B); ongoing community conversations about climate hazards called Risk Dialogues; an evolving outreach strategy called the Neighbourhood Approach (*Strategie Wijkaanpak*), which includes "climate talks", the hiring of local entrepreneurs to implement and communicate project goals, and the establishment of partnerships with local non-profits such as Opzoomer Mee and Water Sensitive Rotterdam (see Appendix B). Though the Weather Wise strategy included provisions for collaborative visioning and goal-setting, its community engagement is more robust on the implementation side than the planning side (Johan Verlinde, personal communication, 13 August 2020; Jorg Pieneman, personal communication, 3 June 2020).

According to Johan Verlinde, the programme manager for Rotterdam's climate-adaptation planning, preliminary questionnaires examined the diversity of adaptation challenges and levels of climate awareness among residents. To maintain this outreach, ongoing "risk dialogues" started immediately after the release of Rotterdam Weather Wise at the neighbourhood scale. These dialogues examine opportunities for both municipal and individual actions, as well as climate hazards experienced by locals. Among the first neighbourhoods to have "risk dialogues" was the Noord district (Johan Verlinde, personal communication, 13 August 2020). Team members working on the strategy note efforts at increased inclusion, especially around the diversity of personal experiences of climate hazards across Rotterdam, and in reaching residents with migration backgrounds that may not have been well-served in previous strategies (Jorg Pieneman, personal communication, 3 June 2020).

Perhaps most noteworthy of the community engagement techniques in Rotterdam Weather Wise is the ongoing development of the Neighbourhood Approach , which is being tested in two neighbourhoods (Oude Noorden and Afrikaanderbuurt). The approach is based on two "scans" of neighbourhoods, one physical and one social, which inform the type of outreach and small projects that can be implemented in a given area based on its existing structures and social landscape. Much like placemaking, the Neighbourhood Approach aims to build on knowledge and capacities already represented in residents and community groups. The strategy for this approach is under continuous development by members of the City Management department, where team members note that the approach is never finished, rather evolving over time to mirror the neighbourhoods it is intended to serve. The

approach is based on learning from existing programmes such as R2C, as well as conversations with locals, entrepreneurs, social housing corporations, and neighbourhood directors. The approach includes climate talks based on climate risk maps for specific areas, which start outreach conversations that both spread awareness of and gain context around locals' lived experiences of climate hazards. It also includes small projects like neighbourhood gardens, nearly always incorporating awareness-building and communications into any on-the-ground adaptation work (Tim De Waele, personal communication, 4 September 2020).

Local funding for projects concerned with water management typically comes from the budget attached to the municipal sewer plan. Certain programmes, such as water squares and green roofs, were expected to run out of funding in 2019 (Rotterdam, 2020a, p. 52). But, more recently, public space adaptation projects have seen new funding opportunities, as they've been linked to wider "greening" efforts and COVID-19 recovery efforts. The 2019 Rotterdam Goes Green Action Plan (*Rotterdam gaat voor groen Actieplan*) set goals for 20 additional hectares of green space in Rotterdam, and provides financial incentives for the creation of new green spaces such as green roofs and schoolyards. The plan also stresses the importance of cooperation on private property, providing gardening training in neighbourhoods where sewer renovations take place (Rotterdam, 2019a). In addition, in early 2020, a set of seven public space projects aimed at greening and COVID-sensitive social-distancing adjustments were announced, along with €233 million worth of funding via the Stronger Through programme (*Sterker Door*) (Rotterdam, 2020b).

Today, multiple other adaptation-related programmes are underway. As mentioned above, Rotterdam is currently working on a heat plan, which is championed by the public health department but heavily involves staff members from the City Management department who work on climate-adaptation strategy (Johan Verlinde, personal communication, 13 August 2020). In addition, a biodiversity programme is under development by the Clean City department of the City Management, which heavily interacts with Weerwoord and its Neighbourhood Approach strategy in supporting gardens on private property, and with Rotterdam Goes Green programmes to expand green space (Joni Reijven, personal communication, August 17, 2020).

Overall, what stands out is progress towards an integrated approach to climate adaptation that takes spatial planning and the social benefits of the public realm into account. This legacy set the stage for today's comprehensive approach to climate adaptation in Rotterdam: one that incorporates the social and the physical and combines placemaking with more technical approaches.

6 Empirical findings

In this section, the results of observational and outreach methods will be demonstrated, including fieldwork observations, insights and quotes from interviews, and mapping exercises. All of these data and the findings to which they give rise will be presented in terms of the four-part framework of public space practice described in Section 3 Analytical Framework: community engagement, design and amenities, programming and use, and management.

6.1 Community engagement

Designers at De Urbanisten led community engagement initiatives for the water square, starting in 2011 with a "diverse group of participants that wanted to invest time to think about the design of the square". Community outreach processes included 30 stakeholders from institutes such as Zadkine College and Graphic Lyceum (students and teachers), members of the *Igreja Adventista do setimo dia em Rotterdam* church, a theatre, and the David Lloyd Gym, as well as residents living in surrounding Agniesebuurt (De Urbanisten, "Water Square Benthemplein", p. 22). Although the square is not directly bordered by residential buildings, De Urbanisten was also able to get in touch with area residents acting as community leaders during their outreach. According to Florian Boer, this process lasted about half of a year, and included initial outreach to nearby organisations and institutions, with the aid of a "comic book" that visually explained the existing concept of water squares: "I explained to them the concept, gave them a book, and invited them to think along with me who could represent their institution." Then De Urbanisten led three themed workshops: one on suggesting ideas for programming and activities; one emphasising "choices" by participants; and a refinement workshop.

Because the overall design and stormwater management functions of the water square were, for the most part, predetermined by the architects and the City of Rotterdam, the community outreach process focused instead on programming choices. This process used creative and collaborative activities, such as "mood boards", to reflect on potential activities that could take place in the square (Florian Boer, personal communication, 8 May 2020). Feedback mostly focused on making the space dynamic for younger visitors and the students known to be frequent visitors to the area, alongside the inclusion of spaces made for play and relaxation, and "green, intimate places". Because the physical-resilience goals for the square were predetermined, the focus of the community engagement process was on uses for the space, and there was little discussion of climate hazards or adaptation measures (De Urbanisten, "Water Square Benthemplein"; Florian Boer, personal communication, 8 May 2020).

Within the municipal government, some outreach and involvement of different departments took place, including those of Public Works, Water Management and Sewerage and, eventually, the city cleaning team. But it is widely suggested that the cleaning team should be brought into the research process earlier, especially when it comes to workshopping design decisions that will have implications for maintenance and management (see "Management" below) (Joop Polfliet, personal communication, 25 August 2020).

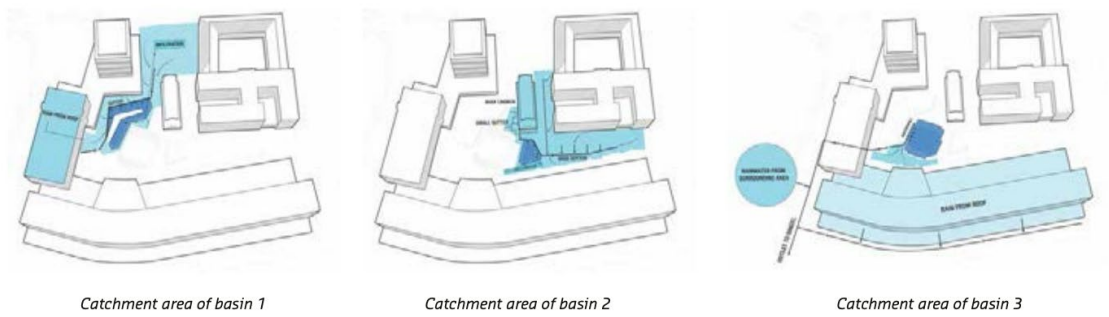
In terms of awareness of climate-adaptation measures, various notices within the space describe its stormwater management functions. However, ongoing community engagement and evaluation is limited for the water square. Florian Boer notes that the church, which renamed itself after the square to be the *Waterpleinkerk*, has sometimes used the basin's seating to hold church services and has, at times, taken part in volunteer clean-ups of the square. Other neighbourhood committees have, in the past, held markets and children's activities in the square (Florian Boer, personal communication, 8 May 2020). But for the most part, in recent years there has not been a particularly active grassroots volunteering or stewardship programme in Waterplein Benthemplein: "because people don't live in this area – so they are not 'by heart' with this environment, they come and go" (Wim van Tiggele, personal communication, 26 August 2020). Despite this lack of ongoing outreach, some concerns about the ease of the space being "polluted" have become clear to designers (see

Management, below) (Florian Boer, personal communication, 8 May 2020). The water square is also not currently part of the "neighbourhood approach" being undertaken as part of the community engagement strategy for Rotterdam Weather Wise (see 5.5.2 Environmental and climate-adaptation policy, above).

6.2 Design and amenities

The design process for the square began in 2011 and was finalised in 2012. According to designer Florian Boer, the space was designed so that more active uses would be concentrated in places where buildings or trees provide shade during the day, with skateboard features such as steel grind surfaces in the "shadowy areas cast by buildings". Meanwhile, informal areas intended for sitting and socialising are placed in sunnier areas. Even so, the design of the space is primarily focused on stormwater management goals (flooding and drought), and did not place emphasis on design choices around other hazards such as heat stress, or lack of access to shade. Climate hazard prioritisation was not based on specific climate data, rather on water-related priorities outlined in Waterplan Rotterdam 2 (see 5.3.2 Environmental and climate-adaptation policy, above) (Florian Boer, personal communication, 8 May 2020).

Figure 2: Three defining catchment basins in Waterplein Benthemplein



Source: De Urbanisten, "Climate Adaptive ZoHo"

The largest of the basins (Basin 3) is in the centre and features a water wall on its southern edge, through which water from its catchment area falls into the basin. The basin's stormwater collection services are paired with its public space uses: Basin 3 has amphitheatre-style stepped seating along its edges, space for basketball or soccer, a drinking water fountain, and a ramp for access. This basin was designed as the focal point for active and communal uses (Florian Boer, personal communication, 8 May 2020). On the southern/southwestern side of the space is a mid-sized basin, Basin 1. This basin has steps that can function as seating, as well as a bench and a raised garden, all within an sunken skating area. At the north side of the square is a smaller, shallower basin, Basin 2, with stepped edges and a raised island platform in the centre, designed for informal performances or other social activities. The north side of the square also has a line of tree-shaded benches that sit slightly below ground level, positioned along rainwater channels that run towards Basin 2. All of these basins are designed so that rainwater is temporarily stored in the basins, then released more slowly into the soil:

> We keep the water that falls on the place, in the place. We simulate as if it were not paved, even though it is because we want to facilitate all sorts of activities. The rain does not disappear into sewage but is via a delayed device brought back into the soil. (Florian Boer, personal communication, 8 May 2020)

Figure 3: Access ramp, amphitheatre-style seating, and drinking fountain in Basin 3

Source: Author

Trees line the north/northwest entry path, as well as the west entry. Multiple raised garden areas break up the hardscape and provide greenery, including at the south entrance, abutting basins 3 and 2, and in the middle of Basin 1. Garden beds are placed near some of the entrances to provide low walls for seating (Florian Boer, personal communication, 8 May 2020).

Meanwhile, stainless steel gutters partially line the edges of the mid-size (skateboard) basin, and the small-size basin. Worth noting is one above-ground steel gutter near the south entrance of the square that releases water from the roof of adjacent buildings into the gutter network in the square (Centre de Cultura Contemporània de Barcelona: Public Space, 2014).

In contrast to other nearby Climate Proof ZoHo projects, such as the ZoHo Rain Garden, Waterplein Benthemplein is mostly dominated by hardscaping. The design of the space remains visually cut off from surrounding neighbourhoods. The south entrance to the park is through a pedestrian underpass beneath the Grafisch Lyceum, which narrows sight lines from within and outside. It lacks connection, both physical and visual, to other nearby spaces such as the Luchtpark or ZoHo Rain Garden. Ground-level uses (both park-facing and external-facing) of the buildings that surround the park are also not particularly active or inviting. The buildings surrounding the park have inward- or park-facing main entrances, meaning that the outward edges of the park offer mostly blank walls, and very little in the way of obvious reasons to enter the park. This leads to the main uses of the park being access to the main entrances of specific bordering institutions, such as the school, fitness centre, or theatre (see 6.3 Programming and use, below).

Amenities in the space are fairly limited. There is no moveable seating in the space, and what seating exists mostly takes the form of bank-style benches or steps on the edges of the three basins. A drinking fountain on the steps of the large basin draws use by people engaging in exercise, and also draws in children who are curious about its unusual appearance. Ample bike parking and rubbish bins are provided in the space.

Accessibility is mixed in the design of the space, which has a few accessibility choke points with stairs-only passage. Only Basin 3 appears to have wheelchair accessibility, in the form of a ramp (Florian Boer, personal communication, 8 May 2020). Meanwhile, the steel rain gutters that encircle the other two basins can make passage difficult for differently abled visitors, including those with mobility challenges or who use crutches, a cane, or a wheelchair.

Based on the performance of Waterplein Benthemplein, design choices for new water squares have been adjusted by staff of the City Management department. Relying less on mechanical features, designs of new and future water squares are based more on gravity-assisted collection of stormwater (Johan Verlinde, personal communication, 13 August 2020).

6.3 Programming and use

The water square designers at De Urbanisten note that they: "didn't want to programme too much, too obviously". During the community outreach process, workshops were guided by visions of the different activities that could take place in the square. As noted in Section 6.2 Design and amenities, designers chose the most popular activities and incorporated them into the design of the square. Features like the basketball hoop and soccer area were placed in the largest basin (Basin 3). Smaller spaces closer to the edges were seen as more "fit for skating activities," and other more strenuous activity, in part due to the shade that falls on them. The steps in Basin 1 were equipped with steel surfaces that enable skateboarders to grind or do tricks. Sunnier areas of the square were designed to be "places where you can just sit and hang out together". Overall, the steps and inclines that define the basins' water collection capacity were seen as multi-purpose features, offering opportunities for multiple social and active uses (Florian Boer, personal communication, 8 May 2020).

Based on observations of the space, the majority of activity and use of the square is for sitting, gathering and socialising in small groups, passing through or to surrounding institutions by foot or by bicycle, or for skateboarding. During the school year, the use of the space rises and falls throughout the day, coinciding with class attendance, especially by Zadkine students. As mentioned in 6.1 Community engagement, the church bordering the square has, in the past, been in touch with designers and held outdoor services in the square (Florian Boer, personal communication, 8 May 2020). But today most programming is passive and/or self-driven, rather than organised (Florian Boer, personal communication, 8 May 2020). Overall, the water square is a relaxed environment that plays host to visitors taking part in a wide range of (mostly passive) activities.

6.4 Management

Due in large part to its innovative design, Waterplein Benthemplein requires unique maintenance and management practices. The square falls under the Noord-Ost area of the

cleaning team and the space can pose a challenge, as compared with other public spaces in Rotterdam, in part because of its physical design differences. Waterplein Benthemplein often accumulates rubbish, broken glass, and debris (dirt, leaves) in basin areas. These challenges were addressed in a specialised water square management plan created by the City Management team, which was also applied to another water square finished in the same year as Waterplein Benthemplein (Johan Verlinde, personal communication, 13 August 2020).

Though claims of frequency vary, it is reported that Waterplein Benthemplein is cleaned at least once a week, during which a team of cleaning staff conduct a regular cleaning with a diesel "Swiper" vehicle designed to sweep and spray paved areas, as well as manually removing garbage in gardens and the basin areas not reachable by sweeper vehicles. Other municipal employees report that the space is checked daily. Over time, the basin design also collects leaves and sediment, which requires the vacuuming, blowing, and shovelling of debris multiple times a year, depending on leaf accumulation. Less frequently, a specialised "deep cleaning" of the basins is conducted by the deep cleaning (*Diepreiniging*) sub-department that has a separate team leader who manages a more intensive cleaning out of basins, leaf removal, and cleaning of graffiti (Bartjan Zilverberg, personal communication, 8 September 2020). Again, reports of frequency vary among City Management employees, but this process usually happens twice a year, and involves pressure washing with special machines, and the cleaning of gutters and sewer-connected features (Wim van Tiggele, personal communication, 26 August 2020; Joop Polfliet, personal communication, 25 August 2020).

Despite the aforementioned specialised management strategies for the square, many employees in the Clean City department point out that the square was designed without "thinking about how to clean it" (Bartjan Zilverberg, personal communication, 8 September 2020; Joni Reijven, personal communication, 17 August 2020). Cleaning department team members were consulted later in the planning and design process for the square than other departments such as Public Works, at which time staff members raised concerns to the designers about maintenance challenges for the above reasons (Wim van Tiggele, personal communication, 26 August 2020; Joop Polfliet, personal communication, 25 August 2020). For example, though neighbouring institutions were consulted during the design and planning of the space (see 6.1 Community engagement, above), cleaning team members do not see these stakeholders upholding promises to assist with long-term maintenance of the square:

> Typical was that before they made this waterplein, they were very much talking with the school, with the environment, with the church and they made appointments about how to manage the plein – they had a role, but they don't take their role with that. (Wim van Tiggele, personal communication, 26 August 2020)

In the water square, there is less evidence of management and stewardship activity as compared to other nearby public spaces such as the Luchtpark, where an information board informs visitors of ways of signing up for volunteer events.

Staff also mention that students in the area are prone to leaving rubbish in the basins and on the ground in the space, with cigarette butts sometimes clogging LED lighting features (Johan Verlinde, personal communication, 13 August 2020). This is hypothesised by cleaning team members to be in part because rubbish bins are only placed outside the basins; team members were eventually allowed to move them to more visible locations. Overall, this pattern of

littering prompted attempts at communication with the Zadkine school by the City Management department, as well as efforts at enforcement of tickets for littering through collaboration with the Monitoring and Enforcement (*Toezicht & Handhaving*) department. Nonetheless, this behaviour is still perceived as a particular challenge for this space among members of the cleaning team. In large part because the square requires more regular cleaning than other public spaces, data-controlled cleaning does not have significant use in Waterplein Benthemplein (Wim van Tiggele, personal communication, 26 August 2020).

The square's performance as a stormwater management feature is continuously monitored. Sensors indicate how often basins take on excess water, and groundwater monitoring is ongoing around the square. However, ongoing engagement about the social performance of the space, and public opinion around its accessibility, comfort, and cleanliness is not often gathered or analysed (Johan Verlinde, personal communication, 13 August 2020).

7 Discussion of results

In this section, performance on metrics for physical and social resilience will be analysed for the selected sites in Rotterdam. Much like the results discussed above, the evaluation of the space's performance will also be examined in light of the analytical framework introduced above of community engagement, design and amenities, programming and use, and management.

This section ranks the performance of the space in terms of "low", "medium", or "high", according to how well the space demonstrates various aforementioned indicators of physical or social resilience (see Section 3 Analytical framework). In each category, if the space has demonstrated 0 to 32 per cent compliance with metrics it will be marked "low" performance, 33 to 66 per cent as "intermediate", and 67 to 100 per cent as "high".

In practice, the water square has seen mixed success. On the level of physical resilience building, its strengths are in its design and amenities; when social resilience is considered, the square is most effective in its programming and use. Meanwhile, the square has opportunities to be enhanced through climate-informed community outreach, improved and specialised management practices, and accessibility, among other efforts.

Table 6: Results

	Community engagement	Design and amenities	Programming and use	Management
Physical resilience	⊗ Integration of observed and potential climate risks (both gradual and sudden onset) into community engagement process	☑ Flexibility and diversity of function[a] ☑ Redundancy and modularity[a] ☑ Ability to fail safely[a] ⊗ Design and amenity choices tailored to full range of local climate hazards ☑ Design choices enhancing ability to resist, absorb[b] ☑ Choice of amenities enhancing capacity to resist, absorb[b]	⊗ Use of climate data in decisions around types of programming taking place in a public space ☑ Physical resilience features support activity and use	⊗ Staffing choices for property management reflect integration with adaptation goals ⊗ Ongoing monitoring for efficacy of resilience features ☑ Creation of specialised management plan and/or strategies to accommodate resilience features
Social resilience	☑ Resourcefulness of community engagement leaders, i.e. thoroughness, representativeness, and diversity of community engagement[a] ☑ Responsiveness of community engagement leaders to community vision[a] ⊗ Resilience as part of the vision of the community ⊗ Sense of stewardship by users	☑ Flexibility and diversity of use[a] ⊗ Accessibility and inclusion through design ⊗ Accessibility and inclusion through amenities	☑ Encouragement of social interaction ☑ Inclusivity of activities (age, gender, ability) ☑ Reflection of the preferences of the community ⊗ Connectedness to local partners ☑ Variety of uses and programming	☑ Adaptability and learning centred approach [a] ⊗ Ongoing evaluation on the basis of use and perception of its users ⊗ Involvement of users in management (i.e. volunteer opportunities)

Note: Red = "low" performance, brown = "intermediate" performance, and orange = "high" performance on the listed metrics

Source: Author; [a] Tyler & Moench, 2012, pp. 312-313; [b] Alexander, et al., 2016

7.1 Analysis of physical resilience

On **community engagement** metrics, physical resilience is ranked as low due to the fact that observed and potential climate risks were not an area of focus during the outreach process led by De Urbanisten. Due in large part to the pre-conceived goals for the space and its function as a stormwater management feature, the outreach process was mostly limited to feedback-gathering workshops centred on activities and uses, as outlined above in 6.1 Community engagement. While these considerations for activating the space are crucially important to the creation of a socially vibrant public space, a deeper conversation around physical hazards broadly faced by Rotterdam residents was not pursued during the community outreach process.

When it comes to **design and amenities**, the space exhibits a high level of performance on physical-resilience measures. The space is multi-functional, displaying a flexibility and diversity of function that blends stormwater collection systems with recreational uses such as skateboarding and basketball and social uses such as seating and gathering areas. The space enhances "redundancy and modularity" in the city's stormwater storage capacity through its inclusion of three stormwater basins alongside multiple gardens and gutter systems, all of which foster delayed infiltration of stormwater into the soil, instead of it being directed into the sewerage system (Tyler & Moench, 2012, pp. 312-313; Florian Boer, personal communication, 8 May 2020). Meanwhile, monitoring of the space through basin sensors guards against "failure" of the square in terms of these physical functions (Tyler & Moench, 2012, pp. 312-313; Johan Verlinde, personal communication, 13 August 2020).

In terms of attention to local climate hazards, design choices do not use a full or comprehensive view of the range of climate hazards faced in Rotterdam, due in large part to the focus of design choices on managing stormwater-related risks. Because the design of the square was based on general stormwater management goals, as outlined in Waterplan Rotterdam 2 (see above "Environmental and Climate Adaptation Policy"), other local risks relevant to the neighbourhood, such as heat stress and shade access, were only included in the design process as secondary considerations. Overall, design choices made for the square enhance the neighbourhood's ability to resist and absorb heavy rainfall events. Though limited, amenities in the space are generally incorporated as part of the functionality of the square in terms of its capacity to absorb rainwater; for example, stepped seating forms the sides of water collection basins (Alexander, et al., 2016).

In terms of **programming and use** for enhanced physical resilience, the space is at an intermediate level on the performance scale. Waterplein Benthemplein is generally host to self-led activities, rather than organised ones. Therefore, the use of climate data in formal programming decisions is not applicable to the space. However, self-led uses of the square generally consist of gathering, sitting, skateboarding, cycling, and passing through to visit surrounding institutions – none of which has a direct relation to climate hazards faced in the neighbourhood. That said, the self-led uses that do take place in the space are well-supported by the physically resilient features of its design, exhibiting a successful layering of physical functionality (i.e. drainage, stormwater collection) with human activity (i.e. skateboarding in basins).

Management of the water square is here ranked at an intermediate level of performance in terms of its ability to enhance physical resilience. Staffing choices for the management of

the space do not differ from other publicly managed spaces in Rotterdam, and vary on a week-to-week basis among members of the cleaning team of the City Management department, which means that specialisation in the cleaning of the water square is difficult. At the same time, ongoing monitoring of the maintenance and cleanliness status of the space has very limited uptake in terms of software and reporting systems such as Stadsbeheer Mobiel and data-driven cleaning intended for this purpose (see 5.3.1 Public space policy and community engagement). Additionally, members of the cleaning team face unique challenges because of the design of the water square, and it is not uncommon for staff to note that the space was designed with insufficient consideration for ongoing maintenance logistics. This can all be observed in the water square, despite the fact that the space received tailored attention with the creation of a specialised management plan and the inclusion of stormwater capacity sensors in the structure of the basins.

Overall, physical resilience has been enhanced by Waterplein Benthemplein, but could have been strengthened further with a few additional considerations. Its greatest strength in this category lies in the choices made around design and amenities, which enhance the square's ability to physically resist and absorb stormwater-related hazards. However, a more involved community outreach process that centred on climate hazards would have likely yielded a more comprehensive view of the climate risks faced by visitors and nearby residents (i.e. heat). Climate-sensitive programming could make the space even stronger, though it is worth noting that the self-led activities that do happen in the square are well-supported by the multi-functional physical structures designed for stormwater collection. And, lastly, although the space has received some special attention in terms of the creation of a tailored management plan, maintenance, in practice, still faces some ongoing logistical challenges and could be improved with staffing continuity and stronger day-to-day monitoring of the space.

7.2 Analysis of social resilience

In terms of **community engagement** metrics for social resilience in Waterplein Benthemplein, the space performs with intermediate proficiency. Designers at De Urbanisten who were hired to conduct outreach were able to convene a series of three workshops, attended primarily by stakeholders from surrounding institutions such as the church, fitness centre, and schools adjacent to the space. Certain municipal departments were also involved in the process, especially Public Works. However, others, such as the cleaning team were not involved until later in the process – a source of ongoing concern among team members. As mentioned above in 6.1 Community engagement, the workshops took place over the course of six months, and each focused on a different goal: the first on programming and activities; the second emphasising "choices" by participants; and the last consisting of a refinement of ideas among participants. The physical-resilience goals for the square were predetermined, so the focus of the community engagement process was on activation rather than on climate-adaptation goals. As a result, climate hazards and resilience weren't highlighted by leaders or participants in the workshops – rather, attendees emphasised the importance of the space being tailored to young visitors and students, alongside the inclusion of spaces made for play and relaxation, and green gathering spaces – all of which are reflected in the final design. Though climate resilience functions are made clear via educational signage throughout the space, evidence of ongoing stewardship or volunteerism is scant in the square.

Design and amenities in the water square also enhance social resilience at an intermediate level. The space provides many different flexible spaces, geared toward different types of activity levels and social dynamics. For example, active uses such as skateboarding are designed to take place in areas that receive more shade, and areas that are more often in the sun are designed for more sedentary uses, such as gathering and socialising. Different types of seating and various distinct parts of the square mean that a visitor's experience can be tailored to their own desired use of the space, from a quiet meeting on a bench or on the steps of one of the basins, to a lively basketball game on the basketball court. Accessibility, however, is not a strong point for the square's design or amenities, which include multiple points where passage would be difficult for people with limited mobility. Some of the most used seating areas, as well as two of the three basins, are not easily wheelchair accessible.

The **programming and use** of Waterplein Benthemplein, meanwhile, exhibits high performance in terms of social-resilience metrics. The space is a hub for socialising, and often hosts small groups of students gathering between classes, or meeting up for an afternoon of skateboarding. These social connections are possible despite the fact that many people merely use the space as a thoroughfare, or pass through on their way to one of the institutions surrounding the square. Activities, as mentioned above, are primarily self-led, and range from active to passive, meaning that activity and uses are flexible and inclusive. Recreational activities like skateboarding tend to attract young visitors, while benches and seating used for resting or socialising are used by visitors of all ages. These activities reflect the character of the neighbourhood, which is active, with student life based on the multiple schools in the area. However, the range of supported activities in the space means that it can attract visitors of all ages and abilities. The space does not show ongoing evidence of connectedness to its surrounding institutions – though the church is said to have held services in the square in the past, these types of programming connections are no longer apparent. Although active, organised programming could strengthen the space, the variety of self-led activities is nonetheless a strong characteristic of Waterplein Benthemplein.

On the scale of social resilience, **management** practices in the square perform at an intermediate level. The management of the square does demonstrate some level of "adaptability and a learning-centred approach" (Tyler & Moench, 2012, p. 315). Staff of the cleaning team who are responsible for maintenance of the square have opportunities for exchange and problem-solving within staff meetings. However, based on insights from staff, robust reporting of acute or ongoing problems through municipal public space management software is not commonplace for this particular water square. Nonetheless, the square has offered learning opportunities on a broader scale. Based on observations of the performance of Waterplein Benthemplein, newer water squares created by the city are to be given updated designs with fewer mechanical features (Johan Verlinde, personal communication, 13 August 2020). However, in terms of visitor experience, the square is not subject to any ongoing evaluation on the basis of use and perception of its users. This limits the extent of knowledge capture and "adaptability" of the space in terms of social uses. Though visitors are able to report maintenance issues in the square via the BuitenBeter app, visitors are not actively engaged in management of the space and, unlike in other nearby parks such as the Luchtpark, repeated site visits showed no clear calls to action for volunteer activities in the space, nor did interviews with local stakeholders refer to long-term stewardship activities in the square.

Overall, in terms of social-resilience metrics, the square performs best on metrics of programming and use. The square is host to a variety of self-led activities, and reflects the character of the neighbourhood well – providing ample space for students and young people to rest, exercise, and/or socialise in their free time. Social resilience, as enhanced by the square, could be further bolstered in other areas. To start with, earlier and more broadly scoped involvement of municipal and resident stakeholders in the community engagement process could have yielded better-informed ideas for long-term management of the space, as well as more comprehensive attention to climate concerns held by nearby residents. Design and amenity choices support social activity and comfort in the square, but show room for improvement with regard to accessibility. Management and maintenance of the space exhibits some movement toward a learning-oriented approach, and outcomes from the square have informed decisions around newer public spaces in Rotterdam. This is despite the fact that reporting systems for maintenance staff in public spaces do not appear to be well-used for Waterplein Benthemplein. Meanwhile, the square does not exhibit many opportunities for volunteerism or stewardship to take root – a key ingredient for locals to feel invested in the success of a public space. The space shows progress on social-resilience metrics, but there remains room for improvement.

In sum, Waterplein Benthemplein has made progress on physical and social resilience simultaneously, demonstrating an imperfect but innovative layering of the two concepts in the context of a multi-functional water square. The Waterplein Benthemplein is an innovative example of re-designing available hardscaped public space to climate-adaptive purposes such as stormwater management, and it offers opportunities for learning and growth in the creation of high-functioning climate-adaptive public spaces that enhance resilience both socially and physically.

8 Recommendations

Rotterdam's Waterplein Benthemplein performs well in certain specific areas of climate resilience. Its design and amenities, in particular, strengthen physical resilience in the neighbourhood, and its programming and uses enhance social resilience. In other areas, the space has made progress, but leaves room for learning and improvement: robust and climate-informed community engagement; monitoring of climate-resilient public spaces; systematic implementation of management techniques designed for resilient public spaces; programming sensitive to local climate hazards; and enhanced accessibility in public spaces. By working to support these aspects of public spaces through the lens of broader climate-adaptation planning Rotterdam can continue to perform better in terms of social and physical resilience to climate.

Though these recommendations are informed by the efforts towards resilience-building in Rotterdam, they can be applied to public spaces in any community working towards the mainstreaming of climate adaptation. In studying the performance of Waterplein Benthemplein on these various metrics, broader lessons and potential pitfalls in resilience-building have become clear, and can guide the way communities incorporate public space projects into their adaptation practices and policies.

8.1 Community engagement

Community engagement must happen from the beginning and continue after the project is finished. As placemaking experts have noted for years. It's important, as with any project that has implications for the public realm, for community engagement to be a part of every aspect of its undertaking. Beginning before the design (or renovation) of a space, input must be sought from diverse stakeholders representative of the surrounding community, rather than presenting them with a pre-conceived design and merely asking them to "fill in the gaps". This process must be conducted with an eye to continuation long after a project has been built or completed, and must also meaningfully include staff of management teams, who can offer insights into the day-to-day realities of maintaining a space. Robust community engagement is the only way to ensure that both physical and social resilience is being enhanced in the space, and to keep the interests of the community at the heart of the way a space is designed, programmed and managed. Thankfully, community engagement for projects in cities has evolved in recent years, incorporating deeply interactive and increasingly inclusive approaches that reach more people in a more intentional way. Rotterdam's Weather Wise strategy and its Neighbourhood Approach are a promising evolution of the city's adaptation planning, and involve more outreach. Even beyond considerations for climate adaptation, this development of a community engagement approach that meaningfully builds on the capacities and experiences of the neighbourhood is one that can be adapted and applied to any public space project in any community.

Resilience projects are strengthened by partnerships and support of non-profits. It is key to the success of resilience projects based on public space that local non-profits and grassroots activists are seen as partners and sources of on-the-ground knowledge. Including non-profits as partners during the course of the community engagement process means that the public space project will be better-informed with regard to the vision of the community, the capacity for ongoing volunteerism and stewardship, and locals' lived experiences of climate hazards. Rotterdam's Weather Wise strategy draws on the reach of organisations such as Water Sensitive Rotterdam and Opzoomer Mee (see Appendix B), as experts and trusted sources of support on public space projects. In any public project, cities and project leaders can make sure that non-profits and other grassroots organisations are seen not only as co-implementers, but also as co-creators (Jurgen Groenenboom, personal communication, 14 July 2020). These organisations can also be included in programming a space, as well as the process of writing broader climate-adaptation strategy. Worth noting is that for any partnership of this type to be genuine and sustainable, organisations and individuals should be fairly compensated and recognised for their insights and time.

8.2 Design and amenities

Climate-adaptive features must not hinder accessibility and inclusion. Adaptation at the expense of accessibility isn't true adaptation. In order for climate-adaptation paradigms to be well-served by integrating the concepts of both physical and social resilience, it is important to make sure that resilience is aimed at inclusion. If physical-resilience features hinder any group of people from accessing or feeling welcome in a given space, it does not inherently improve social-resilience outcomes for that group. From community engagement to management, every part of public space practice offers opportunities for increased

accessibility and inclusion – as well as the chance to address inequities, such as uneven access to green spaces. To that end, a growing body of research around "green gentrification" also provides context around neighbourhood impacts of sustainability projects, implying that potential housing affordability impacts should be taken into account in decisions on public spaces. Broadly speaking, accessibility must be a driving force in any initiative concerning public spaces, whether resilience-oriented or not.

A multi-hazard approach is vital to comprehensive resilience. It is easy to miss less-visible climate hazards such as heat stress, but a multi-hazard approach to climate resilience means that a project addresses climate change in a more complete manner. In Rotterdam, the Waterplein Benthemplein was almost entirely focused on stormwater management priorities, with only minimal design considerations given to heat and shade. However, it is possible that this pattern will change in the near future, as Rotterdam is working on a heat plan. The heat plan is poised to be a cross-departmental effort led by the Public Health Department (GGD), which also includes staff from the City Management department who work on climate-adaptation strategy (Johan Verlinde, personal communication, 13 August 2020). To incorporate local climate hazards more effectively, designs for public spaces should follow the trend shown in municipal adaptation strategies such as that of Rotterdam Weather Wise, which increasingly use locally generated data and engage with locals about their lived experiences of hazards such as flooding or subsidence. This approach, which focuses on data-gathering and prioritises a broad range of local climate hazards, can broadly inform urban climate-adaptation plans and resilience efforts in public spaces.

Resilience goals for public spaces can be nested with other broader goals. Perhaps because Rotterdam faces so many hydrological risks, climate-adaptation projects in Rotterdam are seated within the water sub-department of the City Management department. This integration of climate adaptation within a department of such long-standing importance to Rotterdam means that resilience goals are better mainstreamed and centred in city operations and planning of vital infrastructure such as sewerage. But beyond this, resilience goals as they relate to public space projects are often linked to other broad-sweeping and timely priorities. In 2020, a series of public space projects that combine goals of greening with COVID-19-sensitive adjustments to the public realm were announced, as part of the city's aforementioned Stronger Through programme (*Sterker Door*). Finding ways to work across sectors, goals, and/or departments is essential to mainstreaming adaptation projects in this way (Global Commission on Adaptation, 2019, p. 41). Though not every community faces the same suite of climate hazards, and not every municipality is structured the same way, this approach of linking public space and resilience to other local priorities is nonetheless useful.

8.3 Programming and use

Highly designed public space projects are well-suited to pairing with low-tech initiatives. The City of Rotterdam complements its design-oriented projects such as Waterplein Benthemplein with the support of grassroots actions at the neighbourhood or individual level. Through de-paving and greening subsidies distributed by partners at Opzoomer Mee, as well as direct lending of supplies, the City of Rotterdam encourages small-scale projects and stewardship behaviour. Even beyond the scope of public space projects, communities' central climate-adaptation efforts are enhanced when they overlap with ongoing volunteer and

stewardship efforts. Resilience efforts based on public spaces become more inclusive and engaging with the addition of strategies that are low-tech, nature-based, or exhibit a low barrier to entry.

8.4 Management

Resilient public spaces require specialised management plans. It is crucial to the long-term viability of a public space that an appropriate management plan is created and consistently implemented – maybe especially so in uniquely designed, climate-resilient public spaces. A unique management plan was created for Waterplein Benthemplein, blending standard maintenance practices for public spaces with specialised strategies to maintain its unique physical features and capacity to collect stormwater. Tailoring a management plan to the technical specifications of a climate-adaptive public space is important for its long-term success, but this management plan must also be mindful of how visitors use the space, and what challenges management and maintenance staff face on a day-to-day basis. Both of these can be addressed through cross-departmental communication, as well as ongoing community outreach.

True resilience requires iteration. Waterplein Benthemplein was an experiment stemming from Waterplan Rotterdam 2, and since then has led to an evolving concept of the "water square" design. By observing the performance of Waterplein Benthemplein over time, City Management department team members were able to glean new design ideas for future water squares. Most urban policies and public space projects can be improved through a nimble, iterative approach – regardless of the end goals, an emphasis on flexibility, long-term learning, and continuous improvement ensures more meaningful knowledge capture and an outcome better-suited to accommodating uncertainties (i.e. the impacts of a changing climate).

9 Conclusions

This study sheds light on the under-explored connection between public spaces and climate adaptation: namely, the opportunity for social and physical resilience building in the public realm. The study shows that Rotterdam breaks the mould in resilience thinking, creating public spaces that enhance not only physical resilience to climate change, but simultaneously work to improve measures of social resilience. By undertaking climate-adaptive efforts in public spaces, Rotterdam transcends traditional concepts of resilience, which often centre on physical measures and leave the human experience on the wayside. By acting to link placemaking with resilience-building, Rotterdam acknowledges the vital role of social connections and the public realm in supporting better outcomes in a changing climate – all the while improving everyday quality of life for residents.

Overall, this observation and outreach-based examination of Rotterdam's Waterplein Benthemplein lays the foundation for an emerging community of practice around physically and socially resilient public spaces. Overall, using this dual approach to resilience analysis of Waterplein Benthemplein provides a precedent in attempting to enhance both physical and social resilience in the public realm. Especially given that the space was an early example of the "water square" prototype, it demonstrates a movement towards a new

paradigm for climate-adaptive public spaces: one that layers social functions and placemaking with physical resilience. Though imperfect in some areas of its execution, its value as a public space pilot project is that it offers many lessons in integrating physical and social resilience to climate change into decisions cities make about their urban form.

In any case, Rotterdam offers valuable insights into layering both physical and social resilience to climate change into innovative public space projects. By piloting the concept of the "water square", Rotterdam has put forth a model of resilience-centred placemaking. Grounded by an evolving climate-adaptation strategy that acknowledges social cohesion and quality of life among other more mainstream concepts of physical resilience, Rotterdam has become a robust example in a rapidly evolving area of climate resilience based on public space and placemaking.

While Rotterdam is by no means the only city taking action to enhance climate resilience through choices made in the public realm, it is worth noting that it provides guidance towards best practices that can be applied in other cities that have already begun resilience initiatives in public spaces, or in those beginning to do so. Rotterdam is perhaps comparatively well-positioned to take such an innovative approach due to the fact that much of its climate-adaptation efforts are backed by a long-prioritised and well-resourced water department. Nonetheless, this particular model of analysis, paired with the lessons Rotterdam offers, are valuable in a wide range of urban contexts, and many can be applied to existing or newly developed public space projects alike. Rotterdam's approaches are particularly valuable for cities dealing with hydrological hazards, such as coastal or riverine cities, but the metrics are designed to accommodate the particular context of a given city and its unique climate hazards. Using or adapting this framework to evaluate public spaces can lend context to any community facing climate hazards, regardless of locality or development status.

With all this taken into account, barriers may still remain to using this model of social and physical resilience in public spaces. If these metrics are used in other places, potential challenges might arise due to gaps in capacity at the municipal level. This can manifest in a number of ways: a lack of municipal staff aware of, or equipped to take initiative on, climate-adaptation work; shortfalls in prioritisation of climate-adaptation planning; insufficiency of local climate data; challenges with regard to financial resources behind public space or climate-adaptation projects; political barriers to action on climate change; or limited inter-departmental collaboration (for example, between urban planning and public works departments). Future research and urban climate-adaptation practice should focus on using the framework proposed in this paper to better understand how to overcome the above-mentioned challenges and leverage the potential of placemaking for more habitable and resilient cities.

Cities are beginning to include considerations related to public spaces in sustainability and climate-adaptation plans. Because this is an emerging community of practice, outcomes in cities such as Rotterdam can and must inform a new and growing paradigm around climate-resilience efforts based on public spaces, ensuring that social as well as physical resilience is improved. Rotterdam makes the case for a comprehensive approach to climate-adaptation that focuses on the lived experience and well-being of people, and the public spaces that make communities habitable and, hopefully, more resilient.

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Appendix

Appendix A: Personal communication and interview record

Table A1: Personal communication records			
Interviewee name	**Affiliation**	**Date**	**Sector**
Florian Boer	De Urbanisten	8 May 2020	Private (design firm)
John Jacobs	Water Sensitive Rotterdam	11 May 2020	NGO
Jorg Pieneman	[Rotterdam] Gemeente Rotterdam, Stadsbeheer	3 June 2020	Municipal
Jurgen Groenenboom	Opzoomer Mee	14 July 2020	NGO
Johan Verlinde	[Rotterdam] Gemeente Rotterdam, Stadsbeheer	13 August 2020	Municipal
Joni Reijven	[Rotterdam] Stadsbeheer, Schone Stad, Biodiversity	17 August 2020	Municipal
Bas Sala	Studio Bas Sala	19 August 2020	Private (design firm)
Joop Polfliet	[Rotterdam] Gemeente Rotterdam, Stadsbeheer, Reiniging	25 August 2020	Municipal
Wim van Tiggele	[Rotterdam] Gemeente Rotterdam, Stadsbeheer, Wijk Reiniging Team Noord-Oost	26 August 2020	Municipal
Raymond van den Broek	ZOHO citizen	26 August 2020	Private (neighbourhood network in ZoHo)
Tim De Waele	[Rotterdam] Gemeente Rotterdam	4 September 2020	Municipal
Bartjan Zilverberg	[Rotterdam] Gemeente Rotterdam, Stadsbeheer, Reiniging Team Leader Noord-Ost	8 September 2020	Municipal
Source: Author			

Appendix B: Local non-profits and partnerships

Water Sensitive Rotterdam acts as a public–private joint venture that connects locals to resources they need for grassroots climate resilience projects. Director John Jacobs, who had previously been involved in the creation of municipal adaptation strategies such as Waterplan Rotterdam 2, leads the so-called "movement" of Water Sensitive Rotterdam. The organisation is led with a multidisciplinary and community engagement-centred approach that recognises the importance of both social and physical outcomes of adaptation projects that enhance the quality of the living environment. To that end, Water Sensitive Rotterdam works toward multiple goals: implementing demonstration projects in climate adaptation, ranging from the scale of one house up to an entire neighbourhood, creating and spreading new methods of community engagement and cooperation, and breaking down barriers between departments and disciplines at the municipal level (John Jacobs, personal communication, 11 May 2020).

With more than 200 projects implemented, Water Sensitive Rotterdam engages with businesses, locals, and institutions to support resilience-related projects across the city, and its "café" events to exchange knowledge and ideas are reported to attract more than 100 participants. In its early days, the organisation undertook greening and water storage projects, and in doing so encountered widespread lack of environmental awareness from locals – many of whom were unaware that Rotterdam lies below sea level. Recognising both the high ratio of private to public land ownership in Rotterdam and the importance of individual enthusiasm in taking action on environmental issues, Water Sensitive Rotterdam provides subsidies to locals undertaking projects on their own property (John Jacobs, personal communication, 11 May 2020).

Opzoomer Mee is a local and independent non-profit that is a municipal partner and grassroots implementer of many public realm projects in Rotterdam. The organisation receives funding from the municipality, especially through the City Management and its funding for city-wide greening through *"Rotterdam gaat voor groen" Actieplan*, in addition to its participation as an implementation partner on Rotterdam Weather Wise (Rotterdam's Weerwoord, 2020). For 26 years, Opzoomer Mee has built up a network of more than 30,000 locals working on public space revitalisation at street level, but has also branched out into other areas of work, including supporting volunteers who read to children and provide Dutch-language instruction. With regards to its work related to the environment and placemaking, Opzoomer Mee is a partner on the current Rotterdam Weather Wise strategy, listed on the municipal website as an organisation providing small grants for greening and de-paving projects by residents. Among other things, the organisation aims to set the agenda for individual climate-adaptive actions by providing tools for greening and subsidies for de-paving and gardening projects. In 2020, requests to Opzoomer Mee from residents hoping to de-pave and green their streets number in the hundreds. However, much like Water Sensitive Rotterdam, staff have seen a mixture of motivations driving residents' projects: while some acknowledge climate adaptation as a chief motivator, others look to biodiversity, aesthetics, or even sometimes the questionable motive of preventing "unwanted" behaviours such as groups of young people spending time outside in a specific neighbourhood. However, while Opzoomer Mee is viewed as a translator of municipal goals to residents' actions, and provides support for more than 2,000 "bottom up" projects across the city, it has limited involvement in certain parts of Rotterdam, such as the Agniesebuurt and ZoHo neighbourhoods (Jurgen Groenenboom, personal communication, 14 July 2020).

Overall, the City's partnership with Opzoomer Mee is also valuable because of its contribution to stewardship and social cohesion, as well as the organisation's unique storytelling efforts around adaptation (Tim De Waele, personal communication, 4 September 2020).

Appendix C: Local policy

Table A2: Local policies in Rotterdam
Public space governance and community outreach
• "City Vision" • "Environmental Vision" • "Vision for Public Space 2019–2029" • *Zelfbeheer* programme • "Right to Challenge" programme
Climate adaptation strategies
• Waterplan Rotterdam 2 (2007/2008) • Rotterdam Climate Initiative (Mitigation) • Rotterdam Climate Proof (Adaptation) • Hittestress in Rotterdam report (2011) • Rotterdam Climate Change Adaptation Strategy (2013) • Rotterdam Climate Approach (2019) (Mitigation) • Weerwoord and Rotterdam Weather Wise Urgency Document • "Rotterdam gaat voor groen" Actieplan
Source: Author

The Rotterdam Climate Initiative (RCI) was established in 2006 "by local and regional organisations, and offers a platform for stakeholders from citizens to national government". The initiative focused on mitigation,

was established by local and regional organisations, and offers a platform for stakeholders from citizens to national government. RCI's website shows more than 200 climate-related sustainability initiatives from citizens, private bodies and government. Various investment projects – related to flood risk management and climate adaptation – are formulated in close cooperation with citizens and local stakeholder groups. (Ward et al., 2013, pp. 525-6)

The mitigation-focused staff working on the Rotterdam Climate Initiative at large were eventually incorporated into the City of Rotterdam's Sustainability Department in 2014 (John Jacobs, personal communication, 11 May 2020). Municipal adaptation programmes such as Rotterdam Climate Proof (2008) began soon after Rotterdam Climate Initiative, overseeing production of knowledge products that span topics from heat stress to urban water systems, as well as the implementation of projects such as green roofs and Waterplein Benthemplein (Rotterdam Climate Initiative, "Rotterdam Climate Proof").

In 2011, the national-level Knowledge for Climate (*Kennis voor Klimaat*) programme produced research into heat stress in Rotterdam, in the form of the Heat Stress in Rotterdam (*Hittestress in Rotterdam*) report. Supported by the Rotterdam municipal government, the Greater Rotterdam regional public health department (*Rijnmond*), and the Rotterdam Climate Initiative, the report highlights risks posed by an intensifying urban heat-island

effect, coupled with increasing population density. Areas like the centre of Rotterdam and the Kop van Zuid are identified as particular areas of heat risk, and the report highlights challenges posed by urban forms, including blocking of wind movement, and albedo/reflectivity and emissivity of building materials. Vegetation and surface water are named as potential strategies to lower local temperatures. Among other suggestions for personal behaviour change and public health interventions, the report names public space approaches such as the installation of fountains and greenery, the greening of roofs and façades, changes to building materials used for paving and roofing, and the creation of temporary shade structures. The strategy also emphasises the importance of combining climate-adaptive measures with other built environment interventions, and points to the importance of continuing the Sustainability Programme Office's iterative approach of "learning by doing" (Kennis voor Klimaat, 2011, pp. 11-13).

The Waterplan Rotterdam 2 document and knowledge products produced under the Rotterdam Climate Proof programme later gave way to the Rotterdam Climate Change Adaptation Strategy (2013). The strategy aligns with broader Delta Programme goals across the Netherlands concerned with flood management and spatial planning (Delta Programme Commissioner, s.a.). It also nests with city-wide strategy documents such as the City Vision/Stadsvisie and the Rotterdam implementation strategy *Uitvoeringsstrategie Rotterdam*, the latter of which highlights four priority areas: "the development of talent, the strength of a caring society, an attractive (inner) city and a strong economy" (Rotterdam Climate Initiative, 2013, p. 22). It aims to build upon existing protective infrastructure with adaptive measures.

The Rotterdam Climate Change Adaptation Strategy directly points to goals of a 100% climate-proof city by 2025, and shifts the narrative toward the importance of its "robust system" paired with an adaptive approach. It emphasises awareness-building, safety and accessibility, attractiveness of the city, a stronger economy, protection from surrounding rivers and the sea, and the reduction of climate impacts on inhabitants (Rotterdam Climate Initiative, 2013, p. 23). The strategy aims to achieve these goals through changes to spatial planning and the strengthening of existing infrastructure, while adapting through "use of the entire urban environment", including water squares and green roofs. The plan is based on "specific research carried out by external parties, by the Delta Programme and by the national research programme Knowledge for Climate". As mentioned above, the strategy uses "delta scenarios" based on data from the KNMI (Royal Meteorological Institute of the Netherlands), which overlap socioeconomic changes in Rotterdam with physical climate risks: higher sea and river levels, more intensive rainfall, more prolonged drought, and heat waves (Rotterdam Climate Initiative, 2013, pp. 8, 35).

Broadly speaking, the strategy is two-fold. In outer-dike Rotterdam "multi-layered flood protection through adaptive construction and design" is recommended, including flood-proof public areas and enhancement of biodiversity through efforts towards greening and incorporation of estuary/tidal ecosystems into the city (e.g. tidal parks). Meanwhile, in lower-lying "inner-dike" Rotterdam, prevention is named as the key approach, with storm-surge barrier enhancements and multi-functional reinforcement of dikes, "for example as recreational routes, natural embankments or combined with area development". Additionally, water-robust streets, collective gardens, extensions of canal systems, and rain barrels are suggested (Rotterdam Climate Initiative, 2013, pp. 11, 8, 31, 116). For each set of measures, the document outlines area-specific approaches, long-term adaptation

measures over time, as well as possible linkages to other ongoing initiatives, e.g. "child-friendly districts" (Rotterdam Climate Initiative, 2013, p. 82).

Beyond water management (flood and drought risks), the document also acknowledges heat risks. When it comes to public-space-related measures against extreme heat, many of the same measures for flood and drought management are named a second time, including de-paving and increasing greenery in public and private spaces. In addition, awareness building, coupled with new water features and reflective materials in public spaces, are also highlighted as cooling strategies. Cooperation with initiatives such as wilderness playgrounds and "building with nature" in outer-dike Rotterdam is recommended (Rotterdam Climate Initiative, 2013, p. 94).

The Rotterdam Climate Change Adaptation Strategy document directly acknowledges the role of public spaces in adapting to climate risks, as well as the opportunity for social cohesion to be enhanced through resilience and adaptation measures. Public space measures such as green roofs and water squares (particularly in dense areas) can provide progress towards a "waterproof city", while rain gardens and expanded areas of surface water can help in times of both flood and drought. These structural changes, in addition to de-paving and planting activities "provide a wide range of opportunities for getting the people of Rotterdam more involved with their city and with their own direct living environment in particular. The inhabitants can play an active role, which in turn improves social cohesion." For example, efforts at greening have already been implemented through programmes such as Green Roof Information Days, the "Green Team," and "Paving out, Plants in" (Rotterdam Climate Initiative, 2013, pp. 83, 87).

While the document was successful in providing theoretical links between social and physical climate-adaptation measures, it wasn't always integrated into projects. Climate adaptation was often seen as an additional task, rather than as something to be integrated into various development projects in the public realm (John Jacobs, personal communication, 11 May 2020). Additionally, the strategy was not the result of a robust community input process. According to Florian Boer, one of the co-founders of the urban research and design firm De Urbanisten, which was involved in the drafting of the document, it was requested by an Alderman in Rotterdam and intended primarily for "internal" use. The strategy was built to be somewhat open-ended and applicable to different locations, and was later applied to places such as the Zomerhofkwartier (see projects below). Ultimately, the Rotterdam Climate Change Adaptation Strategy served as an "in-between step" between Waterplan Rotterdam 2 and a more "political" subsequent document, *Weerwoord*, which is more integrated into projects. Today, programmes to partner with non-profits such as Water Sensitive Rotterdam, which acts as an implementing and funding body for on-the-ground adaptation projects in Rotterdam, are still "a concrete way to execute the climate-adaptation plan" (Florian Boer, personal communication, 8 May 2020).

In 2019, the Rotterdam Climate Approach (*Rotterdamse Klimaataanpak*) was released by the Sustainability Department (a sub-department of the Stadsontwikkeling Department), setting out climate goals. These goals are mitigation-focused, and aim to keep Rotterdam in step with wider, global goals for greenhouse gas mitigation. This document does not touch on adaptation efforts or public spaces, and has more to do with energy, consumption, and mobility-related initiatives in Rotterdam (Rotterdam, 2019b).

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